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An experimental analysis of Mediterranean supply chains through the use of cost KPIs

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Abstract

Over the last twenty years, the intensification of trade flows and the rapid growth of demand for goods and services from new emerging countries have led to a deep change in global transport and a dramatic increase in the level of competitiveness among transportation and logistics service providers. To remain competitive, transport and logistics operators are required to carry out operations with maximum efficiency to meet the requirements of a continually growing and diversified demand. Supply Chain Management is one of the areas that have recently attracted much attention in logistics. The proposed study aims to provide simple quantitative tools based on Key Performance Indicators (KPIs) to support the evaluation process of intermodal supply chains. A sample of 44 real-world Mediterranean supply chains has been collected and analyzed. Four quantitative KPIs describing the relationship time-cost and the ratio cost/kilometer have been derived from empirical cost functions and used to characterize the various elements of the analyzed transport chains, and of the chains as a whole, from a cost perspective.

Keywords: KPIs, Supply Chain Efficency, Supply Chain Management

1. Introduction

Over the last two decades, global freight transport has significantly changed as a result of several factors mainly attributable to the critical increase registered in global trade, the openness towards new distant markets and the rapid growth of demand for goods and services by new emerging countries. The process of economic globalization has

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significantly increased trade flows between the production and consumption areas and, as a consequence, the freight transport demand for medium and long haul has intensified (Gattuso and Cassone, 2013). This has led to an increase in the level of competitiveness of transport and logistics services. To remain competitive, transport and logistics operators are required to carry out operations with maximum efficiency to satisfy the requirements of an increasing and diversified demand. In this scenario, the adoption of management models able to assist transport and logistics managers in their decision process becomes crucial for the efficiency of transport operations. Not surprisingly, Supply Chain Management (SCM) is one of the areas that has recently attracted much attention in logistics. Up to a few years ago, it mainly concerned the business management from the company perspective and as such it mainly focused on the aspects of direct interest to the specific company: organization of transport and delivery operations from the production site to the distribution area (or to the final customer), monitoring of delivery and arrival times, optimization of flows of goods, information exchange, etc. The shift of SCM from a company scale to a global scale has led to a significant change, of both structural and organizational nature, throughout the whole transport chain. Specific attention has to be devoted to the management of the various actors involved in the supply chain and to their relationships, as well as to the control and monitoring of the supply chain effects.

This paper deals with the SCM applied on a wide territorial scale. The main aim of the study is to provide simple quantitative tools based on Key Performance Indicators (KPIs) to support the evaluation process of intermodal supply chains. KPIs allow evaluating the performance of logistics systems putting into light potential weaknesses or criticalities to support supply chain managers in identifying the best strategies for their enhancement.

There are several ways in which supply chain performances can be described: the authors have chosen to focus on the transport aspects by describing the supply chain as a sequence of arcs and nodes and by measuring their efficiency through cost and time parameters. This is a choice finalized to put the attention on one of the main aspects that characterize a supply chain, i.e. the transport service. Needless to say that this approach allows having only a partial description of the performance level of a supply chain, which instead is usually analyzed using a Management approach and evaluating the relationships a company has with its suppliers and customers. In this representation, the transport phase is considered as a single item, both in evaluation processes and management models.

Following the chosen transport-based approach, this paper aims to define a set of KPIs derived from empirical data and cost functions that can be used to evaluate the efficiency of transport chains from a cost-time perspective. It is worth noting that transport costs represent almost 50% of the total costs of a logistics chain. Their reduction may result in higher profit margins for producers and / or in lower costs for consumers, so that the use of these monitoring indicators, together with the constant technological progress both in terms of transport and communications, may contribute to a substantial reduction in unit costs and travel times (Gattuso and Cassone, 2013). The adoption of these indicators becomes even more crucial in the analysis of transport chains based on intermodal logistic networks, where the efficiency along network nodes (ports, intermodal terminals, logistic platforms, etc.) has a direct impact on the efficiency of the transport system as a whole.

The structure of the paper is as follows: after this introduction, Section 2 illustrates a brief literature review on supply chain indicators and performance measures, Section 3 describes the data and the proposed methodology, Section 4 discusses the results of the performed application, and Section 5 concludes.

2. Supply Chain indicators. A brief literature review

The crucial role played by performance measures for enhancing the efficiency of logistics and business systems is widely recognized in the literature (Beamon, 1999; Shepherd and Günter, 2006) and several methodologies are suggested for their evaluation (Gunasekaran and Kobu, 2007) and their management (Hanno and Balste, 2013). KPIs are among the main tools used to carry out comparative analyzes between different logistics chains and allow to understand and monitor the quality of the performances in relation to fixed strategic objectives, such as the quality of the services provided (Morales-Fusco et al., 2016).

A traditional supply chain performance management is often based on a top-down process, structured in six steps: a) setting goals; b) modeling; c) planning; d) monitoring; e) analyzing; f) reporting (Cai and Li, 2007).

Generally, Supply Chains are considered in their entire product life cycle, starting from material procurements until to final customers, taking into account also reverse logistics processes (Guide et al., 2003). The growth of globalization, the opening of new markets, the increase of outsourcing have shifted the focus of supply chain from manufacturing process level (internal analysis) to enterprise management level (Gunasekaran et al., 2004). This new approach changes the perspective of the supply chain management and underlines the importance of measuring the performances of each component that makes up the supply chain to enhance the efficiency of the entire logistics process (Ralston et al., 2015). It means that the efficiency of the supply chain management is mostly based on components' integration, functions' connection and flows' management rather than on a not integrated analysis of suppliers, manufacturing firm and customers (Najmi et al., 2013). In this way, the measure of performances becomes meaningful in supply chain management, because it allows assessing the level of performance achieved by the entire logistics process. Several authors have underlined the significant role of performances' measurement system (Kaplan and Norton, 1992). Gunasekaran et al. (2007) have proposed a classification of performances' measurement system based on three categories: i) perspective-based approach; ii) process-based approach; iii) hierarchical-based approach. The perspective-based approach is the most diffused in research field as it allows to have a unique vision of a supply chain based on a specific product-oriented perspective: each researcher can provide a different vision of the supply chain and therefore use different measures to assess its performance level. Otto and Kotzab (2003) consider six perspectives: organization, logistics, IT, system dynamics, strategic planning, marketing, though some of them have been less used in practical activities. Aramyan et al. (2007) investigate food supply chains by using KPI's dedicated to four specific measures: food quality, efficiency, flexibility, and responsiveness. Robb et al. (2008) calibrate a structural equation model to investigate furniture by analyzing the entire operational dimensions. Lin and Li (2010) have developed a specific model for high-tech supply chains, while Charkha and Jaju (2014) analyze the textile supply chain, defining three performances measures as human resources, production scheduling, and inventory level. Cuthbertson and Piotrowicz (2011) analyze the automotive supply chain, while Bhattacharya et al. (2014) use a similar approach to investigate green supply chains. Several methods have been used to analyze performances measures, among the others, multicriteria methods (Brans and Vincke, 1985; Bass, 2004; Chan et al., 2013; Galankashi et al.; 2014) and balanced scorecard methods (Kaplan and Norton, 1992; Gunasekaran et al., 2001; Bhagwat and Sharma, 2007; Varma et al., 2008; Yang, 2009).

The process-based approach investigates the various processes belonging to the supply chain framework. Chan et al. (2003-a, 2003-b) classify these processes into five categories: a) supplying; b) inbounding; c) manufacturing; d) outbounding; e) selling. Gunasekaran et al. (2004) and Parkan and Wang (2007) define only four processes (planning, sourcing, making, delivering) giving a simplified structure of the supply chain. On the contrary, Yeh et al. (2007), Dasgupta (2003) and Lin and Li (2010) introduce the six-sigma metrics, including three components: team structure measurement, supply chain process measurement, and output measurement. To measure the efficiency of supply chains using this process-based approach, Kotzab et al. (2006), Cai et al. (2009), Banomyong and Supatn (2011) define a number of tools to describe the performances of supply chain processes; El-Baz (2011) proposes a fuzzy model based on a linear function using several input variables, while Lauras et al. (2011) propose a classification of KPIs into three categories related to several management abilities: ambition, reality, and facility. Some researchers use DEA (Data Envelopment Analysis) to analyze the efficiency of entire supply chains (Tavana et al., 2015; Wong, 2009; Wang and Chin, 2010), while others (Liepina and Kirikova, 2011; Ramaa et al., 2009; Bullinger et al., 2002) use a SCOR (Supply Chain Operations Reference) model based on five processes: planning, sourcing, making, delivering, returning.

Finally, the hierarchical-based approach uses different performance measures based on strategic, tactical and operational levels. Gunasekaran et al. (2001) propose a metric analysis based on both financial and non-financial categories and indicate financial indicators as the most appropriate ones for strategic level analysis(see Gunasekaran and Kobu, 2007). Theeranuphattana and Tang (2008) use a fuzzy technique to calculate the preferences measures for each hierarchic stage, while Berrah and Clivillé (2007) and Bhagwat et al. (2008) define the performances indicators at strategic, tactical and operational levels by using the previously described SCOR model.

Which approach does this article follow? As known, transportation activities involve the whole supply chain, from the suppliers to the final customers. They have a direct impact on the competitiveness and efficiency of logistics processes and the performance of the logistics system as a whole. It means that whatever the approach is used to analyze the efficiency of supply chains, transport variables need always to be considered as key performances measures of logistics processes. The most widespread transport KPIs used to describe the supply chain efficiency are typically related to cost or financial aspects. Generally speaking, the costs that characterize the various steps and processes of a supply chain are usually related to traveled distances, amount of goods or delivery times.

This study focuses on transport aspects by describing the supply chain as a sequence of arcs and nodes and by characterizing them through cost and time parameters. A set of quantitative KPIs describing the relationship time-cost and the ratio cost/kilometer have been derived from empirical data and cost functions and used to evaluate the efficiency of the various elements that make up the transport chain, and of the chain as a whole, from a cost perspective.

3. Data and Methodology

The application of the SCM evaluation tools to the management and monitoring of a broader multimodal network implies a higher level of complexity with respect to its application to a simpler single-mode transport system. The main differences concern:

- the territorial dimension, as we are not considering a short-medium haul network but a long-medium haul network (international or intercontinental);
- the involvement of many actors (carriers, port operators, 3PL, 4PL, etc.) in the management of the various components of the chain;
- the central role assumed by the nodes of the chain, which become strategic for the efficiency of the entire network.

It is widely recognized that nodes are the most critical elements of intermodal supply chains. Changes in transport mode, operator, system, but also delays, waiting times and time loss occur at the node, and may negatively impact on the total time and cost of the transport with notable repercussions on the logistics and opportunity costs of the goods transported. While on the one hand, from the perspective of a supply chain manager, the management of transport operations along the arcs composing the network seems to be quite simple as the activities are rather standardized, on the other hand, a large room for improvement can be realized at the nodes, where an optimal organization of logistics operations can positively affect the efficiency throughout the whole transport chain. It is clear that monitoring the performance of the nodes, i.e., measuring their impedance within the overall network, it is a crucial element in order to pursue the efficiency of the entire supply chain.

In this paper, the characterization of a sample of supply chains, with a specific focus on their nodes, is performed through the use of measurement tools based on KPIs aiming at highlighting critical aspects of the analyzed systems and providing managers with the cognitive elements necessary to implement the most appropriate strategies and actions for their improvement. KPIs can be defined as a set of indicators able to evaluate the performance of a supply chain by measuring the performance of the activities and processes occurring along its nodes and arcs. This study considers KPIs related to both the nodes and the arcs of a transport chain. More specifically, the developed KPIs concern times (travel, waiting, handling, etc.) and costs (tariffs) of the various elements composing the chain. Table 1 lists the proposed KPIs. Each KPI is described in terms of unit of measure, description, application field, type of transport (accompanied or not) and type of goods (perishable or not).

A sample consisting of 44 supply chains currently used to exchange goods between Mediterranean countries has been collected and evaluated. More specifically, the analyzed chains have been divided into two sub-groups concerning the geography of trade that characterizes them:

- the first group includes 20 transport chains connecting the north-western shore of the Mediterranean area with the south-eastern one. These chains were collected within the OPTIMED project (Fadda et al., 2017). For the purpose of the study, these transport chains are referred to as medium-haul chains;
- the second group includes 24 transport chains connecting Italian and French regions. These chains were collected within the Go SMart Med project funded by Interreg It-Fr Maritime Programme 14-20. For the purpose of the study, these chains are referred to as short-haul chains.

Each analyzed supply chain is characterized by the following cost-, time- and operational parameters: origin and destination nodes, intermodal unit used, route travelled and mode(s) of transport used, overall transport cost and duration, cost and time spent along each node and arc of the chain (the type of goods and the presence of a driver are also considered). Only maritime nodes have been analyzed; terrestrial nodes have been excluded from the analysis due to data unavailability.

Table 1. List of KPIs proposed.

name	measure	description	application field	type of transport	type of goods
CHS	€/h	Cost per hour along a sea arc	sea medium/short range (haul)	Accompanied/ Unaccompanied truck	any
CHR	€/h	Cost per hour along a road arc	road	any	Perishable/Nonperishable
TSN	h	Total time at a port node	port	Accompanied truck	any
TKC	€/km	Medium value of total cost per km	whole journey with and without intermodal nodes	road + sea	Perishable/Nonperishable

The database has been built through a direct survey campaign involving a number of transport operators and companies that exchange goods within the Mediterranean area. The collection of information, although difficult due to privacy policies adopted by companies or logistics operators, made it possible to make a first distinction based on the geography of trade, by distinguishing short-haul transport chains from medium-range ones. In this way, it has been possible to study transport chains that were as similar as possible, in order to obtain representative values of a supply chain. Since the analyzed transport chains concern different types of products, to perform the study they have been merely grouped into two main categories:

- the food supply chain, which includes perishable goods such as fruits, vegetables, meat, beverages, sauces, etc.
- the non-food supply chain, which includes nonperishable goods such as chemicals, clothing, building materials, agricultural machinery, etc.

For each of these categories, all the road and maritime arcs have been separately analyzed in order to reconstruct the various time and cost relationships. The following considerations are assumed to define the cost functions:

- Maritime arcs - since the cost of the maritime arc does not depend on the type of goods transported, it is assumed it varies only in relation to the size of the vehicle used to perform the transport and to the type of transport (accompanied or unaccompanied);
- Port nodes - the total time at each port node includes waiting times before embarkation or after disembarkation, loading and unloading times and delays during port operations, if any. Since for unaccompanied units the waiting time varies widely depending on a number of operational aspects, only the observations related to accompanied trucks have been used to calculate time-related KPIs for port nodes.

Through the linear regression method, a number of cost functions have been developed to investigate time and cost relationships. The significance of the proposed regression models has been examined through the observation of the R-square index and of the statistical analyzes F-Test, T-Test and Durbin-Watson (the adjusted R-square has not been used as it is useful only in the case of multiple regressions).

4. Results

As previously described, the analysis has been performed once by considering separately the three basic elements composing a transport chain (maritime arc, road arc, and port node), and once by considering the transport chain as a whole. Following the same structure, this section discusses the results of the performed application by presenting the developed KPIs related to: i) Arcs – maritime and road; ii) Port nodes; iii) Whole transport chain.

Arcs

The cost function obtained for the arcs, both maritime and road, is $y = ax$. The dependent variable, *y*, is the total cost (€), while *x*, the independent variable, is the transport time (h).

Since the main objective of the study was not to calibrate a cost function but to define a set of KPIs useful to evaluate the performance of supply chains, a simple linear equation has been chosen without the constant term.

Maritime arcs

Two types of maritime arcs have been considered depending on their length (short and medium) in relation to the two samples of transport chains (short-haul and medium-haul) described in Section 3:

- short-range arcs: their analysis has included either accompanied and unaccompanied transport;
- medium-range arcs: their analysis has included only unaccompanied transport.

Figure 1 shows the time-cost relationship for maritime arcs, distinguishing between short- and medium- range transport:

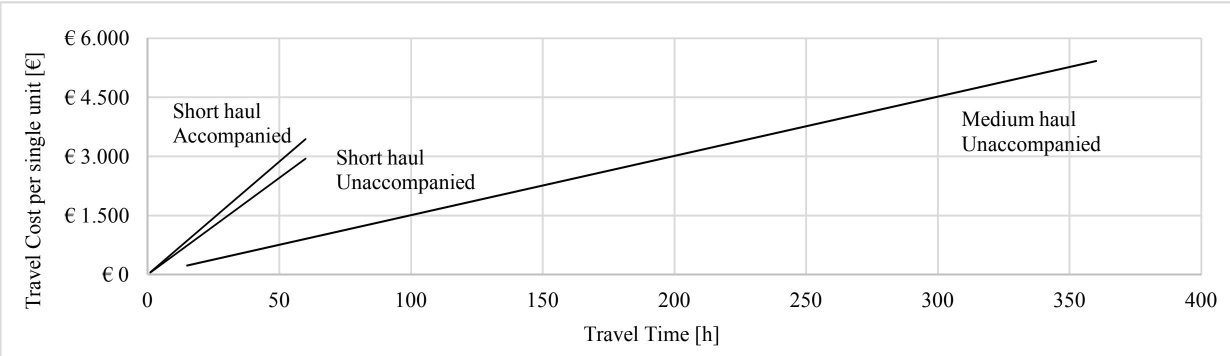

Fig. 1. Cost-Time relationship for maritime arcs: short haul and medium haul.

- short-range transport: the average travel cost is € 53 per hour. Two different curves show the cost-time trend for a single load unit (truck) in the case of accompanied and unaccompanied transport. As evidenced by the slopes of the two lines, the two cost-time trends are very similar. The line related to accompanied transport appears slightly more expensive (+ 14.5%) because it is influenced by the hourly cost of the driver and by the bigger size of the vehicle that now includes the drive unit. In Table 2 it can be seen that in both cases the value of R2 is very high (R2 = 0,993 for unaccompanied transport and R2 = 0.979 for accompanied transport) confirming the high statistical significance of the analyzed relationship.
- medium-range transport: the average travel cost is € 15 per hour. The cost-time trend shows a significantly lower slope with respect to the-short-range curves, confirming the important differences existing between the two types of transport chains (short-range and medium-range) that characterize the two samples analyzed. Even in this case, the high value of the R2 index reported in Table 2 (R2 = 0.979) confirms the high statistical significance of the analyzed cost-time relationship.

Road Arcs

Two type of goods (perishable and nonperishable) have been considered in the analysis of road arcs. Figure 2 shows the cost-time trends for the two categories of goods. By analyzing the slope of the two curves, it emerges that perishable goods have a transport cost of over € 87 per hour, 28.4% higher (+24 €/h) than nonperishable goods (63 €/h). In fact, perishable goods need to arrive shortly at their final destination; thus the service offered by transport companies is supposed to be more expensive. Moreover, the development of the two lines highlights that the travel times of perishable goods are significantly lower than those of nonperishable goods.

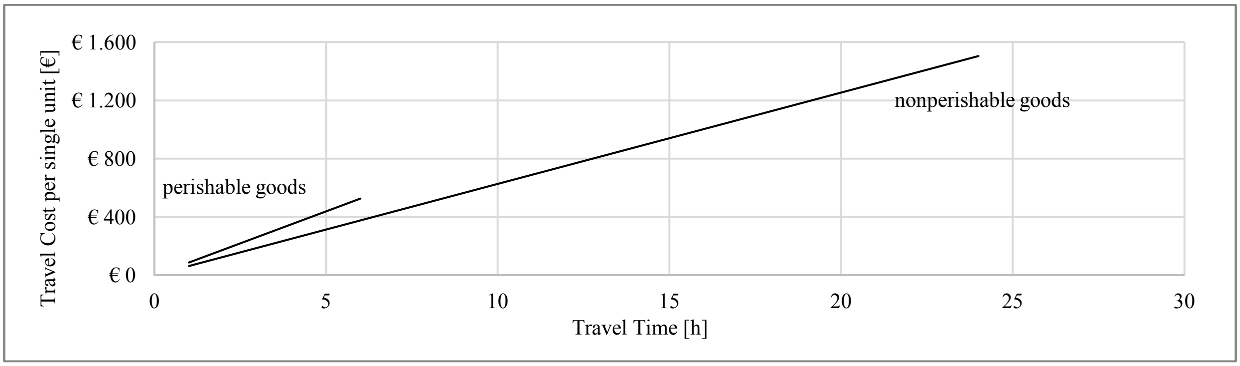

Fig. 2. Cost-Time relationship for road arcs: perishable and nonperishable goods.

Table 2 shows the statistical results of the analyzed regressions, while Table 3 lists the values of the two cost KPIs concerning maritime and road arcs. The KPI named CHS refers to maritime arcs and describes the travel cost per hour (€/h) of a single load unit that moves along a maritime arc. It is differentiated for medium- and short-haul transport and for accompanied and unaccompanied transport. The KPI named CHR refers to road arcs and describes the travel cost per hour (€/h) of a single load unit that moves along a road arc. It is differentiated for perishable and nonperishable goods.

Table 2. Statistical results.

	Maritime Arc			Road Arc	
	Unaccompanied Medium haul	**Unaccompanied Short haul**	**Accompanied Short haul**	**Nonperishable goods**	**Perishable goods**
R-square	0,979	0,993	0,979	0,934	0,877
Standard Error	420,431	58,459	98,427	171,082	77,965
F	281,080	1243,319	854,198	84,229	142,054
Significance F < 0,05	1,379E-05	4,580E-10	5,649E-16	2,576E-4	2,906E-10
Stat t	16,765	35,261	29,227	9,178	11,919
P-Value < 0,05	2,875E-06	5,867E-11	1,271E-16	9,428E-05	1,533E-10
Durbin-Watson	0,340	2,966	3,528	1,270	2,787

Table 3. Cost KPIs for arcs: CHS (€/h – sea leg) and CHR (€/h – road leg).

CHS (€/h) Maritime Arcs			**CHR (€/h) Road Arcs**	
Medium haul	**Short haul**		**Nonperishable goods**	**Perishable goods**
unaccompanied	**unaccompanied**	**accompanied**		
15,061	49,065	57,359	62,642	87,544

Port nodes

The analysis of port nodes has included only the case of accompanied trucks as waiting times of unaccompanied units depend mainly on the organization of the terminal and vary according to the type of goods transported. For the purpose of the study, waiting times, divided into inbound and outbound times, are measured by splitting maritime liner services into two categories:

- high-frequency services with more than 10 departures per day (they apply only to very short distances: less than 10 nautical miles);
- regular frequency services with 1-2 departures per day or less.

Inbound time can be defined as the time spent by a truck from the moment it enters the port to the moment it is loaded on a ship, while outbound time can be defined as the time spent by a truck from the moment it is unloaded from the ship to the moment it leaves the port. As of high frequency services, it was found that in all the logistics chains analyzed, the total inbound time spent in port is between half an hour and one hour, while the total outbound time never exceeds half an hour. As regard regular frequency services, it was found that 46% of the logistics chains analyzed are characterized by a total inbound time of 3 hours, while the total outbound time is 1 hour in 51% of cases. Figure 3 shows the distribution of the frequencies of both inbound and outbound times for the sample of chains analyzed. It emerges that during inbound phase the variability of waiting times is broad, while outbound times are rather concise as shown by the peak curve (within 2 hours): in fact, operating delays are less relevant during outbound operations and the waiting time after disembarkation is quite short. Table 4 provides the values of the time-KPI named TSN for port nodes.

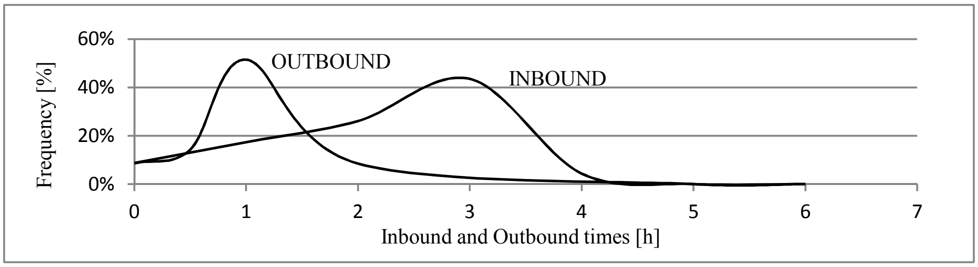

Fig. 3. Distribution of the frequencies of inbound and outbound times assuming the case of regular frequency services.

Table 4. Time KPI for port nodes: TSN (h) - Time spent at a port node.

	Inbound Time (h)	Outbound Time (h)
Ports served by high frequency services	0.5-1	0-0.5
Ports served by regular frequency services	3	1

Global transport chains

The trend of the cost-time relationship for the whole supply chain is shown in Figure 4. The two lines describe the trend of the cost-time relationships for an accompanied transport chain characterized by short-range maritime arcs distinguishing between perishable goods (dashed line) and nonperishable ones (continuous line). The two lines highlight how the hourly transport cost varies along a supply chain: in particular, the cost at the port nodes is indicated by the slope of the line: the greater the cost in the port (with the same number of hours spent), the greater the slope.

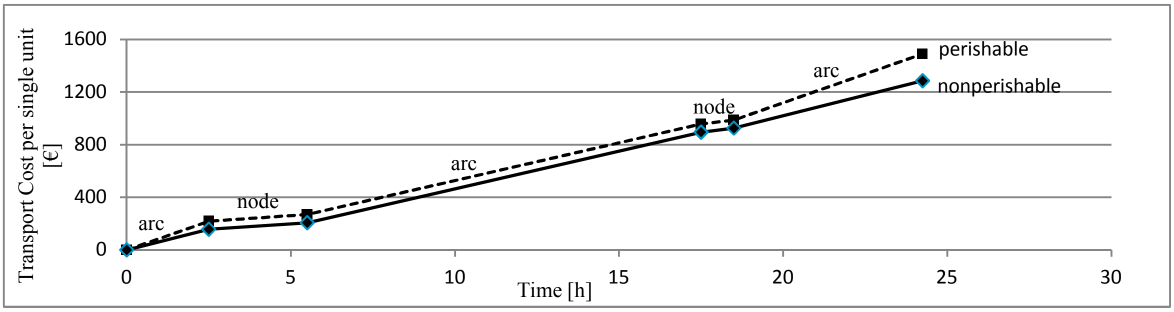

Fig. 4. Cost-time relationship for a transport chain characterized by short-range maritime arcs - Accompanied transport.

Table 5 illustrates the values assumed by the KPI named TKC (Total Kilometrical Cost) for each type of supply chain analyzed. The TKC indicator measures the relationship total cost/total traveled kilometers for the entire transport chain. TKC values are differentiated for supply chains consisting of short-range maritime arcs and supply chains characterized by medium-range maritime arcs. The numerical results related to the first group are further differentiated depending on the type of transport (accompanied or not), on the type of goods (perishable or not) and on the possible presence of intermediate nodes (warehouses, distribution centers, interports, etc.), while the results concerning the second group refer only to non-perishable goods and unaccompanied transport.

Table 5. KPI for whole transport chains: TKC (€/km) - Total Cost per Kilometer.

		TKC (€/km)			
		Perishable goods		Nonperishable goods	
		Without intermediate node	With intermediate node	Without intermediate node	With intermediate node
SC with Short haul maritime arcs	Unaccompanied	1,579	2,300	1,576	na
	Accompanied	1,689	na	1,658	1,962
SC with Medium haul maritime arcs	Unaccompanied	na	na	0,815	na

The numerical values of the TKC indicator confirm that the cost per kilometer (€/km) is higher when supply chains are based on the accompanied transport. Moreover, the presence of intermediate nodes further affects costs and total time, by increasing them. On the other hand, it is worth noting that the cost per kilometer of nonperishable goods along medium-range chains is almost 50% lower than in short-range ones. Results highlight to what extent the nodes of a supply chain are characterized by a great level of impedance as they constitute points of high increase both in terms of time and cost, although there is no physical advance of the goods towards the final destination.

5. Conclusions

This study has proposed four quantitative KPIs derived from empirical data and cost-functions to assess the performance of a sample of 44 Mediterranean transport chains. Two of the four proposed indicators apply to the analysis of the arcs (both maritime and road) that make up intermodal SCs and are basically based on the analysis of time-cost functions; the third indicator applies to port nodes and focuses on the time factor, while the fourth provides a global measure of the transport service of a SC through the total cost per kilometer parameter. A linear function between cost and time, alternative to the traditional one based on costs and distances, has been used to define cost KPIs. The proposed study aimed to provide simple quantitative tools to support the evaluation process of intermodal supply chains from a cost- and time- perspective. The performed analysis confirms the validity of the proposed approach and its usefulness as a useful decision support tool to measure the performance of a specific process of the supply chain, and of the chain as a whole, in order to put into light the critical elements that most affect overall performance. From the information provided by the indicators, the supply chain manager can decide which actions need to be taken to improve the performance of a specific area and the chain as a whole.

References

Aramyan, L. H., Oude Lansink, A. G., Van Der Vorst, J. G., Van Kooten, O., 2007. Performance measurement in agri-food supply chains: a case study. SCM: An International Journal 12.4, 304–315.

Banomyong, R., Supatn, N., 2011. Developing a supply chain performance tool for SMEs in Thailand. SCM: an International Journal 16.1, 20–31.

Bass, F. M., 2004. Comments on “A new product growth for model consumer durables”. The bass model. Management Science 50, 1833–1840.

Beamon, B. M., 1999. Measuring supply chain performance. International Journal of Operations & Production Management, 19.3, 275–292.

Berrah, L., Clivillé, V., 2007. Towards an aggregation performance measurement system model in a SC context. Comput. Industry 58.7, 709–719.

Bhagwat, R., Chan, F. T., Sharma, M. K., 2008. Performance measurement model for SCM in SMEs. Int. J. Glob. Small Bus. 2.4, 428– 445.

Bhagwat, R., Sharma, M. K., 2007. Performance measurement of SCM: a balanced scorecard approach. Comp. Ind. Eng. 53.1, 43–62.

Bhattacharya, A., Mohapatra, P., Kumar, V., Dey, P.K., Brady, M., Tiwari, M. K., Nudurupati, S. S., 2014. Green supply chain performance measurement using fuzzy ANP-based balanced scorecard: a collaborative decision-making approach. Prod. Plan. Control 25.8, 698–714.

Brans, J. P., Vincke, P., 1985. Note—a preference ranking organisation method: (the PROMETHEE method for multiple criteria decision-Making). Management Science 31.6, 647–656.

Bullinger, H. J., Kühner, M., Van Hoof, A., 2002. Analysing supply chain performance using a balanced measurement method. International Journal of Product Research 40.15, 3533– 3543.

Cai, J., Liu, X., Xiao, Z., Liu, J., 2009. Improving supply chain performance management: a systematic approach to analyzing iterative KPI accomplishment. Decision Support System 46.2, 512–521.

Cai, J., Zhang, Y., Li, D., 2007. Business Performance Management: Concepts, Methods, and Applications. Tsinghua Univ. Press, Beijing, China.

Chan, F. T., Qi, H. J., 2003. Feasibility of performance measurement system for supply chain: a process-based approach and measures. Integrated Manufacturing Systems 14.3, 179–190.

Chan, F. T. S., Qi, H. J., 2003. An innovative performance measurement method for supply chain management, SCM Int. J. 8 (3/4), 209– 223.

Chan, T., Nayak, A., Raj, R., Chong, A. Y. L., Manoj, T., 2013. An innovative supply chain performance measurement system incorporating research and development (R&D) and marketing policy. Comput. Ind. Eng. 69, 64–70.

Charkha, P. G., Jaju, S. B., 2014. Designing innovative framework for supply chain performance measurement in textile industry. Int. J. Logist. Syst. Manage. 18.2, 216–230.

Cuthbertson, R., Piotrowicz, W., 2011. Performance measurement systems in supply chains: a framework for contextual analysis. Int. J. Product. Perform. Manage. 60.6, 583–602.

Dasgupta, T., 2003. Using the six-sigma metric to measure and improve the performance of a supply chain. Bus. Excell. 14.3, 355–366.

El-Baz, M. A., 2011. Fuzzy performance measurement of a supply chain in manufacturing companies. Expert Syst. Appl. 38.6, 6681–6688.

Fadda P., Fancello G., Pani C., Serra P., 2017. The OPTIMED project: A new Mediterranean hub-based ro-ro network. Transport Infrastructure and Systems: Proceedings of the AIIT International Congress on Transport Infrastructure and Systems. ISBN 978 1138030091.

Galankashi, M. R., Memari, A., Anjomshoae, A., Ma'aram, A., Helmi, S. A., 2014. Selection of supply chain performance measurement frameworks in electrical supply chains. Int. J. Ind. Eng. Manage. 3.5, 131–137.

Gattuso, D., Cassone, G. C., 2013. I nodi della logistica nella supply chain. FrancoAngeli, Milano, 2013.

Guide, V. D. R., Jayaraman, V., Linton, J. D., 2003. Building contingency planning for closed-loop supply chains with product recovery. J. Oper. Manage. 21.3, 259–279.

Gunasekaran, A., Kobu, B., 2007. Performance measures and metrics in logistics and supply chain management: a review of recent literature (1995–2004) for research and applications. International journal of production research 45.12, 2819-2840.

Gunasekaran, A., Patelb, C., McGaughey, R. E., 2004. A framework for supply chain performance measurement. Int. J. Prod. Econ. 87, 333–347.

Gunasekaran, A., Patelb, C., Tirtiroglu, E., 2001. Performance measures and metrics in a SC environment. Int. J. Op. Prod. Manag. 21.1/2, 71–87.

Hanno, F., Balste, A., 2013. Supply-Chain Risk Analysis with Extended Freight Transportation Models, in Moshe Ben-Akiva, Hilde Meersman, Eddy Van de Voorde (ed.) “Freight Transport Modelling”, 217-232.

Kaplan, R., Norton, D., 1992. The Balanced Scorecard Measures That Drive Performance, Harvard Business Review, January–February 1992.

Kotzab, H., Grant, D. B., Friis, A., 2006. SCM implementation and priority strategies in Danish organizations. J. Bus. Logist. 27.2, 273– 300.

Lauras, M., Lamothe, J., Pingaud, H., 2011. A business process oriented method to design supply chain performance measurement systems. Int. J. Bus. Perform. Manage. 12.4, 354–376.

Liepina, L., Kirikova, M., 2011. SCOR based ISS requirements identification, Business Information Systems Workshops, Springer, Berlin Heidelberg, 232– 243.

Lin, L. C., Li, T. S., 2010. An integrated framework for SC performance measurement using six-sigma metrics. Softw. Qual. J. 18.3, 387–406.

Morales-Fusco, P., Saurí, S., Lekka, A. M., Karousos, I., 2016. Assessing customs performance in the Mediterranean ports. KPI selection and best practices identification as part of the MEDNET project. Transportation Research Procedia 18.201, 374 – 383.

Najmi, A., Gholamian, M. R., Makui, A., 2013. Supply chain performance models: a literature review on approaches, techniques, and criteria. J. Oper.Supply Chain Manage. 6.2, 94–113.

Otto, A., Kotzab, H., 2003. Does supply chain management really pay? Six perspectives to measure the performance of managing a supply chain, Eur. J. Oper. Res. 144.2, 306–320.

Parkan, C., Wang, J., 2007. Gauging the performance of a supply chain, Int. J. Product. Qual. Manage. 2.2, 141–176.

Ralston, P. M., Blackhurst, J., Cantor, D. E., Crum, M. R., 2015. A structure-conduct-performance perspective of how strategic supply chain integration affects firm performance. J. Supply Chain Manage. 51.2, 47–64.

Ramaa, A., Rangaswamy, T.M., Subramanya, K.N., 2009. A review of literature on performance measurement of supply chain network, Emerging Trends in Engineering and Technology (ICETET), 2009 2nd International Conference, IEEE 802–807.

Robb, D. J., Xie, B., Arthanari, T., 2008. Supply chain and operations practice and performance in Chinese furniture manufacturing. Int. J. Prod. Econ. 112.2, 683–699.

Shepherd, C. and Günter H., 2006. Measuring SC performance: current research and future directions. International Journal of Productivity and Performance Management, 55.3/4, 242–258.

Tavana, M., Kaviani, M. A., Di Caprio, D., Rahpeyma, B., 2015. A two-stage data envelopment analysis model for measuring performance in three-level supply chains, Measurement 78, 322–333.

Theeranuphattana, A., Tang, J. C. S., 2008. A conceptual model of performance measurement for supply chains alternative considerations. J. Manuf. Technol. Manage. 19.1, 125–148.

Varma, S., Wadhwa, S., Deshmukh, S. G, 2008. Evaluating petroleum supply chain performance: application of analytical hierarchy process to balanced scorecard. Asia Pac. J. Mark. Logist. 20.3, 343–356.

Wang, Y. M., Chin, K. S., 2010. Some alternative DEA models for two-stage process. Expert Syst. Appl. 37.12, 8799–8808.

Wong, W. P., 2009. Performance evaluation of supply chain in stochastic environment: using a simulation based DEA framework. Int. J. Bus. Perform. Supply Chain Modell. 1.2, 203–228.

Yang, J., 2009. Integrative performance evaluation for supply chain system based on logarithm triangular fuzzy number-AHP method. Kybernetes 38.10, 1760–1770.

Yeh, D. Y., Cheng, C. H., Chi, M. L., 2007. A modified two-tuple FLC model for evaluating the performance of SCM: By the Six Sigma DMAIC process. Appl. Soft Comput. 7.3, 1027–1034.