

Ports Logistics Performance: Comparative Analysis

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Abstract

Ports performance has become more complex due to the fact that ports work today as nodes of global logistics chains. One of the great challenges of ports it is how to measure their logistic performance. The main objective of this dissertation is to carry out a comparative analysis of the main Portuguese ports logistic performance focused on containerized cargo. Thus this dissertation was developed with the purpose of knowing how the ports logistic performance is being measured with the aim of suggesting an appropriate model to the Portuguese ports reality that allows to do the desired comparative analysis. In order to do that, an in-depth literature review on performance measurement approaches, port actors, logistic performance and port performance indicators was carried out.

The evaluation model was built using a battery of performance indicators based on the literature review. Although logistic performance is the main purpose of the evaluation model, some aspects related to the size, capacity and activity of the port were also incorporated in this model since they are aspects that enhance or limit logistic performance

Data gathering was made in order to feed the chosen performance indicators. To do that, it was used data from the main Portuguese ports (Lisbon, Leixões, Sines and Setúbal). Although it was not possible to gather data as much as desirable, the results from the analysis allow to reach several conclusions and that may be useful to the Portuguese ports.

Keywords: Comparative Analysis; Logistic Performance; Performance Indicators; Ports; Containers

1. Introduction

Ports play a key role in international trade with the most of the world's goods being transported by ships and through ports thanks for the cost benefit relationship of this transport mode. Since the ports have this surgical role in the economy it is imperative that they follow the technological development of other industries

by creating tools that analyze and evaluate their performance in a continuous way.

Efficiency in logistics operations plays a differentiating role in the development of world trade and their competitiveness. Assuming vitality in the creation of new markets and distribution of goods across the geographical borders such are the gains or losses that the logistics operations can induce in the system (Ringsberg and Lumsden, 2015).

The performance of ports and terminals it is not a simple issue to address because there are several determinants that affect port performance such as worker-related issues, number and type of cargo handling equipment used, quality of port support areas, land access, customs efficiency and concessions (UNCTAD, 2015)

This paper was developed with the purpose of suggest a model for an evaluation of the Portuguese ports logistic performance focus on containerized cargo and apply it in a comparative analysis. The aim is to understand which are the main actors of this activity that play critical roles, and that performance measurement has potential interest for the better functioning of the system as a whole.

2. Literature review

The port logistics performance depends of several factors. Thus, the literature review focused aspects as port performance measurement and their actors, port performance evaluation techniques, benchmarking and port performance indicators.

So the port logistics performance concept was clarified. There are two main ports logistical lines. In a first line, are included container movement operations from the terminal to the ships, thus a good efficiency, articulation, productivity and resources management considerable aspects. A second line considers the relationship between the port and the surrounding environment, focusing in particular on issues such as intermodal transport and cargo added-value services.

In these two logistical lines there are several components such as cargo handling capacity, port and support infrastructures, efficiency and

operations productivity, operations time and costs and service quality provided that will define the competence and performance.

3. Evaluation model proposed

The evaluation model proposed is result of the fulfilled literature review. This model appears after has been verified a lack of key performance indicators to measure the logistic performance by the ports or terminals. Although logistic performance is the main purpose of the model some aspects related to the size, capacity and activity of the port were incorporated in this model since they are aspects that enhance or limit logistic performance.

3.1. Approach – Performance

Indicators Battery

Performance indicators are pieces of information used to measure and evaluate the performance of a system (Sarwar, 2013). These are developed to reflect on the achieved performances which is a crucial activity for the success of a company or system. Through their use performance indicators allow not only the measurement of performance but also comparisons with other companies/systems through analysis of the contained information which makes them a tool that allows the establishment of goals and targets for development.

With the heterogeneity of the Portuguese ports and the definition of logistic performance and also the actors involved in the ports operations it was assumed as most useful for the comparative analysis the use of key performance indicators. This method allows separate the various elements inherent to the logistic performance and analyze them in an

isolated way. This is an approach that benefits from several factors as a formal simplicity which does not resort to sophisticated techniques and is understandable by anyone which facilitates the communication and results dissemination. This simplicity is also in line with the current state of Portuguese ports performance assessment.

3.2. Model construction

The construction of the desired model implies the key domains selection for it which means highlight critical success factors that are essential to the port competitiveness particularly in the logistical performance.

With this a careful selection of domains and indicators is necessary in order to the model can represent port reality in their multiple dimensions with relevance to the logistic performance the best possible.

This model was based in part on the World Bank Logistics Performance Index (LPI) seeking to transpose their criteria into the port context. In other part was based in the criteria used by Le Havre port in her Container Performance Indicators report (Paschetta e Martel, 2014). This analogy aims to create groups of indicators that can represent the main dimensions in ports logistic performance. After select the main domains of the model these ones was feed with some performance indicators founded on the literature review.

3.2.1. World Bank Logistics Performance Index (LPI)

The Logistics Performance Index is a benchmarking tool developed by the World Bank that measures performance along the logistics supply chain within a country. Allowing comparisons between countries this tool help

countries identify challenges and opportunities and improve their logistics performance (The World Bank, 2016).

The LPI analyzes countries in six components:

- The efficiency of customs and border clearance (“Customs”).
- The quality of trade and transport infrastructure (“Infrastructure”).
- The ease of arranging competitively priced shipments (“Ease of arranging shipments”).
- The competence and quality of logistics services – trucking, forwarding, and customs brokerage (“Quality of logistics services”).
- The ability to track and trace consignments (“Tracking and tracing”).
- The frequency with which shipments reach consignees within scheduled or expected delivery times (“Timeliness”).

Five of these six components were used as starting points in the choice of the domains to the designed model.

3.2.2. Port of Le Havre Container Performance Indicators

Le Havre Port provides to all the stakeholders involved or interested in the vitality of their port community a set of performance indicators related with the containers operations.

This indicators are divided in four detailed sets that every reader can assess and compare the results. The sets of indicators that covers all the operations of port logistics according to Le Havre Port perspective are the shipping

performance, the transit of goods, onshore performance and customs and health performance.

Le Havre Port Performance Indicators could be considered as a reference about logistic performance thanks for several indicators about waiting times and timeliness that provides useful information to all stakeholders and are more innovating when compared with another works analyzed in the literature review.

3.3. Model domains

Thanks to an analogy with the previously mentioned documents, were selected the domains to be evaluated in this work that are presented in Figure 1.

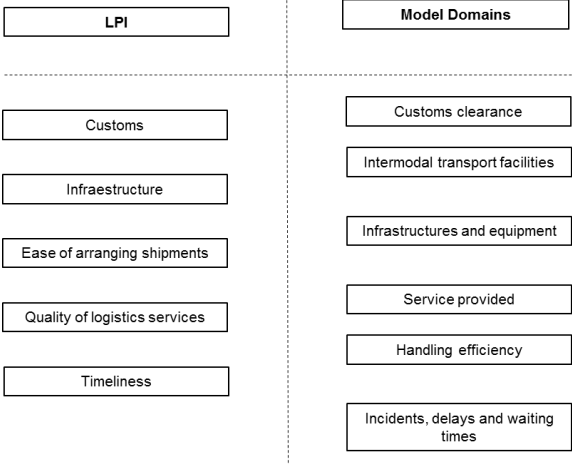


Figure 1 - Model domains

In the port environment, customs are public domain offices that control the movement of goods into and out so they have to consider the relationship between the requirements of control and facilitation of processes. It is perceived that customs clearance plays a relevant role both in port exercise and in logistics chains port integration due to the impacts it causes in times and costs of the system. Therefore it is a point that deserves

attention in terms of port performance evaluation.

Chen et al. (2016) summarize that the physical properties of the port-hinterland connection are the basis of the measurement of their connectivity and that depends on the intermodal transport and the terrestrial facilities to which the goods follow. Thus, the intermodal transportation facilities are of interest in the study of this theme because they allow us to understand how the hinterland connection is made, where the containers logistics activities are carried out and the support infrastructures quality. This factors quantify the port reality in terms of Hinterland connection quality.

The port infrastructure is a field of relevance in the evaluation of the port logistics performance. Bassan (2007), Notteboom and Rodrigue (2009) and De Langen (2008) are some of the authors who argue that port infrastructure is a good representation of the performance, the capacity and the competitiveness of the port since every product produced by the port is dependent on them.

In addition to the good port operational performance in the perspective of the direct users the position of the client should be considered in order to be able to analyze what port offers based on their infrastructures and operating conditions. As LPI suggests the provision of transport services as a criteria in the port reality it is also essential to evaluate the service provided by the port with regard to the available services and the costs / tariffs.

The absolute volume and cargo handling efficiency are the most used domains reviewed in the literature about port performance evaluation. The absolute volume of cargo

handled is the most used indicator by port communities to represent the production and to classify ports (De Langen et al., 2007). The terminals handling process efficiency with particular attention to the equipment, facilities and labor is another point of attention because it represents utilization quality and performance of the actors that intervene in this crucial phase to port process.

Incidents, delays and waiting times there are the last domain suggested by the model. In the literature review was found some indicators connected with them and the decision to group the three is related with the fact of them expose the operations negative points.

3.4. Performance Indicators in study

In this point pretends to show the performance indicators for each domain. Though several indicators are just capacity indicators they are considered the same because they have influence in the logistic performance. The indicators selection was based in the literature review and in some meetings with port and terminal actors that help this document with their empirical knowledge. A total of 72 indicators were selected.

3.4.1. Customs Clearance

In this domain three indicators were chosen. The first is the time that the container takes to exit the port after the client request. The remaining two are the lead-time to obtain a gate out authorization with and without physical inspection, this means the period of time that elapses since the withdrawal requisition until the exit authorization is guaranteed.

3.4.2. Intermodal Transport Facilities

This field intends to analyze the intermodal transport quality from the port to their hinterland and so it is divided into two categories: rail and road.

Thus in the railway field the chosen indicators are the number of train's calls, the number of TEU transported by railway, the share of consolidated rail traffic, the average number of TEU transported by train composition, the transit time until a reference railway point and the average time that a train stays in the port.

About the road mode the indicators are the number of trucks that entering the port, the number of TEU that enter the port by road mode, the number of TEU that exit the port by road mode, the average number of TEU transported by each truck, the share of consolidated road traffic, the transit time until a highway and the average time that each truck stays in the port.

The last indicators of this domain are related with the place where happen the cargo value added activities. To evaluate this the model suggest as indicators the share of containers that logistic activities areas, logistic platforms and dry ports, warehouses of logistic operators and the final client.

3.4.3. Infrastructures and Equipment

The infrastructure and equipment characterization is considered a good representation of the port reality, capacity and size.

The logistics activities area is one of the indicators because represents the areas where cargo logistics operations occur.

Other aspect to consider is the terminal storage capacity. Thus as indicators the model contemplates the terminal size, the number of TEU slots available and the average time that a container is parked in the terminal for import and for export.

Finally the indicators related with containers handling equipment. In this field the model considers the number of berth cranes, the throughput capacity installed in the terminal and units of land equipment.

3.4.4. Service Provided

For this domain were considered aspects in order to analyze in a summary way the port service, their rates and the tools used to provide it.

About the rates the model analyses the price of load/unload operations, storage and storage days free of taxes.

The number of workers in the terminal operations, the number of labour hours, the technological tools available, the number of maritime services offered by the port and the share of intercontinental maritime services are another service indicators.

Finally the model consider as indicators in this domain the relationship between empty and full containers added value services as quality control, product refinement, repackaging and consolidation/deconsolidation works.

3.4.5. Handling Efficiency

This domain incorporates three aspects: containers and ships throughput, throughput efficiency and utilization share of the terminal.

The first includes as indicators the total number of container ship port calls, the port TEU

throughput, the number of TEU in transshipment and the index containers/TEU.

The second contains as indicators the number of TEU throughput by crane and the number of TEU throughput by worker.

The third embrace in terms of terminal utilization the number of TEU by quay meter, the number of ships by quay meter and the quay utilization share. Focus the storage areas includes as indicators the number of TEU throughput by terminal square meter and the relationship between the average number of containers storage and the terminal storage capacity.

3.4.6. Incidents, delays and waiting times

In order to quantify the elements of port operation that suffered any kind of physical damage were selected as indicators the share of TEU with incidents (TEU per thousand) and the share of ships with physical damages (ships percent).

In the delays field the model suggest to identify the delay responsibility. Thus, there are four indicators that are the share of ships delayed with responsibilities to i) the port; ii) the quay; iii) the towing and iv) bureaucracy.

The third aspect in this domain are the waiting times who were considered 6 indicators. The average ship waiting time by terminal incapacity, the average time that a ship stays in the port, the average ship berth time, the average time that a ship waits for the operations beginning, the average time that a ship stays berthed without occur any operation and the average truck waiting time to get in the port.

4. Results Analysis

This point purpose is apply the suggested indicators battery in the previous section to the follow Portuguese ports: Lisbon, Leixões, Sines and Setúbal. This ports were selected as study because they are responsible of the almost every Portuguese containers throughput. To this end, a collection of data is required from ports and container terminals, which is admittedly complicated since some data are confidential or in some cases non-existent.

From the data collection, the comparative analysis was performed with the indicators that the available data could feed. In relation to those that have not been obtained information, total or partial, the suggestion is that they can be approached in future analyzes.

For the desired comparative analysis it was sought to collect data of 2015 and therefore, the data collected for Lisbon, Leixões and Sines are from that year although for Setúbal only information regarding 2016 was obtained.

From the 72 indicators that made up the suggested model, only for 10 indicators were obtained data from the 4 ports initially under study and for 17 indicators was collected information for 3 ports. Of the remaining indicators, it should be noted that for 10, was collected information to 2 ports, with 17 of the indicators for which only 1 of the ports obtained data and 18 in which there were no records. These last two cases do not allow for any kind of comparative analysis.

The Intermodal Transport Facilities indicators which data was gathered is exposed on Table 1.

In the railway mode, the port of Sines stands out as the one that most TEU move both in an absolute and relative way because it is in this port that the largest movement volume occurs (208 thousand TEU), the largest number of TEU moved by each (43 TEUs per composition) and the highest share of TEUs handled by railway in relation to the total volume (16%). In Sines, this value of 16% gains a larger dimension consider that this port is specialized in transshipment and therefore, if the analysis is only done to the TEUs throughput to the hinterland, the railway mode assumes a 74% fraction of this movement, being this the preponderant mode of transportation in this port. This value is much higher when compared to the ports of Lisbon and Setúbal.

Road transport represents the main hinterland connection in Lisbon and Setúbal, where it assumes 67% and 90% of the total TEUs throughput, respectively. From the results obtained, it was observed that in Lisbon, on average, each truck carries 1.44 TEU while in Setúbal this value is 1.77 TEU, which may indicate that in the port of Setúbal more often occurs the ideal situation in which the same truck unloads and carries a container in the port.

Table 1 - Intermodal Transport Facilities

4.4.2	Lisbon	#	Leixões	#	Sines	#	Setúbal	#
A	24.023	2º			208.950	1º	14.068	3º
B					4.886	1º	543	2º
C					43	1º	26	2º
D	155.524	1º					72.401	2º
E	166.609	1º					67.985	2º
F	223.333	1º					79.143	2º
G	1,44	2º					1,77	1º
H	25	2º					15,32	1º
I	4,99%	3º			15,68%	1º	8,99%	2º
J	66,9%	2º					89,7%	1º

A – TEU transported by railway; B – number of train's calls; C – TEU transported by train composition; D – number of TEU that enter the port

by road mode; E – number of TEU that exit the port by road mode; F – number of trucks calls; G – average number of TEU transported by each truck; H – average time that each truck stays in the port (min); I – share of consolidated rail traffic; J – share of consolidated road traffic;

The Infrastructures and Equipment indicators which data was gathered is showed on Table 2.

In the Leixões and Sines cases, which there are logistic activities areas associated to the port and this area is measured, it is possible to relate the area dedicated to logistic activities available to the port with the nominal installed movement capacity and thus conclude that this relation is greater in Sines than Leixões, which means that in Sines is expected more area dedicated to logistic activities for each TEU throughput in the port.

In an analogous way but considering Lisbon and Leixões ports, it is possible to relate the terminals storage capacity of containers and the total area of the terminal and thus conclude that the port of Leixões has more storage capacity in TEU for each terminal hectare.

Table 2 - Infrastructures and Equipment

4.4.3	Lisbon	#	Leixões	#	Sines	#	Setúbal	#
A	0	3 ^o	66	2 ^o	245	1 ^o		
B	33,5	2 ^o	18,5	4 ^o	39,1	1 ^o	20,2	3 ^o
C	21.178	1 ^o	19.000	2 ^o			8.736	3 ^o
D	11	1 ^o	6	2 ^o	11	1 ^o	2	3 ^o
E	39	1 ^o	23	2 ^o			7	3 ^o
F	930.000	2 ^o	600.000	3 ^o	2.100.000	1 ^o		

A – Logistics Activities Area (hectare); B – Terminal size (hectare); C – TEU available slots; D number of berth cranes; E – number of land equipment's; F – nominal throughput capacity installed;

The Handling Efficiency indicators which data was gathered is showed on Table 3.

Through the joint analysis of the indicators related to the number of berth cargo handling equipment and the installed handling capacity, it is possible to speculate on their quality and

the operating capacity they have. With that, on average, each equipment has a nominal capacity to handle approximately 84,000, 100,000 and 190,000 TEUs per year in Lisbon, Leixões and Sines, respectively, so it is understood that in the case of Sines there is a better equipment utilization or better quality equipment.

In the years under study, the port of Sines was the one that most TEU throughput, followed by Leixões, Lisbon and Setúbal. The greatest part of Sines throughput (79%) was in transshipment. The number of TEU throughput in Leixões that same year (624 thousand TEU) exceeded what is the nominal capacity of annual announced movement of the port (600 thousand TEU), reason why this will be near a saturation point. In Lisbon and Sines cases there were values in the order of 51% and 63% of use of what is the nominal capacity of movement installed in the port, respectively.

The berth use by the number of ships to operate was more intense in the port of Leixões than in the in the others, since this was the one that received the most ships and also presented the highest rate of ships received by berth each meter available.

Table 3 - Handling Efficiency

4.4.5	Lisbon	#	Leixões	#	Sines	#	Setúbal	#
A	945	3 ^o	1.288	1 ^o	1.126	2 ^o	441	4 ^o
B	481.289	3 ^o	624.009	2 ^o	1.332.200	1 ^o	156.567	4 ^o
C			36.008	2 ^o	1.048.285	1 ^o		
D	43.754	4 ^o	104.002	2 ^o	121.109	1 ^o	78.284	3 ^o
E	260,0	3 ^o	693,3	2 ^o	1162,5	1 ^o	216,0	4 ^o
F	0,92	3 ^o	1,43	1 ^o	0,98	2 ^o	0,61	4 ^o
G	1,44	3 ^o	3,37	2 ^o	3,41	1 ^o	0,78	4 ^o

A – number of container ship port calls; B – TEU throughput; C – TEU in transshipment; D – TEU throughput by crane; E – TEU throughput by quay meter; F – Ships by quay meter; G - TEU throughput by square meter;

From the point of view of the TEU movement due to the physical characteristics of the terminal, Sines stands out, not only because it has the highest total number of TEUs handled, but also because it has the highest rate of TEUs handled by berth handling equipment in the terminal and also the largest number of TEUs operated by each berth meter. With this, we can conclude that is in Sines that the berth and the cargo handling equipment reach higher profitability. From the relationship between the number of TEUs throughput with the terminal area, Sines appears again with the best use, but this time with Leixões have a value of quite similar use.

The Incidents, delays and waiting times indicators which data was gathered is showed on Table 4.

When taking into account the two temporal indicators that can be analyzed, it is observed that the port of Setúbal has the best behavior. This conclusion is taken from the fact that Setúbal presents an average trucks stay time in the port (Table 1) inferior to Lisbon and also for the average time that each ship stays in the terminal that is inferior comparing with Leixões.

Table 4 - Incidents, delays and waiting times

4.4.6	Lisbon	#	Leixões	#	Sines	#	Setúbal	#
A			18,8	2 ^o			16	1 ^o

A - Average ship berth time;

5. Conclusions

This document allows to draw some conclusions on the logistic performance of ports in addition to the results analysis made.

From the literature review, it was concluded that the most used port performance evaluation techniques were divided into two main groups:

production functions (DEA, SFA, etc.) and key performance indicators (KPI). There are also several notions about terminals and their logistics chains integration. In the case of container terminals, their activities can be divided into four large groups, the land-sea cargo movements (from ships to land, and vice versa), cargo handling inside the terminal, storage and the terminal connection with their hinterland. Since the junction of the first two groups indicated forms the first terminal logistic line and the second two groups form the second terminal logistic line. In order to define what is the logistic performance two fundamental aspects were extracted for it. The first one is a good performance in the operations that occur inside the terminal and the second one is a good articulation and integration with their surroundings. Thus, from these two aspects, the various actors present in the port and with influence in them (customs, port services, shipping agents, maritime terminals, etc.) were identified in order to direct battery of indicators to them.

With the suggested indicators battery, was identified 72 indicators through which the comparative analysis between the ports under study would be elaborated. The available data scarcity was one limitations to this study, so the indicators can be divided into three groups. The first one where 37 indicators could be fully or partially fed and therefore it was possible to draw up the comparative analysis. A second one, composed by 17 indicators, which only was obtained information for one port and where several indicators of the "Service provided" and "Incidents, delays and waiting times" domain are found. And a third in, which no data were obtained, where the indicators of the domain "Customs clearance" and

"Incidences, delays and waiting times" are mostly inserted.

Some proposals for the development of this paper that can be taken into account in the near future and which would complement the present work and contribute to the development of the port logistics sector: 1) It would be desirable to restructure the suggested indicators as there was a large part of them for which no information was obtained. In this restructuring, it is advisable to verify the applicability of the same and replacing them with others that are considered more practicable. 2) It would be of interest to suggest more indicators or areas of evaluation for which it is relevant to develop port performance indicator sets. 3) Since for a number of indicators only one port data was recorded (transit time until a reference railway point, average time that a container is parked in the terminal for import and for export, number of maritime services offered by the port, share of intercontinental maritime services, added value services, TEU throughput by worker, the relationship between the average number of containers storage and the terminal storage capacity, share of TEU with incidents, share of ships with physical damages, average truck waiting time to get in the port), it will be encouraging seek to collect this data from the missing ports in order to enrich the present comparison of the logistic performance of the Portuguese ports in a deeper and more comprehensive way.

References

Bassan, S. (2007). Evaluating seaport operation and capacity analysis - preliminary methodology. *Maritime Policy & Management*, 34 (1), pp. 3-19

Chen, S-L., Jeevan, J. e Cahoon, S. (2016). Malaysian container seaport-hinterland connectivity: status, challenges and strategies. *The Asian Journal of Shipping and Logistics*, 32 (3), pp. 127-137

De Langen, P. W. (2008). *Ensuring Hinterland Access – The Role of Port Authorities*. Erasmus University Rotterdam and Port of Rotterdam Authority. Netherlands: Joint Transport Research Centre.

de Langen, P., Nijdam, M. e Van der Horst, M. (2007). New indicators to measure port performance. *Journal of Maritime Research*, (4) 1, pp. 23-36

Paschetta, C. e Martel, H. (2014). *Container Performance Indicators*. Porto de Le Havre e HAROPA

Rodrigue, J.P. e Notteboom, T. (2009). The Terminalization of Supply Chains: Reassessing the Role of Terminals in Port/Hinterland Logistical Relationships. *Maritime Policy & Management*, 36 (2), pp. 165-183

Ringsberg, H. e Lumsden, K. (2015). *Managing logistic port operations based on a standardized framework*

Sarwar, N. (2013). *Time-related key performance indicators and port performance: a review of theory and practice*. Faculty of Technology and Maritime Sciences - Vestfold University College

The World Bank (2016). *Connecting to compare - trade logistics in the global economy. The logistics performance index and its indicators*

UNCTAD (2015). *Review of maritime transport 2015*. United Nations Conference on Trade and Development