D.T1.2.1 WORK PAPER

Methodology for analysis of market potentials for rail freight transport

Version 1.0
01.2020

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1. Introduction

The following sections describe the results of the market potential analysis, which has been developed within the REIF project with the aim of estimating the potential rail service demand for the next decade, in terms of volumes and spatial relationships. Even thanks to the current interventions for the infrastructure upgrade, the railway port system is expected to be able to meet such potential demand, providing an adequate capacity and a proper operations model. In this regard, the estimated potential rail traffic volumes represent a useful element to evaluate the system performances.

2. Status quo Analysis of Market Potential

2.1. Analysis of regional rail network and services

The analysis of regional rail network and services has been performed according to two different levels of detail: indeed, the following sections describe the railway infrastructural elements and the transport service offer regarding, respectively, the specific case of the Port of Trieste and, on a wider extent, the TEN-T (*Trans European Network - Transport*) corridors that pass through the territory of the Friuli Venezia Giulia Region, which are the Baltic-Adriatic and the Mediterranean ones.

2.1.1. The Port of Trieste

Thanks to its strategic position in the centre of Europe, to it great water depth and to the peculiar fiscal regime of Free Port, the Port of Trieste represents an important international hub for freight trade with Central and Eastern Europe marketplaces and, more recently, also with Far East. Besides, the development of freight intermodal transport in the Port of Trieste is sustained by the presence of two TEN-T corridors in the Friuli Venezia Giulia region and of an internal railway network which is connected to the national and international one. The Port of Trieste is composed by two main parts, distinguished according to the type of activity they are dedicated to: on one side, the commercial port, including the areas called Punto Franco Nuovo, and on the other side, Scalo Legnami, Punto Franco Oli Minerali, and the industrial port, which is located in the area of the Canale Navigabile.

The current configuration of the railway infrastructures in the Port of Trieste includes the following stations, which are linked both with external national network and among them:

- Trieste Campo Marzio Smistamento, located in the Punto Franco Nuovo e directly connected both to the national network by means of the junction called “Galleria di Cintura” and the line Trieste Centrale-Bivio di Aurisina, and to Villa Opicina station (Slovenian border) through a single-track line (“linea Transalpina”);
- Trieste Servola, in the proximity of the industrial establishment called Ferriera;
- Trieste San Sabba, situated between the areas of Servola and Punto Franco Oli Minerali;
- Trieste Aquilinia, located in the area of the Canale Navigabile.

The station of Trieste Centrale Scalo has been disused for years, while the one of Trieste Central is dedicated only to passenger railway services.

The main infrastructure component of the railway network in the Trieste node is constituted by a circular double-track line under a tunnel which links the Trieste Centrale station with the one of Trieste Campo Marzio. At the present moment, this latter represents the merging station not only of traffic flows generated in the area of Punto Franco Nuovo, but also of those originated by Scalo Legnami, Ferriera and Punto Franco Oli Minerali, since all the composition and decomposition operations of freight trains are carried out in the Trieste Campo Marzio station. This trains management approach is going to be modified in the near future thanks to the reopening of the junction between the railway switches called San Giacomo and Cantieri, which connects the Southern part of the port directly with the Galleria di Cintura without passing through the Trieste Campo Marzio station. Except for the sections Trieste Aquilinia-Trieste Campo Marzio and Trieste Campo Marzio-Villa Opicina, all the sections in the railway node of Trieste are double track (their technical features are described in Table 2).

Based on their location, the various terminals of the Port of Trieste refer to the diverse stations composing the railway network described above, as reported in detail in Table 1.

Table 1 - Terminals of the Port of Trieste and respective referring station
Source: our elaboration

Terminal	Station
Riva Traiana and MoloV	Campo Marzio
Molo VI	
Molo VII	
Scalo Legnami	Servola
Ferriera	
Punto Franco Oli Minerali	S. Sabba
Canale Navigabile	Aquilinia
Noghere	
Wärtsilä	

The use of spaces and docks of the different terminals is given in concession by the Port Network Authority of the Eastern Adriatic Sea (PNAEAS) to various operators, who manage the movement of freights belonging to several handling categories. More specifically, the following freight typologies are handled in the Port of Trieste: containerized freights, fruit and vegetable products, coffee, cereals, metal, engines, steel and chemical products, wood, solid and liquid bulk, crude oil and its derivative products.

The rail services performed by the principal economic entities in the Port of Trieste represent freight intermodal transport solutions destined mainly to Austria, Germany, Luxembourg, Hungary, Czech Republic and Slovakia; indeed, only a limited number of those services is directed towards Italy.

On behalf of railway companies, shunting operations for arriving and departing freight trains in the Trieste Campo Marzio station are carried out by the company Adriafer S.r.l., constituted and owned by the PNAEAS, which has been represented the only operation manager for the Punto Franco Nuovo since 2016. Furthermore, Adriafer S.r.l. performs shunting operations at one of the terminals managing oil products and at the Interporto di Trieste, which is an inland terminal located in Fernetti and connected to the Villa Opicina station.

2.1.2. The Baltic-Adriatic and Mediterranean Corridors

As mentioned previously, two of the nine TEN-T corridors (Figure 1) are present on the territory of the Friuli Venezia Giulia region, namely the Baltic-Adriatic and the Mediterranean ones (Figure 2).

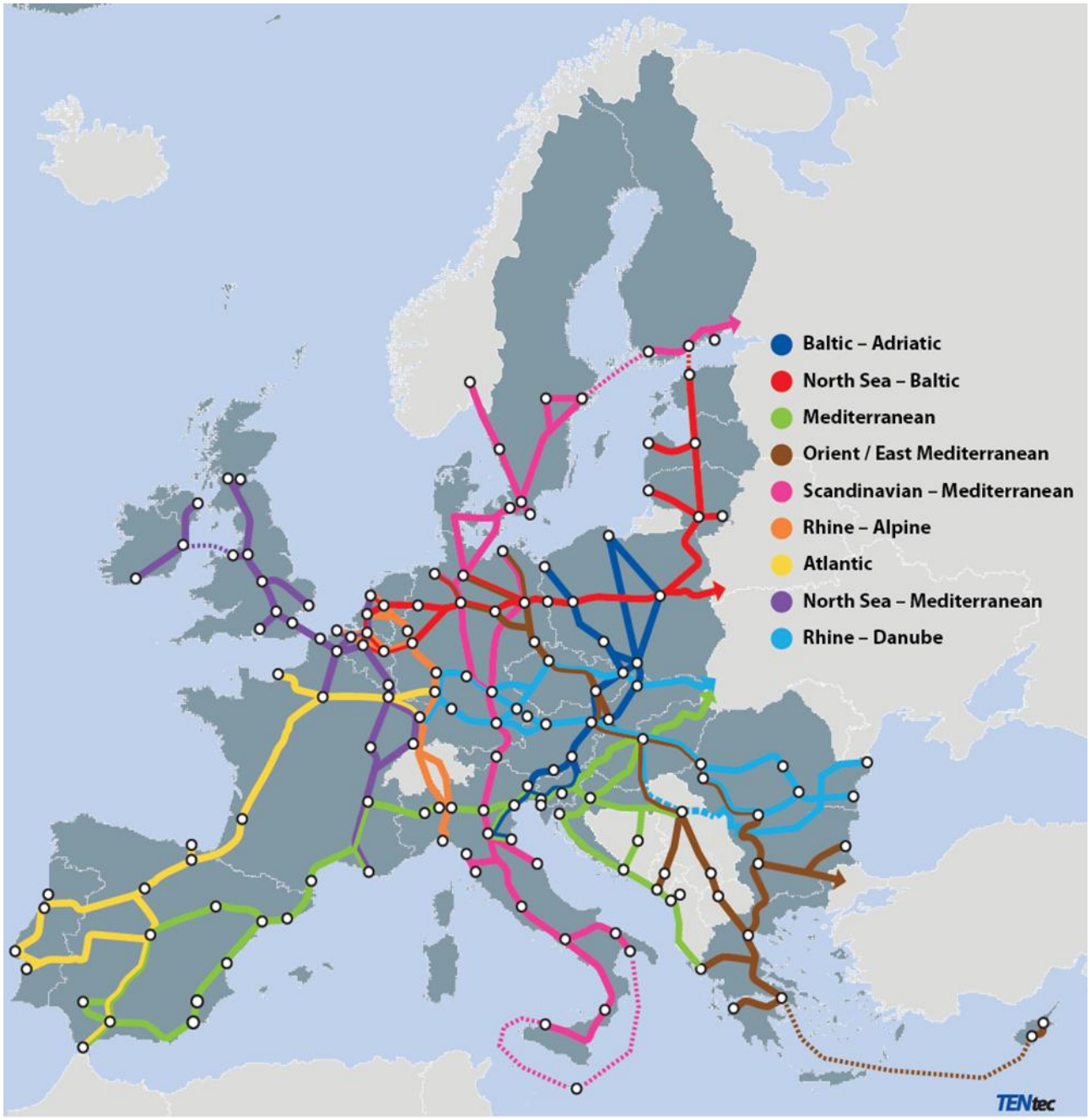

Figure 1 - TEN-T Corridors
Source: Eurostat

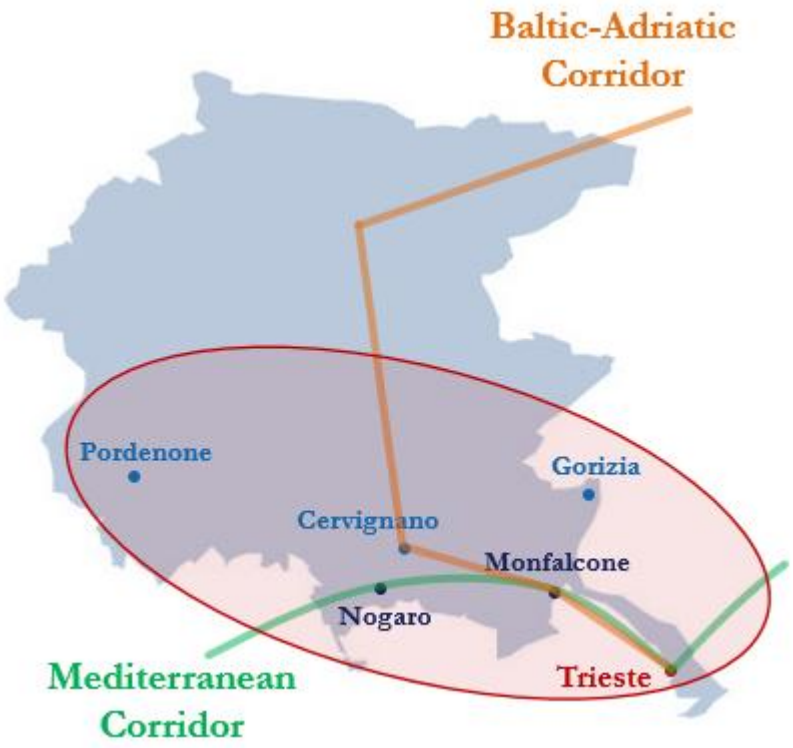

Figure 2 - TEN-T Corridors present in the Friuli Venezia Giulia region

Source: Our elaboration

The Baltic-Adriatic Corridor connects the ports of Poland, Slovenia and Italy with the main inland terminals of those nations, extending from the north to the south of Eastern Europe along the following main route: Świnoujście / Gdynia – Katowice – Ostrava / Žilina – Bratislava / Vienna / Klagenfurt – Udine –Venice / Trieste / Bologna / Ravenna / Graz – Maribor – Ljubljana – Koper / Trieste. In addition to the principal route, the Baltic-Adriatic Corridor encompasses both some diversionary routes, used for re-routed trains in case of disturbance on the main lines, and some sections linking terminals and inland areas with the principal lines. The total length of the Corridor is about 5000 km, of which approximately 40% pertains to Poland and its extension involves further countries like Austria, Czech Republic and Slovakia. Among the nations engaged by the considered Corridor, only Poland, Slovenia and Italy are located on the sea and thus have the opportunity to connect the Corridor to their respective ports of Gdańsk, Gdynia, Świnoujście, Szczecin, Koper, Trieste, Venice and Ravenna.

Table 2 contains the main technical features characterizing the line sections of the Baltic-Adriatic Corridor passing through the Friuli Venezia Giulia region. In particular, the following parameters are reported: section length, type of line, number of tracks, type of traction/power supply, maximum train length, maximum axle load, maximum load per meter, maximum line speed for freight, profile, control and command system, and telecommunication system.

Table 2 - Technical features of the line sections of RFC 5 in the Friuli Venezia Giulia region
Source: Book 5 - Implementation Plan, Corridor Information Document RFC 5

Line section	Section length [km]	Type of line	Number of tracks	Type of traction/ Power supply	Max train length [m]	Max axle load [tons/axle]	Max load per meter [tons/m]	Max line speed for freight [km/h]	Profile (P/C)	Control and command system	Telecommunication system
Tarvisio Boscoverde (confine AT/IT)- Carnia	49,121	Principal route	Double track	3kV DC	625	22,5	8	140	P/C 80	Italian system - class B	GSM-R
Carnia-PM VAT	35,176	Principal route	Double track	3kV DC	625	22,5	8	140	P/C 80	Italian system - class B	GSM-R
PM VAT-Udine	4,493	Principal route	Single track	3kV DC	625	22,5	8	120	P/C 80	Italian system - class B	GSM-R
Udine-Gorizia	32,862	Principal route	Double track	3kV DC	595	22,5	8	140	P/C 80	Italian system - class B	GSM-R
Gorizia-Bivio S. Polo	20,829	Principal route	Double track	3kV DC	595	22,5	8	100	P/C 80	Italian system - class B	GSM-R
Bivio S. Polo-Bivio d'Aurisina	14,183	Principal route	Double track	3kV DC	600	22,5	8	100	P/C 80	Italian system - class B	GSM-R
Bivio d'Aurisina-Trieste	14,539	Principal route	Double track	3kV DC	600	22,5	8	100	P/C 80	Italian system - class B	GSM-R

Udine-Treviso	105,73	Principal route	Double track	3kV DC	575	22,5	8	140	P/C 80	Italian system - class B	GSM-R
Udine-Cervignano	28	Diversionary route	Single track	3kV DC	625	22,5	8	100	P/C 80	Italian system - class B	GSM-R
Cervignano-Ronchi dei Legionari Sud	13	Diversionary route	Double track	3kV DC	600	22,5	8	140	P/C 80	Italian system - class B	GSM-R
Ronchi dei Legionari Sud-Bivio S. Polo	2	Diversionary route	Double track	3kV DC	600	22,5	8	100	P/C 80	Italian system - class B	GSM-R
Bivio d'Aurisina-Villa Opicina	15,013	Principal route	Double track	3kV DC	600	22,5	8	80	P/C 80	Italian system - class B	GSM-R

Table 3 contains a brief analysis of the bottlenecks regarding both railway infrastructure and operations that could possibly occur on some line sections or nodes of the Baltic-Adriatic Corridor in the Friuli Venezia Giulia region, due to the future increase in railway freight traffic in the considered territory and, more in general, along the TEN-T Corridors.

Table 3 - Bottlenecks analysis of line sections and nodes of RFC 5 in the Friuli Venezia Giulia region
Source: Book 5 - Implementation Plan, Corridor Information Document RFC 5

Line section or node	Bottlenecks	
	Infrastructure	Operations
Udine node	Limited capacity due to the presence of the single-track line	Limited capacity due to the presence of traffic promiscuity
Padova-Trieste/Tarvisio line	Station conditions and line limit trains length	
Trieste node	Station conditions limit the length of trains entering/exiting the Port of Trieste	Limited capacity due to the increase in railway traffic rom/to the Port of Trieste

Finally, Table 4 reports a list of terminals and transfer stations along the part of the Baltic-Adriatic Corridor passing through the Friuli Venezia Giulia region, and their connectivity with the different transport modes.

Table 4 - Terminals/transfer stations along RFC 5 in the Friuli Venezia Giulia region and their relative connectivity
Source: Book 5 - Implementation Plan, Corridor Information Document RFC 5

Terminal/Transfer station	Connectivity		
	Road	Rail	Water
Cervignano Interporto	x	x	
Udine Parco	x	x	
Pier VII – Trieste Campo Marzio	x	x	x

The Cervignano inland terminal (“Interporto di Cervignano”) represents an integrated system of logistics infrastructures for freight transport and it is constituted by an area of 460,000 sqm, on which an intermodal terminal, various warehouses and yards, management headquarters and some means for freight movement operations are present. Thanks to its position, the Cervignano inland terminal is able to serve the Ports of Trieste, Monfalcone and Nogaro, and it is characterized by direct or indirect connections with the highway, railway and the regional airport. In particular, regarding the railway

mode, the Cervignano inland terminal possesses 3 sets of 2 750-meter long tracks, on which the Venice-Trieste, Cervignano-Palmanova-Udine and Udine-Tarvisio lines converge. Concerning the services offered by the Cervignano inland terminal, different types of freights originated by both intermodal and conventional traffic flows are handled from road to rail and vice versa.

The realization of a 40,000 sqm yard is currently under development, enabling the enlargement of the areas dedicated to the storage of vehicles.

The station called Udine Parco is located on the Udine-Trieste line and its tracks are deployed not only for rail-road intermodal transport, but also for the composition and decomposition operations of freight trains and for the parking of rolling stock.

The Pier VII of the Port of Trieste is constituted by a port terminal of 400,000 sqm with an internal railway park composed by 5 600-meter long tracks and some freight loading and unloading vehicles able to operate on the biggest existing containerships (post Panamax). The terminal presents also a wide area with open and covered warehouses for freight storage. In the Pier VII, a variety of logistics services are carried out according to the diverse nature of freight, which differ from handling category and size. The terminal offers maritime connections with the Far East, the Mediterranean area and, to a lesser extent, with the Middle east, India, Pakistan and Eastern Africa. As far as railway traffic is concerned, it provides connections mainly with Austria, Germany, Hungary, and more marginally also with Slovakia, Czech Republic and Italy.

With the aim of fostering intermodality for freight transfers, some financial investments are considered to realize new railway links and to carry out infrastructural and technological modernisation interventions of various line sections and nodes located in the Friuli Venezia Giulia region and included among the Baltic-Adriatic Corridor infrastructural components. On the basis of their extent, those initiatives require a different duration for their actualization and thus they are currently under diverse development phases. More in detail, the investment plan elaborated for the long term considers the construction of the Venice-Ronchi dei Legionari, Ronchi dei Legionari-Trieste and Trieste-Divača railway lines; while the investment plan for the short term includes modernisation and technological upgrading works in the Udine and Trieste nodes and on the some line sections of interest for the Corridors and for the Port of Trieste, like the ones between Trieste and Bivio d'Aurisina, Bivio d'Aurisina and Villa Opicina, Bivio San Polo and Bivio d'Aurisina, Monfalcone and Udine via Gorizia, Palmanova and Udine, and the connection line with Venice. All these interventions will enable to remove some of the bottlenecks limiting the railway operations along the Baltic-Adriatic Corridor and, due to its strict interaction with the Mediterranean Corridor, also this latter will benefit from the effects of the implemented initiatives.

As far as the Mediterranean Corridor is concerned, it connects South-Western Europe with Eastern Europe and involves Spain, France, Italy, Slovenia, Croatia, and Hungary, extending along the following route: Almeria-Valencia / Algeciras / Madrid-Zaragoza / Barcelona-Marseille-Lyon-Turin-Milan-Verona-Padua / Venice-Trieste / Koper-Ljubljana / Rijeka-Zagreb-Budapest-Záhony.

Similarly to the Baltic-Adritaic Corridor, also the Mediterranean one is constituted by a principal route, diversionary routes and links connecting the most relevant terminals for freight traffic to this Corridor. Besides, in some cases even those lines running parallel to the Mediterranean Corridor have been included, since they could contribute to guarantee the sufficient capacity needed by the Corridor in the future. Furthermore, lines that currently do not play a significant role in long-haul freight transfers have been also considered, thanks to their potential usefulness. Finally, all the lines characterized by a

dedicated capacity and that are expected to hold pre-arranged train paths have been referred to this Corridor.

The total length of the Mediterranean Corridor equals approximately 8,000 km, of which more than 40% develop on the Spanish territory; overall, 90 terminals have been designated to this Corridor, distributed differently among the involved countries.

Table 5 contains the main technical features characterizing the line sections of the Mediterranean Corridor in the Friuli Venezia Giulia region. In particular, the following parameters are reported: section length, type of line, maximum train length, maximum axle load, maximum load per meter, train speed, profile, power supply, signaling system, and gradient.

The only terminal of the Friuli Venezia Giulia region designated for the Mediterranean Corridor is the Pier VII of the Port of Trieste (Interporto di Trieste), managed by the terminal operator called Trieste Marine Terminal; its main characteristics have previously described in the section regarding the Baltic-Adriatic Corridor.

The investment plan elaborated for the enhancement of freight traffic along the Mediterranean Corridor considers the realization of the following set of infrastructural interventions in the Friuli Venezia Giulia region, with their relative beneficial impacts on railway freight transfer:

- The infrastructural and technological advancement of the Trieste node, encompassing works inside and outside the port area, the modernisation of the Trieste Campo Marzio station, of the line “Linea di Cintura” and of the Servola and Aquilinia stations, and the development of the intermodal integration, aimed at increasing the capacity of the Corridor;
- The introduction of 750-meter long trains (which is the standard train length on TEN-T Corridors) on all the line sections of the Corridor and the upgrading of the Venezia-Trieste line by speeding up the existing line;
- The implementation of ERTMS on all the main sections of the Corridor;
- The infrastructural and technological upgrading of the railway line Trieste-Divača, in order to enhance the capacity.

Analogously to the Baltic-Adriatic Corridor, the interventions that are intended to be implemented on the Mediterranean Corridor are currently under a different development phase, according to the extent of the initiatives and thus to their expected duration.

Table 5 - Technical features of line sections of RFC 6 in the Friuli Venezia Giulia region
Source: Book 5 - Implementation Plan, Corridor Information Document RFC 6

Line section	Section length [km]	Type of line	Max train length [m]	Max axle load [tons/axle]	Max load per meter [tons/m]	Train speed [km/h]	Profile	Power supply	Signaling system	Gradient [‰]	
										Towards NE	Towards SO
Padova-Bivio d'Aurisina	131	Principal route	575	22,5	8	90<v≤100	80/410	3kV DC	BACC, SCMT	9	10
Portogruaro-Bivio d'Aurisina	43	Principal route	600	22,5	8	90<v≤100	80/410	3kV DC	BCA, SCMT	9	10
Bivio d'Aurisina-Villa Opicina	15	Principal route	600	22,5	8	75<v≤90	80/410	3kV DC	BEM, SCMT	15	0
Bivio d'Aurisina-Trieste	14	Principal route	600	22,5	8	75<v≤90	80/410	3kV DC	BACC, SCMT	14	1

2.1.3. Railway infrastructure and service overview

The present section reports a brief overview of railway infrastructures and services characterising the Port of Trieste and, more in general, the Friuli Venezia Giulia region; this description is functional for the understanding of the analysis of current and potential traffic flows, which is illustrated in the following sections of the present document.

The Port of Trieste has an internal railway network at the service of the various terminals and connected with the national one by means of the Trieste Campo Marzio station, where at the moment all traffic flows generated by the other port stations converge.

The various terminals of the commercial port handle containers, Ro-Ro, conventional freight, and solid and liquid bulk, which are destinated mostly to Central and Eastern Europe and, more marginally, also to Italy.

Analysing the railway context according to a wider perspective, the Port of Trieste has a good connection with the stations located in the proximity of the state borders which are present in the Friuli Venezia Giulia region, namely the Austrian and Slovenian ones (Figure 3).

Figure 3 - Main railway network of the Friuli Venezia Giulia region
Source: Rete Ferroviaria Italiana

More in detail, the railway network that connects the Port of Trieste with state border stations can be divided into the following infrastructural components:

- Trieste node;
- Trieste-Bivio Aurisina line section;
- Aurisina-Villa Opicina-Slovenian state border line section;
- Udine-Tarvisio-Austrian state border line section;
- Bivio di Aurisina-Bivio San Polo line section;
- Bivio San Polo-Udine line section;
- Other links between the regions of Friuli Venezia Giulia and Veneto.

All the line sections considered in the infrastructural components listed above are double track, electrified and characterized by a profile P/C80, but they differ from the gradient of the route.

As far as the railway network usage is concerned, Figure 4 proposes a graphical representation of the residual capacity on the line sections connecting the Port of Trieste with state border stations, which has been determined as the difference between their maximum capacity (estimated by the national infrastructure manager called Rete Ferroviaria Italiana) and their actual use, based on the official planned timetable with reference to a weekday. The colours reported in Figure 5 have been attributed to different value intervals related to used and residual capacity, according to the following classification:

- Light green: used capacity between 0% and 40%, and residual capacity between 100% and 60%;
- Dark green: used capacity between 40% and 60%, and residual capacity between 60% and 40%;
- Yellow: used capacity between 60% and 75%, and residual capacity between 40% and 25%;
- Orange: used capacity higher than 75% and residual capacity lower than 25%;
- Black: line section with no traffic (currently closed).

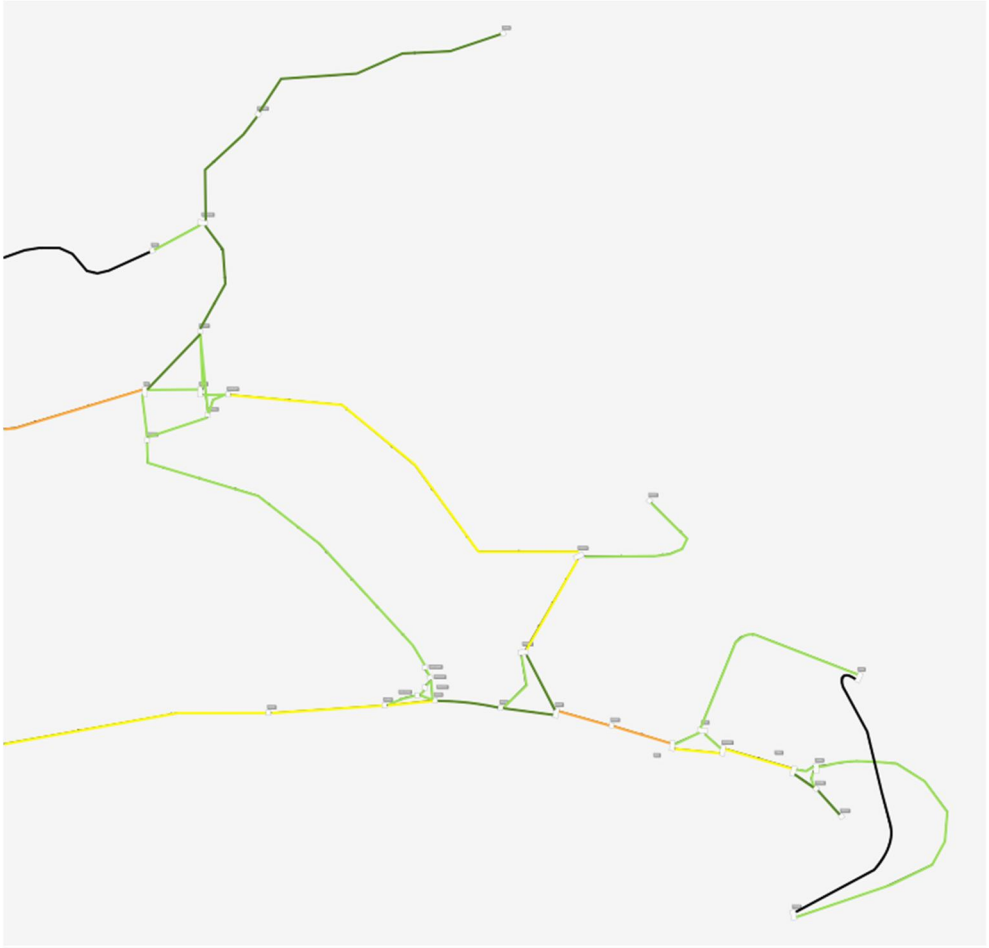

Figure 4 - Residual capacity of line sections connecting the Port of Trieste with cross border stations

As it can be noticed from Figure 4, along the route between Trieste and Tarvisio (Austrian cross border), the most critical line section in term of residual capacity is the one between Bivio di Aurisina and Bivio San Polo, where railway flows coming from North-South and East-West traffic routes converge. This limitation could hinder an increase in traffic volumes expected for the Port of Trieste in the future, which can be achieved also thanks to the enhancement of the two TEN-T Corridors passing through the Friuli Venezia Giulia region, namely the Baltic-Adriatic and the Mediterranean ones.

2.2. Analysis of the logistic market (Development and Trends)

With the aim of investigating the potential market of new railway service from/to the Port of Trieste, an in-depth analysis of transport flows currently or potentially passing through the Friuli Venezia Giulia region and, more specifically, the Port of Trieste, has been performed considering their characteristics in terms of traffic routes, transport mode and handling category. In line with the methodological approach proposed within the REIF project, such analysis represents a fundamental preliminary step in order to perform a realistic assessment of the railway capacity needed to meet the traffic demand that could concern the Port of Trieste in the future.

Besides, the present section illustrates the results of a study carried out with the aim of defining and evaluating some possible development scenarios for intermodal traffic in the Port of Trieste in 2030. Indeed, after a detailed analysis of intermodal traffic dynamics in the Port of Trieste in the last 15 years, the main hypothesis characterizing the considered future development scenarios have been set and discussed. Finally, the outcomes of the projections regarding intermodal traffic in 2030 have been described and examined in light of the initial assumptions, taking into account the consequences that they could implicate in terms of meeting the freight transport demand from/to Central-Eastern Europe.

2.2.1. Methodological approach

The analysis of traffic flows has been developed using a 2016 quantitative data base deriving from the update of some Origin/Destination (O/D) matrices elaborated by the European Commission for the update to 2010 of the Trans-Tools model, which corresponds to the data base of the European project called “European Transport Information System” – ETIS PLUS. The Trans-Tools model is the model used for the definition and assessment of the Trans-European transport Network (TEN-T).

In the present study, it has been necessary to define an adequate zoning model for the study area, in order to develop an analysis of the freight transport demand concerning the Friuli Venezia Giulia region and the Port of Trieste which enables a multimodal and multisector investigation of the transport system. The proposed zoning model is articulated on two different levels:

- The first one considers 14 aggregated “traffic zones”, with the aim of performing an initial skimming of the traffic relationships that could affect the development of the regional transport system:
  - The Friuli Venezia Giulia region and other macro areas for the rest of Italy;
  - Aggregation of 6 macro areas for the external European areas (north-west, north, north-east, east, south-east, and west);
  - At continental level for Africa, North and South America, and Asia and Oceania.
- The second and more detailed level considers 25 zones, with the goal of focusing on European marketplaces according to a national scale or on the basis of smaller aggregated sets of different countries:
  - The Friuli Venezia Giulia region and other macro areas for the rest of Italy;
  - At regional level for Austria, Slovenia and Croatia;
  - At national level or small aggregated sets of contiguous countries for the rest of Europe;
  - At continental level for Africa, North and South America, and Asia and Oceania.

The two zoning models, which are reported respectively in Tables 6 and 7, are characterized by similar denominations but, at the same time, also by some differences, that are explained in the following. Firstly, Turkey has been separated in the codification of the "south-eastern Europe" area of the 25-zone model, since it currently represents a relevant marketplace for the Port of Trieste, but it could become even more significant in the future. Secondly, the "eastern Europe" area in the 14-zone model has been divided into 3 specific traffic areas: one encompassing Slovenia and the northern region of Croatia, one including three countries of the former Soviet Union (Moldavia, Rumania and Ukraine) and, finally, one considering the Russian Federation.

Furthermore, a difference in the zones denominated "western Europe" has to be highlighted: in the more disaggregated zoning model, western Europe encompasses also the area called "north-western Europe" in the 14-zone model (Great Britain, Ireland and Island) and excludes Switzerland, to which a specific area has been dedicated in the 25-zone model. This rearrangement has been motivated by the assumption that no trade relationships originated by this zone are possible with the Port of Trieste, especially with reference to intermodal sea-rail logistics chains. On the other side, the exclusion of Switzerland derives from the fact that this country could become an area of interest for the Port of Trieste.

In conclusion, regarding the adopted methodological approach, it is useful to notice that the attention has been drawn on freight transfers exceeding 300 km. Indeed, it is acknowledged both in literature and among practitioners that this distance represents the threshold determining the competitiveness of railway transport over the road one. Although this assumption concerning the extent of freight transfers limits the scope of the analysis, at the same time it enables a more realistic evaluation of the potential development of the intermodal rail-sea transport sector.

Table 6 - Aggregated zoning model with 14 traffic macro-zones
Source: our elaboration

ID	Zone name
1	Friuli Venezia Giulia
2	Other north-eastern Italian regions
3	North-western Italy
4	Central-southern Italy
5	North-western Europe
6	Northern Europe
7	North-eastern Europe
8	Eastern Europe
9	South-eastern Europe
10	Western Europe
11	Africa
12	North America
13	South America
14	Asia and Oceania

Table 7 - Disaggregated zoning model with 25 traffic zones
Source: our elaboration

ID	Zone name
1	Friuli Venezia Giulia
2	Other north-eastern Italian regions
3	North-western Italy
4	Central-southern Italy
5	Benelux countries
6	Germany
7	Switzerland
8	Western Austria
9	Eastern Austria
10	Hungary
11	Czech Republic
12	Slovakia
13	Poland
14	Scandinavian countries
15	Baltic countries
16	Other former Russia countries
17	Russian Federation
18	Slovenia e northern Croatia
19	South-eastern Europe
20	Turkey
21	Western Europe
22	Africa
23	North America
24	South America
25	Asia and Oceania

The definition and evaluation of development scenarios for intermodal traffic in the Port of Trieste in 2030 has been performed adopting a methodological approach that consists in the following steps:

- A quantitative informative base concerning both the Port of Trieste and the competitive context in which it operates, has been created with a twofold goal: on one hand, to analyse the historical

trends regarding freight movements in the Port of Trieste according to specific sectors and, on the other hand, to assess such trends with respect to past forecasts and to the performances of the principal rival ports;

- Development scenarios for intermodal traffic in the Port of Trieste, and their split among land transport modes, have been created and appraised in order to estimate the potential traffic flows concerning the rail network.

The informative base has been created using both statistics data available not only on the web site of the Port Network Authorities (PNA) of the Eastern Adriatic Sea (including its port information system) and of the North Adriatic Sea, but also statistics data provided by ASSOPORTI and reported by other information sources (Confcommercio-Isfort, CONFETRA, SRM, ecc.). Such task has enabled the creation of a historical series, from 2004 to 2019, of the traffic concerning the Port of Trieste according to each sector (with particular attention to the intermodal sector), which has been used to determine past trends of every considered sector and to compare these trends with the ones of rival ports of the Mediterranean Sea, and even of the Black and Baltic Seas. All the cited port systems are actually in competition with each other to serve the expanding marketplaces of the Central-Eastern Europe.

The creation of the described time series allows also the comparison of the performances of the Port of Trieste with respect to past forecasts, which were elaborated mainly at the beginning of the 2010s.

Finally, as far as the creation of development scenarios of sea-rail intermodal traffic for the Port of Trieste in 2030, the adopted methodological approach has been based on the definition of some hypothesis both for the increase in traffic volumes and for the modal split. In the first case, an average value has been determined according to the 2009-2019 historical trend and then an upper value (corresponding to an optimistic scenario) and a lower value (corresponding to a pessimistic scenario) have been set using the statistical concept of the deviation standard. Conversely, for the modal split a base value has been determined referring to the 2019 rail share, assuming a reasonable potential growth of its entity in order to define a medium and a higher level of competitiveness of such transport mode.

However, since from the analysis of the historical series it was observed that the two considered intermodal traffic sectors (containers and Ro-Ro) have been characterized by quite diverse evolution trends in the recent past, it was decided to create two separate development scenarios with the aim of reflecting such difference. As a matter of fact, an “Aggregated” scenario has been created jointly considering the two intermodal sectors, whose traffic flows have been expressed in terms of tons; while a “Disaggregated” scenario has been developed distinguishing a different value for traffic growth and modal split between the two intermodal sectors and using the respective measurement units, i.e. TEUs for the containers and the number of vehicles for the Ro-Ro sector. The two developed scenarios have been compared transforming, on one hand, the tons in TEUs through the 2019 average weight value in the “Aggregated” scenario and, on the other hand, homogenizing the number of vehicles in TEUs by means of an appropriate coefficient based on the available 2019 data in the “Disaggregated“ scenario.

In conclusion, traffic estimations for the two developed scenarios have been subjected to a counterfactual assessment in order to verify the reasonability of the initial assumptions. To this end, starting from the quantitative informative base created to examine the potential freight volumes regarding the Port of Trieste, the traffic study has been further detailed in order to better specify the features of Central-Eastern European marketplace that could concern such port. The analysis has consisted in estimating the share of the total freight volumes generated/attracted by the

abovementioned area and headed to extra continental marketplaces passing through the "Northern Range" gateways and Poland, which is a country that has been taken into account as part of the competitive port context under study. Furthermore, based on the expected economic development reported in literature, an approximate estimation of the potential trade market for the Port of Trieste in 2030 has been performed, evaluating the possible implications in relation to the results obtained from the analysis of the intermodal traffic development scenarios adopting the "what-if" approach.

2.2.2. Characterization of freight transport demand to/from the Friuli Venezia Giulia region

In line with the aim of investigating the market potential for the Port of Trieste in terms of catchment areas, the first step of the study has consisted in the analysis of commercial exchanges generated or attracted by the Friuli Venezia Giulia region and carried out along the TEN-T Corridors. The task was performed in order to provide an analysis of those freight transfers with respect to their modal share, handling category and traffic route.

The adopted zoning model, in particular the 14-zone one, has enabled to approximately estimate the traffic flows along the TEN-T Corridors passing through the Friuli Venezia Giulia region, namely the "Baltic-Adriatic" Corridor (Corridor 1), the "Scandinavian-Mediterranean" Corridor (Corridor 5 – for the south-north route) and the "Mediterranean Corridor" (Corridor 3 – for the east-west route). More specifically, the correspondences with the 25-zone zoning model has been defined as follows, distinguishing national and international exchanges for the Corridor 3:

- O/D flows between the Friuli Venezia Giulia region and North-East Europe have been attributed to the Baltic-Adriatic Corridor;
- O/D flows between the Friuli Venezia Giulia region and the other Italian areas have been attributed to the Mediterranean Corridor, since also commercial exchanges with Central-South Italy are partially performed along the east-west route. Even commercial exchanges with Western and Eastern Europe have been attributed to the Mediterranean Corridor;
- O/D flows between the Friuli Venezia Giulia region and the two zones which constitute the North-West European area have been attributed to the Scandinavian-Mediterranean Corridor, although the initial part of the considered itinerary passing through the Friuli Venezia Giulia region actually belongs to the Baltic-Adriatic Corridor.

It must be noticed that, as the considered TEN-T Corridors are land corridors, the maritime transport mode should not be taken into account in the analysis. Indeed, on one hand, the flows between the Friuli Venezia Giulia region and the extra continental macro areas have not been considered in the study, as it can be observed by the way in which O/D flows have been attributed to the different Corridors. Even traffic flows between the Friuli Venezia Giulia region and south-eastern Europe have not been considered, due to the following two reasons: not only because this latter zone represents a macro area encompassing Greece and Turkey, whose commercial exchanges with the Friuli Venezia Giulia region are carried out mainly by sea, but also because it is difficult to attribute the existing limited land flows to one of the examined Corridors. On the other hand, the possible presence of sea flows characterized by a route similar to the itinerary of one of the considered Corridors has been pointed out (for example,

the sea exchange relationship between the Friuli Venezia Giulia region and the northern European area has been attributed to the Scandinavian-Mediterranean Corridor).

According to these premises, Table 8 illustrates the traffic flows generated or attracted by the Friuli Venezia Giulia region in 2016 and referred to distances greater than 300 km, distinguishing the different handling categories and transport modes. The total annual amount of freight related to these flows equals approximately 37 million tons, of which 66% have been transferred by sea, 28% by road and only 6% by rail.

As far as the handling categories interested by these traffic volumes, Table 8 describes their impact on the modal share of flows. Indeed, it can be noticed that the sector of oil products prevails over the other ones, as it constitutes the 43% of total flows, using almost exclusively the sea mode (for about 98% of the transfers). In this regard, it must be underlined that once oil products arrive at the dedicated terminal at the port of Trieste (Terminal Marino), they reach their destination refinery by means of the Transalpine pipeline, whose itinerary passes through the Friuli Venezia Giulia region, Austria and Germany.

The second most important sector in terms of handling category is the one encompassing transport equipment, machinery, manufactured objects and miscellaneous articles, which represents almost the 26% of total flows. Among all the various sectors, this field is characterized by the highest share of freight transfers by road (more than 44%), while it covers over 20% of traffic flows carried out by rail and 19% by sea. However, with respect to the modal share within the field itself, it can be observed that rail transport plays a marginal role (slightly more than 4%) as compared to the other two transport modes, among which the total traffic volumes are almost equally distributed.

Regarding the other handling categories, Table 8 highlights that the sea mode is the main transport mode in the sectors related to the transfer of fossil minerals, metal products and fertilizers. The prevalence of rail mode is registered only for metal waste movements, whereas the road mode is the most used transport solution to transfer agricultural products, non-metallic minerals, food and chemical products.

Finally, it is useful to underline the level of mode friendliness of the various handling categories in reference to the sea and rail modes. Indeed, with respect to the sea mode, more than 83% of transfers concerned the sectors related to oil products and to the one encompassing transport equipment, machinery, manufactured objects and miscellaneous articles. Furthermore, over 500,000 tons of freight including metal products, food, non-metallic minerals, and chemical products were transferred by sea during 2016. As regard the rail mode, more than 88% of transfers concerned the following three products: metal wastes (47%), transport equipment, machinery, manufactured objects and miscellaneous articles (21%), and non-metallic minerals (20%). Besides, more than 100,000 tons of oil products and slightly less than 50,000 tons of agricultural products were transfers by rail in the reference year.

Table 8 - Trade flows on medium-long haul distances generated or attracted by the Friuli Venezia Giulia region in 2016, according to handling category and transport mode [1000 tons]
Source: our elaboration

	Transport mode

Product category	Road	Rail	Sea	Total
0. Agricultural products and live animals	722	47	272	1.041
1. Foodstuff and animal fodder	759	1	729	1.489
2. Solid mineral fuels	30	11	311	352
3. Oil products	184	155	15.670	16.009
4. Ores and metallurgy waste	879	958	233	2.070
5. Metal products	800	20	1.393	2.214
6. Crude and manufactured minerals and building materials	1.688	397	641	2.726
7. Natural and chemical fertilizers	32	1	49	82
8. Chemical products	691	5	631	1.327
9. Transport equipment, machinery, manufactured objects and miscellaneous articles	4.579	424	4.535	9.538
Total	**10.365**	**2.020**	**24.463**	**36.848**

Adopting a different perspective in analysing the obtained results, Figure 6 shows the freight volumes transferred by the different transport modes for each of the considered TEN-T Corridors. Overall, out of the total 37 million tons generated or attracted by the Friuli Venezia Giulia region, more than 31 million tons (84%) are transferred along the Mediterranean Corridor; in particular, 50% of those freight movements consist of international trade exchanges, while 34% of them represent the traffic flows with the other Italian areas. Approximately 6 million tons of freights were transferred along the north-south transport axis, distributed almost equally between the Baltic-Adriatic and Scandinavian-Mediterranean Corridors. Besides, a few relevant differences among the various Corridors can be observed also in terms of modal share:

- The sea mode prevailed over the other ones in the international trade exchanges along the east-west transport axis, as it covered almost 91% of total transfers. Regarding the trade exchanges between the Friuli Venezia Giulia region and the other Italian regions, the share between sea and land modes was more balanced, while the rail mode still played a marginal role (only 2% of the transfers);
- Along the north-south transport axis, the road mode prevailed in the trade exchanges towards north-eastern Europe (more than 61% of the transfers), but also the sea and rail modes played a quite significant role (respectively, 27% and 12% of the transfers). On the contrary, the transfers towards central-eastern Europe were carried out mainly by rail (48%) and road (43%), and only in a marginal way by sea (less than 10%).

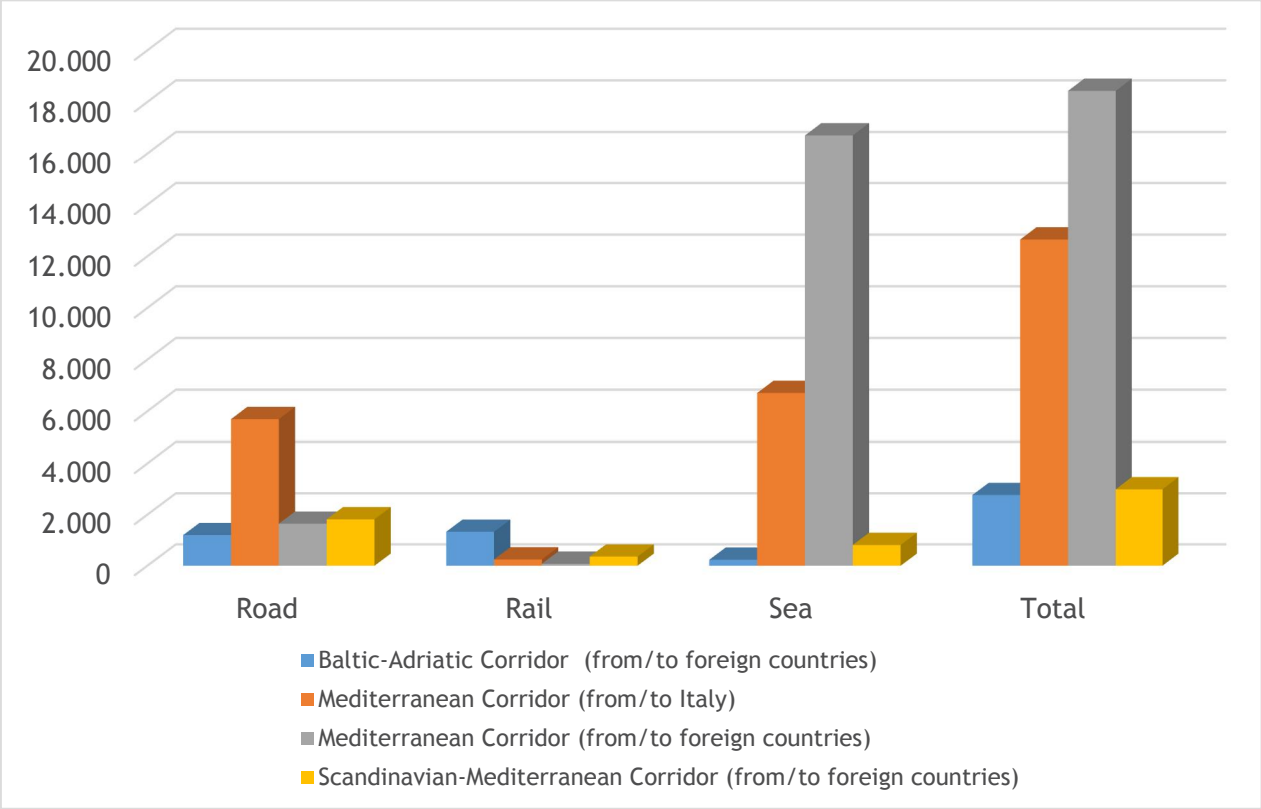

Figure 5 - Trade flows on medium-long haul distances generated or attracted by the Friuli Venezia Giulia region in 2016, according to transport mode and TEN-T Corridor [1000 tons]

2.2.3. Development scenarios for intermodal traffic in the Port of Trieste

In this section, the elaborated development scenarios for intermodal traffi cin the Port of Trieste in 2030 are illustrated considering the reference context before the Covid-19 outbreak. First of all, the performances of the Port of Trieste in the last 15 years (until the most recent 2019 data) have been analysed focusing the attention on intermodal transport sectors and then, they have been evaluated with respect to the competitive context in which the examined port operates and in relation to the traffic expectations forecasted at the beginning of the 2010s. Subsequently, the main hypothesis on which the development scenarios have been created, have been illustrated and discussed. Finally, the outcomes obtained by the study have been reported and examined, also in relarion to the counterfactal assessment carried out in order to determine the implications regarding the freight transport demand (in terms of specific sectors and trans-European freight corridors) which could concern the Port of Trieste in the next decade.

2.2.3.1. Performances of the Port of Trieste in the second millennium

Since the beginning of the second millennium, the Port of Trieste has been able to undertake a deep renovation process in terms of its traffic composition in order to adapt to the structural changes of the international maritime trade, exploiting its strengths like the greatest water depth in the whole Adriatic Sea (SRM, 2012), the closeness to the most rich and dynamic European marketplaces, the position at the intersection of the north-south and east-west axis of the Trans-European Network (primarily the "Baltic-Adriatic" Corridor in the north-south direction and the "Mediterranean" Corridor in the east-west direction, but also the "Scandinavian-Mediterranean" Corridor in the north-south direction and its maritime extension represented by the sea motorways network), and, lastly but not least, the Free Port regime.

Having managed almost 62 million tons in 2019, the Port of Trieste has been representing for a few years the main Italian sea port for the total amount of handled freight (also thanks to its strategic role played in the liquid bulk sector), and in 15 years (since 2004 to 2019) it has more than doubled the managed volume of general cargo (from 8,3 to 16,9 million tons with an average annual rate of 4,5%). As it can be noticed in Figure 6, such result has been obtained by the relevant growth in container traffic that has increased almost five times in the considered time horizon (from 1,9 to 9,2 million tons). An analogous growth has been recorded also in the non-unitized share of such intermodal sector, but its relative influence is lower than 10%. Finally, the Ro-Ro sector has remained almost constant (equalling to more than 6 million tons), following a quite volatile dynamic. Nevertheless, it must be underlined that such trend has been determined by the strong traffic reduction occurred in 2019 with respect to 2018 (-24,8%) that, even if in a more significant way, reflects the weakness encountered in the Italian marketplace due to the Turkish economic crisis (Quarati, 2020).

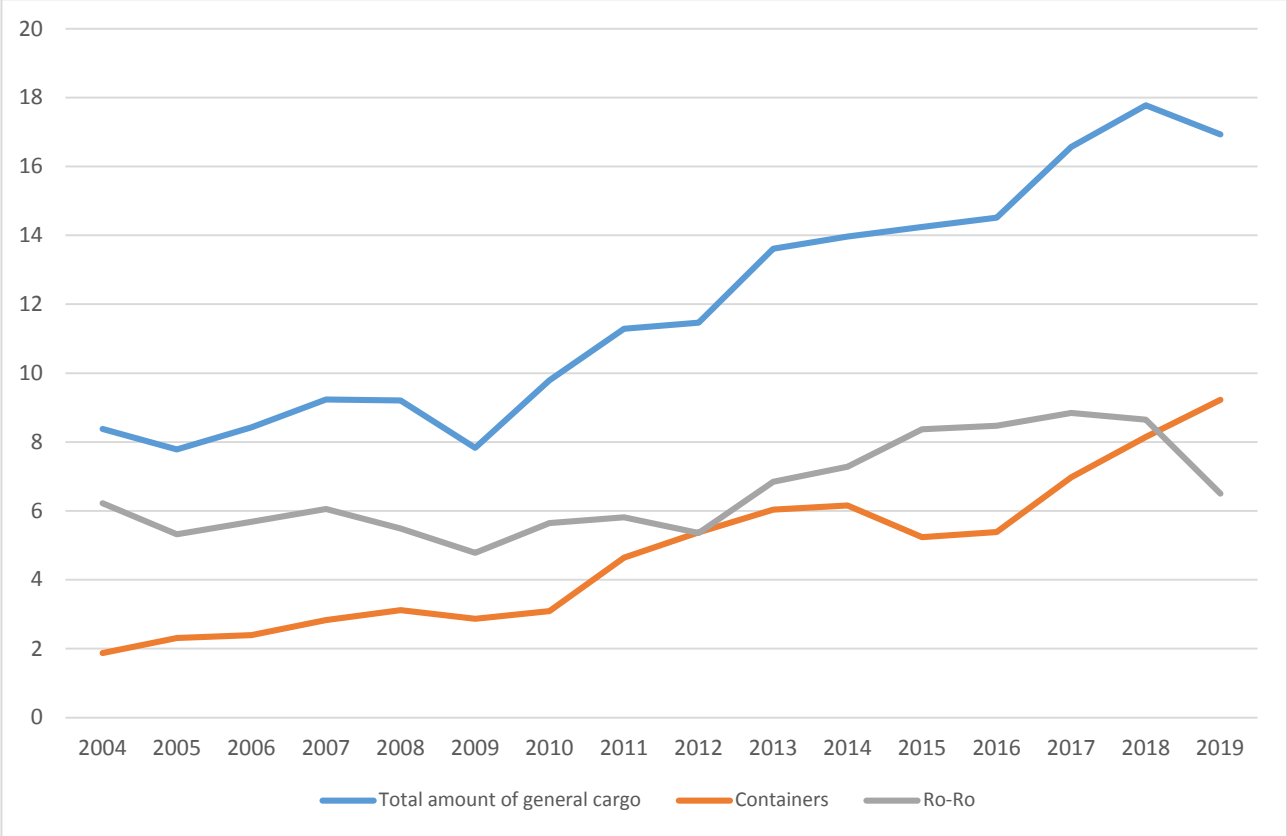

Figure 6 - Total amount of different general cargos handled in the Port of Trieste according to the specific traffic sector [mln tons] – 2004-2019
Source: our elaboration based on data provided by the PNA of the Eastern Adriatic Sea (various years)

The trend of the general cargo sector has determined a relevant increase in its relative share against the total amount of freights handled by the Port of Trieste: this latter share has raised from 18% in 2004 to 27% in 2019, with a limited reduction with respect to 2018 caused by the contraction of the Ro-Ro sector, as mentioned above. Such variation is even more evident in relative terms, considering that the consequences of the 2008 economic-financial crisis, occurred mainly in 2009, had decreased the entity of the general cargo share to the 2004 value, because the elasticity of the economic trends of this freight traffic component is very high, both at a general scale and especially for the Port of Trieste (this evidence can be deduced by overlapping the trend reported in Figure 6 and the Italian and/or European economic growth in the reference time period).

It must be highlighted that the reported positive performances of the Port of Trieste have occurred also thanks to the great investment effort, which still has to be completed and it has been illustrated in the Port Development Plan (PDP - *Piano Regolatore Portuale*). The procedural process of such development plan started at the beginning of the second millennium and ended in 2016 with the final approval of the Regional Council of the Friuli Venezia Giulia Region with resolution n. 524 (ASP del Mare Adriatico Orientale, 2020). The investment effort undertaken by the Port of Trieste consists of a series of

superstructural and infrastructural interventions aimed at upgrading the port, in light of its role of relevant transport node within global logistics chains with specific reference to the market segment of unitized freight transfers, which represent the most dynamic component of maritime transport.

Framing the great performances obtained by the Port of Trieste in the recent years in the unitized freight transport sector with respect to its reference catchment areas, i.e. the North Adriatic and Mediterranean Seas, can help to better capture the positive traffic trends of the port. Indeed, for the first term of comparison, Figure 7 illustrates the container traffic of the 3 main North Adriatic Sea, namely Koper, Trieste and Venice (all these ports belong to the North Adriatic Port Association – NAPA) in the 2009-2019 time period. It can be noticed that the Port of Trieste has not only performed much better than the Port of Venice, even if starting from a less promising condition, but it has also greatly recovered on the Port of Koper (which is currently the most important port of the North Adriatic Sea for container traffic), showing better performances at the beginning and in the last three-year period of the 2010s, reducing the gap from 23,9% to 21,5%.

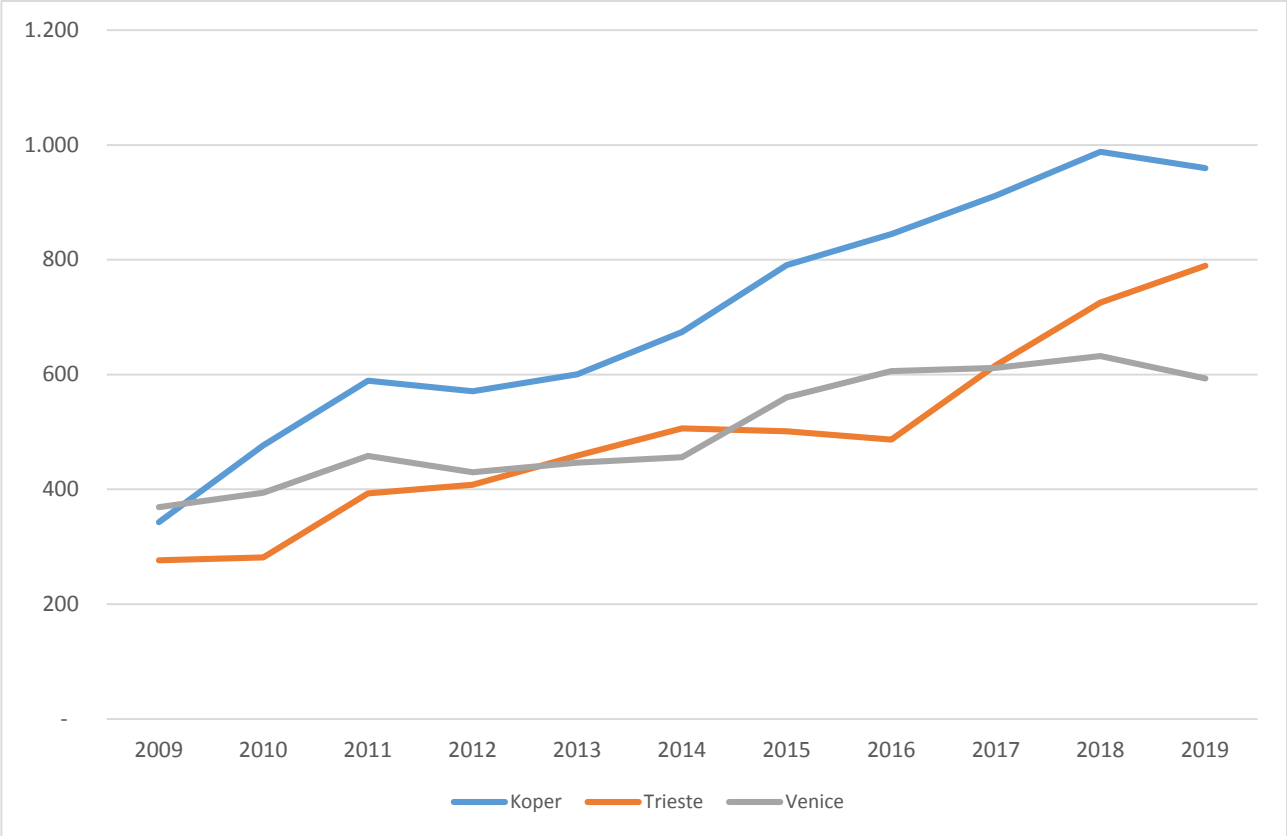

Figure 7 - Total amount of the container traffic handled in the Ports of Koper, Trieste and Venice [1000 TEUs] - 2009-2019
Source: our elaboration based on data provided by the PNA of the Eastern Adriatic Sea (various years)

It must be underlined that, regardless the performances of each individual port, in the last decade all the ports belonging to the NAPA have recorded much greater growth trends with respect to the previous

decade and to the forecasts estimated at the beginning of the 2010s, proving that the North Adriactic area could represent, in the future or even in the current days, one of the main European gateways to the Mediterranean Sea in the context of the global trade exchanges. Indeed, with an advance of 11 years, already in 2019 the traffic volumes of the Ports belonging to the NAPA (including Ravenna and Rijeka) equalled to more than 2,8 million TEUs, exceeding the number of containers forecasted for 2030 in the "Business-as-Usual" scenario defined in the "ITS Adriatic Multiport Gateway" project, funded by the TEN-T Program, which estimated 2,6 million TEUs in 2030 for such intermodal sector (Bonaldo, 2012 and TRT, 2012).

As regard the second term of comparison, the report by Confetta entitled "The Mediterranean Sea: Geo strategic scenarios of Italian port systems in the Mediterannean-Black Sea context" ("*Il Mar Mediterraneo: Scenari geo strategici della portualità italiana nel quadrante Mediterraneo-Mar Nero*" - 2018) points out the fifth position of the Port of Trieste (after Piraeus, Tangeri, Koper, and Ashdod in Israel) with respect to the global variation in the 2009-2017 time period for the 30 ports handling more than 500 thousand TEUs (the Port of Venice is in the tenth position of the cited ranking). In this regard, such traffic dynamics has enabled the Italian North Adriatic Ports to gain significant market shares against rival ports of the North Tyrrhenian Sea.

Tables 9 and 10 allow to capture the remarkable connotation of the Port of Trieste towards environmental sustainability, i.e. an aspect which is intended to become a distinctive "quality feature" of port hubs, enabling them to enhance their competitiveness in a socioeconomic context, where the attention paid on safeguarding and improving environmental sustainability will represent one of the main driving forces for future developments. The sustainable connotation of the Port of Trieste is twofold. On one hand, it is motivated by the absolute annual number of managed trains, which equalled almost to 10 000 trains in 2019, with an growth of 63% in 5 years; more in particular, the container traffic share has more than doubled in the last 5 years, almost reaching the number of trains used to performed Ro-Ro services. Referring to freight volumes, 4,5 million tons were transferred by train in 2019, showing no significant variations with respect to the previous years. On the other hand, Table 10 highlights the modal split for the unitized traffic in the 2018-2019 biennial, reporting the modal shares with respect to both the total amount of traffic volumes (including transhipment operations, which equalled to 15%) and specifically in relation to land transport. In this latter case, it can be observed that the rail modal share represents one third of all land transfers, with a quite modest increase with respect to 2018, also due to the decrease in Ro-Ro traffic recorded in the last year. Values reported in Table 10 refer to the sum of container and Ro-Ro traffic, but these two intermodal sectors are characterized by very different modal shares since they differ in their structure: in 2019, the rail share for the former sector is close to 35%, while for the latter sector it is approximately around 29%.

Such values reinforce the leadership of the Port of Trieste in the Italian context with respect to the environmental sustainability of landside connections, continuing to undertake a strategic action which led the rail mode share reaching the value of 33% for container traffic at the beginning of the 2010s (SRM, 2012). This latter figure represents an important achievement for the Port of Trieste, since in 2003 the rail modal share equalled to 8% against the total amount of freight transfers (Piano Regolatore Portuale, 2011). The mentioned data shows an improvement in the rail modal share with respect to the forecasts reported in the Port Development Plan, in which an average rail modal split (for all port transport sectors) of 24% was estimated for 2020 (ASP del Mare Adriatico Orientale, op. cit.). More in detail, the rail modal share concerning container traffic is in line with the estimations included in the

Port Development Plan, while the value regarding Ro-Ro traffic by train is almost six times higher than the expectations elaborated in such document, as it considered a rail share of 5%.

In conclusion, it must be observed that the great performances demonstrated by the Port of Trieste confer it a leader position not only within the Italian port system, but also a significant role in the European context since even the relevant Ports of Antwerp, Le Havre and Rotterdam recorded lower rail modal shares in 2011, respectively 10%, 7% and 11%, notwithstanding the different scale extent of their activities (Nazemzadeh 2012). Such lower values in the rail modal share are counterbalanced, in the case of the Ports of Antwerp ad Rotterdam, by an extensive use of inland navigation, whose share equalled, respectively, to 51% and 33%. Hamburg is the large European port that is connected at best to the railway network, through which more than 2 million TEUs are handled, with a market share exceeding 40% (Merk e Notteboom, op. cit.).

Table 9 - Train movements from/to the Port of Trieste [number] – 2015-2019
Source: our elaboration based on data provided by the PNA of the Eastern Adriatic Sea (various years "Sinfomar statistics", 2020)

	2015	**2016**	**2017**	**2018**	**2019**
Total train movements	5.980	7.631	8.682	9.733	9.771
of which for:					
- Liquid and solid bulk	n.a.	1.854	2.299	2.137	1.825
- Containers	n.a.	1.664	2.235	3.214	3.766
- Ro-Ro	n.a.	3.672	3.849	4.019	4.052

Table 10 - Modal share for unitized traffic in the Port of Trieste (containers+Ro-Ro) – 2018 and 2019
Source: our elaboration based on data provided by the PNA of the Eastern Adriatic Sea (various years "Sinfomar statistics", 2020)

	2018			**2019**		
Item	Mln tons	% on total	% on land traffic	Mln tons	% on total	% on land traffic
Road	9,7	57,6%	67,9%	8,8	56,1%	66,1%
Rail	4,6	27,2%	32,1%	4,5	28,8%	33,9%
Total (without sea)	**14,3**	**84,9%**	**100,0%**	**13,4**	**84,9%**	**100,0%**
Sea	2,5	15,1%		2,4	15,1%	
Total (containers + Ro-Ro)	**16,8**	**100,0%**		**15,7**	**100,0%**	

To conclude this analysis concerning the Port of Trieste, it must be considered also the spatial structure of the port traffic in relation to the hinterland, for which the port represents the gateway. On one hand, the port benefits from the trade exchanges generated and attracted by the economic development of the territory and, on the other hand, it supports the socioeconomic growth by favoring the acquisition of raw materials and semi-finished products at low prices and offering the entrepreneurial system new opportunities, new marketplaces for local, regional and, more in general, territorial productions.

Furthermore, in the widely acknowledged strategic vision of ports (see for example EC, 2019 o Deloitte, 2020), in the future such intermodal transport hubs will be able to tight their connection with the hinterland, not only promoting technological development and innovation in the immaterial economy, but also guiding the sustainable economic growth by testing and applying solutions for the energy saving and the limitation of negative externalities (greenhouse gas emissions, air pollution, noise, congestion, etc…).

In this regard, since the beginning of the millennium when the strategic vision of the Port Development Plan started to be developed, the Port of Trieste has been returning to its roots, when it represented the gateway to the Mediterranean Sea for the Austrian-Hungarian Empire in the XVIII century and, thus, to the "Mitteleuropean" area, on which the eastward shift of the European "heart" is based. This fact is proved by the information reported in Table 11, which includes the number of weekly rail connections of the Port of Trieste according to diverse countries, in 2012 and 2018 (the aforementioned great increase in the rail mode share is evident). The structural change of rail connections can be immediately captured: other than the strengthening of trade exchanges with the European industrial economic driver (Germany) and the stability of the relationships with Northern Italy and Austria, the direct connections with Hungary, Czech Republic and Slovakia (but even Romania) currently constitute a relevant share of the port hinterland transfers.

Table 11 - Pairs of trains from/to the Port of Trieste according to origin and/or destination country – 2012 and 2018
Source: our elaboration based on data provided by the PNA of the Eastern Adriatic Sea ("Sinfomar statistics", 2020 and RSM, 2012)

Country	2012	2018
Germany	12	37
Austria	48	24
Italy	12	21
Hungary	2	10
Luxembourg		9
Czech Republic		8
Belgium		3
Slovakia		5
Romania		1
Total	**74**	**118**

2.2.3.2. The Port of Trieste: definition and evaluation of development scenarios for intermodal traffic e modal split in 2030

As mentioned before, this section illustrates the definition and discussion of the development scenarios for unitized traffic and its rail-road modal split that could concern the Port of Trieste in the next decade (until 2030). More specifically, following the methodological approach described in section 2.2.1, based on the results of the analysis reported I the previous section, it was decided to examine the considered intermodal traffic sectors according to a twofold perspective: an aggregated one encompassing the total volume (in tons) of container and Ro-Ro traffic and a disaggregated one defining different scenarios for the two traffic sectors (using their relative measurement units, i.e. TEUs and number of vehicles), since they differ in structure and have been characterized by a diverse historical evolution trends.

Regarding the future growth in unitized traffic, the definition of the aggregated and disaggregated development scenarios has been based on the historical trends recorded by the Port of Trieste, firstly determining an average value and then a reasonable value range in order to outline the variation between the minimum and maximum growth values. Table 12 illustrates the average annual growth rates (AAGRs) between 2019 and 2030, that have been adopted in the two development scenarios in the three different elaborated hypotheses. Such values have been defined in the following way:

- For the "Aggregated" scenario:
  - Hypothesis for the average growth (base value): the average annual growth rate of unitized traffic (container+Ro-Ro) in the 2009-2019 time period has been considered;
  - Hypothesis for minimum growth: the average annual growth rate of unitized traffic (container+Ro-Ro) in the 2004-2019 time period has been considered, taking into account the drastic traffic reduction due to the 2008 economic-financial crisis;
  - Hypothesis for maximum growth: the standard deviation of the series of the annual variations recorded in the 2009-2019 time period (equalling to +10,1%) has been added to the base value of the growth rate of unitized traffic (container+Ro-Ro);
- For the "Aggragated" scenario:
  - Hypothesis for the average growth (base value): the average annual growth rate of the container and Ro-Ro sectors in the 2009-2019 time period has been considered;
  - Hypothesis for minimum growth: the standard deviation of the series of the annual variations recorded in the 2009-2019 time period (equalling to -11,4% for containers and -17,7% for the Ro-Ro sector) has been subtracted to the base value of the growth rate;
  - Hypothesis for maximum growth: : the standard deviation of the series of the annual variations recorded in the 2009-2019 time period (equalling to +11,4% for containers and +17,7% for the Ro-Ro sector) has been added to the base value of the growth rate.

Therefore, it can be noticed that a methodological approach based on the statistical concepts of average value and standard deviation has been adopted throughout the process of outlining development scenarios, except for the definition of the minimum growth rate in the "Aggregated" scenario. On one hand, such difference is motivated by the fact that the Ro-Ro sector is more volatile than the one regarding traffic (also because it is related to road transport dynamics and to incentive policies – Quarati, 2020) and it was subjected to a quite relevant contraction in the 2004-2019 time period. On the other hand, a different value for the growth rate in the Ro-Ro sector has been intentionally considered in order to take into account a

significant differential with respect to the average value, whose entity is in line with growth rate recorded by the ports of the Mediterranean Sea, which equalled to 3% in the 2007-2017 time period and to 4,6% in the 2009-2017 time period (Confetta, 2018).
Regarding the growth rates assumed in the "Disaggregated" scenario for the container sector, their values could seem to be quite high, but they are actually reasonable considering that:

- The European economic framework, and even the global one, will likely be unchanged in the next decade with respect to one of the recent past (ref. to Table 13);
- According to the estimations elaborated by Drewry reported in the study for the European Commission entitled "Analysis of the potential of the development of rail container transport market in Poland" (EC, op. cit.), the total container traffic in all the ports of the world should equal to 1 billion TEUs in 2023, increasing by an annual rate of 5,5% between 2019 and 2023 (in 2017 the total container traffic equalled to 753 million TEUs);
- The great growth rate of the Port of Trieste in the container sector is confirmed by the stability of such traffic component recorded in the last 15 years and taking into account that all the investment projects considered in the Port Development Plan have not been completed yet;
- Analogous evolutive dynamics have not been recorded only in the Port of Trieste within the European context and the one related to the Mediterranean and Black Seas, but also in various ports of the Baltic Sea (S. Petersburg, Gdańsk, Gdynia, Aarhus and Riga), of the Black Sea (ports in Russia, Goergia, Bulgaria, Romania, and Ukraine) and of the Mediterranean Sea (Piraeus, Tangier, Koper, and Ashdod).

Finally, as far as the specific hypothesis assumed for the Ro-Ro traffic are concerned, it can be noticed that actually the average growth rate forecast seems to be quite conservative considering the following reasons. On one hand, except for 2019 (when a remarkable contraction has been recorded with respect to 2018), in the 2004-2018 and 2009-2018 time periods such sector has increased, respectively, by 2,1% and 6,1% every year. On the other hand, this kind of intermodal transport is one of the strengths of the Italian port system (having showed an annual growth rate of 5,3% in the 2005-2014 time period and of 2,5% in the past 3 years due to the contraction of the last year), which has proved to be able to benefit from the advantageous strategic position in the Mediterranean Sea and from the intensification of trade exchanges of the Southern European coast with Turkey and the African countries in the north-south direction (SRM, 2019).

Table 12 – "Aggregated" and "Disaggregated" scenarios: average annual growth rate in the 2019-2030 time period [%]
Source: our elaboration

	Aggregated	Disaggregated	
Hypothesis on growth	**Tons**	**TEUs**	**Vehicles**
Minimum	4,5%	9,8%	2,1%
Medium	7,5%	11,0%	2,5%
Maximum	8,2%	12,3%	3,0%

Regarding the modal split for inland connections in the Port of Trieste, as described in section 2.2.1, due to the lack of information concerning its historical trend, some hypothesis have been assumed to define three different levels (high, medium and low) of modal shares based on the values referred to 2019, which have been deduced by the official statistics of the Port and by the more detailed data recorded by the port information system "Sinfomar". Such figures have been assumed as base values both in the "Aggregated" and in the "Disaggregated" scenario, considering that the stability of their entity in 2030 would enable the Port of Trieste to perform well in terms of the environmental sustainability of its development, even in comparison with the expected performances of other European ports (for example, in the Port of Rotterdam aims to reach a rail modal share equalling to 20% in 2030, with respect to the 2018 rail modal share which corresponded to 12,7% - OECD, 2010).

Table 13 - Scenarios for the average annual economic growth according to areas and countries [%] – 2019-2028
Source: our elaboration according to data reported in EC (2019), based on The Conference Board (2018)

Countries/Groups of countries	2013 - 2017	2019 - 2023	2024 - 2028
Mature economies	2,1%	2,0%	1,7%
Europe	1,7%	1,6%	1,2%
Europe - Euro area	1,4%	1,6%	1,1%
Germany	1,8%	1,7%	1,7%
USA	2,4%	2,2%	2,0%
Developing economies	4,0%	3,8%	3,6%
China	5,1%	3,8%	3,4%
India	7,0%	5,9%	5,5%
Russia	0,3%	0,6%	0,5%
World	3,1%	3,0%	2,8%

It must be underlined that, in this case, modal split shares are referred to the total amount of port traffic, including also the sea mode (i.e. transhipment transfers). Such consideration enables not to elaborate further assumptions for the modal share related to transhipment. Therefore, starting from the 2019 rail modal shares (calculated with respect to tons in the "Aggregated" scenario and to the respective loading unit in the "Disaggregated" scenario), an increase of 5% and 10% in the rail modal share has been assumed to define the medium and high hypothesis in the "Aggregated" scenario and in the "Disaggregated" scenario only with respect to the container traffic. On the contrary, for the Ro-Ro traffic the increase of the rail modal share in the medium and high hypothesis has been assumed as corresponding respectively to 2,5% and 5%. Such lower growth in the rail modal share for the Ro-Ro traffic seems to be reasonable considering that the 2019 rail modal share, which represents the base value, is quite relevant, almost equalling to 29% (the Port Development Plan aimed at reaching a rail modal share of 5% in 2020), so that further improvements of that value are deemed difficult to be accomplished if no incentive policy supporting the road-sea or rail-sea combined transport are not put in place.

2.2.3.3. The Port of Trieste: results of the development scenarios for intermodal traffic and modal split in 2030

The growth rates related to the "Aggregated" scenario described in the previous section consider the increase in the tonnage handled by intermodal traffic in the Port of Trieste in 2030 from 63% for the minimum growth hypothesis to 139% for the maximum growth hypothesis, which means from almost 16 million tons in 2019 to, respectively, about 26 million tons and 38 million tons in 2030. On the other side, in the "Aggregated" scenario, the number of containers handled by the Port of Trieste would vary from 2,2 and 2,8 million TEUs (with an increase equalling, respectively, to 180% and 260%, as compared to the 2019 value of 760 000 TEUs); while the number of vehicles handled by the Ro-Ro sector would range from 293 and 323 000 vehicles per year (with a variation ranging from 26% and 38% with respect to the 2019 value of 233 000 vehicles).

As far as the rail share of intermodal traffic is concerned, the charts reported in Figures 8 and 9 illustrate the results, in terms of thousands of TEUs, obtained by applying the hypothesis assumed for both the traffic growth and the increase in the rail modal share (Tables 22, 23, 24 and 25 included in the Annex A contain more detailed values of such results for each elaborated development scenario). It must be underlined a relevant difference among the two proposed development scenarios. In the "Aggregated" scenario, since the estimations refer to tonnes, the values obtained in relation to the number of handled TEUs consider only full containers. On the contrary, in the "Disaggregated" scenario, the direct estimation of loading units considers the total number of TEUs, including the empty ones. In order to homogenize the comparisons among values, an average weight referred to 2019 values has been used to transform tonnes into TEUs in the "Aggregated" scenario, thus considering also empty containers (such value equals to 12,4 tons/TEU). Another parameter has been used to homogenize the two different loading units considered in the "Disaggregated" scenario (i.e. TEUs and vehicles): such coefficient refers to 2019 values and corresponds to 22,23 TEUs/vehicle.

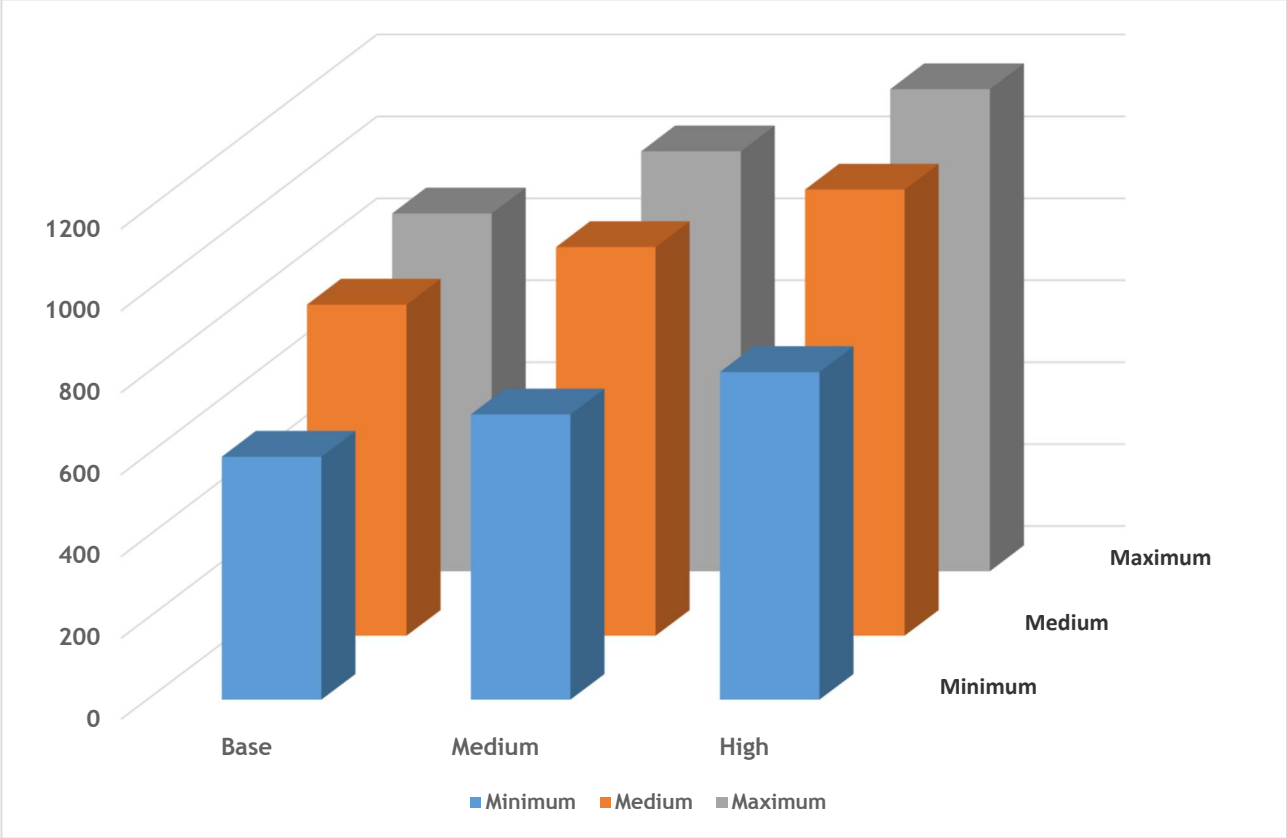

Figure 8 - Port of Trieste: "Aggregated" scenario for the rail transport growth (containers and vehicles) [1000 TEUs] – 2030
Source: our elaboration

The "Aggregated" and "Disaggregated" scenarios outline a quite wide variation range for the rail traffic growth in the unitized transport sector, which varies between 595 000 TEUs in the "Aggregated" scenario, with the minimum hypothesis for traffic growth expressed in tonnes (equalling to 4,5% every year) and an unchanged value for the rail modal share with respect to 2019 (corresponding to 29%), and 1,5 million TEUs in the most favorable hypothesis of the "Disaggregated" scenario, which is characterized by an annual growth rate for container and vehicle traffic equalling, respectively, more than 2% and 3%, and the rail modal share increased by 10% in the container sector and by 5% in the Ro-Ro sector. Among all the 18 cases created in the two groups of development scenarios, 16 of them are characterized by a total amount of rail traffic volumes which exceeding 800 000 TEUs, which almost doubles the 2019 value corresponding to 423 000 TEUs. Besides, in more than 11 elaborated cases, the total amount of rail traffic volumes would exceed 1 million TEUs, with an increase of more than 2 times the initial value.

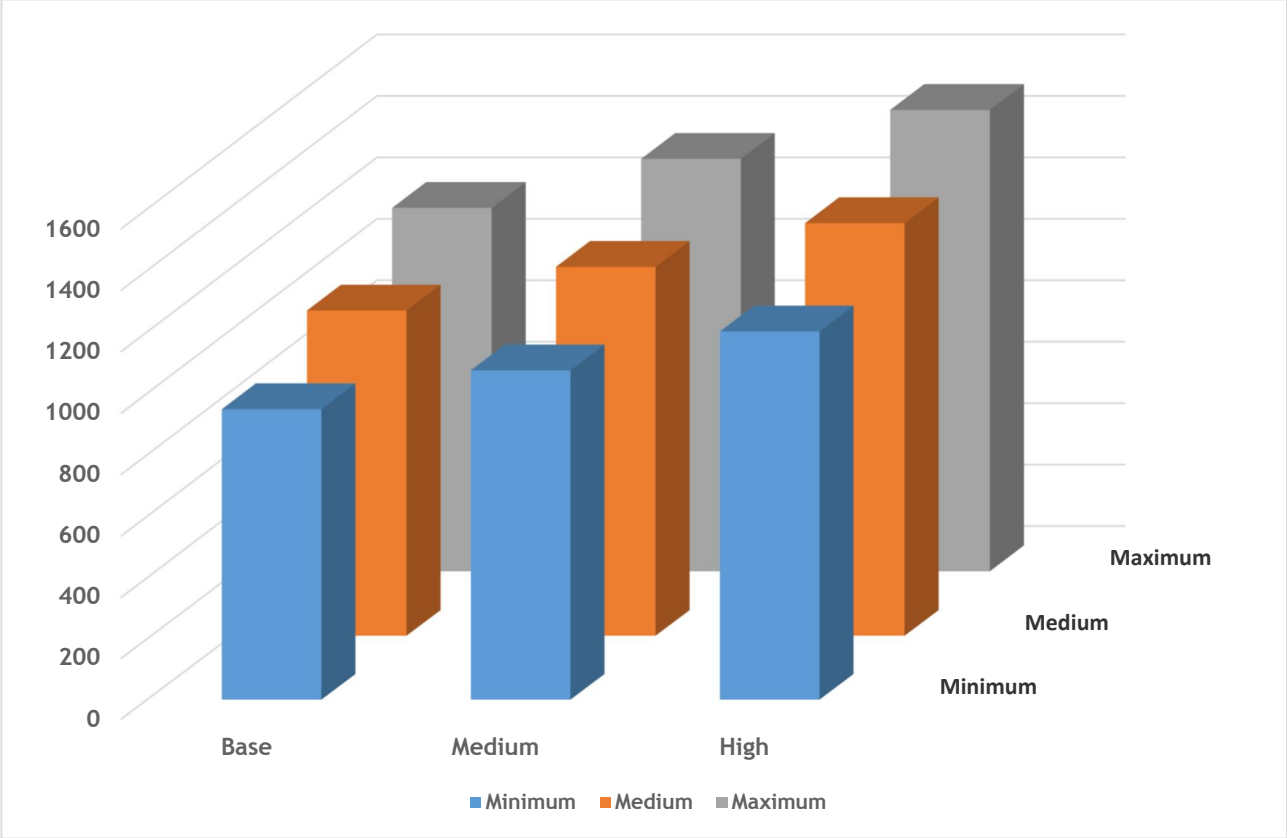

Figure 9 - Port of Trieste: "Disaggregated" scenario for the rail transport growth (containers+vehicles) [1000 TEUs] – 2030
Source: our elaboration

Taking into account the hypothesis of medium growth of intermodal traffic in the two different development scenarios, in the "Aggregated" scenario the amount of handled TEUs would vary from a little bit more than 800 000, to almost 950 000 and about 1,1 million TEUs whether the rail modal share remain stable to the 2019 value or on it increases, respectively, of 5% or 10%; in this latter case, the rail modal share would reach a market share corresponding to 40%. Such result would entail a growth in intermodal traffic equalling, respectively, to 91%, 124% and 158% with respect to the value recorded in 2019 which correspond to 423 000 TEUs (considering containers and vehicles transformed into equivalent TEUs) (ASP del Mare Adriatico Orientale, 2020). On the contrary, in the "Aggregated" scenario, the hypothesis of medium growth in the container and Ro-Ro sectors (corresponding respectively to 11% and 2,5%) would entail an increase in rail traffic between 2,5 and 3,2 times the 2019 value (equalling respectively to 1,1, and 1,3 million TEUs), depending on the possibility of increasing the rail modal share in the container traffic from 35% recorded in 2019 to 45% expected in 2030 and in the Ro-Ro traffic from the current value of 29% to the future value of 34%.

In conclusion, this section reports a discussion on the impacts of the proposed development scenarios on freight movements from/to the Port of Trieste. As mentioned before, in 2019 almost 10 000 trains have been handled, of which about 80% (more than 7800) were dedicated to transfer intermodal loading

units. Each of these trains transferred on average 54 loading units (ASP del Mare Adriatico Orientale, 2020), having a length of approximately 500 meters. Considering such train dimension figures also for 2030, the annual number of intermodal trains would range between 15 000 and almost 25 000, referring to the two development scenarios as characterized by a medium traffic growth and the variation of the rail modal share from the 2019 value in the "Aggregated" scenario to an increase of that value equalling to 10% in the "Disaggregated scenario".

These values concerning the number of trains could be modified assuming that the number of intermodal loading units per train could be increased up to 60, as considered in literature and forecasted in the Port Development Plan. In this latter plan, the annual number of trains in 2020 was expected to be more than 26 000, of which almost 23 000 used to perform intermodal services, 93% of them dedicated to container traffic (ASP del Mare Adriatico Orientale, 2011).

2.2.3.4. The Port of Trieste: implications of the development scenarios in terms of freight transport demand

In the previous sections, the results of the elaborated development scenarios for the Port of Trieste have been presented in terms of unitized traffic (containers+Ro-Ro) in 2030, focusing the attention of the share of such volumes that could be transferred by rail. However, as already highlighted in the present study, traffic flows are generated by the freight transport demand which originates from the structure of production and consumption systems and their interactions. Therefore, in this section the implications, in terms of traffic flows, deriving from the hypothesis assumed for the intermodal traffic growth and the rail modal share are illustrated. In other words, the main topic of this section consists in the counterfactual assessment of the reasonability of the hypothesis elaborated for the formulation of the proposed development scenarios.

Analysing the market potential of the Port of Trieste according to the spatial structure of transport flows that concerned Europe in 2016, it has been underlined the presence of relevant traffic flows coming from the Central-Eastern European area and heading to or arriving at the main gateways of Europe (i.e. the "Northern Range" ports) by rail or road, having as origin or as final destination the extra continental areas (Africa, America and Asia). Notably, the amount of freight transferred between Central Europe (Austria, Hungary, Czech Republic, and Slovakia) to/from Belgium, Holland and Germany has been quantified in more than 100 million tons, of which 90% has been exchanged only with Germany. More limited freight volumes (almost 3,5 million tons) have been transferred from Romania and Ukraine to/from the Norther-Western European area, the majority of which has still been exchanged with Germany (the contribution of Benelux countries is higher than the one of Germany in relation to sea transport). Regarding the modal split, it has been noticed that such trade relationships are characterized mainly by the road mode, whose share equals to more than 70%.

Bearing those facts in mind, the scope of the traffic analysis performed in the present study has been widened in order to include also Polish ports (in particular Gdansk, which is the second most important port of the Baltic Sea, having handled more than 1,6 million TEUs in 2017), considering them as gateways to access different global marketplaces from the Central-Eastern European regions (EC, 2019). The verification of the informative framework created starting from the ETIS-PLUS database, updated to 2016, has enabled to quantification the trade exchanges between these areas and Poland, with respect to both the road and rail mode, which correspond to more than 54 million tons, of which 74% coming from the central area

composed by Austria, Hungary, Czech Republic, and Slovakia. Such value leads to the total amount of freight generated and/or attracted by the Central-Eastern European area and headed towards, or coming from, the Benelux countries, Germany and Poland to exceed 160 million tons per year.

Not all these freight volumes are intended to be destinated to the trans-oceanic marketplaces since a part of them, whose quantification is not possible using the information made available by the ETIS-PLUS database, is likely to head towards the productive and consumption systems of the considered Norther European area, and more specifically of Germany, which possesses one of the most remarkable industrial systems of the world. Such part of freight volumes does not represent a market potential for the Port of Trieste. Nevertheless, an approximate estimation of the share which could concern the Port of Trieste can be defined considering the shares of trans-oceanic freight flows which arrive at or leave the Northern Range and Polish ports. These latter shares correspond, respectively, to 33,5% for Netherlands, 11,4% for Germany and 6,1% for Poland.

In this way, as trade exchanges between these three areas and the Central-Eastern European areas refer to trade relationships with extra continental marketplaces, the total amount of road and rail traffic flows that can represent a "potential market" for the Port of Trieste is considerably reduced to almost 31 million tons per year (in 2016), of which 68% is carried out by road.

Finally, taking into account the sectoral composition of such flows (Figure 10), the estimation reported above can be further refined pointing out that almost 84% of those freight volumes is related to the sector of miscellaneous articles (37,2%), non-metallic minerals (10,4%), metal products (9,8%), agricultural products (9,6%), chemical products (9,4%), and foodstuff (7,3%). Therefore, the total amount of the volume representing the potential market for the Port of Trieste originated by the Central-Eastern European countries corresponds approximately to 26 million tons, of which 65% coming from Central Europe. Referring to the estimations elaborated by Prince-Waterhouse (2011) for 2030, which consider an increase in the traffic flows between Europe and Far East of 6,2%, in real terms, between 2009 and 2030, a slight decrease in traffic flows between Europe and United States (equalling to 0,7% per year) and a non-quantified increase of trade exchanges with Africa and Latin America, it seems reasonable to forecast an annual growth in the aforementioned traffic flow which varies between 5% and 7%. This increase would lead the traffic volume cited above to reach a value ranging from 51 and 66 million tons.

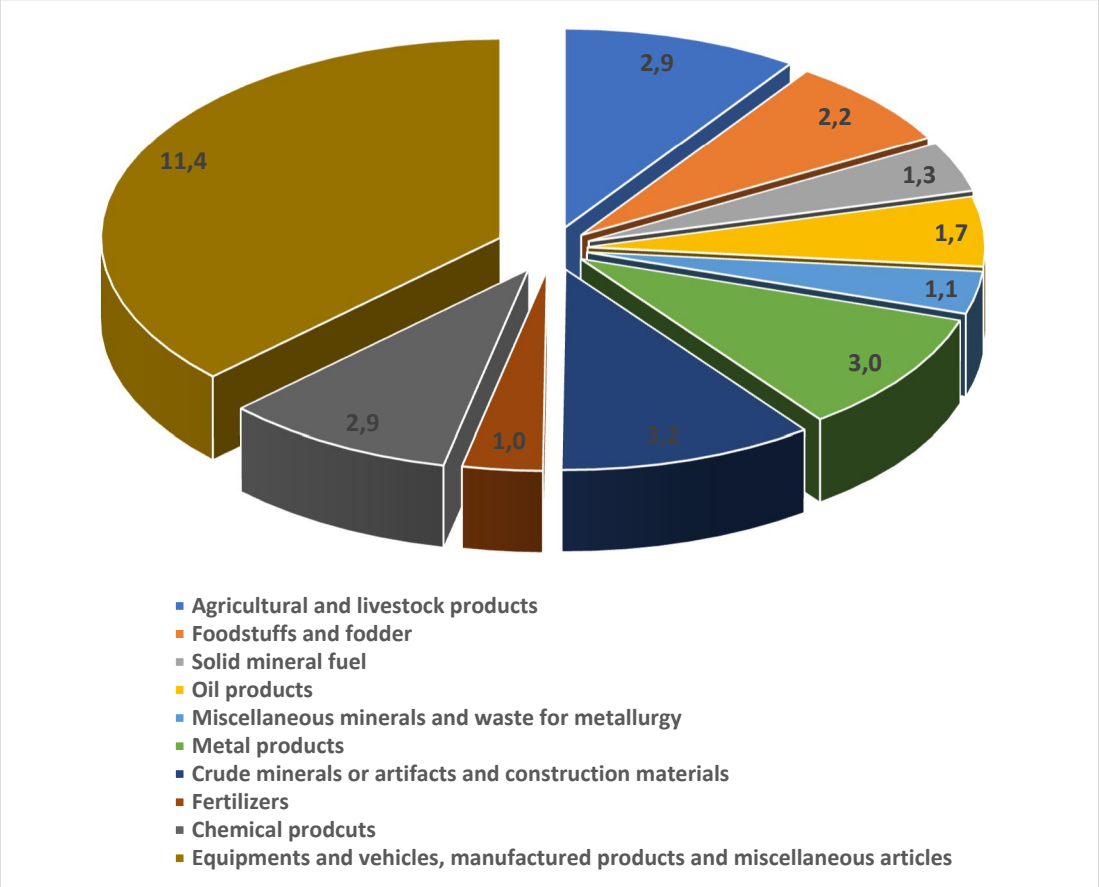

Figure 10 - Market potential of the Port of Trieste: trade exchanges between Central-Eastern Europe and Benelux countries, Germany and Poland, according to handling sector [mln tons] – 2016
Source: our elaboration

If the Port of Trieste was able to acquire a 10% share of such potential market, its volumes of unitized freight transferred by rail would more than double, which in 2019 corresponded to 4,5 million tons, equalling to 423 000 TEUs. These forecasts have to be evaluated considering that:

- As illustrated in Table 7, the rail connections of the Port of Trieste have increased of 60% from 2012 to 2018, in particular with reference to the relationships with Germany, Belgium and from/to the Central European area;
- For the estimation of the potential market for the Por of Trieste, the traffic flows originated/attracted by the Central-Southern German area have not been taken into account due to the limitations characterizing the used databased;
- Analogously, also the traffic flows that, coming from Northern Italy, are headed to or arrive at Northern Range ports, rather than other Italian ports (in the past such flows corresponded to 30% of the total amount of flows generated/attracted by the Northern Italian regions): for example, (ASP del Mare Adriatico Orientale, “Sinfomar” data 2020), as opposed to 2012 (SRM, 2012), currently

there are no direct rail connections between the Port of Trieste and the inland terminals of Northern Italy (Padua, Bologna, Modena, Melzo, etc…).

2.2.4. Conclusion

First of all, the present chapter illustrates the in-depth analysis that has been carried out with the aim of identifying the traffic flows that currently or potentially concern the territory of the Friuli Venezia Giulia region and more specifically the Port of Trieste, in terms of traffic directions, transport mode and sectoral composition. This analysis has been performed using an informative base referred to 2016 which derives from the database of European Informative System on Transport (ETIS PLUS), that has been considered for the definition and evaluation of the TEN-T program.

Notably, the analysis has been initially developed in order to characterize trade exchanges that are originated or attracted by the Friuli Venezia Giulia region and that are performed on the European transport corridors passing through such region, entailing freight transfers which cover more than 300 kms. This task enabled to highlight relevant differences in the modal split, in relation to the sectoral composition and traffic directions.

It has been noticed that almost 70% of such flows regards the following two handling categories: oil products and miscellaneous articles. Within these two categories the modal split is very different: indeed, oil products are transferred almost exclusively by sea, while miscellaneous articles are transferred equally by road and sea, and in a marginal way by rail. As far as the other handling categories are concerned, it must be underlined that sea transport is the main transport mode used in the sectors related to fossil minerals, metal products and fertilizers. The rail mode prevails only when transferring metal waste, whereas the road mode is the most common transport mode used to transfer agricultural products, non-metallic minerals, foodstuff, and chemical products.

For the scope of the present study, it must be pointed out also that the rail mode is characterized by a high level of sectoral concentration. As a matter of fact, more than 88% of rail traffic flows are related to the following 3 sectors: metal waste (47%), miscellaneous articles (21%) and non-metallic minerals (20%). The total transferred volumes of oil products equal to over 100 000 tons per year, while the one regarding agricultural products corresponds to almost 50 000 tons. Among the cited handling categories, the rail mode proves to be very competitive for transferring metal waste, it covers a quite modest market share in sector related to non-metallic minerals, but it is used marginally for the transfer of products belonging to the other cited handling categories.

Focusing on traffic directions, the performed analysis has revealed that:

- Along the east-west axis, the sea mode prevails over the road and rail ones in international trade exchanges (as it is used in almost 91% of the total freight transfers). On the contrary, regarding trade exchanges with the other Italian regions the use of the road and sea modes is more balanced, while the one of the rail mode is still limited (only 2%);
- Along the north-south axis, trade exchanges heading towards Northern-Western Europe are performed mainly by road (more than 61% of the total freight transfers), but also by sea (27%) and rail (12%). On the contrary, trade exchanges heading towards Central-Eastern Europe, freight transfers are carried out principally by rail (48%) and road (43%), and less than 10% of them by sea.

Secondly, in line with the goal and the methodological approach of the REIF project, the present section illustrates the main results of the study aim at identifying and evaluating development scenarios for intermodal traffic in the Port of Trieste in 2030. The study has initially focused on the creation of an informative framework, especially in qualitative terms, concerning future scenarios of economic development, current trends in the shipping sector and the implications of these latter on ports. Subsequently, starting from the analysis of historical trends of the Port of Trieste and of its competitive context, two groups of development scenarios have been defined and assessed: an "Aggregated" scenario which jointly considers container and Ro-Ro traffic and a "Disaggregated" scenario that separately takes into account those two sectors. Such scenarios have been created assuming a series of hypothesis for the intermodal traffic growth and for inland modal split in order to outline the expected freight volumes to be transferred by rail. Finally, a counterfactual evaluation has been performed to verify the reasonability of the principal assumptions which the development scenarios have been created on.

With reference to the main issues discussed in the present section, the most relevant outcomes of the study are briefly reported din the following.

- Performances of the Port of Trieste in the second millennium:
  - *Relevant growth: in the last 15 years, and even more in the last 10 years, the Port of Trieste has greatly performed in the general cargo sector, and especially in the container sector (with an increase of almost five times in the handled freight tons between 2014 and 2019, at an annual average growth rate of more than 11%), exceeding the most optimistic forecasted elaborated at the beginning of the 2010s (for example, in the Port Development Plan and in the "ITS Adriatic Multiport Gateway" project);*
  - *Intermodality: in the last 5 years the Port of Trieste has enhanced its intermodal connotation, that has enabled it to be the first Italian port and one of the most virtuous ports in Europe with respect to the rail mode use for inland connections, increasing the total number of trains up to almost 10 000 trains per year and more than doubling the share of rail services to transfer containers;*
  - *"Mitteleuropa": in addition to the strengthening of trade relationships with the industrial economic driving force of Europe (i.e. Germany) and the stability of trade exchanges with Northern Italy on one side and with Austria on the other side, as opposed to previous years the direct rail intermodal connections with Hungary, Czech Republic and Slovakia (but also with Romania) currently show that the scope of inland connections of the Port of Trieste has been shifted towards Central-Eastern European marketplaces;*

- Development scenarios for intermodal traffic in the Port of Trieste:
  - *Definition of the development scenarios: with reference to 2030, two groups of development scenarios, i.e. the "Aggregated" and the "Disaggregated" scenarios, have been elaborated by combining different hypothesis concerning the increase in intermodal traffic (based on historical trends recorded by the Port of Trieste and validated in relation to macroeconomic forecasts and the dynamics registered in analogous contexts) and the modal split of such traffic sector (based on 2019 data and on reasonable progressive increases of modal shares);*
  - *Results in terms of loading units: the 18 created development scenarios encompass a variation range of the handled freight volumes between 600 000 and 1,5 million TEUs per*

year but, overlooking the extreme values, the variation of that interval reduces between 700 000 e 1,3 million TEUs per year. In 11 of the 18 created development scenarios the total amount of intermodal freight volume in the Port of Trieste would exceed 500 000 TEUs, with an increase of more than twice the 2019 value which equalled 423 000 TEUs;

- *Results in terms of number of trains per year: assuming to adopt the dimensional parameters referred to 2019 as base values (i.e. 54 TEUs per train), by way of example the number of trains per year has been estimated considering the medium traffic growth rate and the variation of the rail intermodal share from the 2019 constant value in the "Aggregated" scenario to an increase in such value of 10% in the "Disaggregated" scenario. The outcomes of the estimation revealed that the number of trains per year would be, respectively, 15 000 and almost 25 000, against the value of 10 000 trains registered in 2019. Further improvements in the considered rail transport services, entailing 70 TEUs per train, would decrease the aforementioned values to, respectively, 11600 and 19190 trains per year;*

- Potential traffic demand:

  The outcomes deriving from the elaboration of development scenarios have been evaluated through a counterfactual assessment, estimating the freight traffic demand concerning the Central-Eastern European area and the one that could concern the Port of Trieste for its connections with the extra continental global marketplaces. Such potential traffic demand, which currently concern Northern European ports (Holland, Belgium, Germany, and Poland), corresponds to 26 million tons (with reference to 2016) and regards the sectors related to miscellaneous articles, agricultural products and foodstuff, chemical and metal products, and non-metallic minerals. According to general macroeconomic forecasts, in 2030 those potential freight volumes could vary between 51 and 66 million tons. The acquisition of a 10% share by the Port of Trieste would double the amount of tons handled by train (which equalled to 4,5 million tons in 2019), in line with the forecasts in terms of loading units proposed in the elaboration of the development scenarios.

2.3. Analysis of the economic, political and technical market conditions

In light of the study performed with the aim of defining and evaluating development scenarios for intermodal traffic in the Port of Trieste in 2030, the present section illustrates the results of the literature review that has been carried out to determine the reference framework in terms of macroeconomic forecasts and to identify the most significant and influencing trends in the shipping sector and of the factors affecting actors' selection process of ports.

2.3.1. Methodological approach

The methodological approach adopted for the literature review has consisted in an in-depth desk work aimed, on one side, at describing the expected evolutions of economic systems and of trade exchanges in the medium-long term and, on the other side, at illustrating the key factor and the main trends that characterize sea trade relationship at the present time and in the future. More specifically, due to the strong link between economic development, global trade and sea transport flows, an extensive review of the scientific and institutional literature (EC, OECD, UNECE, UNCTAD, WB, WTO, etc…) has been performed with the purpose of outlining the worldwide macroeconomic dynamics and their implications in terms of trade exchanges among countries and of sea transport flows. Subsequently, attention has been paid to the key factors that have been characterizing global cargo shipping (containerization, mega ships, sectoral concentration, technological development, environmental sustainability, etc…) for over twenty years and that will likely continue influencing the structure of maritime routes, especially the trans-oceanic ones, in the next decade. Finally, the analysis has been focused on the elements that determine the selection of ports by the main involved actors responsible for the organization and management of door-to-door transport services (i.e. shipping companies, MTOs and freight forwarders), with the aim of identifying the levers that decision makers can operate on to improve port attractiveness.

2.3.2. International economic and transport scenarios: trends emerging from literature

The freight transport demand concerning a port system or a port, especially when it represents a gateway, is strictly linked, or rather is derived from the characteristics of the production and consumption system of its catchment area. Therefore, the elaboration of development scenarios is a quite difficult task, as underlined by the Italian Ministry of Infrastructure and Transport in the 2015 document entitled "Strategic National Plan for Ports and Logistics" *("Piano Strategico Nazionale della portualità e della logistica"*), because several factors come into play, with non-linear evolutive dynamics that are difficult to understand and often not under the direct control of port managers. This has been made even more evident after the 2008 economic-financial crisis, which proved that in many cases future demand forecasts in relation to relevant infrastructural investments were too optimistic, determining an excessive port capacity for shorter or longer time periods (Brooks et al., 2014).

In essence, it can be said that the forecast of freight sea transport demand is connected, on one hand, to the dynamics concerning economic systems at different geographical scales and to the trade relationships that are established among them. On the other hand, in a context that is more and more determined by the global value of logistics chains, evolutive trend which are peculiar of the shipping market come into play

tending to influence the spatial structure of maritime trade routes (especially the trans-oceanic ones) and the selection of ports. Notwithstanding the significant role of ports with respect to macroeconomic trends and to the ones related to the shipping sector, ports operate in a more and more competitive environment in which the quality of their superstructures and infrastructures have, or can potentially have a quite important role in determining the relative success of ports, because such structures represent necessary, but not sufficient, operational conditions.

2.3.2.1. Long-term macroeconomic scenarios and trends of international trade exchanges

Macroeconomic scenarios play a remarkable role when formulating forecasts on transport flows, especially in the case of maritime transport. According to the economic perspective, transport demand is defined as a "derived demand" since it is generated by the spatial (and temporal) transfer of production and consumption activities related to goods and services. Indeed, trade exchanges among diverse economic systems generate freight transport flows. On one hand, transport flows depend, inter alia, on the performances of the involved economic systems and, on the other hand, foreign trade flows are an essential component of the aggregated demand and, thus, of the Gross Domestic Product (GDP) of countries.

This close interrelationship between the performance of economic systems in terms of GDP and trade flows lies under the economic theories that have supported in the past, and continue to support at present, the liberalization of trade exchanges (against protectionist policies) and the affirmation of globalization processes occurred in the last decades. As pointed out in a report by Price-Waterhouse (2011), in the time period between 1980 and 2008, the share of goods export on GDP has increased from 17% to 25% at global scale. This fact was evident especially after the inclusion of China in the World Trade Organization (WTO – UNECE, 2010). Notwithstanding that a lack of dependency (the so-called "decoupling") between the growth in economic systems and trade flows occurred in the years immediately after the 2008 economic-financial crisis, since 2016 the differential between the growth in international trade and the global GDP has been increasing as well as the intensity of trade exchanges, both in terms of volumes and value (Confcommercio and Isfort, 2019). Such trends are reported in Figure 11.

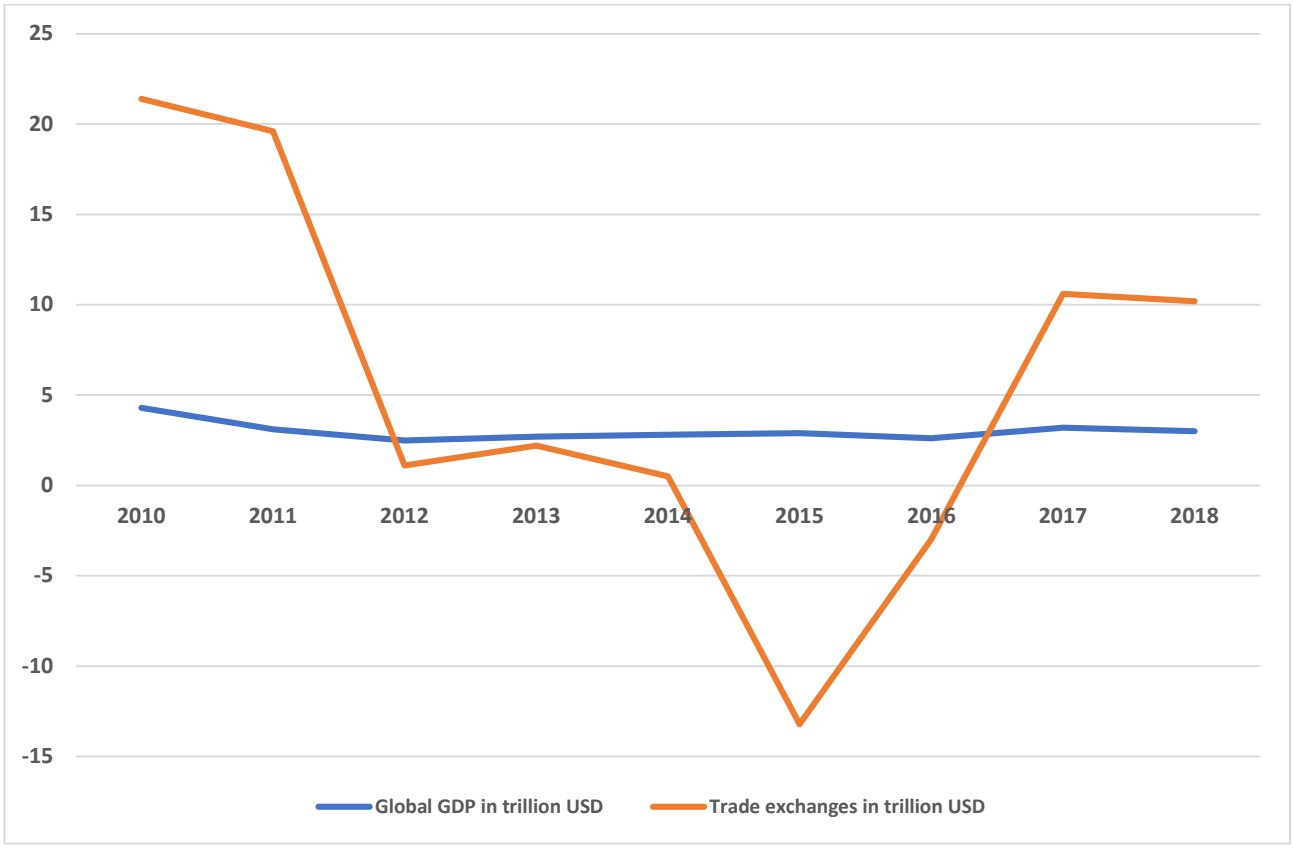

Figure 11 - Annual growth of GDP and global trade [% based on USD] – 2009-2018
Source: elaborations on data provided by Confcommercio and Isfort (2019)

Since maritime transport is the mode by which almost 80% of the global volumes of trade exchanges are performed (74% of the foreign European trade and 37% of the internal European trade – EC, 2013), the forecast of maritime flows is closely linked to the trends of the reference economic systems. This fact is confirmed especially when examining ports that mainly, or exclusively, represent gateways, just like in the case of the Port of Trieste. As opposed to ports that are used as transhipment hubs, the former ports serve catchments areas with a different boundary extent, whose definition, on one hand, strictly depends on ports and, on the other hand, contributes to the development of ports.

Therefore, macroeconomic forecasts are essential both because they identify the geographical areas that will generated and attract freight traffic flows in the future, and because they suggest the main routes along which trade relationship will develop, determining the spatial routes of traffic flows. In this regard, with respect to the goal of the present study it is useful to summarize, regardless their precise quantification, the principal trends shared by public and private institutes that are engaged in forecasting global economic trends for various purposes (for example, the European Commission, the International Monetary Fund, OECD, the World Bank, the World Trade Organization, the Economic Intelligence Unit, Price-Waterhouse, and the Roland Berger Institute).

It can be underlined that in the long period:

- Emerging economies will growth in line with the tendencies of the last decades and, as expected, more than the already developed economies, but in both cases a progressive decrease in the growth rate will be registered, with respect to the values of such indicator that have been recorded until nowadays;
- Considering the current trend, the centers of gravity of global economy will move towards East: towards Eastern Europe in relative terms and towards Asia in absolute terms, especially due to the increase in population and to its structure by age. By 2030, China will be the first economy in the world, while India the third one; however, the latter is supposed to prevail even over China in a longer time period (OECD, 2018);
- As the economic growth will be driven by demographic trends, the catching up of emerging economies in terms of per capita income will be less significant and, thus, Western economies will continue to benefit from a remarkable advantage (Roland Berger Institute, 2018);
- Global trade will continue to growth more than the global GDP (for example, the Roland Berger Institute – 2018 - considers an average annual growth rate of exports equalling to 5,9% between 2015 and 2030, expressed in nominal terms, and the one of GDP corresponding to 5,5%; this means that the value of exports will more than double in the 15-year examined time period). This fact will occur especially in the already developed economies, whose economic growth will be driven more by external trade rather than by domestic demand. The opposite phenomenon will occur in the emerging economies, even though exports will remarkably continue to grow (for example, in nominal terms, the Roland Berger Institute considers a growth rate equalling to 7,1% in the time period between 2015 and 2030);
- New trade routes will affirm mostly in the north-south direction (within Asia and between this latter and Africa on one hand, and Latin America on the other hand), but traditional trade routes between Asia and Europe and between Asia and North America will continue to grow and to play an important role on the world stage, especially with reference to trade exchanges from/to Asia. On the contrary, despite the fact that trade relationships between United States and Europe will be slightly affected by a contraction, they will continue to play a significant role.

Regarding this last aspect, following a re-elaboration of the 2030 forecasts provided by Price-Waterhouse (op. cit.), Figure 12 reports the 25 most important trade relationships in the world (among the ones which necessitate sea or air transport to be performed), grouped according to macro-relationships and with reference to 2009 and 2030 (expressed in million USD at 2009 constant prices). It can be immediately noticed the boom of inter-Asiatic trade exchanges, the very sustained grow of the relationship between Asia and Europe, the emerging of new traffic routes, the stability of the exchanges along the route between America and Asia, and the decrease in historical intra-European relationships, which are essentially based on trade exchanges between Great Britain on one hand and Germany, Holland, France, Belgium, and Ireland on the other hand.

Basically, regardless the criticism on the advantages of globalization and even if the parameters of such process will change in the next decades, GDP and the global trade will continue to grow as well as the Foreign Direct Investments (FDI), among which the most relevant is represented by the “Belt&Road” Initiative promoted by China. Given the abovementioned relationship between global trade and maritime transport, according to all the observers and operators of the analysed sector, a relevant increase in maritime transport is likely to be recorded in the next two or three decades, in analogy with the recent long-term trend in which sea transfers have increased on average by 3,8% per year, from 4,7 to 10,7 million tons between 1995 and 2017 (Confcommercio and Isfort, op. cit.).

However, the formulation of reasonable forecasts or projections becomes even more difficult when passing from the macroscopic to the microscopic perspective because, in addition the global economic dynamics, also the ones specifically related to the sea transport sector have to be considered, which encompasses an increase in number of actors and factors that come into play (such as national strategies, the ability of ports of attracting and managing transport flows, the decisions of relevant shipping companies, etc…). Therefore, in relation to the goal of the present study, attention has to focus on a few main issues, which are the past and expected dynamics of sea transport (especially of container traffic) and the role of the Mediterranean Sea in the spatial structure of maritime trade exchanges (further meaningful aspects concerning the sea transport sector are discussed in the following sections).

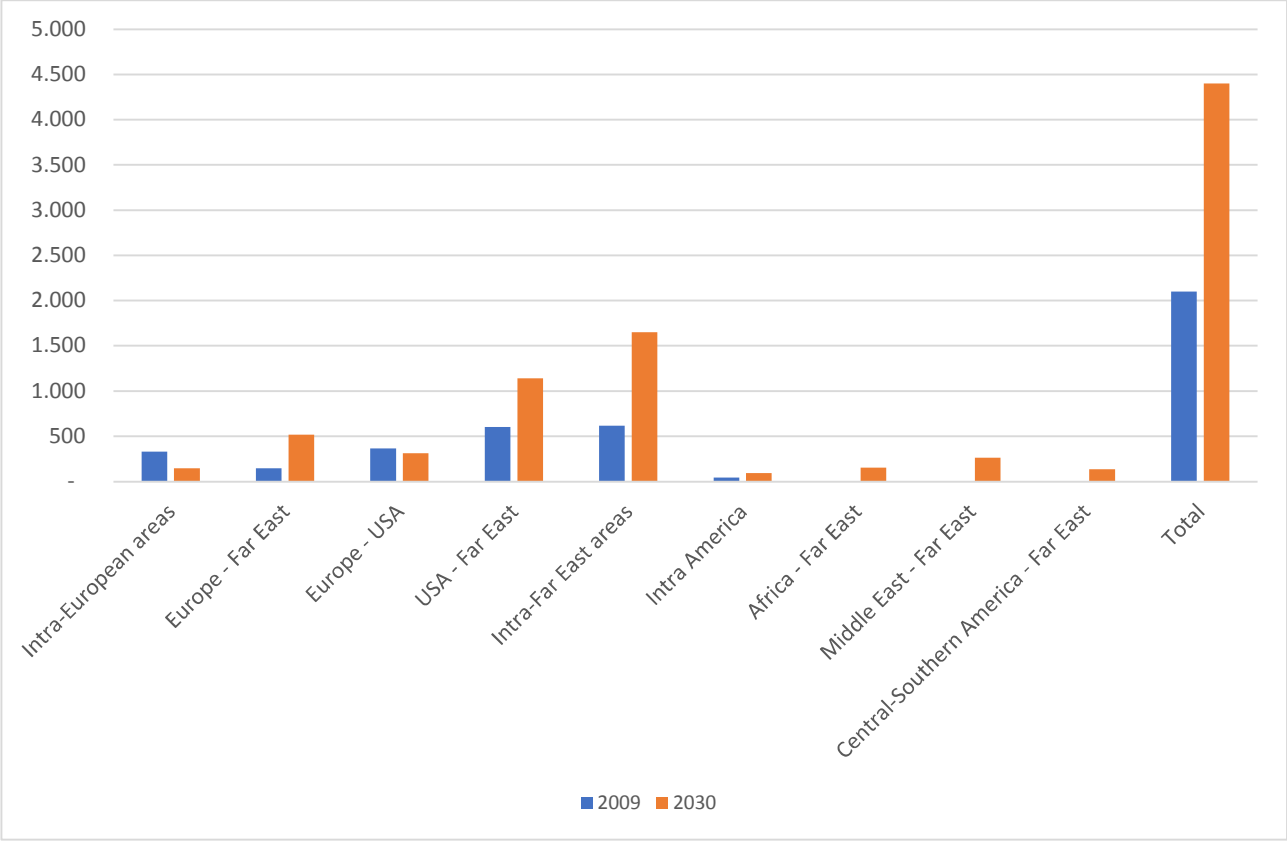

Figure 12 - Main global trade macro-relationships by air and sea [2009 mln USD] – 2009-2030
Source: elaboration based on data provided by Confcommercio and Isfort (2019)

As far as the first aspect is concerned, Table 14 includes a non-exhausted list of different informative sources that have provided in various years some estimations of the expected growth of sea transport, at diverse time horizons and geographical scales. Assuming the inherent validity of reported data and of its variability, it must be pointed out that such informative sources agree in considering that the container sector is the one for which the most relevant growth is expected in the next decades, just as occurred in the recent past (please refer to Table 15), but perhaps with a slightly more limited growth rate. Nowadays (referring to 2017), the container sector represents the 17% of the total amount of tons transferred by sea (such share increases up to 60% if its monetary value is considered – SRM, 2019), which corresponds to twice the 1995 value.

Regarding the central role of the Mediterranean Sea, the chart reported in Figure 13 highlights that Asia in general, and more in particular China, Hong Kong and Taiwan, represents the most dominant area of the world in the container sector on a global scale, while Europe is the second one having handled almost 120 million TEUs and possessing a 16% share of the market. Taking into account the container traffic services on the 3 main east-west routes (i.e. the Trans-Pacific route connecting Asia and North America, the European-Asiatic one and the Trans-Atlantic one linking Europe and North America), through which more than 60 million TEUs were handled in 2018 (EC, 2019), it can be noticed (Table 16) that since the end of the past millennium until nowadays the market share of trade routes between Europe and Asia has increased from 27% to 41% (even if a certain stability along the other two routes has been observed in the last 4 years).

Table 14 - Forecasts regarding the growth in sea transport at different geographical scales and time horizons
Source: our elaboration based on different informative sources

Source	Forecast period	Territorial context	Variable	AAGR	Notes
UNCTAD (2017): Review of maritime transport 2017	2018-2023	World	Containers (Mln tons)	6,40%	
UNCTAD (2017): Review of maritime transport 2017	2018-2023	World	Total	4,40%	
UNCTAD (2017): Review of maritime transport 2017	2018-2023	Exchanges among Asia, Europe and America	Mln TEUs	4,38%	
DIPE 2016: 'Iniziativa di studio sulla portualità italiana (aggiornamento"	2015-2030	Italy	Containers (Mln tons)	0,80% or 2,5%	From 10,2 Mln tons to 11,5/14,7 Mln tons
Logisticamente (2014): "Porti marittimi europei: le opportunità per la logistica"	2012-2030	World	Mln TEUs	3,93%	From 590 to 1180
EC (2013): "ports 2030"	2011-2030	European ports	Bn tons	2,16%	From 3,7 to 5,55
London Gateway (2013):	2012-2030	World	Containers (Mln tons)	from 3% to 5%	
London Gateway (2013):	2012-2030	World	Containers (Mln tons)	2,57%	From 95 to 150

TRT (2012): "Studio di traffico e marketing - ITS Adriatic Multiport Gateway Prj"	2011-2030	NAPA ports (North Adriatic Ports)	Ro-Ro traffic (Mln tons)	2,37%	From 11,4 to 17,8
Bonaldo S. (2012): "ITS Adriatic Multiport Gateway, Principali Risultati Dello Studio Economico"	2010-2030	NAPA ports (North Adriatic Ports)	Mln TEUs	S. BAS: 3,53% S. AD MP: 7,95%	S. BAS: 1,3-2,6; S. AD MP: 1,3-6
Bonaldo S. (2012): "ITS Adriatic Multiport Gateway, Principali Risultati Dello Studio Economico"	2010-2030	Ports of the Northern Tyrrhenian Sea	Mln TEUs	2,59%	From 3,6 to 6
Bonaldo S. (2012): "ITS Adriatic Multiport Gateway, Principali Risultati Dello Studio Economico"	2010-2030	"Northern range" ports	Mln TEUs	2,13%	From 20,4 to 31,1
EC (2011): "EuroMed-2030 Long term challenges for the Mediterranean area"	1990-2030	Mediterranean Sea	Mln tons	3,53%	From 50 to 200

Table 15 - Global sea traffic according to the specific sector [Mln tons] – 1995 and 2017
Source: our elaboration based on data provided by SRM (2019)

	Years		Var. %	AAGR (%)
Traffic sector	**1995**	**2017**		
Containers	371	1.834	394,3%	7,5%
Solid bulk	2.230	5.722	156,6%	4,4%
Liquid bulk	2.050	3.146	53,5%	2,0%
Total	**4.651**	**10.702**	**130,1%**	**3,9%**

According to many observers, the increase in the market share of trade routes between Europe and Asia is an important indicator of the renewed centrality of the Mediterranean Sea on the stage of freight international exchanges, which has been confirmed by the growth in traffic passing through the Suez Canal after its reopening in 2016, that enables the contemporary passage of ships in opposite directions reducing waiting time and costs. The report released by Confcommercio-Isfort (2019) highlights that the number of ships has not increased a lot (approximately of 2% between 2011 and 2018), but rather a significant increase (42%) in the amount of transferred tons has been registered in the same time period. In this regard, another important aspect is represented by the increase in container traffic in the main ports of the Mediterranean and Black Seas, which occurred in the recent past (Figure 14). In an 11-year time horizon, from 2006 to 2017, container traffic has increase by more than 50% (from 36 million TEUs to almost 57 million TEUs), at an annual average rate equalling to slightly more than 4% , which has further increase since 2009 with an annual average rate of 4,6%.

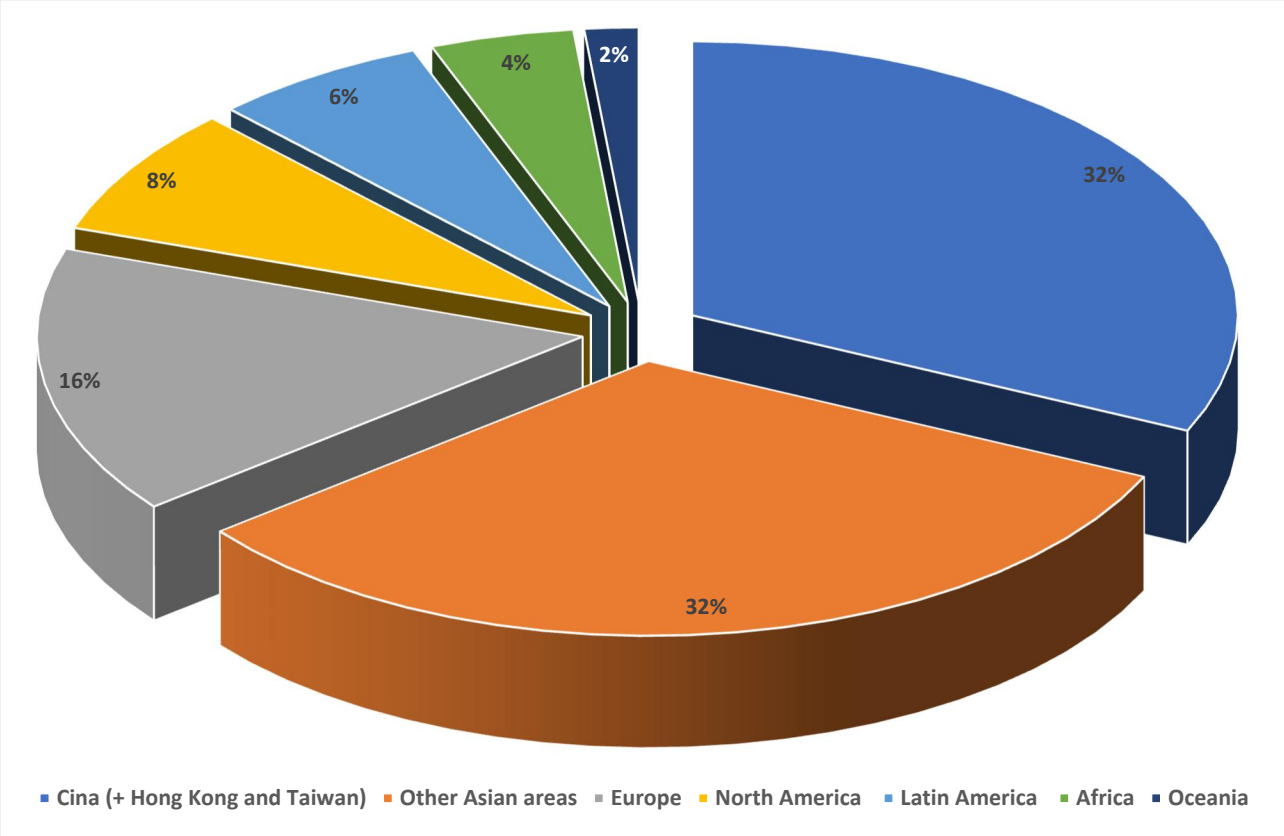

Figure 13 - Container volumes handled around the world according to geographic area [Mln TEUs] – 2017
Source: elaborations based on data provided by SRM (2019)

Moreover, n the SUPREME (SUpporting maritime spatial Planning in the Eastern MEditerranean) project, which is dedicated to the territorial planning of the Eastern Mediterranean Sea, in reference to the scenarios elaborated in the study “Euromed” by the EropeanCommission (2011) the Italian Ministry for Infrastructure and Transport maintains that, even in face of a slowdown in the growth of trans-oceanic

traffic along the Mediterranean Sea, an intensification of trade exchanges between Mediterranean countries and Europe could occur (increasing four times the 1990 values of traffic volumes by 2030, i.e. going from 50 million tons to more than 200 million tons). Consequently, this would entail a strong growth of Short Sea Shipping (SSS), and also of liquid and solid bulk for the supply of raw materials.

The same trend is reported even in the study performed by the European Commission in 2015, which addresses an analysis of the sea transport market both at European and global level. First of all, such study claims that Italian ports cannot compete with the "Northern Range" ports in serving the Central-Eastern European regions in terms of handled freight volumes and due to the presence of the natural barrier composed by the Alps. Secondly, the study of the European Commission illustrates three development scenarios: in the one denominated "Fragmented development scenario" (in opposition to the "Sustainable development scenario" and to the "Accelerated growth scenario"), a slowdown in the "Deep Sea" traffic is considered, to the benefit of the SSS, because of the regionalization of productive systems, and thus of commercial flows, and of the shortening of logistics chains, which are caused by the rise of geopolitical tensions.

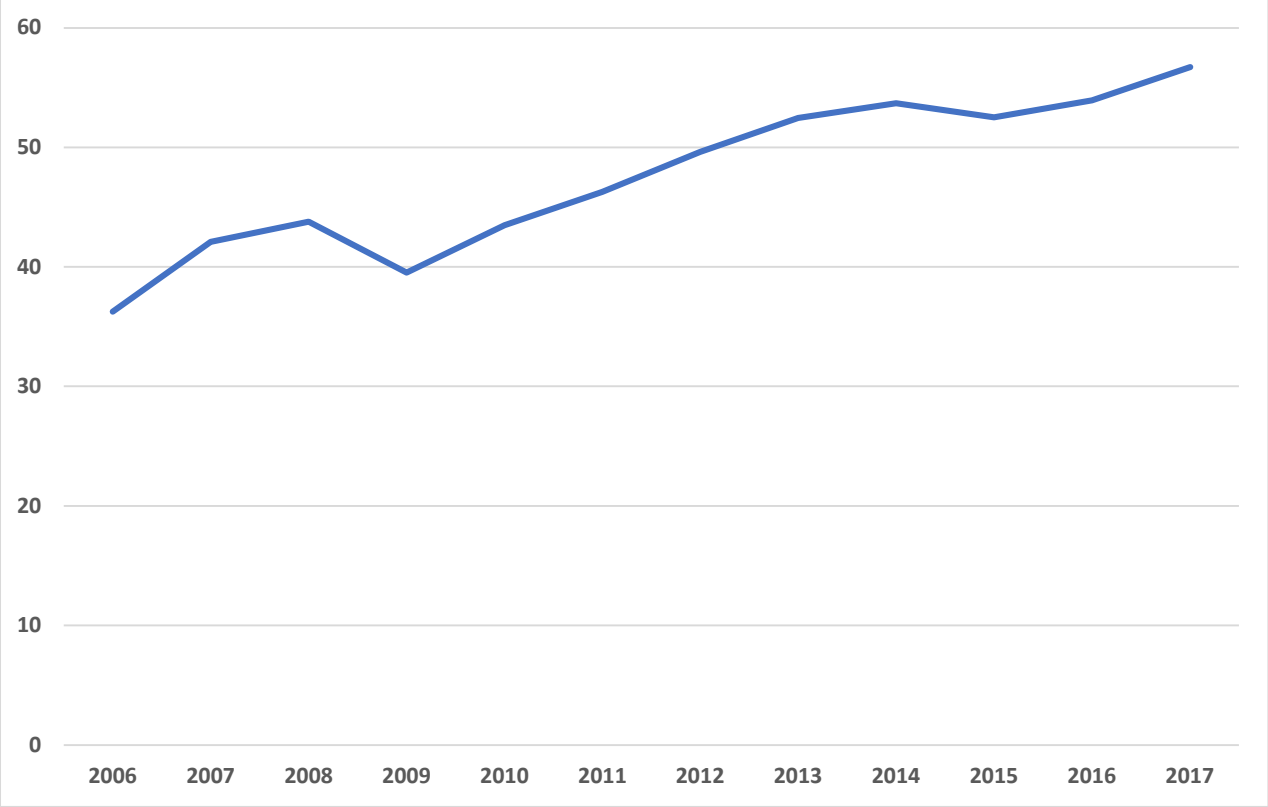

Figure 14 - Container traffic in the main Mediterranean and Black Sea ports [mln TEUs] – 2006-2017
Source: elaboration based on data provided by Confetra (2018)

Such trend could be further sustained by the shift in the long period of the dramatic effects, in terms of deaths and recession of the global economy in the short period, caused by the Covid-19 outbreak, which affect the whole world in 2020. Various observers and researchers are dealing with this issue (please refer, for example, to OECD, 2020 and to Van Til, 2020) because, even if the pandemic has

consisted in a symmetric shock within the global context, its uncertain developments lead to different future scenarios characterized by relevant implications on the spatial structure of global trade exchanges. However, the resilience of economic systems will depend also on the time duration of such economic shock.

On one side, according to a pessimistic perspective (bearing in mind that globalization processes, which have accelerated at the end of the previous millennium, have determined a remarkable reduction in the poverty levels in the whole world), exacerbating to a greater or lesser extent the current tensions (protectionism, populism, etc…) and trends (environmental sustainability, technological revolution, international trade of services, etc…), the destruction of global value chains could be reached in favor of the interregional and/or regional ones with inevitable consequences for traffic flows along the oceanic routes. Under the best circumstances, in Europe a strengthening of intra-European exchanges and of those between the European Community nations and the Eastern European countries could occur. On the contrary, at worst, the affirmation of strong national ideologies could entail a drastic reduction in the international trade relationships, with severe consequences to all the stakeholders that are more or less directly involved in the economy of the sea.

Table 16 - Shares representing the incidence of container traffic on the main east-west routes [% based on mln TEUs] – 1995-2018
Source: our elaboration based on data provided by EC (2019) and SRM (2019)

East-west routes		1995	2014	2015	2016	2017	2018
Trans-Pacific route	*Eastern Asia vs North America*	n.d	62%	64%	64%	64%	64%
	North America vs Eastern Asia	n.d	28%	27%	28%	27%	27%
	Total	**53%**	**45%**	**46%**	**46%**	**46%**	**46%**
Asia-Europe route	*Northern Europe and Mediterranean area vs Eastern Asia*	n.d	27%	26%	26%	26%	26%
	Eastern Asia vs Northern Europa and Mediterranean area	n.d	57%	57%	56%	57%	57%
	Total	**27%**	**42%**	**41%**	**41%**	**41%**	**41%**
Trans-Atlantic route	*North America vs Northern Europe and Mediterranean area*	n.d	11%	10%	10%	10%	10%
	Northern Europe and Mediterranean area vs North America	n.d	15%	16%	15%	16%	16%
	Total	**20%**	**13%**	**13%**	**13%**	**13%**	**13%**

On the other side, according to a more optimistic and positive perspective with respect to globalization, it can be stated that, based on similar previous experiences, global economy and its integration will resume their development following a “V” path, perhaps thanks to new supply sources and new market opportunities (Southern Asia, Middle East, Africa, and South America), but addressing a more environmentally sustainable line of action.

2.3.2.2. Key factors influencing maritime transport in the international context

Regardless the uncertainty given by the macroeconomic forecasts and geopolitical tensions, which are expected in a context characterized by socioeconomic development levels of the various subsystems it is composed of and by trade relationship patterns varying according to reciprocal conveniences, the

technological development currently revolutionizing the structure of production and distribution systems, the increasing pressure towards the environmental sustainability of economic activities and the inherent trends of the sea transport sector are the elements that will influence the volumes and the spatial structure of sea trade exchanges.

The technological innovation (Big Data management, Artificial Intelligence, digitalization, automatization, etc…), which currently affects modern economic systems and represents to a greater extent their "success factor", will entail relevant consequences on maritime transport exerting opposite forces. For example, by reducing the need of cheap labor and of raw materials and semi-manufactured products, robotics and 3D print could cause a shortening of logistics chains. On the contrary, by favoring a reduction in unit costs thanks to an increase in the efficiency of transport and handling activities, these two innovative solutions could further reduce the time-space distance and thus promoting the exchanges from/to very far marketplaces or the use of mega ships.

Another significant tendency for maritime transport is related to the fact that the industrial world is increasingly changing productive systems to suit the transfer of productions to container traffic (Hermansson, 2018), as this transport mode enables great benefits in terms of the efficiency of the logistics chain from the producer to the customer and, at the same time, it permits to reduce possible freight damages caused by handling operations. In this regard, freight traffic management in Sweden represents a best practice, since it considers the use of containers to send and receive a large variety of products. Many observers estimate that in the future 90% of freights belonging to the "general cargo" sector will be handled using containers, and also other products like malt, paper, wood, and fertilizers will be likely transferred by containers.

Regarding the changings in the shipping sector (i.e. ship size and sectoral concentration), they represent the third phenomenon that strongly affects maritime transport in general, and more in particular port systems. On one hand, the increase in the ship size, driven by the economies of scale, is very significant considering that nowadays ships can transfer 20/22 000 TEUs and that at the beginning of 2018 the average size of new ships almost doubled the one of the existing fleet, growing from a little more than 4000 TEUs to over 7600 TEUs (MIT, 2015). This fact definitely entails some implications on the competitiveness between ports and port systems for two reasons:

because relatively few ports are able to (a) moor ships of such dimensions (for example, a 10 000 TEU ship needs a 16/18-meter water depth for mooring operations), (b) efficiently manage loading and unloading operations and (c) transfer containers towards the hinterland;

because increasing the ship size, the number of touched ships in the various ports decreases, directly affecting the spatial structure of maritime routes. In this regard, it must be underlined the possibility of creating new trade connections to be performed using medium sized ships.

On top of all these considerations, it must be observed that the implementation of a weekly transport service using mega ships (which transfer almost 20 000 TEUs) requires a traffic demand of al least 500 000 containers per year in both directions (i.e. performing both loading and unloading operations). Such demand can be meet only by ports playing a quite relevant role in the reference market, which means that they have to offer adequate logistics capabilities in order to guarantee effective consolidation and deconsolidation of goods, even by means of transhipment operations, just like in the case of Northern Adriatic Italian ports. In addition, in relation to the expansion of urban centers in the surrounding of ports, attention has to be drawn to the issue concerning the efficient land use, which requires the maximization

of spatial productivity of port activities (for example, referring to the berth length, the number of movements per meters) (Deloitte, 2020).

The tendency for the growth in the ship size could be stopped, or at least decelerated, by different reasons, among which the scarce flexibility and the fact that huge economies of scale present decreasing marginal profits, making the transfer of full containers an essential requirement to exploit financial benefits (MIT, 2018). Moreover, the concentration of mega ships in a few ports has led to an increase in the revenues of such ports, further reducing the marginal profit of shipping companies (OECD/ITF, 2018).

On the contrary, sectoral dynamics converging towards a very high concentration of the market (especially in the container and Ro-Ro sectors) are evident considering that the 3 major global alliances operating since Spring 2017 (2M, Ocean and THE Alliance) cover 80% of the global container sector and possess the 95% of the capacity of ships travelling along the east-west route. Furthermore, the 3 principal European transport operators (Maersk, MSC and CMA CGM) manage the 46% of the capacity of global transfers (EC, 2019).

Other than directly affecting the competitive aspects of the shipping sector (for example, by imposing barriers to the entry of other transport operators on the east-west routes), such circumstance has relevant implications also in terms of the impact on the selection of ports, on the structure of maritime routes and networks, on the distribution of costs and benefits among the transport operators, and between mangers and operators of port infrastructures, and on the competitiveness among port terminal operators (SRM, 2019). In the logic of value of global chains, these implications entail a reduction in the bargaining power of ports against shipping companies and their alliances. Indeed, even only modifying alliances, shipping companies can influence the sort of ports (as occurred in Taranto with negative consequences or in the Piraeus port with a positive effects), or reduce the profitability of terminal activities, and introduce disruptive elements in the competitiveness both among ports and among terminal operators within the same port, through processes of horizontal and vertical concentration.

The combination of the increase in ship size and of the establishment of alliances among shipping companies has determined the shift, from the seaside to the landside, of the principal component of the overall cost of the global logistics chain (Merk e Notteboom 2015). Indeed, on one hand, those two trends have entailed a reduction of the sea transport cost and, on the other hand, in the logic of the global value of logistics chains, such fact has caused a relative increase in the inland transport cost, which has summed to the tendential growth of this latter. Nowadays, the incidence of the inland transport cost varies between 40% and 80% of the total transport cost. Consequently, with respect to the overall logistics chain, inland connections have become a crucial aspect for the competitiveness of ports. As reported in the next section of the present study, this last concept is acknowledged by many contributions of the scientific literature.

2.3.2.3. International competition of port systems: the ability of attracting traffic flows

The analysis reported in the previous section has highlighted how the affirmation of the concept of the global value of logistics chains have often reduced the bargaining power of these latter (OECD/ITF, 2008), so that, for example, the offering of low tariffs is no more a sufficient condition to gain market shares over other competitive ports, because further factors which are not under the direct control of ports significantly influence the decision processes of the engaged actors (shipping companies, maritime agencies, freight forwarders, etc…). Besides, it has been pointed out that the most relevant part of the overall transport cost has shifted from the sea transport cost to the inland one (Merk e Notteboom op.

cit.): as a consequence, the selection of routes and ports largely depends on the quality of inland transport systems.

Of course, also port tariffs and the efficiency in performing port operations are relevant aspects in the selection of routes and port hubs (OECD/ITF, 2008), as well as the role of ports in supporting the growth of the economic systems they are related to (Portugal-Perez e Wilson, 2012; Brooks et al., 2014; Clark et al, 2004). In this regard, the UNCTAD (2018) maintains that a 10% improvement in port efficiency, inducing a reduction of sea transport costs by 2,3%, generates in turn an increase in exports equalling to 1,8%.

The main issue consists in the fact that nowadays, even if ports are at the center of global logistics chains, they operate in a highly competitive context (especially for the container sector) competing for the handling of the freights produced by the global market. In this respect, referring to the Mediterranean and the Black Seas, over 30 of the 66 ports considered in the study entitled "Il Mar Mediterraneo: Scenari geo strategici della portualità italiana nel quadrante Mediterraneo-Mar Nero" ("The Mediterranean Sea: Geostrategic scenarios of the Italian port system in the context of the Mediterranean and Black Seas" - Confetta, 2018) handled more than 500 000 TEUs in 2017.

Extending the comparison to a larger spatial scope, an interesting discussion can be carried out examining the competitiveness among European ports in serving the Central-Eastern European area denominated by the economists as "Orange Pumpkin" (in opposition to the "Banana Blue" one that extends from Northern Italy to Great Britain, passing through Germany and the Netherlands), which is characterized by more and more accelerated economic dynamics with respect to the rest of Europe. It represents a quite relevant area, whose connection with global marketplaces has historically been performed mostly through the "Northern Range" ports. However, in the latest years, due to congestion problems in the usual port hubs, such global trade exchanges have been executed exploiting new gateways, like the North and the Baltic Sea ports in the north, the Tyrrhenian and the Adriatic Sea ports in the south, and the Black Sea ports in the south-east.

However, in the future, these transport patterns in such competitive context could be significantly changed by the establishment of new international routes like, on one side, the inland connection between China and Europe and, on the other side, the maritime route between Asia and Europe, passing through the North Sea; both routes have to be intended as alternative solutions with respect to the passage through the Suez Canal (EC, 2015). According to the cited study, in spite of the need of relevant financial investments, the China-Europe "Landbridge" will be able to transfer between 200 000 and 500 000 containers per year, which corresponds to a market share between 2% and 5% of the total trade exchanges between the two involved areas. By adopting complex transport models, further studies (ad for example, Tavasszy et al., 2011), estimate a market share ranging from 10% to 20%, with reference only to the Central-Eastern European area (as the Central-Western European area is not considered to be competitive enough).

Regarding the maritime route passing through the Artic sea, the cited study highlights that this route would enable significant savings in terms of the distances travelled in the connections between Europe and Northern Asia (Northern China, Japan and Korea), as compared to the ones travelled passing through the Mediterranean Sea and the Suez Canal. However, other factors, related to the difficulties in performing sea transport even under favorable conditions, the uncertainty of travel times and the inadequacy of communication systems, balance the advantage given by the shorter travelled distance.

Such factors, together with the need of relevant investments and the limitations on the ship size, seem to significantly reduce the competitive potential of that maritime route in the container traffic sector, at least in the short-medium period, even if climate changes could favor a better navigability of the Artic Sea. Nevertheless, in the optimistic growth scenario elaborated in the abovementioned study by the European Commission, such route is considered as a valid seasonal alternative to the one encompassing the Suez Canal, with remarkable consequences on container traffic passing through the Mediterranean sea and concerning its port hubs, in favor of Baltic and Scandinavian ports.

It is a common belief that, in this complex scenario, the ability of maximizing the global value of the logistics chain will be key factor in determining the relative market share of the various ports and that the relative advantage of ports will depend on the maritime accessibility, the ability of handling freights, the offer of value-added services, and the availability of good inland intermodal connections (London Gateways, 2013). The study concerning port investments drafted by the European Sea Ports Organization (ESPO, 2018) estimated that in the latest years the European ports belonging to the "core network" had an investment capacity equalling to 2,2 billion Euros per year to implement different kinds of projects addressing the issues listed above (and also in relation to the implementation of infrastructure for the energy sustainability of ports).

Analysing the preferences of transport operators (freight forwarders, maritime agencies and shipping companies) related to the ports of Hamburg, Antwerp and Rotterdam through the adoption of the "Analytical Hierarchy Process - AHP" and "Analytical Network Process – ANP" methods, developed by Saaty (1977 and 1996) and applied in many case studies in the transport field, Nazemzadeh (2012) considers the following 5 factors for the selection of port hubs: port tariffs, inland connections, geographical location, port productivity, and port capacity. Regardless the differences in the marks attributed by diverse involved stakeholders and in the performances of ports (Table 17), the author concludes that the quality of inland connections is the most critical factor in the selection of ports, followed by port tariffs, with a quite relevant marginal priority over port localization, productivity and capacity. This latter factor is surprisingly ranked always in the last position. Such fact is confirmed, for example, in the "Discussion paper nr. 8" of the "International Transport Forum" (Brooks et al. 2014), which underlines that, after the 2008 financial crisis, the evolution of port capacity has not been always followed by an increase in traffic flows, determining a surplus in port capacity for long time periods (this condition typically occurs in Europe due to, inter alia, the long duration of planning processes). In this regard, the cited document reports two case studies as examples: the project for a 2,7-million-TEU terminal in the port of Jade Weser in Wilhelmshaven, which has never reached the expected capacity after its opening in 2012, and the 1-millio-TEU terminal denominated Ceres-Paragon1 in the port of Amsterdam that, after 10 years of operations, has handled at maximum 300 000 TEUs (with reference to the time in which the document was drafted).

Even the priority attribute to port tariffs in the contribution of Nazemzadeh is quite surprising since, as discussed in the previous section (Merk e Notteboom op. cit.), the composition of the overall transport cost has been dominated more and more by the cost for inland transport, which in some cases exceeds by a value ranging from 5 and 30 times the one for maritime transport. Therefore, port tariffs could be expected to assume a lower priority value, which is still quite considerable (OECD/ITS, op. cit.).

On the contrary, the importance of the quality of inland connections is widely acknowledged in the scientific literature, especially in the most recent contributions. For instance, examining the performances of ports in relation to issue of selecting port hubs adopting an approach based on multi-

criteria analysis, (Rezaei et al., 2019) find out not only that costs and time duration along the whole transport chain are connected to each other, but also that they are the most dominant parameters (other important criteria are customers' satisfaction, port reputation and service flexibility). Another scientific contribution confirming the significance of the quality of inland connections is represented by the COREALIS (Capacity with a pOsitive enviRonmEntal and societAL footprInt: portS in the future era) project, funded by the Horizon 2020 program and involving 5 European ports (Antwerp, HaminaKotka, Leghorn, Piraeus e Valencia). In this project, the connections of the engaged ports have been analysed considering not only infrastructures, but also the sustainability of the whole transport chain and of the supplied services, evaluating the IT solutions that are able to support inland connectivity at best. In addition to identifying the inland connections as the key factor for port competitiveness, the deliverable 2.1 (Pérez, 2018) outlines their main aspects, namely infrastructures, the efficient use, the coordination of the chain, sustainable and attractive services.

Table 17 - Factors for the selection of port hubs (with reference to the ports of Hamburg, Antwerp and Rotterdam)
Source: our elaborations base on Nazemzadeh (2012), table 5.11

Selection factor / Method / Decision maker	AHP			ANP		
	Shipping companies	Maritime agencies	Freight forwarders	Shipping companies	Maritime agencies	Freight forwarders
Localization	0,18	0,22	0,14	0,18	0,24	0,13
Capacity	0,04	0,05	0,07	0,06	0,06	0,06
Costs	0,44	0,42	0,49	0,36	0,35	0,48
Productivity	0,10	0,08	0,12	0,14	0,10	0,11
Quality of inland connections	0,22	0,22	0,18	0,26	0,23	0,18

2.3.3. Conclusion

The present chapter reports the results of the study performed with the aim of building, especially in qualitative terms, an informative framework concerning future scenarios of economic development, the current tendencies in the shipping sector and the implications of these latter on ports.

With reference to the main issues discussed in the present chapter, the most relevant outcomes of the study are briefly reported in the following.

- Long-term macroeconomic scenarios and trends in the international trade exchanges:
  - *Towards the east: macroeconomic forecasts, to which the ones concerning trade exchanges and maritime transport flows are related, are inherently characterized by a high level of uncertainty, which tends to increase proportionally to the extent of the time horizon of such forecasts. However, a tendency for a shift of the gravity centers of global economy towards the east seems to be the main consideration on which future economic scenarios are based;*
  - *New routes: The shift towards the east and the advancements in the emerging and less developed economies are expected to define a new structure of trade relationships. In*

addition to intra-Asian exchanges, the new emerging commercial routes connect Asia to Africa and to Latin America along the north-south direction. "Traditional" routes between Asia and America, and between Asia and Europe will continue to dominate, increasing according to quite relevant growth rates (the second one will increase more than the first one). On the contrary, traffic along the trans-Atlantic route will likely to be drastically reduced, even if such route will continue to represent one of the most significant trade relationships.

- *Containers: it is widely acknowledged that the global maritime traffic will continue to grow according to significant growth rates, even if in a more limited way with respect to the past years. Its most important sector, in terms of the values of trade exchanges, is represented by the container sector, for which significant growth rates will be recorded also in the future (it increased from 750 million TEUs in 2017 up to more than one billion TEUs in 2023, with an annual growth rate exceeding 7%);*
- *Mediterranean Sea: this sea will continue to play a central role in the context of global trade exchanges, both for the continuous increase in traffic flows along trans-oceanic routes and for the intensification of trade exchanges between Europe and Africa. By inducing a shortening of logistics chains, the occurrence of macro scenarios characterized by a global fragmented economy (due to geopolitical tensions) could further reinforce the role of the Mediterranean Sea, especially in the Short Sea Shipping;*

- Key factors influencing maritime transport within the international context:
  - *Technological development: on one hand, it is intended to enhance efficiency, security and reliability (with a consequent reduction of costs) of port operations, but on the other hand, due to the revolution of productive system using robotics and 3D print, it could entail a shortening of logistics chains and a change in the product structure of commercial exchanges;*
  - *Containerization: it transformed global trade in the 1950s and it is likely to be developed even more in the future, since many companies are transforming their productive systems so as to be suitable for this transport solution;*
  - *Mega ships and sectoral concentration: naval gigantism (which seems to be close to its maximum extent) and sectoral concentration will continue to put significant pressure on ports, affecting the spatial structure of maritime routes, attributing more and more importance to inland connections and reducing the bargaining power of ports;*

- International competition among port systems:
  - *High competitiveness: the marginalization of port systems due to the affirmation of the concept of the global value of logistics chains has led, among other consequences, to an increase in the competitiveness between port systems and ports. In the last decade the European marketplace was served almost exclusively by the "Northern Range" ports, while nowadays, even due to congestion problems in such ports and to the shift of the economic gravity center towards the east, the competitive context has*

enlarged including also the Baltic ports in the north, the Mediterranean ports in the south and the Black ports in the south-east;

- *Northern Adriatic Sea: in the last 10 years the ports of the Northern part of the Mediterranean Sea, in particular Koper and Trieste, have recorded on average better performances with respect to the ones of the Mediterranean and Black ports, shortening the gap with the most relevant transhipment hubs (like the ports of Piraeus and Tangier);*
- *Inland connections: the consideration that inland transport cost currently represents a share ranging between 40% and 80% of the total transport cost in logistics chains has drawn more and more the attention to the quality of inland connections. In many contributions of the scientific literature it is acknowledged that such component of the total transport cost is the most critical factor in the selection of port hubs by the "big players" involved in the shipping sector, followed by other parameters like the geographical localization, the efficiency of port operations and the loading/unloading capacity of ports.*

2.4. Analysis of the industrial structure and clusters (potential customers)

2.4.1. Market potential for the Port of Trieste: spatial distribution of trade exchanges over Europe

This section illustrates the results of the assessment of the market potential for the Port of Trieste, in which attention has been drawn on the analysis of the spatial distribution of trade exchanges that could possibly pass through the Friuli Venezia Giulia region and, thus, involve the entire regional logistics system, in particular the Port of Trieste. The analysis has been performed bearing in mind the strategic vision according to which the Port of Trieste represents one of the main gateways to continental Europe, thanks to its advantageous geographical position for global trade relationships. In this latter context, the African continent and especially the extensive Asian continent are assuming more and more relevance.

To accomplish the purpose of the analysis, a top-down approach has been adopted. First of all, using the aggregated 14-zone model described earlier, a study of macro O/D relationships has been performed in order to identify the ones that can be interesting for a development of the Port of Trieste, which is increasingly oriented towards an enhancement of sea-rail intermodality. Subsequently, referring to the disaggregated 25-zone model, an analytical investigation has been focused on the most promising macro O/D relationships. The analysis has been limited to freight transfers exceeding 300 km, since this distance represents the threshold determining the competitiveness of railway transport over the road one.

2.4.1.1. Traffic analysis according to geographical macro areas

According to the 14-zone zoning model, 27 O/D relationships of potential interest for the Port of Trieste have been identified: they could benefit from the geopolitical advantage that characterizes the Friuli Venezia Giulia region within the context of global trade exchanges. Indeed, as it can be noticed in Table 9, this set of trade relationships have been selected based on either a direct impact on port activities due to an increase in maritime flows, or on an indirect impact on port operations due to a traffic growth on road and rail infrastructures. The future usage of these latter transport network components, which the completion of the Mediterranean Corridor could contribute to, could indirectly influence the traffic of the Port of Trieste, reducing the ability of its land infrastructures, especially of the railway one, of meeting the additional freight volumes generated by an increase in the maritime traffic. More in detail, as reported in the third column of Table 9, 20 O/D relationships have been considered of great interest for the Port of Trieste.

The annual amount of transferred freights considered in identified set of O/D relationships exceed 700 million tons, i.e. almost 17% of the total freight volume transferred on a distance greater than 300 km, which equals to more than 4 billion tons. Excluding the 7 O/D relationships with no direct impacts on the Port of Trieste, the potential basin of reference for the examined port could correspond to more than half billion tons, which is almost the 79% of the total freight volume that could transit through the whole Friuli Venezia Giulia region. Therefore, it turn out to be evident that these estimated freight volumes are related to the sea mode, which accounts for more than 90% in the identified set of trade relationships (regardless of whether the entire set is taken into account or only those relationships

impacting directly on the Port of Trieste are considered). However, it must be observed that, referring solely to the relationships of interest for the Port of Trieste, the freight flows carried out by the road and rail modes equal almost to 36 million tons. Concerning the 7 O/D relationships with no direct impacts on the Port of Trieste, the road mode plays a less significant role: indeed, its contribution decreases from 5,6% to 2,4%, which means from 34,5 to 13,6 million tons. On the contrary, for those relationships, no significant variations in the rail modal share are present, even though a reduction of 3 million tons is recorded.

Analysing the relative importance of the various trade relationships, it can be noticed that the most relevant ones are those between the northern European area and the Asian and African continents; notwithstanding, significant relationships between this European macro area and south-eastern Europe are registered. Also trade exchanges between north-eastern Europe and the areas outside Europe (North America, South America, Asia and Africa) appear to be quite relevant. Further meaningful relationships are observed, on one side, between eastern and south-eastern Europe, and on the other side, between eastern and western Europe. Those exchanges could be more significant for the whole Friuli Venezia Giulia region, rather than specifically to the Port of Trieste, with respect to the capacity usage of land infrastructures.

Focusing on the potential traffic flows of particular interest for the Port of Trieste, it must be highlighted that the abovementioned trade relationships prove to be much more significant due to the great share of sea transport. As a matter of fact, the relationships among north Europe, Asia and Africa accounts for almost 60% of the total amount. A very different scenario is observed when considering land modes:

- Regarding the road mode, the relationships between south-eastern Europe and northern Europe, north-eastern Europe and the regions of northern Italy (except for the Friuli Venezia Giulia region) prevail. Also trade exchanges of north-eastern Europe and eastern Europe with central-southern Italy appear to be significant;
- Regarding the rail mode, traffic flows are concentrated mostly on two routes involving north-eastern Europe: freight transfers from/to south-eastern Europe and the Asian continent accounts for almost 90% of the total transfers. Traffic volumes concerning the relationships between south-eastern Europe and northern Italy (especially the regions of north-western Italy) and between north-eastern Europe and central-southern Italy are quite marginal.

Table 18 - Potential transit flows (for distances greater than 300 km) concerning the Friuli Venezia Giulia region and the Port of Trieste, according to bidirectional O/D relationship and transport mode in 2016 [1000 tons]
Source: our elaboration

ID	O/D relationship	Of potential interest for the Port of Trieste	Transport mode			
			Road	Rail	Sea	Total*
1	From north-eastern Europe to other north-eastern Italian regions	No	7.297	1.165	385	8.847
2	From north-eastern Europe to north-western Italy	No	9.252	1.727	527	11.506
3	From north-eastern Europe to central-southern Italy	Yes	2.620	342	4.107	7.069
4	From north-western Europe to south-eastern Europe	No	132	3	5.890	6.025
5	From northern Europe to south-eastern Europe	Yes	3.903	189	21.226	25.613
6	From northern Europe to Africa	Yes	-	-	112.397	112.397
7	From northern Europe to Asia and Oceania	Yes	-	-	194.495	194.495
8	From north-eastern Europe to south-eastern Europe	Yes	3.415	5.761	7.694	17.408
9	From north-eastern Europe to Africa	Yes	-	-	15.531	15.531
10	From north-eastern Europe to North America	Yes	-	-	34.540	34.540
11	From north-eastern Europe to South America	Yes	-	-	18.752	18.752
12	From north-eastern Europe to Asia and Oceania	Yes	129	5.023	23.645	28.796
13	From eastern Europe to other north-eastern Italian regions	No	2.485	37	7.051	9.573
14	From eastern Europe to north-western Italy	No	3.234	138	6.014	9.385
15	From eastern Europe to central-southern Italy	Yes	1.029	13	17.605	18.647
16	From south-eastern Europe to other north-eastern Italian regions	Yes	1.243	114	7.535	8.891
17	From south-eastern Europe to north-western Italy	Yes	1.291	480	8.643	10.414
18	From eastern Europe to western Europe	No	2.837	139	66.547	69.524
19	From south-eastern Europe to western Europe	No	598	19	31.995	32.612
20	From eastern Europe to Africa	Yes	-	-	9.496	9.496
21	From eastern Europe to North America	Yes	-	-	3.298	3.298
22	From eastern Europe to South America	Yes	-	-	4.851	4.851
23	From eastern Europe to Asia and Oceania	Yes	-	-	11.099	11.099
24	From Africa to other north-eastern Italian regions	Yes	-	-	6.329	6.329
25	From Africa to north-western Italy	Yes	-	-	15.879	15.879
26	From Asia and Oceania to other north-eastern Italian regions	Yes	-	-	4.252	4.252
27	From Asia and Oceania to other north-western Italian regions	Yes	-	-	14.780	14.780
0	Not concerning the Friuli venezia Giulia region	No	858.458	285.262	2.232.598	3.555.426
Total amount of freight volumes			**897.922**	**300.412**	**2.887.162**	**4.265.435**
Total amount of relationships of interest for the Friuli Venezia Giulia region			**39.464**	**15.150**	**654.563**	**710.009**
Rate of relationships of interest for the Friuli Venezia Giulia region on the total amount of freight volumes			**4,4%**	**5,0%**	**22,7%**	**16,6%**
Total amount of relationships of interest for the Port of Trieste			**13629**	**11921**	**536154**	**562536**
Rate of relationships of interest for the Port of Trieste on the total amount of relationships concerning the Friuli Venezia Giulia region			**34,5%**	**78,7%**	**81,9%**	**79,2%**
**The total amount of freight volumes contained in this column does not correspond to the sum of the ones related to the 3 considered transport modes, since also inland navigation traffic has been included.*						

For the Port of Trieste, these results suggest the adoption of strategic traffic initiatives considering the development of new sea-rail intermodal services, that can be intended with a twofold meaning: on one hand, they can provide an alternative route to existing logistics chains and/or, on the other hand, they can offer an alternative sustainable solution to those trade relationships that are currently performed totally by road or adopting road-sea intermodality also for medium-long haul distances.

In the following, the main results are described in terms of modal split for each product category. It can be noticed that:

- In relation to the sea mode (Table 10), excluding oil products (which constitute the most relevant category), the sectors concerning transport equipment, machinery, manufactured products and miscellaneous articles, and chemical products prevail, followed not very closely by the food field. The contribution of all the remaining handling categories accounts for less than 5% each, though corresponding to quite significant freight volumes (for example, the sector concerning fertilizers is the least important, but its related traffic equals almost to 12 million tons);
- Regarding the rail mode (Table 11), the sector concerning transport equipment, machinery, manufactured products and miscellaneous articles plays the most relevant role, followed by the ones related to non-metallic minerals, to oil products and solid fossil minerals, and to agricultural products. Also freight transfers referred to fertilizers and metal waste prove to be significant;
- Concerning the road mode (Table 12), the traffic share generated by the sectors dealing with not only transport equipment, machinery, manufactured products and miscellaneous articles, but also agricultural products and food are is significant. On the contrary, the fields handling chemical products, metal and non-metal minerals plays a more marginal role.

Table 19 - SEA MODE - Potential transit flows (for distances greater than 300 km) concerning the Friuli Venezia Giulia region and the Port of Trieste, according to unidirectional O/D relationship and transport mode in 2016 [1000 tons]
Source: our elaboration

ID	O/D relationship	Flow route	Handling categories										All handling categories
			0	1	2	3	4	5	6	7	8	9	
1	From north-eastern Europe to central-southern Italy	N-S + E-O	10	235	838	1.257	120	453	402	20	74	243	3.652
2	From central-southern Italy to north-eastern Europe	O-E + S-N	28	235	2	8	4	68	93	0	4	14	456
3	From northern Europe to south-eastern Europe	N-S	317	492	51	835	4.338	1.560	168	201	1.474	1.056	10.491
4	From south-eastern Europe to northern Europe	S-N	659	1.329	0	1.017	221	802	808	0	2.052	3.848	10.735
5	From northern Europe to Africa	N-S	3.315	4.460	118	14.146	443	1.807	1.501	1.346	6.971	10.786	44.893
6	From Africa to northern Europe	S-N	3.192	4.466	9.553	30.401	7.317	1.279	770	1.055	4.429	5.043	67.503
7	From northern Europe to Asia and Oceania	N-S	4.076	9.194	178	14.524	334	2.402	802	2.094	23.579	23.749	80.931
8	From Asia and Oceania to northern Europe	S-N	3.154	12.766	8.586	29.901	3.355	2.430	1.557	1.024	12.663	38.129	113.563
9	From north-eastern Europe to south-eastern Europe	N-S	260	340	624	1.115	1.775	635	443	65	464	525	6.246
10	From south-eastern Europe to north-eastern Europe	S-N	70	219	9	84	219	188	560	1	24	74	1.448
11	From north-eastern Europe to Africa	N-S	2.736	320	1.052	2.759	765	789	581	301	1.004	948	11.255
12	From Africa to north-eastern Europe	S-N	245	408	106	1.066	401	322	337	1.155	110	126	4.276
13	From north-eastern Europe to North America	N-S	245	814	1.154	20.299	131	337	336	747	2.794	1.231	28.088
14	From North America to north-eastern Europe	S-N	326	224	2.990	624	341	151	736	4	737	319	6.453
15	From north-eastern Europe to South America	N-S	836	276	3.362	2.002	257	377	571	1.165	1.003	567	10.417
16	From South America to north-eastern Europe	S-N	655	1.628	1.032	2.081	776	441	782	47	229	661	8.335
17	From north-eastern Europe to Asia and Oceania	N-S	1.551	865	2.026	4.357	2.698	1.386	1.728	98	1.884	2.096	18.689
18	From Asia and Oceania to north-eastern Europe	S-N	131	675	1.486	261	225	169	221	334	174	1.280	4.955
19	From eastern Europe to central-southern Italy	E-O	295	661	398	10.241	246	1.666	685	76	446	386	15.099
20	From central-southern Italy to eastern Europe	O-E	42	331	1	1.596	6	49	79	3	130	269	2.506
21	From south-eastern Europe to other north-eastern Italian regions	E-O	368	120	-	893	173	545	3.990	59	244	419	6.812
22	From other north-eastern Italian regions to south-eastern Europe	O-E	27	59	2	134	11	56	111	7	106	210	724
23	From south-eastern Europe to north-western Italy	E-O	109	223	-	5.628	24	93	403	9	339	257	7.085
24	From north-western Italy to south-eastern Europe	O-E	49	63	2	246	10	56	77	16	373	667	1.558
25	From eastern Europe to Africa	E-O	1.225	8	1	194	70	206	108	176	473	1.519	3.978
26	From Africa to eastern Europe	O-E	433	154	1.752	442	459	906	484	505	159	224	5.518
27	From eastern Europe to North America	E-O	0	9	-	109	28	59	1	193	209	58	666
28	From North America to eastern Europe	O-E	134	217	1.015	338	306	72	111	-	337	102	2.632
29	From eastern Europe to South America	E-O	7	2	0	17	13	196	6	28	30	75	374
30	From South America to eastern Europe	O-E	562	1.931	38	67	1.631	37	55	2	136	18	4.477
31	From eastern Europe to Asia and Oceania	E-O	1.630	197	-	800	114	927	31	310	996	1.916	6.921
32	From Asia and Oceania to eastern Europe	O-E	201	280	656	618	350	170	46	67	541	1.250	4.179
33	From Africa to other north-eastern Italian regions	E-O	76	121	268	3.957	102	249	612	203	81	78	5.747
34	From other north-eastern Italian to regions Africa	O-E	10	29	1	192	7	145	68	4	45	81	582
35	From Africa to north-western Italy	E-O	163	394	155	10.675	58	108	194	167	457	536	12.909
36	From north-western Italy to Africa	O-E	89	264	1	470	7	206	171	20	486	1.256	2.971
37	From Asia and Oceania to other north-eastern Italian regions	E-O	43	553	161	851	178	422	185	57	172	302	2.923
38	From other north-eastern Italian regions to Asia and Oceania	O-E	22	98	2	78	13	286	239	7	219	364	1.328

39	From Asia and Oceania to north-western Italy	E-O	234	2.555	1.511	1.027	26	337	147	51	1.247	3.404	10.538
40	From north-western Italy to Asia and Oceania	O-E	115	395	0	355	8	85	51	5	893	2.333	4.242
Total amount of freight volumes of interest for the Port of Trieste			**27.637**	**47.609**	**39.130**	**165.663**	**27.558**	**22.475**	**20.252**	**11.625**	**67.789**	**106.418**	**536.154**

Table 20 - RAIL MODE - Potential transit flows (for distances greater than 300 km) concerning the Friuli Venezia Giulia region and the Port of Trieste, according to unidirectional O/D relationship and transport mode in 2016 [1000 tons]
Source: our elaboration

ID	O/D relationship	Flow route	Handling categories										All handling categories
			0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
1	From north-eastern Europe to central-southern Italy	N-S + E-O	33	2	26	0	91	3	3	35	0	99	292
2	From central-southern Italy to north-eastern Europe	O-E + S-N	0	0	-	11	2	4	14	-	0	18	50
3	From northern Europe to south-eastern Europe	N-S	2	4	2	35	7	3	17	8	8	20	106
4	From south-eastern Europe to northern Europe	S-N	0	0	-	0	0	3	1	5	9	65	83
5	From northern Europe to Africa	N-S	-	-	-	-	-	-	-	-	-	-	-
6	From Africa to northern Europe	S-N	-	-	-	-	-	-	-	-	-	-	-
7	From northern Europe to Asia and Oceania	N-S	-	-	-	-	-	-	-	-	-	-	-
8	From Asia and Oceania to northern Europe	S-N	-	-	-	-	-	-	-	-	-	-	-
9	From north-eastern Europe to south-eastern Europe	N-S	706	5	300	463	106	169	625	298	103	695	3.471
10	From south-eastern Europe to north-eastern Europe	S-N	288	16	85	637	165	32	130	364	53	518	2.290
11	From north-eastern Europe to Africa	N-S	-	-	-	-	-	-	-	-	-	-	-
12	From Africa to north-eastern Europe	S-N	-	-	-	-	-	-	-	-	-	-	-
13	From north-eastern Europe to North America	N-S	-	-	-	-	-	-	-	-	-	-	-
14	From North America to north-eastern Europe	S-N	-	-	-	-	-	-	-	-	-	-	-
15	From north-eastern Europe to South America	N-S	-	-	-	-	-	-	-	-	-	-	-
16	From South America to north-eastern Europe	S-N	-	-	-	-	-	-	-	-	-	-	-
17	From north-eastern Europe to Asia and Oceania	N-S	61	21	178	49	83	44	194	48	42	602	1.324
18	From Asia and Oceania to north-eastern Europe	S-N	161	61	469	118	219	115	511	126	110	1.809	3.699
19	From eastern Europe to central-southern Italy	E-O	-	-	0	-	0	-	0	-	-	10	11
20	From central-southern Italy to eastern Europe	O-E	-	-	-	-	-	-	-	-	-	2	2
21	From south-eastern Europe to other north-eastern Italian regions	E-O	-	0	1	-	56	-	55	0	-	1	113
22	From other north-eastern Italian regions to south-eastern Europe	O-E	0	0	0	0	0	-	0	0	-	0	1
23	From south-eastern Europe to north-western Italy	E-O	0	0	10	0	109	0	326	0	-	6	452
24	From north-western Italy to south-eastern Europe	O-E	-	-	0	0	0	0	25	-	0	2	27
25	From eastern Europe to Africa	E-O	-	-	-	-	-	-	-	-	-	-	-
26	From Africa to eastern Europe	O-E	-	-	-	-	-	-	-	-	-	-	-
27	From eastern Europe to North America	E-O	-	-	-	-	-	-	-	-	-	-	-
28	From North America to eastern Europe	O-E	-	-	-	-	-	-	-	-	-	-	-
29	From eastern Europe to South America	E-O	-	-	-	-	-	-	-	-	-	-	-
30	From South America to eastern Europe	O-E	-	-	-	-	-	-	-	-	-	-	-
31	From eastern Europe to Asia and Oceania	E-O	-	-	-	-	-	-	-	-	-	-	-
32	From Asia and Oceania to eastern Europe	O-E	-	-	-	-	-	-	-	-	-	-	-

33	From Africa to other north-eastern Italian regions	E-O	-	-	-	-	-	-	-	-	-	-	-
34	From other north-eastern Italian to regions Africa	O-E	-	-	-	-	-	-	-	-	-	-	-
35	From Africa to north-western Italy	E-O	-	-	-	-	-	-	-	-	-	-	-
36	From north-western Italy to Africa	O-E	-	-	-	-	-	-	-	-	-	-	-
37	From Asia and Oceania to other north-eastern Italian regions	E-O	-	-	-	-	-	-	-	-	-	-	-
38	From other north-eastern Italian regions to Asia and Oceania	O-E	-	-	-	-	-	-	-	-	-	-	-
39	From Asia and Oceania to north-western Italy	E-O	-	-	-	-	-	-	-	-	-	-	-
40	From north-western Italy to Asia and Oceania	O-E	-	-	-	-	-	-	-	-	-	-	-
Total amount of freight volumes of interest for the Port of Trieste			**1.252**	**109**	**1.071**	**1.315**	**838**	**374**	**1.901**	**886**	**325**	**3.848**	**11.921**

Table 21 - ROAD MODE - Potential transit flows (for distances greater than 300 km) concerning the Friuli Venezia Giulia region and the Port of Trieste, according to unidirectional O/D relationship and transport mode in 2016 [1000 tons]
Source: our elaboration

ID	O/D relationship	Flow route	Handling categories										All handling categories
			0	1	2	3	4	5	6	7	8	9	
1	From north-eastern Europe to central-southern Italy	N-S + E-O	408	128	62	69	19	67	59	13	159	602	1.587
2	From central-southern Italy to north-eastern Europe	O-E + S-N	129	103	4	126	4	54	122	3	77	410	1.033
3	From northern Europe to south-eastern Europe	N-S	216	388	1	24	5	58	18	20	177	1.096	2.003
4	From south-eastern Europe to northern Europe	S-N	291	398	0	16	20	215	84	2	71	804	1.900
5	From northern Europe to Africa	N-S	-	-	-	-	-	-	-	-	-	-	-
6	From Africa to northern Europe	S-N	-	-	-	-	-	-	-	-	-	-	-
7	From northern Europe to Asia and Oceania	N-S	-	-	-	-	-	-	-	-	-	-	-
8	From Asia and Oceania to northern Europe	S-N	-	-	-	-	-	-	-	-	-	-	-
9	From north-eastern Europe to south-eastern Europe	N-S	264	237	47	46	2	111	129	12	193	700	1.743
10	From south-eastern Europe to north-eastern Europe	S-N	313	240	0	35	22	167	106	32	163	595	1.672
11	From north-eastern Europe to Africa	N-S	-	-	-	-	-	-	-	-	-	-	-
12	From Africa to north-eastern Europe	S-N	-	-	-	-	-	-	-	-	-	-	-
13	From north-eastern Europe to North America	N-S	-	-	-	-	-	-	-	-	-	-	-
14	From North America to north-eastern Europe	S-N	-	-	-	-	-	-	-	-	-	-	-
15	From north-eastern Europe to South America	N-S	-	-	-	-	-	-	-	-	-	-	-
16	From South America to north-eastern Europe	S-N	-	-	-	-	-	-	-	-	-	-	-
17	From north-eastern Europe to Asia and Oceania	N-S	36	10	-	-	-	2	3	-	0	77	129
18	From Asia and Oceania to north-eastern Europe	S-N	-	-	-	-	-	-	-	-	-	-	-
19	From eastern Europe to central-southern Italy	E-O	98	56	0	70	10	28	77	1	25	188	553
20	From central-southern Italy to eastern Europe	O-E	40	16	2	93	2	28	104	4	48	139	476
21	From south-eastern Europe to other north-eastern Italian regions	E-O	150	114	0	9	14	30	38	5	117	253	731
22	From other north-eastern Italian regions to south-eastern Europe	O-E	48	69	0	3	2	37	82	7	37	228	512
23	From south-eastern Europe to north-western Italy	E-O	91	110	0	8	6	68	25	8	116	268	701
24	From north-western Italy to south-eastern Europe	O-E	24	67	0	3	1	74	61	11	56	293	590
25	From eastern Europe to Africa	E-O	-	-	-	-	-	-	-	-	-	-	-
26	From Africa to eastern Europe	O-E	-	-	-	-	-	-	-	-	-	-	-

27	From eastern Europe to North America	E-O	-	-	-	-	-	-	-	-	-	-	-
28	From North America to eastern Europe	O-E	-	-	-	-	-	-	-	-	-	-	-
29	From eastern Europe to South America	E-O	-	-	-	-	-	-	-	-	-	-	-
30	From South America to eastern Europe	O-E	-	-	-	-	-	-	-	-	-	-	-
31	From eastern Europe to Asia and Oceania	E-O	-	-	-	-	-	-	-	-	-	-	-
32	From Asia and Oceania to eastern Europe	O-E	-	-	-	-	-	-	-	-	-	-	-
33	From Africa to other north-eastern Italian regions	E-O	-	-	-	-	-	-	-	-	-	-	-
34	From other north-eastern Italian to regions Africa	O-E	-	-	-	-	-	-	-	-	-	-	-
35	From Africa to north-western Italy	E-O	-	-	-	-	-	-	-	-	-	-	-
36	From north-western Italy to Africa	O-E	-	-	-	-	-	-	-	-	-	-	-
37	From Asia and Oceania to other north-eastern Italian regions	E-O	-	-	-	-	-	-	-	-	-	-	-
38	From other north-eastern Italian regions to Asia and Oceania	O-E	-	-	-	-	-	-	-	-	-	-	-
39	From Asia and Oceania to north-western Italy	E-O	-	-	-	-	-	-	-	-	-	-	-
40	From north-western Italy to Asia and Oceania	O-E	-	-	-	-	-	-	-	-	-	-	-
Total amount of freight volumes of interest for the Port of Trieste			**2.109**	**1.935**	**117**	**503**	**109**	**939**	**907**	**118**	**1.241**	**5.652**	**13.629**

2.4.1.2. Detailed analysis of spatial distribution of transport flows across Europe

The results described above suggested an in-depth examination of transport flows using a more detailed representation of the transport demand, which was based on the 25-zone zoning model. This latter adopts a representation at national level for all the European countries, except for some of them which are usually meant as aggregated, like the Benelux countries, as well as the Scandinavian countries, the Baltic states and the Balkans.

On one hand, the adoption of this approach was motivated by the intention of analysing more in detail the most relevant trade relationships that were identified by means of the investigation at macroscopic level. On the other hand, the implementation of this method was necessary due to the fact that the reference data base, i.e. the one developed in the ETIS Plus project, considers a representation of trade exchanges in terms of logistics chains, rather than of O/D relationships. In other words, a generic traffic flow generated in the zone A and destined to the zone C, transiting through the intermediate zone B, is described as two consequent flows, AB and BC. This approach is particularly evident when examining trade exchanges between Europe and the other continents, Indeed, in such representation of trade exchanges, ports are designated as gateways for traffic flows originated outside Europe.

This is the reason why, for example, trade exchanges between northern Europe and the Asian and African continents are present among the O/D relationships studied at macroscopic level: the ports of the so-called “Northern range” represent the main gateways to Europe. Such consideration clearly emerges in the 4 GIS representations reported in Figures 7, 8, 9, 10, which illustrate the total trade exchanges (i.e. generated and attracted) of all the European areas considered in the 25-zone zoning model with the 4 continents. It can be observed that trade relationships of Benelux countries and Germany with the other continents are less significant than those concerning the western European area only for freight exchanges with Africa, which can be motivated by the fact that this latter area includes Spain, France and Great Britain.

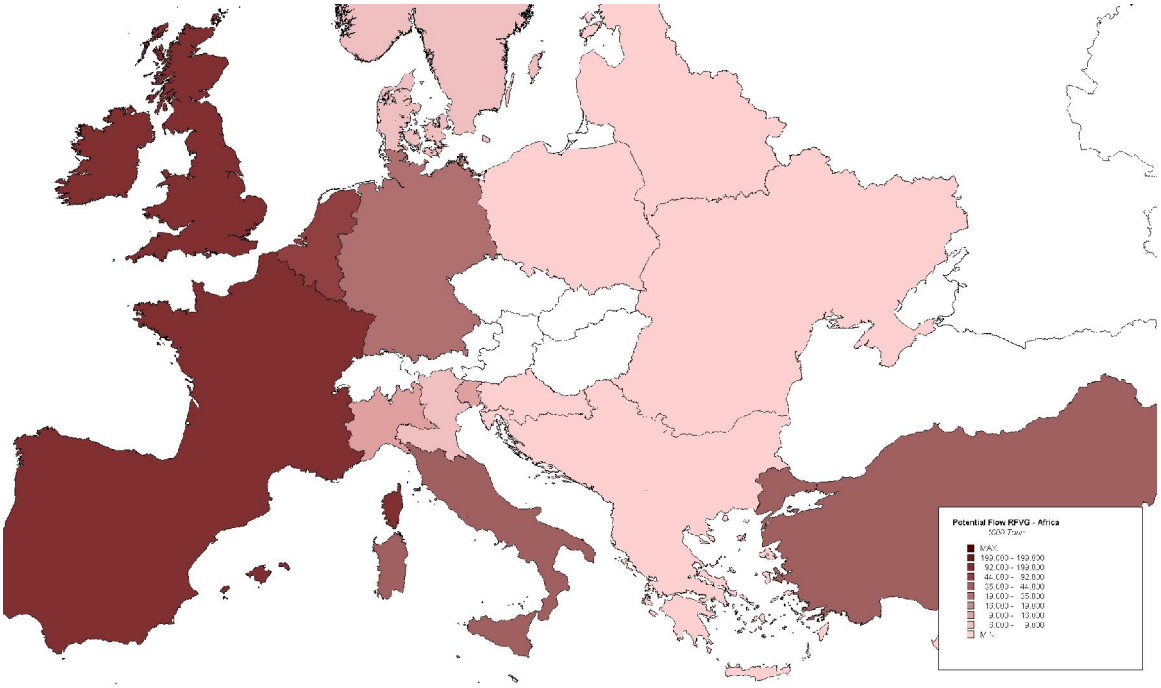

Figure 15 - Spatial distribution of trade exchanges between European areas and Africa in 2016 [1000 tons]
Source: our elaboration

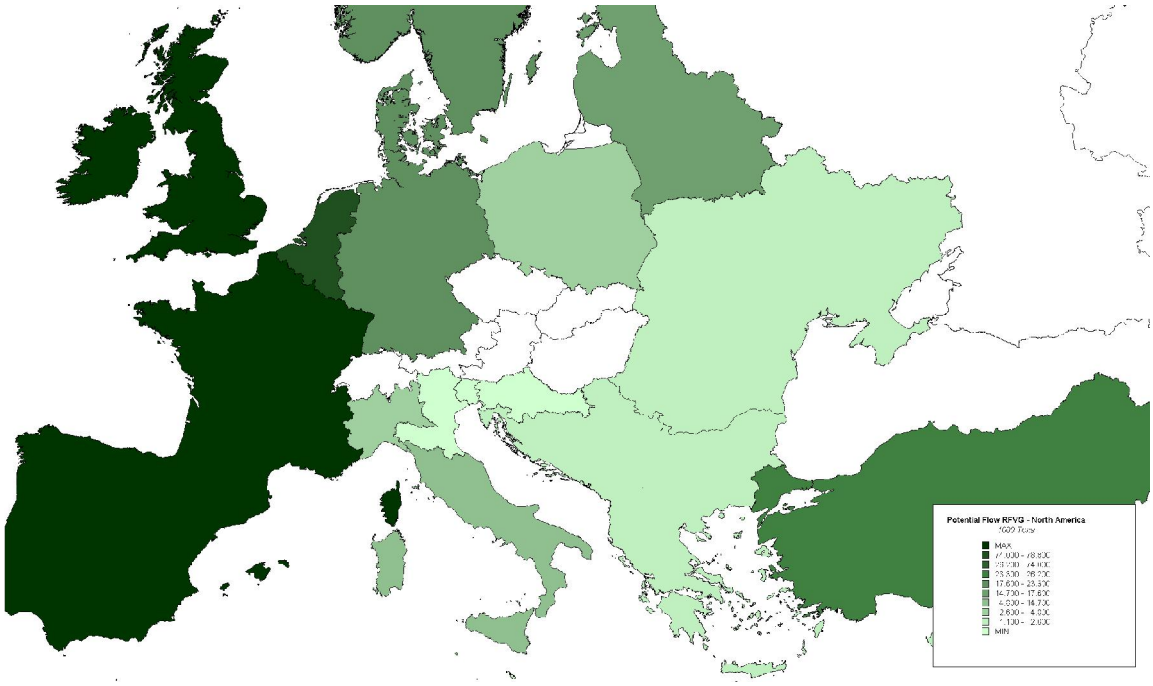

Figure 16 - Spatial distribution of trade exchanges between European areas and North America in 2016 [1000 tons]
Source: our elaboration

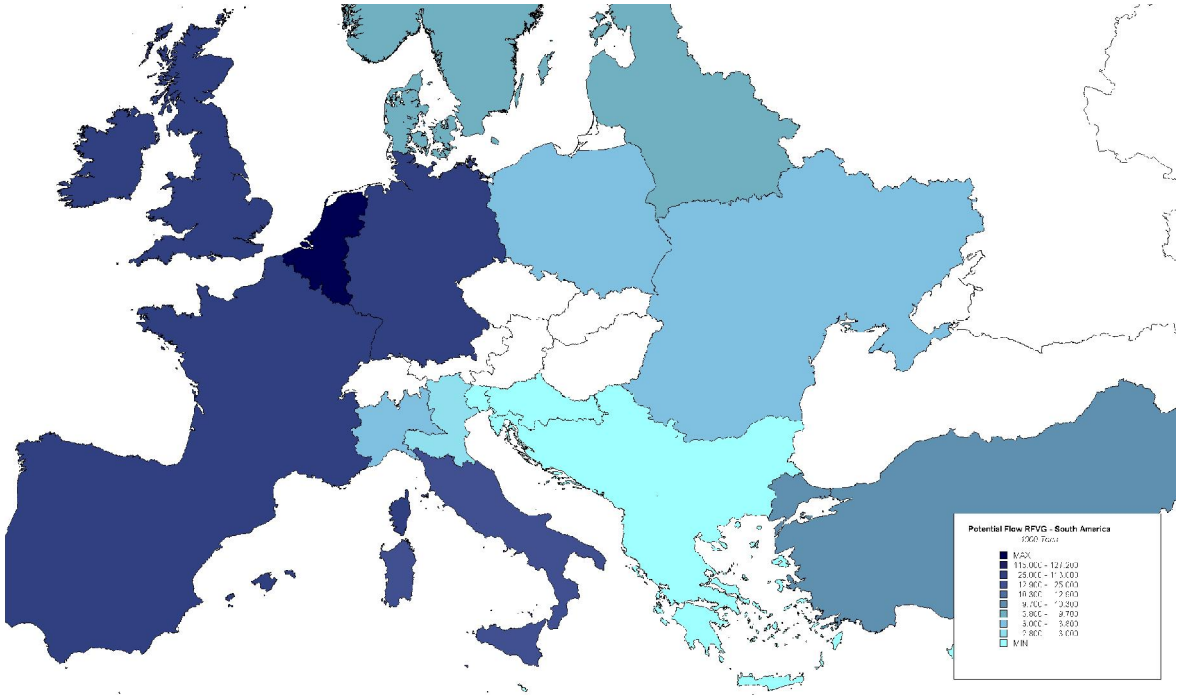

Figure 17 - Spatial distribution of trade exchanges between European areas and South America in 2016 [1000 tons]
Source: our elaboration

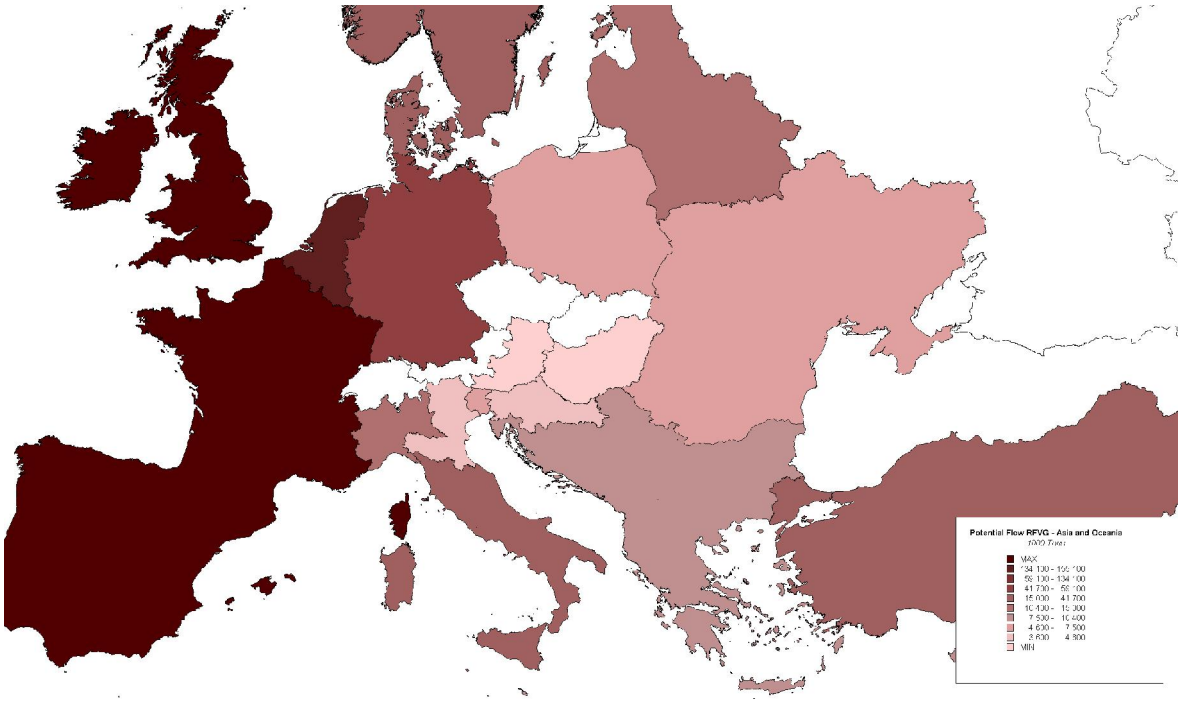

Figure 18 - Spatial distribution of trade exchanges between European areas and Asia in 2016 [1000 tons]
Source: our elaboration

Based on the reported outcomes, attention has been drawn to the European traffic flows generated and attracted by the two zones composing the northern European area at macroscopic level, namely the Benelux countries (Holland, Belgium and Luxembourg) and Germany; the graphical representation of those trade exchanges is illustrated in Figures 11 and 12. It turns out to be evident the great amount of traffic flows concerning the oceanic area and the North Sea, as opposed to the more marginal traffic volumes exchanged with the central European areas. Anyway, excluding trade relationships between the two selected northern European areas, these latter volumes equal to half million tons.

The two charts reported in Figures 13 and 14 indicate the entity of the described trade relationships. The total amount of exchanges between central European nations (i.e. Austria, Hungary, Czech Republic, and Slovakia) and the Benelux countries accounts approximately for 14 million tons, which corresponds almost to the overall volume concerning Italy. Trade exchanges to/from Germany are even more significant and of greater entity with respect to those concerning Italy, since they exceed 100 million tons per year. Freight transfers between the countries pertaining to the former Soviet Union (namely Romania, Ukraine and Moldavia) and both the Benelux countries and Germany are more marginal, even though their total amount is about 9 million tons.

With respect to the modal share, it can be observed that the road and rail modes prevail as they are used to carry out, respectively, the 60% and the 30% of all the examined trade relationships. Finally, it must be highlighted that central European countries take advantage of the main waterways (like the Danube and Elbe rivers) to implement logistics chains based on river-sea intermodality.

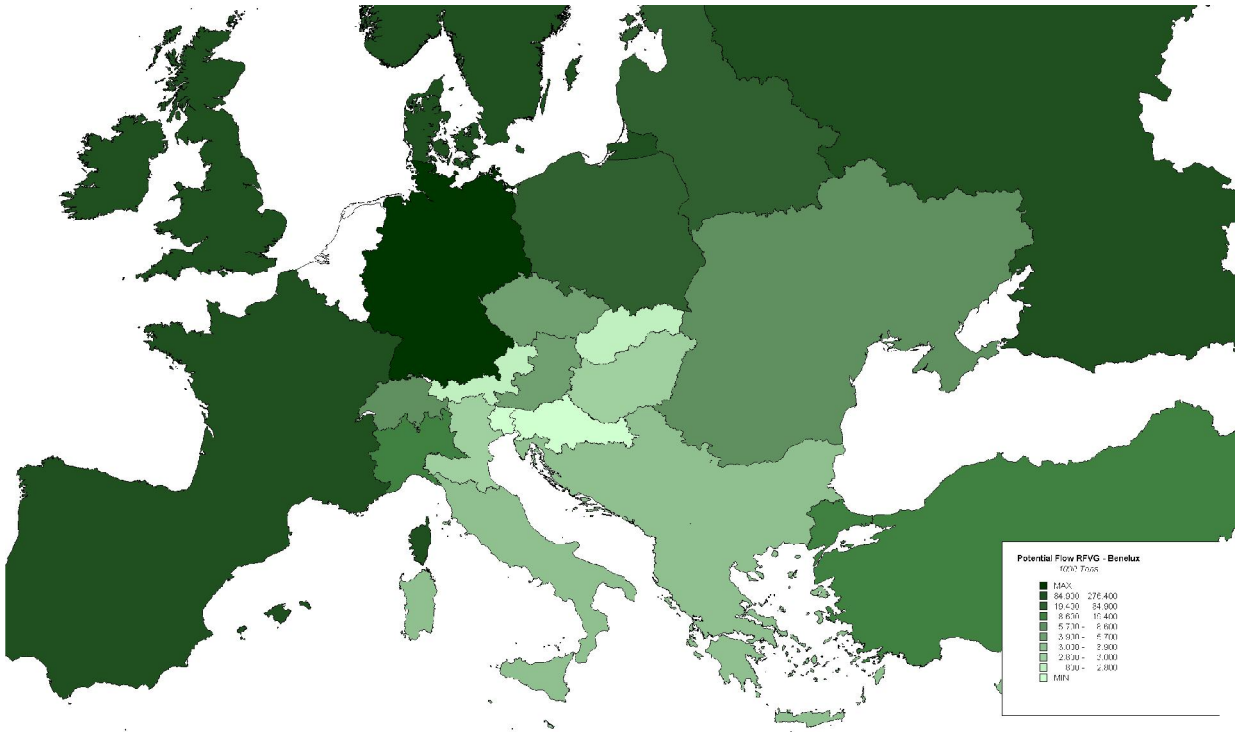

Figure 19 - Spatial distribution of trade exchanges between European areas and Benelux countries in 2016 [1000 tons]
Source: our elaboration

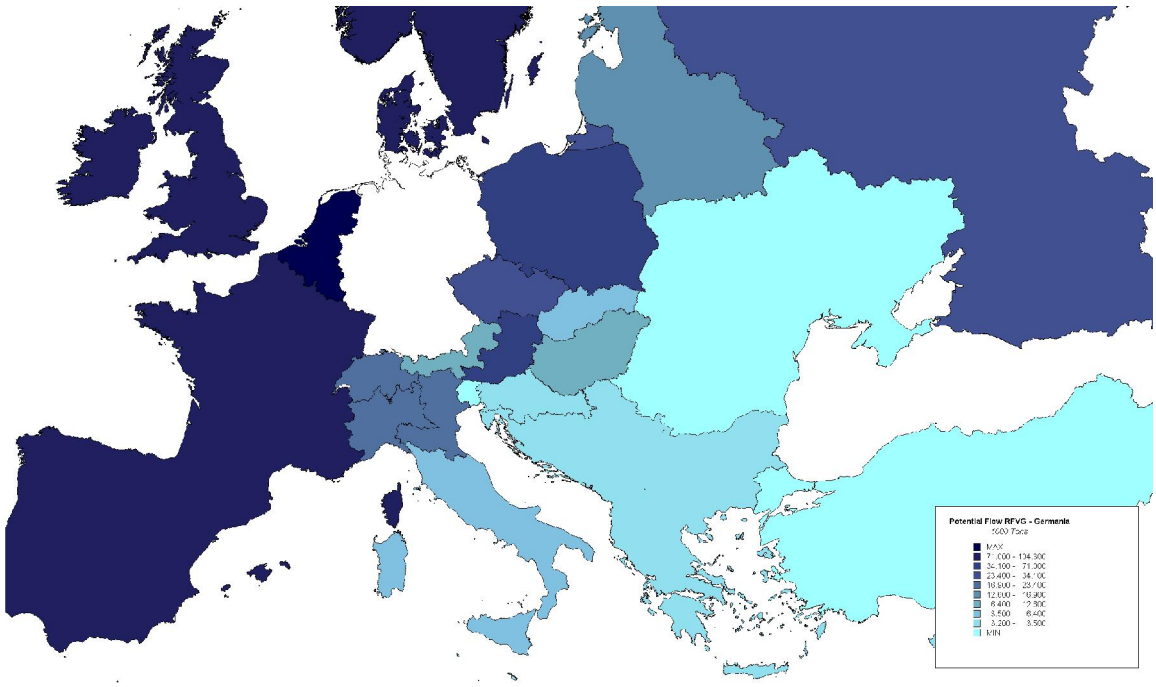

Figure 20 - Spatial distribution of trade exchanges between European areas and Germany in 2016 [1000 tons]
Source: our elaboration

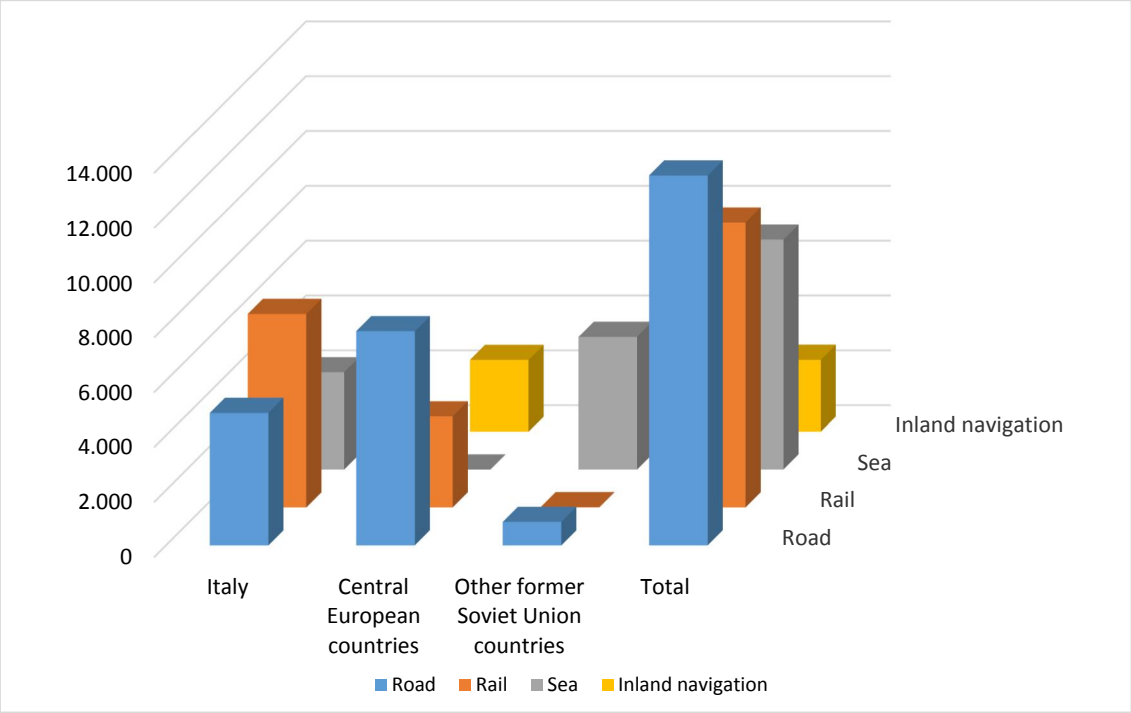

Figure 21 - Spatial distribution of trade exchanges between some Central-Eastern European areas and Benelux countries in 2016 [1000 tons]
Source: our elaboration

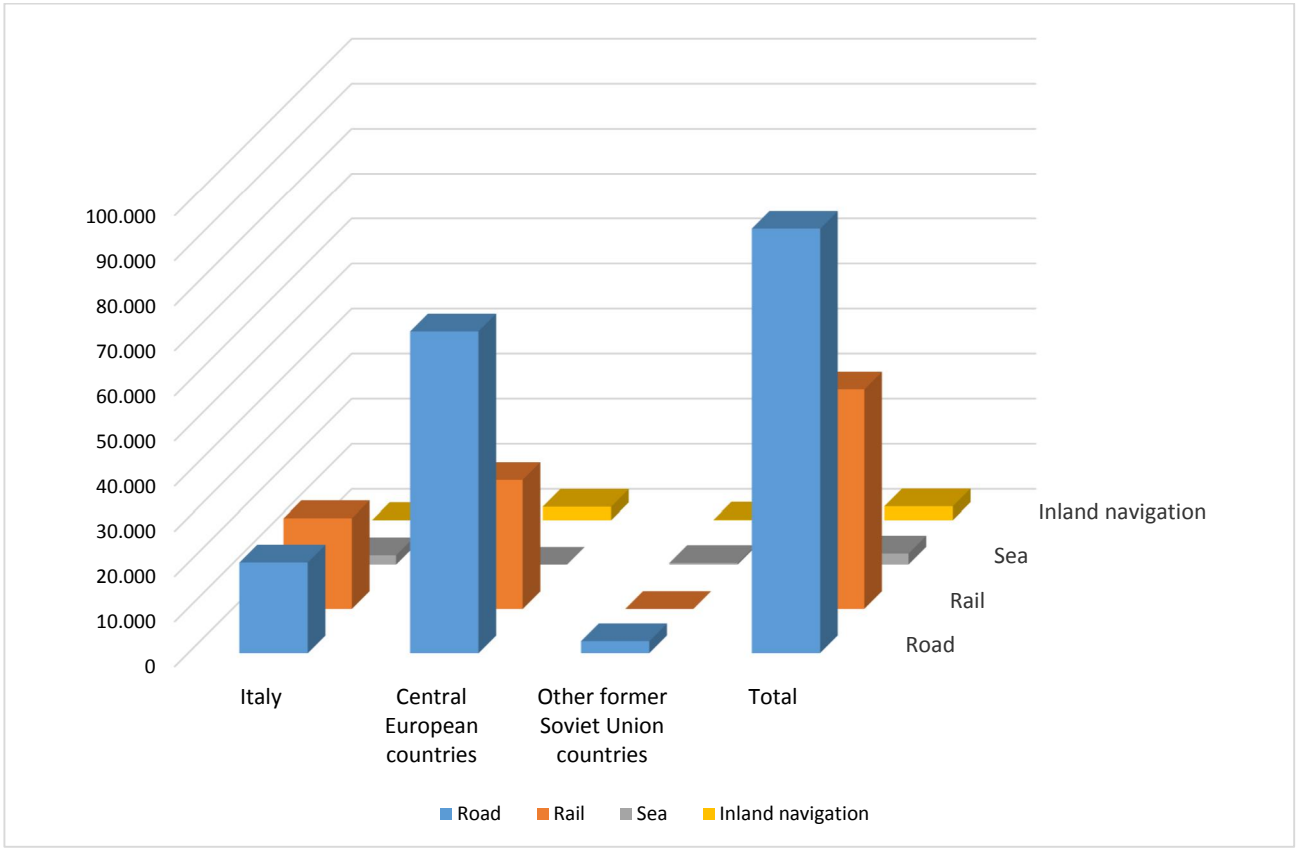

Figure 22 - Spatial distribution of trade exchanges between some Central-Eastern European areas and Germany countries in 2016 [1000 tons]
Source: our elaboration

2.4.2. Conclusion

In light of the characterization of traffic flows originated and/or attracted by the Friuli Venezia Giulia region reported in section 2.2, the present chapter illustrates the results of the analysis performed with the aim of evaluating the market potential for the Port of Trieste. Such analysis has been carried out examining the spatial structure of the traffic flows that could concern the territory of the Friuli Venezia Giulia region, involving the whole logistics system of the region and, more in particular, the Port of Trieste.
Such task has been accomplished according to two different levels of detail. The first phase has consisted in the identification of the "O/D macro-relationships" of potential interest for the Port of Trieste, which is more and more oriented in offering sea-rail intermodal services. Among the 20 identified O/D macro-relationships, the most significant ones in terms of the total amount of transferred freight regard Northern Europe (towards Asia, Africa and Southern-Eastern Europe) and Northern-Eastern Europe (towards Africa, America and Asia).

In the second phase, the analysis has been further detailed examining traffic flows at national level for the whole Central-Northern European area, so as to specify intra-European relationships from and to the Northern European macro-area. This latter area includes the “Northern Range” ports, which represent the main gateways for traffic flows attracted and generated in Europe and coming from or heading to extra-continental areas. Such approach has enabled to highlight that Central-Eastern European countries (Austria, Hungary, Czech Republic and Slovakia) exchange with Germany and Benelux countries (Holland and Belgium) more than 115 million tons of freight per year. Quite relevant trade exchanges occur also between Italy and these two Northern European areas (almost 50 million tons per year, of which 42 million tons with Germany). Bearing in mind the important role played by the “Northern Range” ports, it is reasonable to assume that a significant share of such traffic volumes passes through these ports to reach the other 4 continents. Besides, considering the remarkable share of the road mode to perform these trade relationships (equalling almost to 60%), the implementation of a sea-rail intermodal solution engaging the Port of Trieste, as an alternative to the Dutch, Belgian and German ports, represents a meaningful transport proposal at a European scale also in term of environmental sustainability.

3. Summary and recommendation

Within the context of the REIF project, the present chapter of the document summarizes the results of the study regarding the market potential of freight rail traffic for the Port of Trieste. The description of the methodological approach adopted to elaborate the different chapters of the study at hand is accompanied by a discussion of the obtained results, thanks to which some suggestions for the implementation of a future line of action have been formulated.

The document is structured as follows: first of all, a brief overview of rail network and services of the Friuli Venezia Giulia region and of the Port of Trieste is provided, since it is functional for the understanding of the analysis of current and potential traffic flows reported in the next sections of the report. Indeed, transport flows that currently or potentially concern, in general, the Friuli Venezia Giulia region, and more in particular the Port of Trieste, have been identified considering their characterization in terms of traffic routes, transport mode and sectoral composition, based on a informative source including data at a European scale. Besides, in support of the forecasts of potential traffic volumes regarding the Port of Trieste, future macro-economic scenarios, the trends in the shipping sector and their implications on ports have been examined in qualitative terms. Finally, considering the historical trend of rail traffic in the Port of Trieste and of its competitive context, different development scenarios have been elaborated formulating a series of assumptions for the increase in intermodal traffic and the inland modal split, in order to outline the rail traffic flows expected in 2030.

The Port of Trieste has an internal railway network at the service of the various terminals and connected with the national one by means of the Trieste Campo Marzio station, where at the moment all traffic flows generated by the other port stations converge. The various terminals of the commercial port handle containers, Ro-Ro, conventional freight, and solid and liquid bulk, which are destinated mostly to Central and Eastern Europe and, more marginally, also to Italy.

Analysing the railway context according to a wider perspective, the Port of Trieste has a good connection with the stations located in the proximity of the state borders which are present in the Friuli Venezia Giulia region, namely the Austrian and Slovenian ones. More in detail, the railway network that connects the Port of Trieste with state border stations can be divided into the following infrastructural components:

- Trieste node;
- Trieste-Bivio Aurisina line section;
- Aurisina-Villa Opicina-Slovenian state border line section;
- Udine-Tarvisio-Austrian state border line section;
- Bivio di Aurisina-Bivio San Polo line section;
- Bivio San Polo-Udine line section;
- Other links between the regions of Friuli Venezia Giulia and Veneto.

All the line sections considered in the infrastructural components listed above are double track, electrified and characterized by a profile P/C80, but they differ from the gradient of the route.

As far as the railway network usage is concerned, along the route between Trieste and Tarvisio (Austrian cross border), the most critical line section in term of residual capacity is the one between Bivio di Aurisina and Bivio San Polo, where railway flows coming from North-South and East-West traffic routes converge. This limitation could hinder an increase in traffic volumes expected for the Port of Trieste in the future, which can be achieved also thanks to the enhancement of the two TEN-T Corridors passing through the Friuli Venezia Giulia region, namely the Baltic-Adriatic and the Mediterranean ones.

The in-depth analysis carried out with the aim of identifying the traffic flows that currently or potentially concern the territory of the Friuli Venezia Giulia region and more specifically the Port of Trieste, in terms of traffic directions, transport mode and sectoral composition, has been performed using an informative base referred to 2016 which derives from the database of European Informative System on Transport (ETIS PLUS), that has been considered for the definition and evaluation of the TEN-T program.

Notably, the analysis has been initially developed in order to characterize trade exchanges that are originated or attracted by the Friuli Venezia Giulia region and that are performed on the European transport corridors passing through such region, entailing freight transfers which cover more than 300 kms. This task enabled to highlight relevant differences in the modal split, in relation to the sectoral composition and traffic directions.

It has been noticed that almost 70% of such flows regards the following two handling categories: oil products and miscellaneous articles. Within these two categories the modal split is very different: indeed, oil products are transferred almost exclusively by sea, while miscellaneous articles are transferred equally by road and sea, and in a marginal way by rail. As far as the other handling categories are concerned, it must be underlined that sea transport is the main transport mode used in the sectors related to fossil minerals, metal products and fertilizers. The rail mode prevails only when transferring metal waste, whereas the road mode is the most common transport mode used to transfer agricultural products, non-metallic minerals, foodstuff, and chemical products.

For the scope of the present study, it must be pointed out also that the rail mode is characterized by a high level of sectoral concentration. As a matter of fact, more than 88% of rail traffic flows are related to the following 3 sectors: metal waste (47%), miscellaneous articles (21%) and non-metallic minerals (20%). The total transferred volumes of oil products equal to over 100 000 tons per year, while the one regarding agricultural products corresponds to almost 50 000 tons. Among the cited handling categories, the rail mode proves to be very competitive for transferring metal waste, it covers a quite modest market share in sector related to non-metallic minerals, but it is used marginally for the transfer of products belonging to the other cited handling categories.

Focusing on traffic directions, the performed analysis has revealed that:

- Along the east-west axis, the sea mode prevails over the road and rail ones in international trade exchanges (as it is used in almost 91% of the total freight transfers). On the contrary, regarding trade exchanges with the other Italian regions the use of the road and sea modes is more balanced, while the one of the rail mode is still limited (only 2%);
- Along the north-south axis, trade exchanges heading towards Northern-Western Europe are performed mainly by road (more than 61% of the total freight transfers), but also by sea (27%) and rail (12%). On the contrary, trade exchanges heading towards Central-Eastern Europe, freight transfers are carried out principally by rail (48%) and road (43%), and less than 10% of them by sea.

The study performed with the aim of building, especially in qualitative terms, an informative framework concerning future scenarios of economic development, the current tendencies in the shipping sector and the implications of these latter on ports, has pointed out the following relevant aspects.

- Long-term macroeconomic scenarios and trends in the international trade exchanges:
  - *Towards the east: macroeconomic forecasts, to which the ones concerning trade exchanges and maritime transport flows are related, are inherently characterized by a high level of uncertainty, which tends to increase proportionally to the extent of the time horizon of such forecasts. However, a tendency for a shift of the gravity centers of global economy towards the east seems to be the main consideration on which future economic scenarios are based;*
  - *New routes: The shift towards the east and the advancements in the emerging and less developed economies are expected to define a new structure of trade relationships. In addition to intra-Asian exchanges, the new emerging commercial routes connect Asia to Africa and to Latin America along the north-south direction. "Traditional" routes between Asia and America, and between Asia and Europe will continue to dominate, increasing according to quite relevant growth rates (the second one will increase more than the first one). On the contrary, traffic along the trans-Atlantic route will likely to be drastically reduced, even if such route will continue to represent one of the most significant trade relationships.*
  - *Containers: it is widely acknowledged that the global maritime traffic will continue to grow according to significant growth rates, even if in a more limited way with respect to the past years. Its most important sector, in terms of the values of trade exchanges, is represented by the container sector, for which significant growth rates will be recorded also in the future (it increased from 750 million TEUs in 2017 up to more than one billion TEUs in 2023, with an annual growth rate exceeding 7%);*
  - *Mediterranean Sea: this sea will continue to play a central role in the context of global trade exchanges, both for the continuous increase in traffic flows along trans-oceanic routes and for the intensification of trade exchanges between Europe and Africa. By inducing a shortening of logistics chains, the occurrence of macro scenarios characterized by a global fragmented economy (due to geopolitical tensions) could further reinforce the role of the Mediterranean Sea, especially in the Short Sea Shipping;*

- Key factors influencing maritime transport within the international context:
  - *Technological development: on one hand, it is intended to enhance efficiency, security and reliability (with a consequent reduction of costs) of port operations, but on the other hand, due to the revolution of productive system using robotics and 3D print, it could entail a shortening of logistics chains and a change in the product structure of commercial exchanges;*
  - *Containerization: it transformed global trade in the 1950s and it is likely to be developed even more in the future, since many companies are transforming their productive systems so as to be suitable for this transport solution;*

- *Mega ships and sectoral concentration: naval gigantism (which seems to be close to its maximum extent) and sectoral concentration will continue to put significant pressure on ports, affecting the spatial structure of maritime routes, attributing more and more importance to inland connections and reducing the bargaining power of ports;*

- International competition among port systems:
  - *High competitiveness: the marginalization of port systems due to the affirmation of the concept of the global value of logistics chains has led, among other consequences, to an increase in the competitiveness between port systems and ports. In the last decade the European marketplace was served almost exclusively by the "Northern Range" ports, while nowadays, even due to congestion problems in such ports and to the shift of the economic gravity center towards the east, the competitive context has enlarged including also the Baltic ports in the north, the Mediterranean ports in the south and the Black ports in the south-east;*
  - *Northern Adriatic Sea: in the last 10 years the ports of the Northern part of the Mediterranean Sea, in particular Koper and Trieste, have recorded on average better performances with respect to the ones of the Mediterranean and Black ports, shortening the gap with the most relevant transhipment hubs (like the ports of Piraeus and Tangier);*
  - *Inland connections: the consideration that inland transport cost currently represents a share ranging between 40% and 80% of the total transport cost in logistics chains has drawn more and more the attention to the quality of inland connections. In many contributions of the scientific literature it is acknowledged that such component of the total transport cost is the most critical factor in the selection of port hubs by the "big players" involved in the shipping sector, followed by other parameters like the geographical localization, the efficiency of port operations and the loading/unloading capacity of ports.*

In light of the most meaningful aspects concerning the evolution of macroeconomic tendencies and of the main factors influencing the reference sector, some elaborations aimed at identifying and evaluating development scenarios for intermodal traffic in the Port of Trieste in 2030 have been performed. Indeed, starting from the analysis of historical trends of the Port of Trieste and of its competitive context, two groups of development scenarios have been defined and assessed: an "Aggregated" scenario which jointly considers container and Ro-Ro traffic and a "Disaggregated" scenario that separately takes into account those two sectors. Such scenarios have been created assuming a series of hypothesis for the intermodal traffic growth and for inland modal split in order to outline the expected freight volumes to be transferred by rail. Finally, a counterfactual evaluation has been performed to verify the reasonability of the principal assumptions which the development scenarios have been created on.

The analysis addressing the forecast of the potential rail capacity of the Port of Trieste in 2030 has highlighted the main following aspects.

- Performances of the Port of Trieste in the second millennium:
  - *Relevant growth: in the last 15 years, and even more in the last 10 years, the Port of Trieste has greatly performed in the general cargo sector, and especially in the container*

sector (with an increase of almost five times in the handled freight tons between 2014 and 2019, at an annual average growth rate of more than 11%), exceeding the most optimistic forecasted elaborated at the beginning of the 2010s (for example, in the Port Development Plan and in the "ITS Adriatic Multiport Gateway" project);

- *Intermodality: in the last 5 years the Port of Trieste has enhanced its intermodal connotation, that has enabled it to be the first Italian port and one of the most virtuous ports in Europe with respect to the rail mode use for inland connections, increasing the total number of trains up to almost 10 000 trains per year and more than doubling the share of rail services to transfer containers;*
- *"Mitteleuropa": in addition to the strengthening of trade relationships with the industrial economic driving force of Europe (i.e. Germany) and the stability of trade exchanges with Northern Italy on one side and with Austria on the other side, as opposed to previous years the direct rail intermodal connections with Hungary, Czech Republic and Slovakia (but also with Romania) currently show that the scope of inland connections of the Port of Trieste has been shifted towards Central-Eastern European marketplaces;*

- Development scenarios for intermodal traffic in the Port of Trieste:
  - *Definition of the development scenarios: with reference to 2030, two groups of development scenarios, i.e. the "Aggregated" and the "Disaggregated" scenarios, have been elaborated by combining different hypothesis concerning the increase in intermodal traffic (based on historical trends recorded by the Port of Trieste and validated in relation to macroeconomic forecasts and the dynamics registered in analogous contexts) and the modal split of such traffic sector (based on 2019 data and on reasonable progressive increases of modal shares);*
  - *Results in terms of loading units: the 18 created development scenarios encompass a variation range of the handled freight volumes between 600 000 and 1,5 million TEUs per year but, overlooking the extreme values, the variation of that interval reduces between 700 000 e 1,3 million TEUs per year. In 11 of the 18 created development scenarios the total amount of intermodal freight volume in the Port of Trieste would exceed 500 000 TEUs, with an increase of more than twice the 2019 value which equalled 423 000 TEUs;*
  - *Results in terms of number of trains per year: assuming to adopt the dimensional parameters referred to 2019 as base values (i.e. 54 TEUs per train), by way of example the number of trains per year has been estimated considering the medium traffic growth rate and the variation of the rail intermodal share from the 2019 constant value in the "Aggregated" scenario to an increase in such value of 10% in the "Disaggregated" scenario. The outcomes of the estimation revealed that the number of trains per year would be, respectively, 15 000 and almost 25 000, against the value of 10 000 trains registered in 2019. Further improvements in the considered rail transport services, entailing 70 TEUs per train, would decrease the aforementioned values to, respectively, 11600 and 19190 trains per year;*

- Potential traffic demand:

  The outcomes deriving from the elaboration of development scenarios have been evaluated through a counterfactual assessment, estimating the freight traffic demand concerning the Central-Eastern European area and the one that could concern the Port

of Trieste for its connections with the extra continental global marketplaces. Such potential traffic demand, which currently concern Northern European ports (Holland, Belgium, Germany, and Poland), corresponds to 26 million tons (with reference to 2016) and regards the sectors related to miscellaneous articles, agricultural products and foodstuff, chemical and metal products, and non-metallic minerals. According to general macroeconomic forecasts, in 2030 those potential freight volumes could vary between 51 and 66 million tons. The acquisition of a 10% share by the Port of Trieste would double the amount of tons handled by train (which equalled to 4,5 million tons in 2019), in line with the forecasts in terms of loading units proposed in the elaboration of the development scenarios.

In conclusion, in light of the characterization of traffic flows originated and/or attracted by the Friuli Venezia Giulia region, an analysis aimed at evaluating the market potential for the Port of Trieste has been carried out examining the spatial structure of the traffic flows that could concern the territory of the Friuli Venezia Giulia region, involving the whole logistics system of the region and, more in particular, the Port of Trieste. Such task has been accomplished according to two different levels of detail. The first phase has consisted in the identification of the "O/D macro-relationships" of potential interest for the Port of Trieste, which is more and more oriented in offering sea-rail intermodal services. Among the 20 identified O/D macro-relationships, the most significant ones in terms of the total amount of transferred freight regard Northern Europe (towards Asia, Africa and Southern-Eastern Europe) and Northern-Eastern Europe (towards Africa, America and Asia).

In the second phase, the analysis has been further detailed examining traffic flows at national level for the whole Central-Northern European area, so as to specify intra-European relationships from and to the Northern European macro-area. This latter area includes the "Northern Range" ports, which represent the main gateways for traffic flows attracted and generated in Europe and coming from or heading to extra-continental areas. Such approach has enabled to highlight that Central-Eastern European countries (Austria, Hungary, Czech Republic and Slovakia) exchange with Germany and Benelux countries (Holland and Belgium) more than 115 million tons of freight per year. Quite relevant trade exchanges occur also between Italy and these two Northern European areas (almost 50 million tons per year, of which 42 million tons with Germany). Bearing in mind the important role played by the "Northern Range" ports, it is reasonable to assume that a significant share of such traffic volumes passes through these ports to reach the other 4 continents. Besides, considering the remarkable share of the road mode to perform these trade relationships (equalling almost to 60%), the implementation of a sea-rail intermodal solution engaging the Port of Trieste, as an alternative to the Dutch, Belgian and German ports, represents a meaningful transport proposal at a European scale also in term of environmental sustainability.

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Annex A

Table 22 - Port of Trieste: "Aggregated" scenario for rail traffic development (containers and vehicles) [mln tons] – 2030
Source: our elaborations

Base values		AAGR 2019-2030		2030 rail share		
Variables	Values			Base	Medium	High
				28,8%	33,8%	38,8%
Intermodal traffic (containers and Ro-Ro) - 2019 (mln tons)	15,7	Minimum	4,5%	7,4	8,6	9,9
Average annual growth rate of intermodal traffic (containers and Ro-Ro) - 2009-2019 period (%)	7,5%	Medium	7,5%	10,0	11,7	13,5
Rail traffic volumes - 2019 (mln tons)	4,6	Maximum	8,2%	10,8	12,7	14,6
Rail-road modal shift - 2019 Rail share (%)	28,8%					
TEU average weight - 2019 (tons)	12,4					
Base year	2019					
Time horizon	2030					

Table 23 - Port of Trieste: "Aggregated" scenario for rail traffic development (containers and vehicles) [1000 TEUs] – 2030
Source: our elaborations

Base values		AAGR 2019-2030		2030 rail share		
Variables	Values			Base	Medium	High
				28,8%	33,8%	38,8%
Intermodal traffic (containers and Ro-Ro) - 2019 (mln tons)	15,7	Min	4,5%	595	699	802
Average annual growth rate of intermodal traffic (containers and Ro-Ro) - 2009-2019 period (%)	7,5%	Medio	7,5%	809	949	1.090
Rail traffic volumes - 2019 (mln tons)	4,6	Max	8,2%	874	1.025	1.177
Rail-road modal shift - 2019 Rail share (%)	28,8%					
TEU average weight - 2019 (tons)	12,4					
Base year	2019					
Time horizon	2030					

Table 24 - Port of Trieste: "Disaggregated" scenario for rail traffic development (containers) [1000 TEUs] – 2030
Source: our elaborations

Base values		AAGR 2019-2030		2030 rail share		
Variables	Values			Base	Medium	High
				34,5%	39,5%	44,5%
Container intermodal traffic - 2019 (1000 TEUs)	789,6	Minimum	9,8%	760	871	981

Average annual growth rate of container intermodal traffic - 2009-2019 period (%)	11,0%	Medium	11,0%	862	987	1.112
Containers transferred by rail - 2019 (1,000 TEUs)	272,3	Maximum	12,3%	976	1.117	1.259
Rail-road modal shift - 2019 Rail share (%)	34,5%					
Base year	2019,0					
Time horizon	2030					

Table 25 - Port of Trieste: "Disaggregated" scenario for rail traffic development (Ro-Ro) [1000 vehicles] – 2030
Source: our elaborations

Base values		**AAGR 2019-2030**		**2030 rail share**		
Variables	**Values**			**Base**	**Medium**	**High**
				28,8%	31,3%	33,8%
Ro-Ro intermodal traffic - 2019 (1000 Vehicles)	233,4	Minimum	2,1%	84,4	91,7	99,0
Average annual growth rate of Ro-Ro intermodal traffic (Vehicles) - 2009-2019 period (%)	2,5%	Medium	2,5%	88,5	96,2	103,9
Vehicles transferred by rail - 2019 (1000 Vehicles)	67,2	Maximum	3,0%	92,9	101,0	109,0
Rail-road modal shift - 2019 Rail share (%)	28,8%					
Conversion factor from vehicles to TEUs	2,2					
Base year	2019					
Time horizon	2030					