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## Integrated evaluation methodology and its application to freight transport policies in the port of Trieste

Caterina Caramuta, Cristian Giacomini<sup>1</sup>, Giovanni Longo, Elio Padoano, Michela Zornada

University of Trieste, P.le Europa, 1 Trieste, 34127, Italy

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### Abstract

In port cities, a smooth integration of the port and the city represents a relevant feature, as it allows to avoid negative mutual effects which can compromise the functioning of the two systems. In fact, the interaction between the port and the city regards not only the economy and transport, but also the environmental, managerial and social fields. Thus, it is essential to identify and design the most appropriate course of action in order to boost the interrelationship between these two entities, along with an efficient performance of port operations: this is possible by adopting a well-structured evaluation methodology that permits to consider many features of the issue at hand and the perspective of various stakeholders. This paper introduces an integrated evaluation method, which combines an analysis by indicators and a multi-stakeholder multi-criteria decision analysis. The method was applied to evaluate the possible implementation of two activities aiming at promoting the port-city integration through the enhancement of freight management in the Port of Trieste. The explicit engagement of the most significant stakeholders in the appraisal procedure and the understanding of their influence over the main goal of the evaluation are specific features of the method.

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*Keywords:* Freight transport, policies, evaluation, indicators, AHP, multi-stakeholder assessment.

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<sup>1</sup>\* Corresponding author. Tel.: +39 040 5583573.  
E-mail address: [cristian.giacomini@dia.units.it](mailto:cristian.giacomini@dia.units.it)

## 1. Introduction

The remarkable complexity characterizing ports is related foremost to the deployment of many activities that are of interest for different stakeholders, who act at both institutional and operational level in order to enhance the competitiveness of the whole system. The planning and management of ports is made more difficult even by the fact that they are often immediately adjacent to an urban or metropolitan area and, thus, the integration between the port and the city is a fundamental, but also controversial, issue that must be faced for permitting a seamless and profitable coexistence of the two parts. The urgency of strengthening the port-city interrelationship has been stressed in a few Communications of the European Commission, in which the forthcoming challenges that ports have to tackle are explained and some strategic solutions to these issues are suggested (Commission of the European Communities, 2007; Commission of the European Communities, 2013). Indeed, key topics for the development of ports are the increasing international transport demand, the technological evolution in the maritime sector, the need of reducing the polluting emissions and the constant collaboration among institutional entities, stakeholders and the city. During the past years, the role of ports has changed along with the development of the global supply chain, with significant consequences also on urban freight transport: in fact, they have turned from the traditional intermodal interfaces for transshipment to an active component of a wide distribution channel, providing logistics services (Radhika, 2012). The need of improving port productivity has always represented a central matter for the local and national economy but, especially in recent times, the scarcity of resources has drawn the attention to the advancement of processes rather than to the realization of new structures or infrastructures (Regan et al., 1987), which could have negative impacts on the neighbouring city. More specifically, the performances of port facilities can be boosted thanks to the implementation of solutions exploiting the advancements of technology.

In general, interventions must be evaluated before their implementation in order to select the most effective one. An appropriate assessment has to take into consideration at least three features: the individual performance of the activity in relation to every examined aspect (analysis by indicators), the aggregation of the different performances (multi-criteria analysis) and the involvement of several stakeholders (multi-actor analysis). These items make the appraisal procedure a powerful tool to better analyse both the performances of interventions and the whole implementation process (Dziekan et al., 2013).

The port-city interrelationship has already been analysed in literature, especially in terms of transport related problems due to the combined presence of port and city traffic, but it seems difficult to find researches concerning the mutual influence between the two entities from a wider point of view, which includes not only technical aspects, but also, social, environmental, governance and economic issues. Moreover, usually, the decision-making process, regarding technical aspects characterizing specifically the port or the city (e.g. an urban traffic plan), is carried out autonomously by the two parts without a proper collaboration.

Intentionally, in this paper, some technical activities, which are addressed to improve the management of freight handling in the Port of Trieste have been chosen as application of an integrated evaluation methodology, expecting to recognise some impacts also on the city: in the appraisal different effects of these port activities have been taken into account (like emissions, security, acceleration in the decision making-process) involving, not only the port representatives, but also the local administration and other relevant stakeholders. The proposed assessment methodology consists in the integration of an analysis by indicators and a multi-criteria method: the combination of these two evaluation techniques stays in the fact that the key indicators have been assumed as criteria in the decision model. Besides that, the hierarchical model, created according to the principles of the AHP (Analytic Hierarchy Process) method, explicitly considers the key stakeholders involved in the assessment process: these actors have been engaged to judge not only the priorities of the criteria, but also their own influence on the attainment of the main goal. The case study explained in this article proves the relevance of performing an appraisal in the preliminary phase of a project realization, since it allows well-founded recommendations to decision makers.

The content of this paper is organized as follows: the second section describes a state of art on the analysis of the interaction between the port and the city and the features of the methodologies used for assessing this relationship; the third and fourth section illustrate, respectively, the application of the integrated assessment methodology used to evaluate freight transport activities and its results; finally, some conclusions on the benefits of the approach in a multi-actor context are drawn up in the fifth section.

## 2. The state of art

In general, it is possible to distinguish two main categories of ports: those which are located close to the cities and those which are situated in new purpose-built areas away from towns (Monios, 2018). Obviously, the formers have to face specific challenges which are related to the interaction of these two entities: the port and the city. In this context, technical problems concerning port operations can have some external impacts on the whole city and, conversely, logistic city-plan can influence port activities. Usually, there are different stakeholders who are involved, separately, in the decision-making process for the management of the port operations and for the development of urban planning activities, without a proper cooperation (European Commission, 2016).

A rich literature focuses separately on the problems related to the port and the urban issues, but an integrated interdisciplinary analysis seems crucial to better comprehend the difficulties of the port-city development (Akhavan, 2014; Xiao and Lam, 2017); several papers deal with the relationship between port and city, analysing the urban congestion problems resulting from the port activities or the economic benefits generated by port operations (Witte et al., 2014; Roso et al., 2009; Notteboom and Rodrigue, 2005; Giacomini et al, 2016). Nevertheless, the impacts of port technical operations on the city have rarely been addressed in the literature; in particular, a limited number of researchers have handled the effects of port operations on the city, explicitly considering aspects which are not associated to freight traffic and logistics, but which are, rather, related to society, environment, innovation and management.

The present study focuses on an evaluation methodology, which has been applied to assess the sustainability of some port technical measures (i.e. a set of operational activities), with regard to the integration of the port and the city; the concept of sustainability has been examined in all its multi-dimensional aspects, i.e. including economic, social, environmental and managerial aspects (Litman, 2011, Jeon et al, 2010, Global Report on Human Settlements, 2013). This methodology can be profitable in order to support the analyst in the selection of the best alternative, help the policy makers to define a set of advices for facilitating the decision-making process and assist the planning process, which encompasses all those activities that have to be done before the implementation of a measure.

The assessment methodology, presented in this paper, is an integration of the analysis by indicators and a Multiple Criteria Decision Making (MCDM) method, notably, the AHP method developed by Saaty (1980): the first one provides very detailed results for each category of indicators, but treats the values only in a disaggregated way, while the latter one allows to achieve a global assessment of the alternatives, explicitly taking into account different stakeholders' points of view. The stakeholders' point of view can be considered in different ways, for example the Novelog Evaluation Tool (Nathanail et al., 2016; Gogas et al., 2017) attributes the stakeholders' weight through the judgment of an external moderator, while, in the present research, every considered stakeholder judges their influence degree on the achievement of the main goal through pair-wise comparisons.

An example of multi-dimensional assessment of a project affecting the port-city interaction in the waterfront regeneration process of Valencia (Spain), which included the implementation of the long-term plan called "Valenciaport" (2002-2015); this course of action aimed at increasing the competitiveness of the port through the realization of twenty-five projects of different nature. In this regard, in (Borriello, 2013), the possible rapprochement between the port and the city has been treated only according to an environmental point of view, considering the impacts of port activities on citizens' life quality. In fact, the degradation of water, air and seabed represents one of the main hindering factors that can compromise the acceptance of port activities by the inhabitants and, consequently, the urbanization of the surrounding areas of the city. The approach adopted for the assessment of the effects of the Valenciaport projects was the Environmental Accounting (EA), which is capable to consider not only environmental aspects, but also those related to economy and land use; EA proves to be a valid evaluation instrument to disseminate the achieved results to citizens, enhancing their participation and awareness. In this case study, the port-city integration was appraised using an indicator which indicates the number of protected areas.

This assessment method can be considered appropriate since it implies precise measurements of the indicator values, that are obtained thanks to a constant and updated monitoring. Differently from the Valencia case study, in the present paper, the indicator suggested for the evaluation of the port-city integration regards the both governance and transport aspects of this issue, as it is expressed, respectively, in terms of increase of cooperation between the port authority and other administrative entities and port-city mobility integration.

In the following sections, the proposed methodology is described in detail and its application to freight transport measures aiming to enhance the port-city integration in the city of Trieste is reported.

### 3. Application

The integrated methodology described in the previous section has been applied to a set of freight transport measures, which are planned in the Port of Trieste in order to improve freight management. These measures constitute a work package in the European project called CIVITAS PORTIS, which aims at enhancing the integration between the port and the city in five different European port cities through the actualization of several activities addressed to sustainable mobility. To this purpose, the measures related to the Port of Trieste consider both technological and governance interventions, that contribute to produce beneficial effects, not only on process efficiency, but also on safety and the environment. More specifically, these positive impacts are meant to be achieved by extending the optic fibre network and creating a new domotic centre, which would allow a faster and more complete traffic data exchange, promoting the interoperability among freight operators and the cooperation between the port authority and the other local administrations. Besides that, the improved monitoring and management of freight and passenger traffic and of emergency situations would be ensured, respectively, by the installation of some access control systems and by the mounting of video-cameras and alarm devices. Finally, a seamless collaboration among the involved public authorities on technical and institutional issues would be fostered by the realization of a port-city platform.

It is important to underline that the evaluation of the two measures has been performed not considering them individually, due to the strong interaction among the activities, even if their implementation is not necessarily supposed to occur jointly.

The appraisal process has been carried out by integrating the analysis by indicators and the MCDM method, in order to provide an overall assessment of the examined measures. As far as the first step of the evaluation procedure is concerned, the indicators have been initially selected from a list of indicators, suggested by (Van Rooijen et al., 2013), for covering the main impact areas (the so called "common indicators") and, then, further indicators which are more strictly related to the measure objectives have been identified (namely the "city-specific indicators"). These indicators are reported, respectively, in Table 1 and in Table 2: they do not consider exclusively general economic and environmental aspects of freight handling operations, but they also reflect specific features concerning traffic management and governance within the Port of Trieste.

The analysis by indicators has represented a preliminary stage for the successive application of a MCMD method: in fact, the main aforementioned indicators have been used as criteria of the decision model, which has been created by applying the principles of the AHP method; further criteria have been introduced into the hierarchy to capture the meaning of the other indicators. According to a top-down approach, the hierarchy has been structured on four different levels: the main goal of the evaluation has been placed at the top, then the involved key stakeholders at the second level, followed by the macro-criteria and the criteria at the third level and, finally, the alternatives (Fig. 1). The main goal of the evaluation consists in improving the management of freight movements in the Port of Trieste, with the ultimate objective of enhancing freight transport sustainability; thus, the following key stakeholders have been engaged into the assessment process:

- Port Network Authority of the Eastern Adriatic Sea, i.e. the public authority that is in charge of managing the Port of Trieste;
- a freight operator, as a representative of the firms that operate in the port;
- Trieste Municipality, which is entitled to make decisions regarding urban mobility;
- the Regional Administration of Friuli - Venezia Giulia, since it stands for citizens' concerns, including those related to transport.

The involvement of the stakeholders has been limited to the four above-mentioned actors, since they are usually involved in the strategic decisions concerning the Port of Trieste and therefore have been considered the most significant ones in relation to the attainment of the appraisal objective. In fact, the current national law regulating the governance relationship between the port and city administrative entities considers that Trieste Port Authority and the municipality have to take part to two formal occasions, i.e. the management committee and the meeting of regional and public agencies. In this regard, specifically within the CIVITAS PORTIS project, a measure addressed to the establishment of a multi-governance office has been proposed in order to facilitate the cooperation between these two public administrative institutions and, thus, to reinforce the bond between the port and the city.

As a consequence of the limitation in the stakeholders' engagement, the effort required for the assessment procedure was reasonable and ensured an efficient, participatory and transparent evaluation process.

The elements of the decision model called macro-criteria and criteria, represent, with a progressive level of detail, the main aspects of the examined measures, according to which the various scenarios of intervention have been evaluated; as it can be noticed in Table 3, there is a correspondence between some of the criteria and the main indicators defined in the previous evaluation stage, while other criteria are capable to reflect the aspects of the remaining indicators.

Four diverse alternatives have been included in the hierarchy: the first two of them assume to individually realize the measures, the third one foresees the combined actualization of the activities of the two measures and the last one takes into account the possibility of implementing no measures at all.

Table 1. Selected common indicators.

Evaluation category and sub-category		Impact	Indicator
ECONOMY	Benefits	Operating revenues	Operating revenues
	Costs	Costs	Capital costs
			Operating costs
ENERGY	Energy consumption	Fuel consumption	Vehicle fuel efficiency
ENVIRONMENT	Pollution and Nuisance	Air quality	CO levels
			NO <sub>x</sub> levels
			Particulate levels
		Emissions	CO <sub>2</sub> emissions
			CO emissions
			NO <sub>x</sub> emissions
Particulate emissions			
SOCIETY	Security	Security	Perception of security
	Quality of service	Quality of service	Quality of service
TRANSPORT	Safety	Transport safety	Injuries and death caused by transport accidents
		Traffic levels	Freight traffic flow - peak
	Transport system	Congestion levels	Freight traffic flow - off peak
			Average freight vehicle speed - peak
		Average freight vehicle speed -off peak	
		Freight movements	Freight vehicles moving in demo area
		Modal split	Average modal split - vehicles
	Governance/planning	Planning process	Sustainable Urban Mobility Plan

Table 2. City-specific indicators.

Impact	Indicator
Efficiency	Efficiency
Interoperability	Interoperability among private operators
	Cooperation with the city
Improvements of the technological system	Fibre optic network
	Video - cameras
	Building connections
Automation	Human control time
	Data exchange speed
	Data exchange completeness
Safety	Immigration
	Freight theft
	Accidents related to hazardous substances
Integration on Old Port Area	Integration on Old Port Area

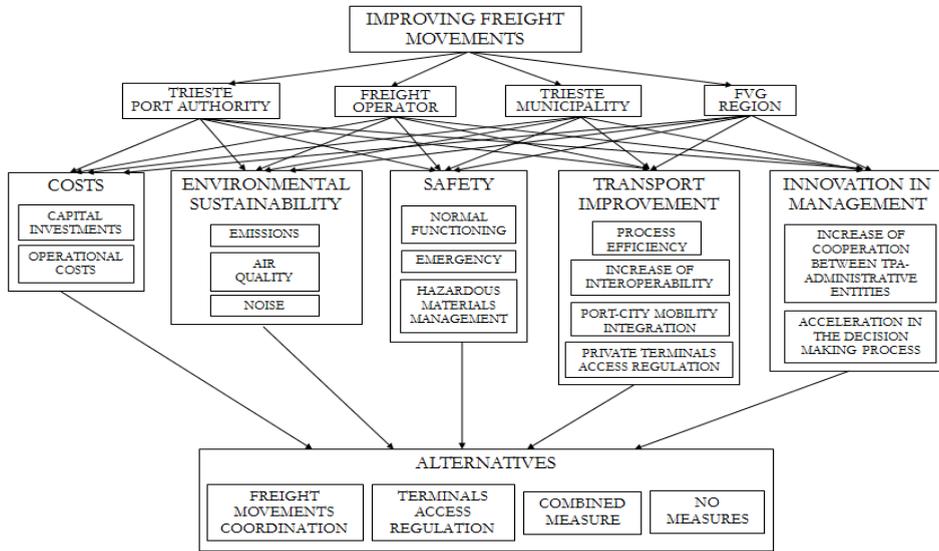


Fig. 1. Hierarchical decision model.

Table 3. Macro-criteria and related criteria.

Macro-criteria	Criteria
Costs	Capital investments
	Operational costs
Environmental sustainability	Emissions
	Air quality
	Noise
Safety	Normal functioning conditions
	Emergency
	Hazardous substances management
Transport improvement	Process efficiency
	Increase of interoperability
	Port-city mobility integration
	Private terminals access regulation
Innovation in management	Increase of cooperation between TPA - administrative entities
	Acceleration in the decision making process

The definition of the priorities of each element of the decision model is a fundamental stage for the identification of the most valuable alternative: to this end, a structured survey was administered to all the key stakeholders, in which they had to perform pair-wise comparisons. Questions were formulated to compare, not only the relevance of macro-criteria with respect to the stakeholders and the importance of criteria with regard to their parent macro-criteria, but also, each stakeholder provided a judgement on the influence degree of all the key actors upon the main goal of the evaluation. In fact, the most essential questions were formulated as follows:

- Considering stakeholder *i* and stakeholder *j*, who is more important with respect to the main goal (or they are equally important)?
- Considering macro-criterion *i* and macro-criterion *j*, which is more important with respect to every single stakeholder (or are they equally important)?
- Considering criterion *i* and criterion *j*, which is more important with respect to their parent macro-criterion (or are they equally important)?

If respondents recognized a certain importance of one element over another one, they were asked to state a value for

expressing their preferences, using Saaty's 1-9 rating scale.

Furthermore, the performances of the alternatives were evaluated, according to a 1-10 scale, by a representative of the Port Network Authority of the Eastern Adriatic Sea, as it is the stakeholder that technically manages all the activities taking place in the Port of Trieste. For assessing the alternatives with respect to all the criteria, the mark 10 was attributed to the best performance, while the value 1 was attached to the worst one; the only exception was the criterion related to capital investments, which was evaluated considering the actual financial expenses and, thus, the judgment scale was inverted.

#### 4. Results

Data gathered through the interviews with key stakeholders were then implemented in the model: the priorities related to the influence of actors and the relative importance of macro-criteria and criteria were obtained, which allowed to determine the ranking of the alternatives.

The synthesis of the answers given by the interviewees regarding their influence on the goal attainment was obtained using the geometrical mean (Aczél and Saaty, 1983): as reported in the Fig.2, the judgements expressed by key stakeholders are coherent in assigning the greatest priority to the Trieste Port Authority, which reveals that this entity is the most influential actor for improving the management of freight movements, within a more sustainable course of action.

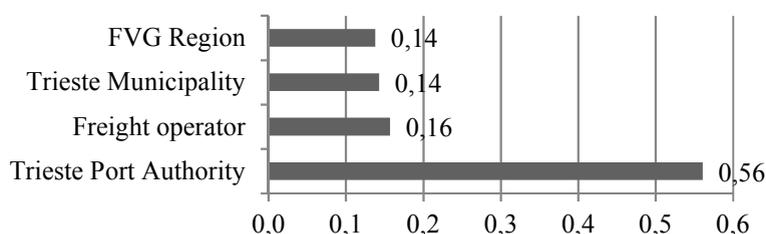


Fig.2. Influence level of key stakeholders over the main evaluation goal.

As far as the macro-criteria are concerned, it turned out clearly that "transport improvement" is the most significant one, followed by "costs", since the advancements that can be reached in the transport field through the examined measures have been considered essential, despite the required financial expenses (Fig.3).

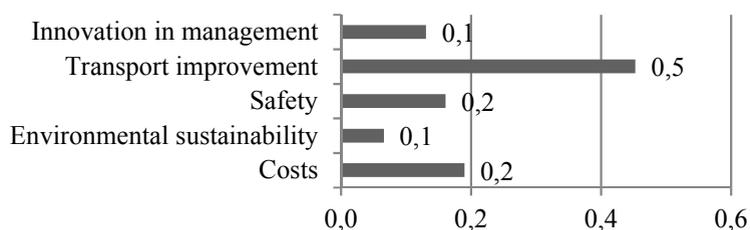


Fig. 3. Priorities of macro-criteria.

Moreover, the normalized values of the priorities of criteria, with respect to their parent macro-criterion, identified the most relevant: "capital investments", "air quality", "safety in normal functioning conditions", "process efficiency" and the "increase of cooperation between Trieste Port Authority and the local administrative entities". The overall ranking provided by the AHP model showed that the most effective alternative is the one foreseeing the implementation of both measures concerning freight transport, with respect to the three remaining scenarios of

intervention explained in the third section. Finally, in order to test the stability of the ranking of the alternatives, in relation to variations in the priority of criteria, a sensitivity analysis was carried out: the classification of the various scenarios of intervention was sensitive in particular to the changes of weights in the criteria regarding "Capital investments" and "Process efficiency", when the respective priority value exceeded, approximately, 0.65 and 0.25.

## 5. Conclusions

Managing port operations represents a central issue in goods distribution and current strategies for increasing the performances of logistics services and freight transport need to consider the implementation of innovative and sustainable measures. The interaction between the port and the city requires that ports' strategic projects be evaluated in a participatory process with the engagement of the key stakeholders. In fact, as shown by the case study reported in this paper, the integration of the analysis by indicators and the multi-actor multi-criteria methods allows to provide appraisal results that are not only founded on an analytical basis, but they are also capable of providing shared recommendations. However, there can be some difficulties in obtaining reliable information by the key stakeholders because of ambiguities or poor understanding of the elements of the assessment model.

An additional advancement of the evaluation process can consist in the adoption of a more complex multi-actor multi-criteria technique, namely the ANP (Analytic Network Process) method, which permits to consider also the interdependency and intradependency among the elements of the decision model; in fact, it allows to evaluate possible transport solutions in a comprehensive, transparent and systematic way, which is required particularly when public policies have to be defined.

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