Demand Analysis

The demand analysis for the Port of Livorno has focused on the proportion of traffic that is more directly interested by the rail segment that the project can improve in terms of infrastructure and efficiency, especially as far as costs and operating times are concerned.

These trades were identified according to the following product categories:

• Containers

• Ro-Ro

• Cars

It has been a long time since these three identified categories have represented significant traffic movements at the Port of Livorno. Nevertheless, the rail "attitude" is different and the rail segment absorbs only a relatively small modal share of the entire traffic (12% at present), although but potentially very interesting for container, absent, also for its own nature, as regards the Ro-Ro, interesting but with a variable pattern for cars.

Based on these distinctions, the analysis was carried out according to different approaches: modeling at the European level for the container, the results of which used directly in the Cost – Benefit Analysis, always with modeling support for the Ro-Ro traffic and through simplified estimates traffic for the cars, the results of both these analyzes used to strengthen the framework forecasting future demand, without direct impact in the estimates of the Cost - Benefit analysis: this on the safe side, to ensure more direct link possible between railway investments proposed and expected traffic.

Demand estimation

The estimation of demand (container freights) in the Livorno Port included two main aspects:

- First, the estimation of total demand expected in the Livorno Port in the future years (2020 and 2030) under the alternative scenarios.
- Second, the estimation of the share of the total demand that would use rail to reach their final destinations (incoming maritime traffic) or to reach the port from the origin zone of the shipment (outgoing maritime traffic).

These two aspects were addressed with reference to several scenarios:

- one "do-nothing" scenario;
- infrastructure scenarios where the construction of the new rail facilities is assumed (see below for details);
- both the "do nothing" and the infrastructure scenarios have been analysed under two alternative assumptions about the maritime container demand growth in the future years.

The estimation was based on a modelling exercise. Namely, the TRUST model (see box below) was the supporting tool for the analysis. The methodology followed to apply the TRUST model for forecasting purpose included five main steps:

- Check and update of model results at the base year.
- Definition of the overall European maritime transport demand trend.

- Simulation of the "do nothing" scenarios.
- Definition of the infrastructure scenarios.
- Simulation of the infrastructure scenarios.

These methodological steps are described in the following.

The TRUST model

TRUST (TRansport eUropean Simulation Tool), is a transport network model developed by TRT in the MEPLAN software environment. The model allows for the assignment of Origin-Destination matrices at the NUTS3 level of detail for passenger and freight demand. The whole Europe is covered, including Accession and Neighbouring countries. The TRUST model includes modules for road and non-road-transport: rail, inland waterways, air and maritime. Each module has its own network and its matrix (for air only a passenger matrix is modelled, for inland waterways and maritime only freight matrices are modelled). The model is calibrated to reproduce tonnes-km and passengers-km by country consistent to the statistics reported in the Eurostat Transport in Figures pocketbook.

The matrices of tonnes and passengers are estimated from various sources, including Eurostat, national statistics and ETISplus database. Matrices are segmented in categories based on freight type and handling categories (e.g. containers).

The networks includes all the relevant links between the NUTS3 regions, e.g. for the road network motorways, primary roads, but also roads of regional and sub-regional interest. Network links are distinguished in different classes, each with specific features (e.g. in term of capacity and free-flow speed). The maritime network connects European ports relevant for national and international freight transport, overseas routes are also considered.

For each transport mode a specific network is modelled in TRUST including physical links and nodes (e.g. roads, ports) as well as "notional" links representing e.g. transhipment, loading and unloading etc. (see example in figure 1). Networks for different modes are connected to simulate intermodality (e.g. combined transport, seaborne inland traffic).

The assignment algorithm is a SUE (Stochastic User Equilibrium). For each Origin/Destination pair, the model distributes demand among available alternative routes using a logit algorithm. The utility of each path is measured in terms of generalised cost i.e. the sum of monetary costs and monetary equivalent of travel time. Travel time depends on link features and, for road, on the level of congestions. Travel cost depends on cost parameters representing the variable operating costs or tariffs relevant for path choice. Costs are different across demand segments as well as values of travel time used to compute the generalised cost.

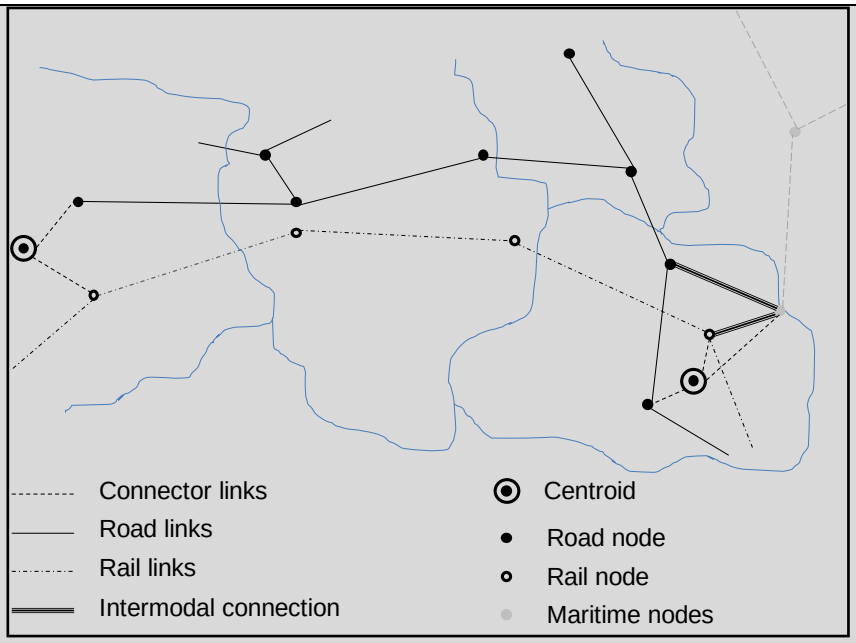


Figure 1: Example of intermodal network in TRUST

The main output of the model is the load on network links in terms of vehicles or passengers or tonnes per day (see example in the figure 2 below). Using load as an input parameter, the model also provides emissions by link for NOx, PM and CO.

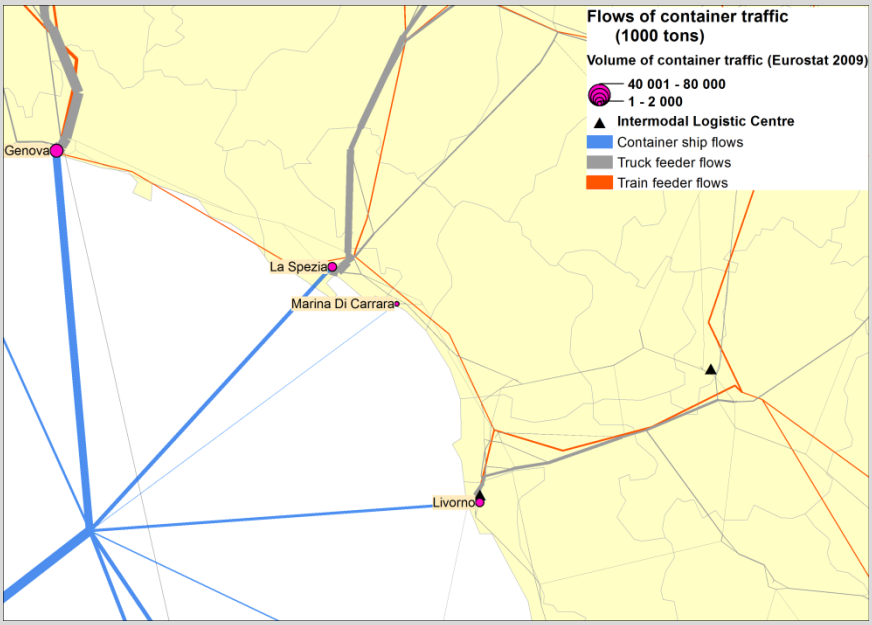


Figure 2: Example of graphical results obtained from the TRUST model

The TRUST model was successfully applied for the assessment of the Eurovignette directive on behalf of the European Commission and for the analysis of the maritime flows in the North Adriatic sea.

Check and update of model results at the base year

In order to represent a reliable tool for demand forecasting, the model should be able to provide a correct representation of the observed conditions at the base year. The first step of the procedure was to compare the results of the model with the most recent available statistics concerning the container traffic in the Port of Livorno and in other competing ports of the area. The parameters of the model were adjusted in order to have a good representation of the observed traffic at ports. In the table below the comparison with respect to the observed data (expressed in terms of tones) has been provided for the containers ports of the Upper Tyrrhenian Sea. The model results can be considered as a reliable and the small overestimation (in range of 5% - 10%) suggests a good level of calibration.

Table 1: Comparison of modelled and observed data for the containers ports of the Upper Tyrrhenian Sea

Port	Observed data (2013, 1000 tons)	Modelled data (Reference year, 1000 tons)	Percentage variation with respect to the observed data
Livorno	6 584	7 144	9%
Genova	19 387	21 341	10%
La Spezia	12 857	13 478	5%
Total	**38 828**	**41 963**	**8%**

Source: TRT elaboration on Assoporti statistics[1] and on the TRUST model results

The demand matrices in the TRUST model are expressed in terms of tones. To be able to argue in terms of TEUs it was necessary to convert the traffic volumes from tones to TEUs. The mentioned above conversion was done by applying a conversion factor of 11.77 tons for one TEU. The conversion factor was estimated by using the statistics provided by the Livorno Port Authority. The Livorno Port Authority reported that in 2013 handled 559 180 TEUs and 6 584 053 tons[2]. In consequence the total container traffic (expressed in terms of TEUs) in the Port of Livorno can be provided. The table below shows the comparison with respect to the observed data for both the overall container traffic and for the modal split of traffic at port between road and rail.

Table 2: Comparison of modelled and observed data for the REFERENCE YEAR (2013)

	Observed data (TEUs)	Modelled data (TEUs)
Road	492 078	524 842
Rail	67 102	82 112
Rail modal share	*12.0%*	*13.5%*
Total traffic in the Livorno Port	**559 180**	**606 955**

Source: TRT elaboration on the Livorno Port Authority statistics and on the TRUST model results

The relative small overestimation in the Livorno container traffic (30.000 TEU road and 15.000 TEU rail) confirms the good level of calibration.

[1] http://www.assoporti.it/sites/www.assoporti.it/files/statistiche/Movimenti_portuali_2013_22ott14.pdf

[2] Therefore the ratio is 11.77 tons for one TEU.

Definition of the overall European maritime transport demand trend

The model provides an estimation of the traffic at ports by assigning a matrix of maritime container traffic in Europe. The first step for demand forecasting was therefore to define the expected growth of this matrix.

Two different assumptions of maritime demand growth were developed for the simulation of the "do nothing" scenarios and were defined as follow (see also table 3 for a summary):

The *first assumption* was of a *Base growth scenario* where the maritime demand matrix of the base year (2013) was projected to the future years (2020, 2030) by applying the growth rate of the so-called organic growth (3% per annum).

The *second assumption* was of a *Higher growth scenario* where the maritime demand matrix at the base year (2013) was projected to the future years (2020, 2030) by applying an average yearly growth rate of 4.8% to estimate the value at the year 2020 and a rate of 4.7% to estimate the value at the year 2030. Higher growth is considered achievable by exploiting the catchment area of the ports toward to the south Europe.

Table 3: Assumptions of maritime transport activity growth (yearly growth rates)

	2013-2020	2020-2030
Base growth scenario	3%	3%
Higher growth scenario	4.8%	4.7%

Source: TRT elaboration on the international forecasts

These assumptions are based on the international projections and assume that the European container shipping market will continue to expand although at lower rates than in the past. Moreover it is worth noticing that these assumptions are relatively precautionary as the most optimistic scenarios see growth rates of container segment above 6% (however foreseeing a higher values for the ports of northern Europe than for those of the Mediterranean Sea). Faster growth is usually assumed for overseas traffic, especially on the Asia-Europe route (about 9% per year until 2030).

Simulation of the "do nothing" scenarios

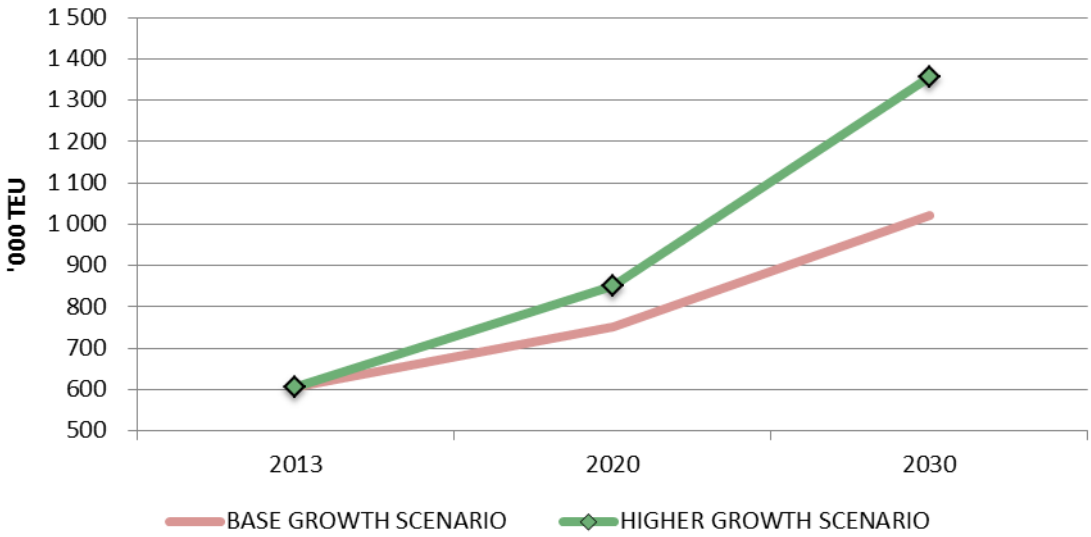
The two future matrices of maritime demand at the European level projected according the assumptions explained above were fed into the TRUST model to estimate the impact on the container traffic in the port of Livorno in the years 2020 and 2030.

The first output of the model is total traffic at port:

In the *Base growth scenario*, the model forecast is that freight demand in the Livorno port would increase by 24% at 2020 and by 68% at 2030 with respect to the base year. This corresponds to 750 000 TEUs in the year 2020 and more than 1 million TEUs in the year 2030 (figure 3).

Under the *Higher growth scenario* demand growth is faster: the increase is 40% at 2020 and as much as 124% at 2030 with respect to the base year. This projection is equivalent to 850 000 TEUs in the year 2020 and nearly 1 350 000 TEUs in the year 2030 (figure 3).

Figure 3: Maritime container transport activity in the Port of Livorno under the two assumptions of "do nothing" scenario



Source: TRT elaboration on the TRUST model results

The second output of the modelling simulation is the modal split of traffic at port between road and rail. Since in the "do nothing" scenarios the simulations do not assume modifications in the relative convenience of the two modes, the mode share of rail is unchanged with respect to the base year: 13.5% of total TEUs at Port of Livorno would use rail. Given the higher overall traffic, this result means that rail terminals would handle 138 000 TEUs in 2030 (base growth scenario) or 185 000 TEUs (higher growth scenario).

Table 4 below summarises the modelling results for the "do nothing" scenario. In the table the volumes of transferred containers at port on trains or on trucks are also provided.

Table 4: Container traffic in the Port of Livorno under the "do nothing" scenarios (TEUs)

	REFERENCE YEAR		**BASE GROWTH SCENARIO**		**HIGHER GROWTH SCENARIO**	
	Observed data	Modelled data				
	2013		**2020**	**2030**	**2020**	**2030**
Road	492 078	524 842	649 954	883 974	736 270	1 172 076
Rail	67 102	82 112	101 400	138 311	115 172	184 957
Rail modal share	*12.0%*	*13.5%*	*13.5%*	*13.5%*	*13.5%*	*13.6%*
Total traffic	**559 180**	**606 955**	**751 354**	**1 022 285**	**851 443**	**1 357 034**
Percentage variation of total traffic with respect to the Reference year			*24%*	*68%*	*40%*	*124%*

Source: TRT elaboration on the TRUST model results

Definition of the infrastructure scenarios

The steps above provided the estimations of container demand in the Livorno Port in the "do nothing" scenarios. In order to estimate the demand in the infrastructure scenarios the next step was to define the input to translate the construction of the rail facilities into modelling input.

The TRUST model simulates the transfer of containers at port on trains or on trucks. Times and costs are associated to this operation. The expected impact of the new rail connections is to reduce the time for the operations of transhipment on rail. As a consequence also transhipment costs could be reduced. The exact impact of the new facilities on these times and costs is hard to assess. Therefore it was decided to define different scenarios corresponding to a decrease of transhipment time or costs. These variables include all terminal activities related to the train operations: waiting time, transfer, loading/unloading.

The reductions of the transhipment time were defined according to the time savings calculated on the expected demand under the infrastructural improvements.

Accordingly, in order to assess the impacts of the new rail facilities different hypothesis of reduction of transhipment times/costs (in particular by 10%/20%) were considered in the next step of the estimation procedure.

Simulation of the infrastructure scenarios

As final step of the estimation procedure, the infrastructure scenarios were simulated using the TRUST model for the years 2020 and 2030 under the two alternative assumptions of demand growth (see above). As results of the simulations the model provided the appraisals of total container traffic for the Livorno port as well as the mode split between rail and road.

In the table below the final summary of the modelling results (when the project scenario is introduced under the base growth assumption) is provided . The project scenario takes into account both the reduction of the transhipment times, mainly, and of the transhipment costs.

Table 5: Container traffic in the Port of Livorno under the base growth assumption and for the project scenario in the future years (TEUs)

	REFERENCE YEAR		**BASE GROWTH "do nothing" SCENARIO**		**BASE GROWTH INFRASTRUCTURE SCENARIO**	
	Observed data	Modelled data				
	2013		**2020**	**2030**	**2020**	**2030**
Road	492 078	524 842	649 954	883 974	649 951	883 788
Rail	67 102	82 112	101 400	138 311	162 380	287 520
Rail modal share	*12.0%*	*13.5%*	*13.5%*	*13.5%*	*20.0%*	*24.5%*
Total traffic	**559 180**	**606 955**	**751 354**	**1 022 285**	**812 330**	**1 171 307**
Percentage variation of total traffic with respect to the "do nothing" scenario					*8%*	*15%*

Source: TRT elaboration on the TRUST model results

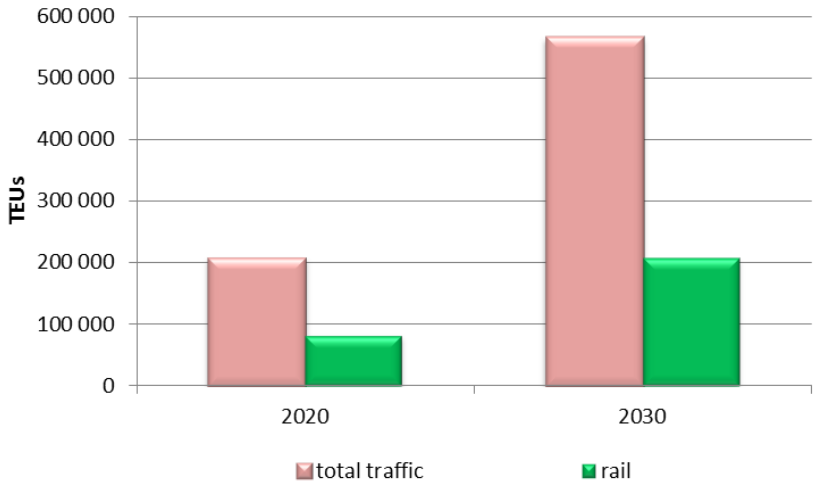
Actually according to the model results, traffic is more sensible to time variations rather than to cost variations.

When the new rail facilities are associated to the transhipment time reduction of about 10% and to the transhipment costs reduction of two percentage points at 2020, the total container traffic in the Port of Livorno is expected to increase by 8% with respect to the "do nothing" scenario in the year 2020. At the same time, the share of rail would be lifted from 13.5% to 20%. The rail terminal would handle nearly 162.000 TEUs in the year 2020.

With the full implementation of the project the transhipment time reduction generated by the new infrastructures is assumed to reach about 20% and the transhipment costs reduction is assumed to reach about 3% at 2030 with respect to current values, the total container traffic in the Port of Livorno is forecasted to increase by 15% with respect to the "do nothing" scenario in the year 2030. At the same time, the share of rail would be lifted to 24.5%, corresponding to nearly 288 000 TEUs in the year 2030.

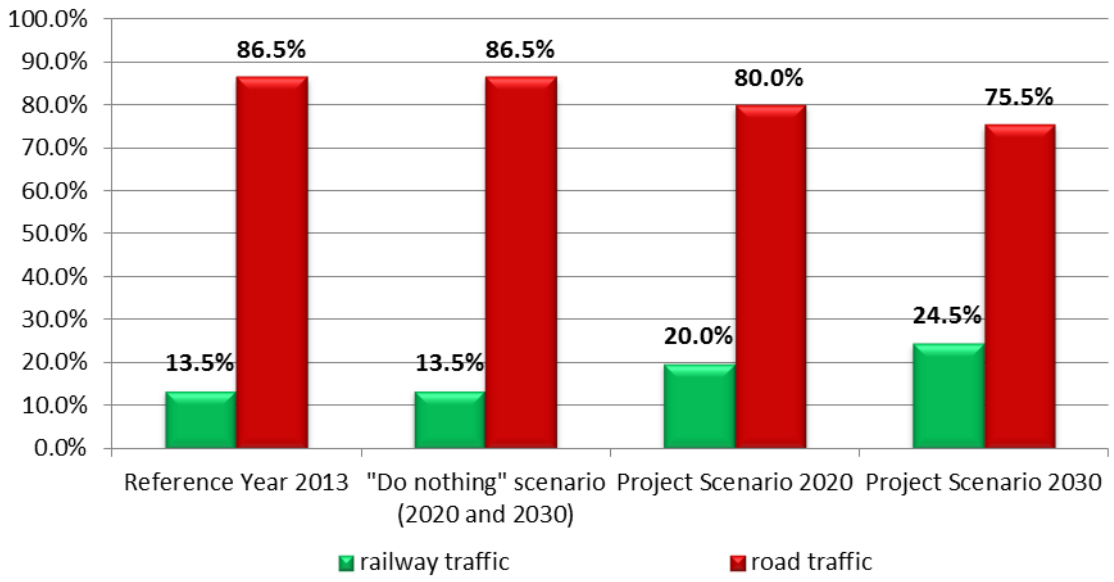
Figure 5 shows the absolute changes of total container traffic and of traffic at rail terminal in the Port of Livorno with respect to the reference year, figure 6 reports the modal split between road and rail.

Figure 5: Total/rail container traffic increase (with respect to the Reference year) in the Port of Livorno under the infrastructure scenario in the future years (TEUs)



Source: TRT elaboration on the TRUST model results

Figure 6: Freight modal split in the port of Livorno under the infrastructure scenario in the future years



Source: TRT elaboration on the TRUST model results

Table 6 shows the final summary of the modelling results when the project scenario is introduced under the higher growth assumption. Also in this case the project scenario takes into account the reduction of the transhipment times, mainly, and of the transhipment costs.

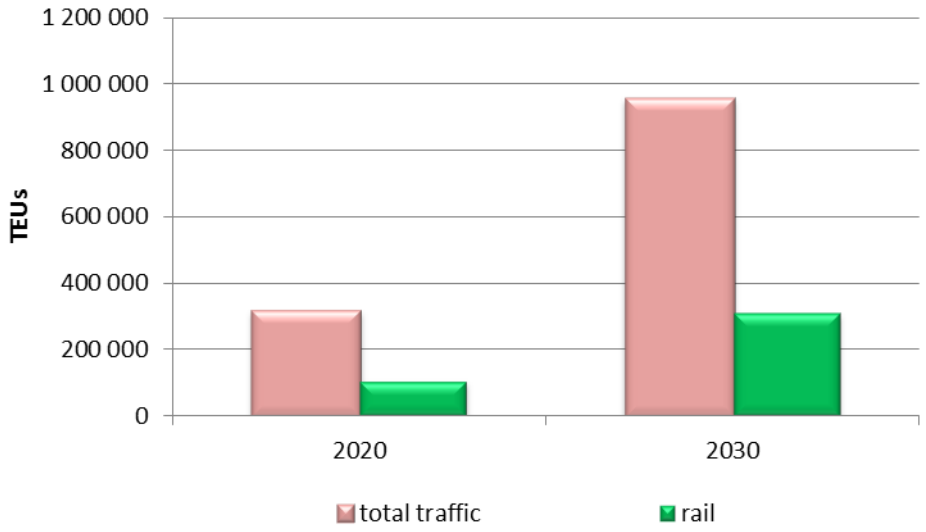
Table 6: Container traffic in the Port of Livorno under the higher growth assumption and for the project scenario in the future years (TEUs)

	REFERENCE YEAR		HIGHER GROWTH "do nothing" SCENARIO		HIGHER GROWTH INFRASTRUCTURE SCENARIO	
	Observed data	Modelled data				
	2013		2020	2030	2020	2030
Road	492 078	524 842	736 270	1 172 076	736 251	1 171 705
Rail	67 102	82 112	115 172	184 957	183 939	389 582
Rail modal share	*12.0%*	*13.5%*	*13.5%*	*13.6%*	*20.0%*	*25.0%*
Total traffic	**559 180**	**606 955**	**851 443**	**1 357 034**	**920 190**	**1 561 287**
Percentage variation of total traffic with respect to the "do nothing" scenario					*8%*	*15%*

Source: TRT elaboration on the TRUST model results

Figure 7 shows the absolute changes of total container traffic and of traffic at rail terminal in the Port of Livorno with respect to the reference year. The modal split between road and rail is the same as in case of the base growth assumption.

Figure 7: Total/rail container traffic increase (with respect to the Reference year) in the Port of Livorno under the infrastructure scenario in the future years (TEUs)



Source: TRT elaboration on the TRUST model results

Afterwards to the estimates of container traffic in TEU, were calculated trains and trucks needed for the transport of the corresponding quantities. This phase of the analysis focused in particular on the base growth scenario, used in the financial and economic analysis.

In particular, the annual container trains crossing sections covered by project were calculated with reference to the relevant years of the project, 2020 entry into operation of the overpass, 2023 entry into operation of the link between the Interporto of Guasticce and the line Vada - Collesalvetti, 2025 entry into operation of the by- pass of Pisa and 2030 with a traffic by then consolidated.

The demand after 2030 was made to grow extra model with a rate of 1% per year until 2040, a conservative rate representative of a growth is assumed should not stop after only five years from the project completion. The following table shows the number of container trains calculated.

Table 7: Traffic of container trains per year

Year	Number of container train / year
2020	1.200
2023	2.400
2025	2.572
2030	3.000
2040	3.300

Source: TRT elaboration

Other traffic categories

The analysis and the traffic forecasts related to the Port of Livorno have been developed through the model on the container traffic, depending on the characteristics of this type of traffic, eligible to the rail and contendible.

Of course, other trades and other merchandise use the Port of Livorno and, depending on particular conditions, can be potentially interested in the rail mode.

These conditions were assessed partially with the model and forecast data, while estimated on realistic assumptions and viable, were not included in the base growth traffic scenario used in the evaluation analysis (financial and cost-benefit analysis) to remain on the safe side.

The following are the traffic data traffic of the port of Livorno in recent years and divided into categories.

Table 8: Traffic of the Port of Livorno

Main traffic categories	Traffic trend					
	2014	2013	2012	2011	2010	2009
Totale movimentazione del porto (tonnes)	28.335.156	27.952.887	24.418.023	29.672.529	30.298.751	26.766.481
TEUs	577.471	559.180	549.047	637.798	628.489	592.050
Rotabili (number)	329.386	307.936	303.692	331.251	304.548	312.427
Passengers (number)	1.878.057	1.821.310	1.768.422	2.085.119	2.552.214	2.467.976
Croceristi (number)	626.356	736.516	1.037.849	982.928	822.554	795.313
New Cars (numbers)	388.031	348.017	356.053	466.246	n.a.	n.a.
Solid bulk (tonnes)	857.537	750.447	638.689	796.798	843.538	682.285
Liquid bulk (tonnes)	7.849.940	8.367.891	8.313.501	7.779.388	9.280.266	7.473.857

Source:Livorno Port Authority

With regard to the above, it is considered that the traffic flows potentially interested in rail services, activatable thanks to infrastructure investments planned, are the following:

- Cars
- Ro - Ro

With regard to cars Livorno has a long tradition to be revalued in view of market recovery in the sector, although carefully evaluated as a function of potential competition from other ports, including abroad.

This type of traffic could develop also considering the opportunities related to the new connection from the inland port (Interporto of Guasticce) and, through the connection with the future line of Collesalvetti, with the dry port "Il Faldo", dedicated to the car market.

As for the Ro-Ro, also with an important historical role in Livorno, the potential for growth are in line with national and Mediterranean expectations, while the opportunity to transfer the semitrailers on the train in order to expand the area of gravitation of this mode, are also linked to the interventions rail, but expected

to be activated, along the north-south corridor Scandinavian - Mediterranean between Florence and Bologna to allow, through the retrofitting of the sections of the galleries, the transit of railway dedicated wagons with semitrailers.

The model TRUST provides also an estimation of the Ro-Ro demand at the Livorno port by assigning a matrix of road HDV traffic in Europe. In particular, according to the model output, the Ro-Ro transport activity at the Livorno port is expected to grow on average by 2.9% per year between the year 2010 and 2025.

The rate mentioned above comes from the simulation of the TRUST model that was successfully applied for the assessment of the "Eurovignette directive" on behalf of the European Commission[3]. Within this project, two transport modelling tools at the European scale are applied in order to assess the impacts of the different policy packages, namely the ASTRA strategic model and the TRUST network model. Results are available as aggregate indicators at European level, as well as by Member State and by road (or Ro-Ro) link. Regarding to the economic and transport demand trends in the Baseline 2025 scenario, the ASTRA model was calibrated to reproduce the projections according to PRIMES model results made available by the Commission. Subsequently, the simulation of the Baseline 2025 scenario in the TRUST model, was based on the average yearly growth rate 2010-2025 for the HDV demand provided by the ASTRA model.

Finally, can be considered some additional trains coming from the port of Piombino which, according to the traffic recovery of steel industry, can use the rail link Vada - Collesalvetti.

The reference years are three:

• 2020 only car traffic

• 2025 car + Ro-Ro once adequate the gauge on the Scandinavian – Mediterranean Corridor (between Bologna and Firenze)

• 2030 car + Ro-Ro consolidated

In a conservative hypothesis traffic of new cars could go from 500 trains / year up to 2020 to 1000 in 2030, corresponding to 100,000 and 200,000 cars, respectively, equal to a percentage of the railroad on the additional traffic of cars (from 160,000 to 250,000) between 60 and 80%. Data are significantly elevated: the optimistic hypothesis provides 100% of the additional cars of Livorno on the train.

As for the Ro-Ro trains will start on 2025: the initial share than the total traffic will be, according a conservative hypothesis, about 2% increasing over time (eg 400 trains at the service startup and 1000 in 2030 amounted to over 3%); in the most optimistic scenario can be reached 5% which results 1,300 trains to the starting and 1,800 in 2030.

[3] Ricardo-AEA et al. (2014). "Evaluation of the implementation and effects of EU infrastructure charging policy since 1995. Final Report" (TASK A) http://ec.europa.eu/smart-regulation/evaluation/search/download.do?documentId=10296156

Table 9: Traffic of Cars and Ro – Ro trains per year

Year	Conservative hypothesis – n. trains/y			Optimistic hypothesis– n. trains/y		
	Cars	Ro-Ro	Total	Cars	Ro-Ro	Total
2020	500		500	800		800
2023	650		650	935		935
2025	750	400	1.150	1.025	1.300	2.325
2030	1.000	1.000	2.000	1.250	1.800	3.050

Source: TRT elaboration