Decision-Making for Maritime Networks: Evaluating Corporate and Social Profitability of an Integrated Short Sea Shipping Network in the Upper Tyrrhenian Sea

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Abstract. This study applies cost benefit analysis (CBA) approaches to evaluate corporate and social profitability of a coordinated management proposal for a Short Sea Shipping (SSS) network in the upper Tyrrhenian area. The profitability of the maritime network is assessed first for the shipping companies operating therein and then for society as a whole. Corporate profitability analysis reveals a supply system currently over-sized compared to actual demand. The reasons for this must be found in the corporate competition strategies that traditionally characterize the free maritime transport market in the area. Social profitability analysis proves the potential positive impact of services rescheduling and coordination in terms of time savings and emission reduction in port areas and demonstrates the benefits new integrated management policies could yield for achieving higher efficiency and sustainability in SSS Tyrrhenian networks.

Keywords: Short Sea Shipping · Motorways of the sea · Cost benefit analysis · Tyrrhenian area · Ro-Ro maritime services

1 Introduction

European transport policy has long highlighted the importance of short sea shipping (SSS) for reducing road traffic, rebalancing the distribution between modes of transport, and contributing to sustainable development. In the framework of SSS, the European Union promotes the Motorways of the Sea (MoS) initiative whose main purpose is to encourage the modal shift from road to sea and improve the accessibility of peripheral and island regions [1]. One of the main objectives of the EU maritime transport policy concerns the exploitation of the full potential of SSS through the complete implementation of MoS projects [2]. In the last decades, the European Commission has been promoting maritime research and innovation by funding various intermodal and MoS development projects. Particularly, Roll-on Roll-of (Ro-Ro) transport is one of the key options European policy is focusing upon to develop intermodal transport and MoS

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policies. This paper is based on the outputs of the Go Smart Med project, funded under the Interreg IT-FR Maritime Program 2014–2020. The purpose of the project was to develop intermodal transport in the high-Tyrrhenian area to improve the accessibility of island regions while providing an essential contribution to how existing Ro-Ro shipping services could be streamlined to render them more competitive. The project originated from the analysis of the existing maritime Ro-Ro freight transport system in the area, which revealed the lack of any distinctive pattern for which the available liner services could be considered as a proper maritime network [3]. The various available routes seem to be conceived singularly and sized mainly based on competition struggles between shipping companies rather than to satisfy demand requirements. However, the inter-company competition regime which is typical of the free market does not appear appropriate to benefit from the potential of the Tyrrhenian area. In such contexts, it is believed that new integrated management policies could potentially yield significant benefits for achieving higher global efficiency and competitiveness [4]. In this regard, the Go Smart Med project proposed an alternative governance model to coordinate Ro-Ro connections between the following six ports in the area: Genoa, Leghorn, Cagliari and Palermo, in Italy, and Toulon and Bastia, in France. The proposed governance model was based on an integrated and optimized network scheme for the maritime Ro-Ro freight services currently operating between the six ports. The operating parameters of the new integrated network were determined through an optimization approach based on the integration of timetables and frequencies of the liner services of interest.

This paper aims to evaluate the profitability of the newly optimized system compared to the existing one. The profitability of the optimized network is assessed both for the shipping company and society as a whole.

The paper is organized as follows. Following this introduction, Sect. 2 presents the case study and its peculiarities. Section 3 describes the new integrated network as it was developed by the Go Smart Med project. Section 4 introduces the cost-benefit analysis approach with a brief review of its applications in maritime literature. The numerical application is in Sect. 5. Finally, Sect. 6 concludes the paper.

2 The Case Study

The case study analyzed concerns the Tyrrhenian area and specifically the maritime Ro-Ro connections between the following ports: Cagliari, Genoa, Leghorn and Palermo in Italy, Toulon and Bastia in France. In the Trans European Transport Network (TEN-T), the first four ports are classified as *core* while the last two as *comprehensive*. Table 1 shows the weekly demand matrix for each O/D pair in terms of Ro-Ro units per week. In particular, the O/D pair takes a zero value when direct or combined transport services were not present in the period analyzed. The total weekly demand of the network is estimated at 6,726 Ro-Ro units. At the time of the analysis, the transport offer serving this network counted 16 liner Ro-Ro and Ro-Pax services operated by eight companies. The service frequency and capacity for each O/D pair are listed respectively in Tables 2 and 3. The service capacity is calculated by multiplying the weekly frequency by the average ship capacity. The total weekly capacity is estimated at 12,180 Ro-Ro units. Considering that the weekly demand was estimated at 6,726 Ro-Ro units, the residual capacity of the network amounts to 39%. Table 4 details the surplus capacity for O/D pair. The highest surpluses are on the routes characterized by overlapping services operated by different companies.

Table 1. Average weekly demand (Ro-Ro units/week) - year of reference: 2016

O/D Demand	Bastia	Genoa	Toulon	Cagliari	Leghorn	Palermo
Bastia	–	13	224	0	196	0
Genoa	19	–	0	357	0	867
Toulon	251	0	–	0	0	0
Cagliari	0	426	0	–	849	150
Leghorn	177	0	0	843	–	643
Palermo	0	791	0	246	676	–

Table 2. Weekly frequency (travels/week) - year of reference: 2016

Frequency	Bastia	Genoa	Toulon	Cagliari	Leghorn	Palermo
Bastia	0	1	7	0	10	0
Genoa	1	0	0	5	0	10
Toulon	7	0	0	0	0	0
Cagliari	0	5	0	0	8	4
Leghorn	10	0	0	8	0	3
Palermo	0	10	0	4	3	0

Table 3. Weekly capacity (Ro-Ro units/week) – year of reference: 2016

Capacity	Bastia	Genoa	Toulon	Cagliari	Leghorn	Palermo
Bastia	–	28	315	0	282	0
Genoa	28	–	0	1,018	0	1,684
Toulon	315	0	–	0	0	0
Cagliari	0	1,018	0	–	1,607	475
Leghorn	282	0	0	1,607	–	681
Palermo	0	1,684	0	475	681	–

Table 4. Surplus capacity (Ro-Ro units/week) – year of reference: 2016

Surplus	Bastia	Genoa	Toulon	Cagliari	Leghorn	Palermo
Bastia	–	15	91	0	86	0
Genoa	9	–	0	661	0	817
Toulon	64	0	–	0	0	0
Cagliari	0	592	0	–	758	325
Leghorn	105	0	0	764	–	38
Palermo	0	893	0	229	5	–

Port waiting times and average travel times in the existing network configuration are listed in Tables 5 and 6. To calculate port waiting times it is assumed that the goods to be embarked are available for boarding from 6 p.m. on the day of arrival at the port. The waiting time is thus calculated as the time that elapses from the time the goods arrive by land to the origin port to the time the boarding operations of the first useful departure to the destination port are completed. The total travel time is here defined as the time that elapses from the moment the goods arrive by land at the origin port until the moment they are disembarked at the destination port, it includes the waiting time, the sailing time, the unloading time and the transhipment time, if any. In Table 6, the values in italics refer to the O/D connections for which there is no direct service or an integrated connection service. The relative waiting times for these connections are calculated considering the first useful coincidence between the various combinable services available. The assessment includes the time necessary for the transhipment operations from one vessel to another.

Table 5. Average port waiting time (h)

Waiting time	Bastia	Genoa	Toulon	Cagliari	Leghorn	Palermo
Bastia	–	75.00	8.09	*39.00*	18.45	*42.79*
Genoa	75.00	–	*88.00*	20.71	–	11.97
Toulon	25.68	*113.00*	–	*70.86*	*36.11*	*52.14*
Cagliari	*35.04*	32.74	*48.57*	–	17.43	31.00
Leghorn	16.26	–	*33.21*	17.43	–	36.35
Palermo	*37.71*	12.84	*51.86*	31.07	30.52	–

Table 6. Average travel time (h)

Travel time	Bastia	Genoa	Toulon	Cagliari	Leghorn	Palermo
Bastia	–	88.00	19.50	*69.71*	25.45	*69.49*
Genoa	88.00	–	*111.00*	55.11	–	42.05
Toulon	38.68	*136.00*	–	*106.86*	*53.11*	*93.49*
Cagliari	*62.75*	77.83	*85.67*	–	39.43	66.93
Leghorn	23.26	–	*50.21*	39.43	–	58.05
Palermo	*63.86*	41.38	*88.00*	75.07	52.69	–

3 The Project Scenario

The Go Smart Med project has proposed an alternative organization of the transport service along the analyzed network based on the integration of the timetables and frequencies of the existing liner services operating therein. A mixed-integer linear programming model was used to determine the optimal allocation of the demand flows on the network while trying to minimize a multi-objective function composed of a weighted sum of travel times and tariffs. For more details on the analytical formulation of the model, the interested reader can refer to [3]. The model was used to reschedule and coordinate existing services and allowed to determine an optimized network option characterized by lower waiting and travel times than the existing configuration.

Tables 7 and 8 show the average port waiting times and travel times relating to the optimized network configuration. The values in italics refer to the O/D connections involving the combination of two services.

Table 7. Average port waiting time (h) - optimized configuration

Waiting time	Bastia	Genoa	Toulon	Cagliari	Leghorn	Palermo
Bastia	–	75.00	3.00	*26.29*	18.06	*40.43*
Genoa	75.00	–	*89.00*	9.86	–	6.10
Toulon	3.00	*89.00*	–	*17.86*	*10.57*	*31.86*
Cagliari	*17.07*	9.86	*27.57*	–	3.26	13.29
Leghorn	9.51	–	*21.71*	4.63	–	28.98
Palermo	*31.79*	6.23	*42.29*	13.29	30.52	–

Table 8. Average travel time (h) - optimized configuration

Travel time	Bastia	Genoa	Toulon	Cagliari	Leghorn	Palermo
Bastia	–	88.00	16.00	*58.00*	25.06	*68.01*
Genoa	88.00	–	*112.00*	49.33	–	36.38
Toulon	16.00	*106.86*	–	*54.29*	*28.00*	*67.78*
Cagliari	*45.21*	55.57	*65.71*	–	25.26	52.64
Leghorn	16.51	–	*40.00*	26.63	–	51.67
Palermo	*60.64*	33.69	*81.14*	57.29	52.69	–

The potential benefit deriving from reorganizing the maritime transport services in the area clearly emerges when comparing the waiting and travel times related to the existing configuration (Tables 5 and 6) with the optimized ones (Tables 7 and 8). Tables 9 and 10 detail the percentage reduction of waiting time and travel time for each O/D pair. Overall, the optimized network would ensure a 32.7% reduction in waiting time and an 18.7% reduction in travel time.

Although these indicators may demonstrate the greater attractiveness of the transport service rendered by the optimized network, its economic and financial profitability has yet to be verified. The scope of the present application is to assess its corporate and social profitability using cost benefit analysis approaches.

Table 9. Optimized vs existing configuration: waiting time variation (%)

VAR %	Bastia	Genoa	Toulon	Cagliari	Leghorn	Palermo
Bastia	–	0.0%	−88.0%	−32.6%	−2.1%	2.5%
Genoa	0.0%	–	1.1%	−52.4%	–	−49.1%
Toulon	−88.3%	−21.2%	–	−74.8%	−70.7%	−38.9%
Cagliari	−51.3%	−69.9%	−43.2%	–	−81.3%	−57.1%
Leghorn	−41.5%	–	−34.6%	−73.4%	–	−20.3%
Palermo	−15.7%	−51.5%	−18.5%	−57.2%	0.0%	–

Table 10. Optimized vs existing configuration: travel time variation (%)

VAR %	Bastia	Genoa	Toulon	Cagliari	Leghorn	Palermo
Bastia	–	0.0%	−18.0%	−16.8%	−1.5%	2.8%
Genoa	0.0%	–	0.9%	−10.5%	–	−13.5%
Toulon	−58.6%	−21.4%	–	−49.2%	−47.3%	−27.5%
Cagliari	−27.9%	−28.6%	−23.3%	–	−35.9%	−21.3%
Leghorn	−29.0%	–	−20.3%	−32.5%	–	−11.0%
Palermo	−5.0%	−18.6%	−7.8%	−23.7%	0.0%	–

4 Economic and Financial Feasibility Assessment

The economic and financial feasibility assessment of the newly proposed maritime network is aimed at evaluating both the improvement of the maritime transport offer in the area and the reduction of negative externalities that would derive by its entry into service in place of the existing system.

Numerous studies have used and demonstrated the validity of cost-benefit analysis (CBA) to evaluate the cost versus the benefits of alternative project proposals. When evaluating alternative projects, there are two main purposes in using CBA: i) to determine if a given project is justifiable and feasible by figuring out if its benefits outweigh costs; ii) to offer a baseline for comparing project alternatives by determining which one is sounder and more justifiable.

The transport literature shows numerous applications of CBA for assessing transport infrastructure projects, see, for example, the papers by [5] and [6]. CBA has also been applied to numerous studies related to the maritime sector. Among others, the paper by [7] uses CBA to assess the potential benefits resulting from the reduction of the time spent by containers in ports. The study by [8] supports the application of CBA as a useful tool in the evaluation of a better coastal maritime policy in New Zealand. The paper by [9] applies CBA to demonstrate the benefits of MoS compared to road transport in a short sea shipping context. The study by [10] applies CBA to dynamic planning of routes in the Baltic Sea. The work by [11] applies CBA to 74 separate and highly diverse port projects undertaken by private businesses to determine if a traditional CBA was used as part of their decision-making process.

In this application, the profitability of the new prospective network is assessed according to two different viewpoints:

1. that of the shipping companies: analysis of corporate profitability;
2. that of the society as a whole: analysis of social profitability.

The former is a private decision tool that represents the perspective of the shipping company, which evaluates profit as a revenue-cost difference (Eq. 1). The analysis of social profitability reflects the objectives of the entire society, is a tool of public decision and evaluates profit as a benefit-cost difference (Eq. 2). In both approaches, the goal is to maximize profit.

$$maxP = \sum\nolimits_i P_i = \sum\nolimits_i (R_i - C_i) \tag{1}$$

$$maxP = \sum\nolimits_i P_i = \sum\nolimits_i (B_i - C_i) \tag{2}$$

Let R_i be the operating revenue in year i, C_i the cost in year i, and B_i the benefit in year i.

While in the analysis of corporate profitability the revenue only refers to the company's monetary income, the concept of benefit is wider and may include every resource that can be produced or saved with the project, such as pollution or safety. Although the benefits are not conventionally expressed by monetary values, in the context of CBA, they can be monetized through formulations proposed in the scientific literature.

In this study, the analysis of corporate profitability is carried out on an annual horizon to assess the profitability of the ship owning system based on the difference between revenues and costs in the same reference year. The analysis of social profitability is developed over a 25-year horizon using the discounting of the benefits and costs realized over the period considered and the evaluation of the Net Present Value - NPV (Eq. 3) and the Internal Rate of Return - IRR (Eq. 4). The last two are the reference indicators for evaluating the profitability of investment projects in CBAs.

$$NPV = -I_0 + \sum\nolimits_{i=0}^{t} \frac{R_i - C_i}{(1+r)^i} \tag{3}$$

$$IRR = r_0 NPV(r_0) = \sum\nolimits_0^t (R_i - C_i)/(1+r_0)^i = 0 \tag{4}$$

Let R_i be the revenue in year i, C_i the cost in year i, and I_0 the initial investment.

5 Application

5.1 Analysis of Corporate Profitability

Corporate profitability of the system has been assessed from the perspective of the eight shipping companies operating in the network. The analysis represents the point of view not of a specific company but the system of companies as a whole.

Calculation of Benefits. The benefits of the system are represented by operating revenues deriving from the payment of the freight rate by users. The freight rate is assessed for a Ro-Ro unit characterized by an average length of 13 m. The average freight rate for each O/D pair (Table 11) is multiplied by the relative weekly demand (Table 1) to obtain the weekly operating revenue.

Table 12 shows the annual revenue, which is obtained by multiplying the weekly revenue by 52 working weeks. The annual operating revenue is estimated equal to € 209,336,634. Table 13 lists the nautical miles (nm) travelled weekly. They are determined by multiplying the sailing distance between a pair of ports by the weekly frequency of the service. The nautical miles travelled in a year can be calculated by multiplying the weekly miles by the number of working weeks in a year. Considering Ro-Ro units with an average length of 13 linear meters (lm), it is possible to estimate a unitary operating revenue equal to 0.17 €/(lm·nm).

Table 11. Average freight rate (€/Ro-Ro unit)

Freight rate	Bastia	Genoa	Toulon	Cagliari	Leghorn	Palermo
Bastia	–	205	394	–	245	–
Genoa	205	–	–	432	–	955
Toulon	394	–	–	–	–	–
Cagliari	–	432	–	–	481	635
Leghorn	245	–	–	481	–	459
Palermo	–	955	–	635	459	–

Table 12. Annual operating revenue (€/year)

Revenue	Bastia	Genoa	Toulon	Cagliari	Leghorn	Palermo
Bastia	–	143,910	4,775,987	–	2,590,963	–
Genoa	204,795	–	–	8,314,558	–	44,702,978
Toulon	5,345,698	–	–	–	–	–
Cagliari	–	9,916,873	–	–	22,029,775	5,140,151
Leghorn	2,343,103	–	–	21,880,487	–	15,938,883
Palermo	–	40,809,035	–	8,441,903	16,757,534	–

Table 13. Nautical miles travelled weekly (nm/week)

Distance	Bastia	Genoa	Toulon	Cagliari	Leghorn	Palermo
Bastia	–	105	1,246	0	610	0
Genoa	105	–	0	1,745	0	4,270
Toulon	1,246	0	–	0	0	0
Cagliari	0	1,745	0	–	2,352	864
Leghorn	610	0	0	2,352	–	1,065
Palermo	0	4,270	0	864	1,065	–

Calculation of Costs. The total operating cost for the provision of the Ro-Ro service has been calculated using the unitary cost of 173 €/nm defined in the study by [12]. The annual operating cost for each OD pair (Table 14) is calculated by multiplying the nautical miles travelled weekly (Table 13) by the number of working weeks in a year (52) and the unitary cost of 173 €/nm.

The annual operating cost is estimated at 229,009,788 €. Considering annual revenues of 209,336,634 €, it emerges a negative cash flow of 19,673,154 €. This data confirms the oversizing of the transport offer compared to the demand detected. Starting from the existing demand equal to 6,726 Ro-Ro units, a variation range of ±15% was investigated to determine the demand value necessary for the company system to cover the transportation costs incurred. The balance between revenues and costs is achieved with a 9.4% demand increase (Fig. 1).

Table 14. Annual operating cost (€/year)

Cost	Bastia	Genoa	Toulon	Cagliari	Leghorn	Palermo
Bastia	–	980,910	11,640,132	0	5,698,620	0
Genoa	980,910	–	0	16,301,790	0	39,890,340
Toulon	11,640,132	0	–	0	0	0
Cagliari	0	16,301,790	0	–	21,972,384	8,071,488
Leghorn	5,698,620	0	0	21,972,384	–	9,949,230
Palermo	0	39,890,340	0	8,071,488	9,949,230	–

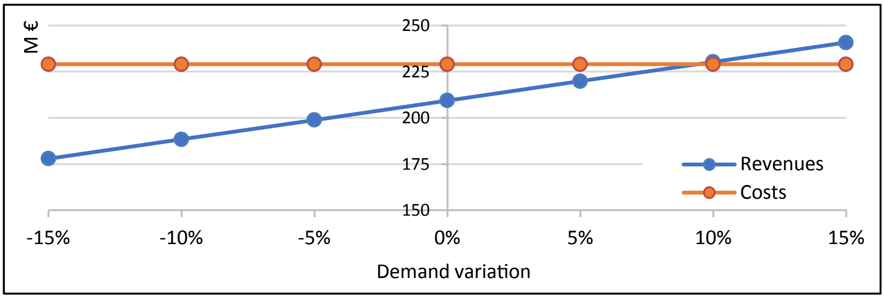

Fig. 1. Point of cancellation of the difference between costs and revenues

5.2 Analysis of Social Profitability

Analysis of social profitability considers a 25-year time horizon and implies hypotheses of variation in demand. A 10% demand increase is assumed in the 25 years, which can be reasonably speculated in the light of the better performance of the transport service offered by the optimized configuration. In this regard, it should be noted that the coordinated scheduling of arrivals and departures at different port nodes allows hauliers to consider several combined connections, which are currently not used, as potential new transport alternatives. The percentage increase in demand over the 25 years is detailed in Appendix 1.

Calculation of Benefits. The benefits considered in this analysis include financial revenues, time savings and the reduction of air pollution in ports.

Financial revenues: they concern the revenue from the transport tariffs paid by users (Table 15). They are valued as the difference between the revenues of the optimized scenario and the existing one.

Time savings: they account for the reduction of travel time which is estimated to occur with the implementation of the new network configuration (Table 10). The value of time (VoT) is assumed equal to 6.82 €/(h·Ro-Ro unit), as assessed by [13]. Time savings are estimated annually at 23,536,919 €.

Pollution reduction: attention should be devoted to port emissions as they directly affect human beings. Reducing the time ships spend in port can thus produce positive effects on air quality and human health. The optimized scenario envisages a 30-minute reduction in the average time spent by ships in port, resulting in better coordination of arrivals and departures. The reduction of air pollution in ports due to shorter hotelling times has been estimated considering the average emissions during the hotelling phase for a ship of gross tonnage of 28.599 tons [14]. The cost associated with air emissions is estimated according to the cost values defined in [15]. Known the reduction in the hotelling time in the optimized configuration, the reduction in the level of port pollution brings a monetary benefit of € 2,673,568 per year.

Table 15. Operating revenues (€)

Year	1	2	3	4	5
Revenue	3,052,308	4,116,892	5,186,798	6,262,054	7,342,687
Year	6	7	8	9	10
Revenue	8,428,722	9,520,188	10,617,111	11,719,519	12,827,439
Year	11	12	13	14	15
Revenue	13,384,168	13,942,290	14,501,807	15,062,722	15,625,040
Year	16	17	18	19	20
Revenue	16,188,764	16,753,897	17,320,443	17,888,405	18,457,787
Year	21	22	23	24	25
Revenue	18,743,190	19,028,949	19,315,066	19,601,540	19,888,373

Calculation of Costs. The costs considered in this CBA include operating costs, investment costs, and costs for the introduction of a tracking system.

Operating costs: operating costs are calculated by multiplying the nautical miles travelled by the unitary operating cost of 173 €/nm introduced in Sect. 5.1. As the service frequencies (and thus the distances travelled) remain unchanged in the two scenarios, the difference in operating costs is zero.

Cost of the new tracking system: the implementation of a tracking system is proposed in the optimized configuration to give users the ability to continuously monitor their goods along the entire transport chain, especially when it includes transhipment operations [16]. The cost of the tracking system is estimated at 19.5 € per Ro-Ro unit. Considering the demand variation in Appendix 1, Table 16 lists the cost of the tracking system year by year.

Investment costs: three start-up cost scenarios attributable to the creation of management and physical infrastructures in the ports considered are hypothesized. The three start-up costs are set as follows: 50 M€ (soft investment), 100 M€ (medium investment) and 200 M€ (hard investment).

Table 16. Annual cost of the tracking system (€)

Year	1	2	3	4	5
Cost	7,193,276	7,229,243	7,265,389	7,301,716	7,338,225
Year	6	7	8	9	10
Cost	7,374,916	7,411,790	7,448,849	7,486,093	7,523,524
Year	11	12	13	14	15
Cost	7,542,333	7,561,189	7,580,092	7,599,042	7,618,039
Year	16	17	18	19	20
Cost	7,637,085	7,656,177	7,675,318	7,694,506	7,713,742
Year	21	22	23	24	25
Cost	7,723,384	7,733,039	7,742,705	7,752,383	7,762,074

The NPV and IRR are calculated for the three hypotheses assuming a 3.5% discount rate. The NPV is positive for all three hypotheses (Table 17), ranging from around 461 M€ (start-up investment cost of 50 M€) to 311 M€ (start-up investment cost of 200 M€).

Table 17. NPV and IRR for the three start-up cost hypotheses

	Hypotheses 1	Hypotheses 2	Hypotheses 3
Start-up Investment (€)	50,000,000	100,000,000	200,000,000
NPV	460,930,812	410,930,812	310,930,812
IRR	48.52%	25.83%	13.43%

6 Conclusions

This paper evaluated the corporate and social profitability of an alternative management proposal for the maritime Ro-Ro freight liner services currently operating between six Tyrrhenian ports. The new network proposal keeps the number of services and their frequencies unchanged compared to the existing transport configuration but proposes their weekly rescheduling in a coordinated and systemic key.

The corporate profitability of the system was assessed from the perspective of the eight shipping companies operating in the network and revealed a negative annual cash flow of around 20 M €, attributable to the strong over-sizing of services currently existing on some routes. The reasons for such an over-sized supply with numerous services overlapping must be found in the corporate competition strategies that traditionally characterize the free maritime transport market. In the current network layout, a 9.4% demand increase would be required for the company system to cover the transportation costs incurred.

The social profitability of the new network scheme was assessed over a 25-year horizon using financial CBA. The analysis proved the positive impact of services rescheduling and coordination in terms of time savings and emission reduction in port areas and demonstrated the greater potential a coordinated network system could offer compared with the single maritime services collectively. Such outcomes can contribute to proving the importance of investigating integrated strategies for improving the quality and sustainability of maritime transport activities in areas such as the Tyrrhenian.

Further developments of this research will concern sensitivity analysis for the CBA discussed and the application of Multi-Criteria methods to widely evaluate corporate profitability and social revenues.

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Appendix 1 - Percentage Increase in Demand Over the 25 Years

Year	0	1	2	3	4	5	6
Annual increase (%)	–	1.56	0.500	0.500	0.500	0.500	0.500
Cumulative increase (%)	0	1.56	2.07	2.58	3.10	3.61	4.13
Demand (Ro-Ro units/year)	6,726	6,831	6,865	6,900	6,934	6,969	7,004
Year	7	8	9	10	11	12	13
Annual increase (%)	0.500	0.500	0.500	0.500	0.250	0.250	0.250
Cumulative increase (%)	4.65	5.17	5.70	6.23	6.49	6.76	7.03
Demand (Ro-Ro units/year)	7,039	7,074	7,109	7,145	7,163	7,181	7,199
Year	14	15	16	17	18	19	20
Annual increase (%)	0.250	0.250	0.250	0.250	0.250	0.250	0.250
Cumulative increase (%)	7.29	7.56	7.83	8.10	8.37	8.64	8.91
Demand (Ro-Ro units/year)	7,217	7,235	7,253	7,271	7,289	7,307	7,325
Year	21	22	23	24	25		
Annual increase (%)	0.125	0.125	0.125	0.125	0.125		
Cumulative increase (%)	9.05	9.19	9.32	9.46	9.60		
Demand (Ro-Ro units/year)	7,335	7,344	7,353	7,362	7,371		

References

1. European Parliament resolution on short sea shipping (2004/2161(INI)) OJ C 33E, 2006/02/09, p. 142–146. https://eurlex.europa.eu/legalcontent/EN/TXT/?uri=celex%3A52005IP0086. Accessed 30 Apr 2020
2. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - Strategic goals and recommendations for the EU's maritime transport policy until 2018, 2009/01/21. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52009DC0008. Accessed 30 Apr 2020
3. Fancello, G., Serra, P., Mancini, S.: A network design optimization problem for Ro-Ro freight transport in the Tyrrhenian area. Transp. Prob. **14**(4), 63–75 (2019)
4. Fancello, G., Pani, C., Serra, P., Fadda, P.: Port cooperation policies in the mediterranean basin: an experimental approach using cluster analysis. Transp. Res. Procedia **3**, 700–709 (2014)
5. Priemus, H., Flyvbjerg, B., Van Wee, B.: Decision-Making on Mega-Projects: Cost-Benefit Analysis, Planning and Innovation. Edward Elgar Publishing, Cheltenham (2008)
6. Jones, H., Moura, F., Domingos, T.: Transport infrastructure project evaluation using cost-benefit analysis. Procedia Soc. Behav. Sci. **111**, 400–409 (2014)
7. Vaghi, C., Lucietti, L.: Costs and benefits of speeding up reporting formalities in maritime transport. Transp. Res. Procedia **14**, 213–222 (2016)
8. Cavana, R.Y.: Coastal shipping policy in New Zealand: the case for an empirical cost benefit analysis. Marit. Policy Manag. **21**(2), 161–172 (1994)
9. Mange, E.: Short sea shipping cost benefit analysis. In: Proceedings of the European Transport Conference, Association for European Transport, Strasbourg, France, pp. 18–20 (2006)
10. Andersson, P., Ivehammar, P.: Dynamic route planning in the baltic sea region–a cost-benefit analysis based on AIS data. Marit. Econ. Logistics **19**(4), 631–649 (2017)
11. Giuliano, G., Knatz, G., Hutson, N., Sys, C., Vanelslander, T., Carlan, V.: Decision-making for maritime innovation investments: the significance of cost benefit and cost effectiveness analysis. Research paper 2016-001 (2016)
12. European Commission. Elaboration of the East Mediterranean Motorways of the sea Master Plan. East Mediterranean master plan of the Motorways of the sea. Deliverable 5.2 (2009). https://ec.europa.eu/transport/sites/transport/files/modes/maritime/studies/doc/mos/east_med_deliverable5.pdf
13. Feo, M., Espino, R., Garcia, L.: A stated preference analysis of Spanish freight forwarders modal choice on the south-west Europe Motorway of the sea. Transp. Policy **18**(1), 60–67 (2011)
14. Serra, P., Fadda, P., Fancello, G.: Investigating the potential mitigating role of network design measures for reducing the environmental impact of maritime chains: the mediterranean case. Case Stud. Transp. Policy **8**(2), 263–280 (2020)
15. Holland, M.: Damages per tonne emission of PM2. 5, NH3, SO2, NOx and VOCs from each EU25 Member State (excluding Cyprus) and surrounding seas. AEA Technology Environment, United Kingdom (2005)
16. Fancello, G., Serra, P., Schintu, A., Zoratti, A.: Performance evaluation of a tracking system for intermodal traffic: an experimentation in the Tyrrhenian area. Eur. Transp. **76**(8), 1825–3997 (2020)