A Framework to Evaluate the Performance of Transport Chains: Case Study: Port of Sines and Janela Única Logística (JUL)

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Outubro de 2019

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Abstract

Modes of transportation and their associated technological development have accelerated globalization and today with a simple click, you can easily get something from the other side of the world.

Intermodal transport uses the same standardized cargo unit and seamlessly combines the various modes of transport to overcome intercontinental distances. The emergence of the container together with information and communication technologies were the great drivers of world trade. Goods transportation started to use containers and because of that, it was possible to streamline the loading and unloading procedures between different modes of transport. As a result, less time in terminals during shuttle exchanges, less damages, theft and loss during transportation service and shorter stays in terminals. However, the inefficiencies inherent due to the number of people involved in the intermodal transportation chain have grown, which requires greater organization and coordination among them and a better sense of responsibility. The different technological levels of agents also make it difficult to interact and share information. Port Community Systems, which was once only dedicated to collecting port information with focus on shipping, figured out the need to extend its role to other transportation modes that serve port nodes.

These platforms are data collection points that can provide updated information and review in order to provide important information to those who actively participate in the intermodal chain. In this sense, it was important to establish a framework that allows us to measure the performance of intermodal chains and some key moments that influence its efficiency in the chain.

In this sense, it was important to establish a framework able to evaluate the performance of intermodal chains, based on the data available on the Port Community System (PCS) – Janela Única Logística (JUL).

Keywords*:*

Intermodal Transportation Chains; Performance Indicator; Framework; Janela Única Logística.

1 Introduction

Globalization is a phenomenon that was possible because of the evolution of transports, with reduced costs and travel time. Today you can buy any good or service from across the world at reduced costs. Intermodal transportation comes up with the emergence of standardized cargo units, more specifically with the container. With this, numerous advantages, including the fact that there is no direct contact with the goods, streamlining procedures in modal exchanges reducing the occurrence of losses and losses and damages. However, it stills being inefficient during modal changes and because of the number of people involved in the intermodal transportation, what makes this transport complex.

According to AMT (2018), maritime transport represented 76% of international traffic in 2017. This is the way that moves the huge amount of cargo. it is in ports that exchanges between sea and land occur. “The term - port - comes from the Latin “portus”, meaning port or exit” (Caldeirinha, V., 2007). According to Caldeirinha, V. (2007), the port “needs decongested ground connections and available and nearby logistics and industrial areas to allow effective flow in connection with hinterland and the installation of new industrial and logistics businesses”.

In the European panorama and in the transport of goods, Portugal is the main entrance of Europe. The country that connects Europe to Africa and America. It is in this sequence that the importance of the Port of Sines comes up, which along time has been increasingly integrating European and worldwide logistics chains, considered nowadays the Atlantic "door" and simultaneously a hub, in the distribution of cargo through transhipment, not forgetting, keeping at the same time its gateway function. Cargo Magazine, based on an analysis by Theo Notteboom, states that Port of Sines represents the largest growth between 2007 and 2017 in Europe. Cargo Magazine also adds "the Portuguese port has increased its container handling by more than 1000%, being the great example of an emerging port in the last decade".

Because of the importance of Port of Sines in the national and international trade, it was considered necessary to analyse the steps towards efficiency. This is why the case study of the Janela Única Logística (JUL) project, which started in 2018, was considered necessary. JUL is a Port Community System, which replaces the JUP, which only compiled information related to ports. The scope of JUL will be extended to land transport, dry ports and logistics platforms. "If a port / terminal is capable to support and integrate all these data sources, then internal decision could be improved, but this cannot be guaranteed without the cooperation of importers, carriers, shipping agents, ship owners and in some cases, a wide variety of local authorities "(Willis, R. and Holgate, S., 2018).

The analysis of performance indicators crosses all areas in search of better results. In intermodal transport, in which various actors participate, it may lead to better levels of commitment from different entities if they recognize that good or bad performance influences the overall performance of the chain. Comparative results from performance indicator analyses by others in the same area of work that prove to be successful, it sharpens the sense of doing more and better, which is the function and purpose of the benchmarking tool.

2 Methodology

In this section, it will be explained the tasks developed to achieve the proposed objective. The first stage was concentrated in literature review to build a solid knowledge of theoretical concepts regarding intermodal transport chains and performance indicators. Literature review resulted in a vast compilation of performance indicators which through a synthesis process resulted in a smaller list of 94 performance indicators. The case study is divided into two parts. The first one describes the Port of Sines and the general architecture of the PCS, JUL. While the second part is the result of the consolidation of the different works developed:

- Analysis of the architecture and the main macroprocesses / processes related to JUL intermodal transport;
- State of the art by creating a deep theoretical basis of concepts and a list of performance indicators;
- Information gathered through interviews, surveys, on-site procedures observation and access to project documentation.

After gathering these three works, it was possible to reduce the list of 95 indicators through interactions, and get a final number of 15 indicators capable of assessing the performance of intermodal transport chains, resulting in the construction of a framework and individual observing forms that could characterize the selected indicators.

3 Case Study: Port of Sines and the JUL

3.1 Port of Sines

The port of Sines is the national leader in total cargo transported and the third in Iberian ports. It is also the busiest cargo in containers in Portugal. It represents more than 50% of the cargo handled in Portugal by sea and where 74% of Portugal's energy products stop. It is a deep water port, capable of receiving all ships, with terminals specialized in all types of goods and capable of expanding, allowing the reception of new customers and businesses. It also has regular weekly services around the world, 24/7 operations, cutting-edge technology and space to host new businesses near the

port. Cargo Magazine, based on the analysis by Theo Notteboom, states that Port of Sines represents the largest growth between 2007 and 2017 in Europe. Cargo Magazine also adds that "the Portuguese port has increased its container handling more than 1000%, and can be considered the greater example of an emerging port in the last decade".

3.2 Janela Única Logística (JUL)

The history of Portuguese port information management began 26 years ago. Until 2013, information systems focused only on port activities. However, this new vision of JUL makes possible to integrate a larger number of actors. This new information system is based on the integration of the best practices developed in each port, resulting in one of the best solutions. Still, it must be adapted to the different port realities and the types of connections with their partners.

Despite the purpose, the Janela Única Logístiva (JUL) only started in February 2018, by the Simplex + program, under the coordination and management of the APP and the responsibility of the Ministry of the Sea. According to the presentation of this project, JUL is the "evolution and natural extension of the Single Port Window (JUP)", with greater scope under "the management of information flows throughout the logistics chain, simplifying and dematerializing procedures to all modes of inland transport and in the connection to the Spanish and national dry ports to Madrid".

"JUL should be built in a modular, planned to services, consisting on central installed components distributed by all the involved actor in the process, as well as mobile device applications for IOS, Android and other platforms." (Notebook Charges - JUL).

JUL will also support the implementation of the dry port. The implementation of this new concept aims to speed up cargo transfer between port terminals and dry ports. Fast release of cargo results in shorter container port times, resulting in increasingly essential space savings due to increased inbound and outbound freight transport.

4 State of the art on freight and performance

"Transportation ensures the link between Chain links providing added value by creating utility of place and time: moving products to the right place at the desired time and in the desired conditions (quantity and quality)." (Carvalho S. et al., 2017, p.194).

The emergence of containerization increased intermodal transport. Gharegozli A. et al. (2019) quoted the description of intermodal transport by Bontekoning et al. (2004):

"The (European) movement of goods in the same, standardized, loading unit, which successively (by transhipment) uses rail or barge transport for long-haul and road transport for the short-haulage in a single seamless journey, without handling the goods themselves in changing modes. Furthermore, the journey is characterized by decentralized control because of the multiple actors in the chain."

Intermodality modes more integration and complementarity between modes, taking advantage of the added value of each mode in order to achieve a more efficient system.

Intermodal transportation chains take advantage of each mode of transport. Capacity, reliability, flexibility, speed and cost are important features of the modes of transport. The choice of transport combinations in the intermodal chain depends on the origin and destination of the goods, their characteristics and their value, combined with the possibilities of existing services. Caldeirinha, V. (2007) says that changes are expected in the future and that it is up to consumers to make the choice between speed or low cost in each case as well as in each product.

4.1 The role of information

Knowledge of information is indispensable for the proper functioning of the intermodal chain. Several authors, such as Gharehgozli A. et al., (2019) point out as a key to success, the availability and sharing of current data and information accurately and efficiently in intermodal chains. Shared information should be seen by agents as a competitive advantage, because it allows them to anticipate decisions

and tasks, speeding up processes and culminating in efficiency gains along the chain. According to Muñuzuri J. et al. (2019), based on studies developed by other authors, he points out the lack or delay of information as the main causes for operational inefficiency.It introduces disturbances and difficulty in programming and planning the upcoming actions. In addition, reduced flow balances of empty and full containers, unexpected congestion or unwanted terminal dwell times are also related.

Gharehgozli A. et al. (2019) consider that the main problems of information exchange are: double information (each organization in the intermodal supply chain uses its own information system, communication language, software and specific structure); wrong information (differences between information systems , structure and language, so it is necessary to clarify what information to enter in the input fields); updated information (sometimes information is not exchanged at the right time); and unknown information (often organizations do not know which relevant information to exchange).

Through the extensive analysis by Macedo P. (2017) it was possible to know the key moments for the performance of the intermodal chain. The author concludes “that the moment of arrival and departure of goods in terminals, the loading / unloading of the cargo, the legalization before the customs service and the change of mode, are critical moments of the chain and that, in most cases, the importation is a slightly a more complex process than exporting. ”

4.2 Information Systems

Posset et al. (2010a e 2010b) underline the importance of modern information and communication technologies role to assure a competition without friction and intermodal transport.

Gharehgozli A. et al, (2019) points out as benefits of using communication platforms: better coordination, lower transaction costs, reliability, shorter transit times, greater security and lower transportation cost.

The adoption of ICT in logistics and transport is mainly due to cost reduction and the provision of better levels of service quality. Other factors mentioned are the monitoring of transport services, and some authors refer to security issues (Muñuzuri J. et al., 2019).
In the ports, PCS came up to that effect, initially compiling information about the port. The PCS is defined by the International Port Community System Association (IPCSA) as "a neutral and open electronic platform enabling intelligent and secure exchange of information between public and private stakeholders in order to improve the competitive position of the sea and air ports' communities". It also adds that the PCS "optimizations, manages and automates port and logistics processes through a single submission of data and connecting transport and logistics chains".

PCS dramatically reduce the role, improve the quality of information, synchronize the integrity of information between different actors and support the planning and management of operations (Simão J., 2012).

The Single Window concept is the act of submitting information or document once in a single place. This term is often associated to the One-Stop-Shop concept, which means a single place to address issues related to multiple entities. Its goal is to solve the problems as duplicate information by reusing the same information for the various actors.

Although PCS have developed a lot in recent years, “Many studies have found that cooperation and communication between actors is poor, while current information systems are often incompatible.” (Gharehgozli A. et al., 2019).

4.3 Performance Indicators

Although performance analysis is transverse among all areas, there isn´t a lot of bibliography available on intermodal transport chain performance. The ones that exist focus on a specific point in the chain, such as the mode of transport or terminal typology. Only the authors Posset et al. (2010a e 2010b) analyse intermodal chains. Other authors focus their work on the specific performance of a particular agent or task without assessing their impact on it.

In the early part of the study by Posset et al. (2010), the authors investigated and compiled the work developed by transport and logistics organizations, criticizing the fact that they focus on “performance indicators for specific transport modes and related infrastructure (rail, road, inland waterways) without taking into account the "Big picture" of intermodal transport. "

Despite the study by Posset et al. (2010a e 2010b) is very complete, it does not include maritime transport, which is fundamental with regarding JUL scope. To fill in the gap of references to maritime transport in the work of Posset et al. (2010a e 2010b), it was considered relevant to analyse articles that include this mode of transport in their studies, such as the article by Ha M. et al. (2019) on performance of container terminals in logistics. It was also considered the work of the authors Morales-Fusco P. et al. (2017) which focuses on the organization of performance indicators for intermodal terminals, namely ports.

One of the studies considered in the bibliography review by Posset et al. (2010a e 2010b) is the LPI (Logistic Performance Index). This project is particular interesting for the inclusion of a set of indicators capable of assessing customs service, more precisely, the efficiency of the clearance process (eg speed, simplicity and predictability of formalities).

5 Framework to evaluate the chain performance based on PCS, JUL

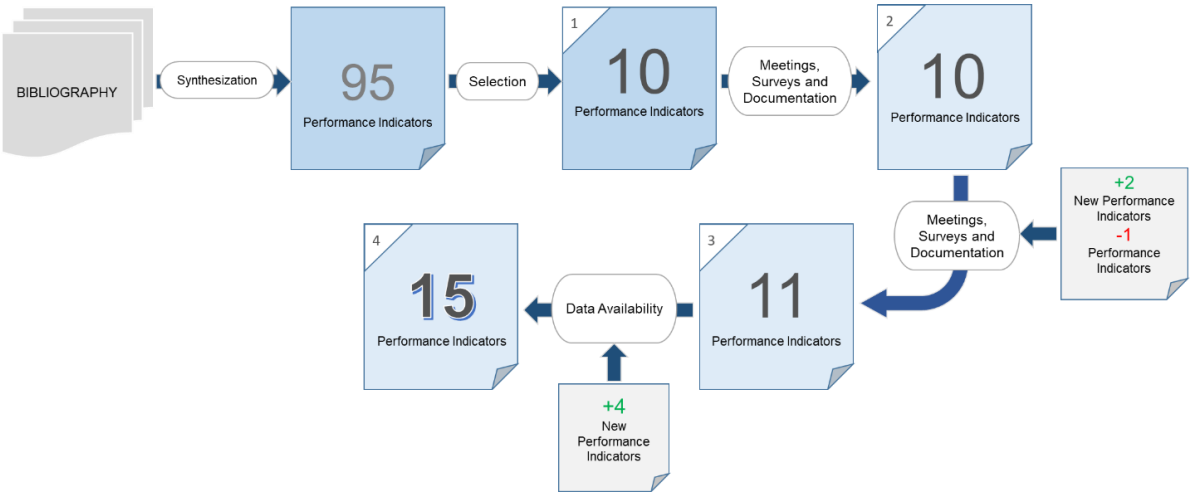

Figure 1 - Performance Indicator Selection Process

Figure 1 shows, in schematic form, the indicator selection phases, until reaching the final set of 15 performance indicators to be included in the reference framework, represented in Table 1.

These indicators were selected with the purpose of assessing the performance of the intermodal chain as a whole, excluding all indicators that are limited to assessing a specific moment in the chain, except, as we shall see, the ones associated to Customs indicators. So, during the selection, there was a special attention while choosing transverse indicators at all times in the chain and that respected the three dimensions (operational, safety and environmental policies) under analysis, which were not redundant and in contrast, were specific. From this first approach, financial indicators were excluded due to the lack of data and information available at JUL regarding costs and prices.

The option to include two indicators related to customs is due to the fact that the customs procedure represents a critical moment in the chain, as analysed by Macedo P. (2017) and because of that, there was a need to monitor its performance.

Throughout the interactions it was necessary to make changes at the designation level to make them more intuitive and even at the content level. The changes made at the content level are mainly due to the unavailability of data in the JUL or because upon observing procedures it was found that the performance indicators would not have practical applicability.

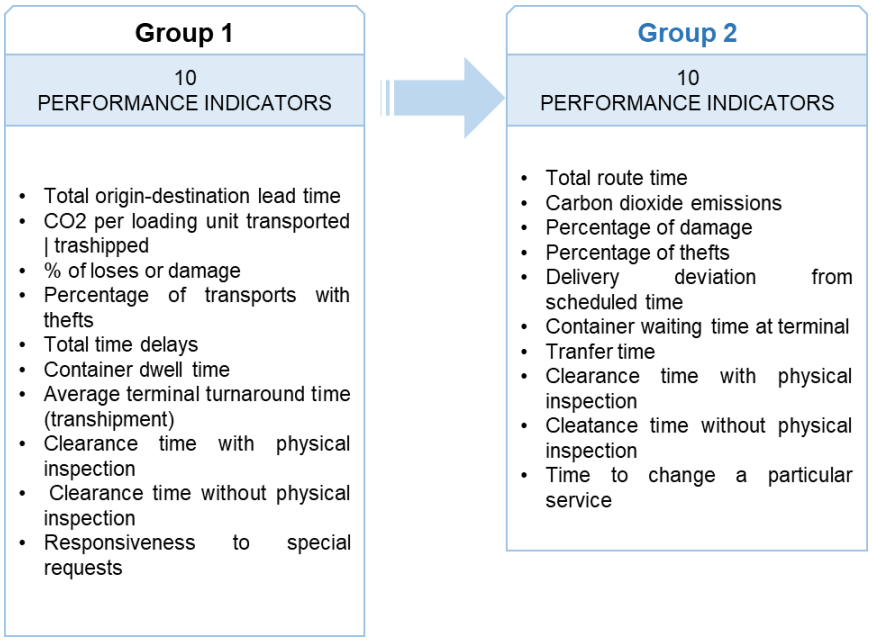

Figure 2 - Performance indicators Groups 1 and 2

Finally, four new indicators were added because there were data that could measure them. Although three of the indicators are specific to particular agents, they explain the performance of intermodal transport chains. The fourth indicator makes it possible to assess the impact/benefit that the implementation of the legal concept of dry port will have on the chains in terms of total journey time.

For each indicator, an individual form was created which can be found in Annex G of the Dissertation: "Quadro de Referência de Avaliação de Desempenho das Cadeias de Transporte: Caso de Estudo Porto de Sines e a Janela Única Logística (JUL)". The individual sheet to point out performance indicators as in Figure 3.

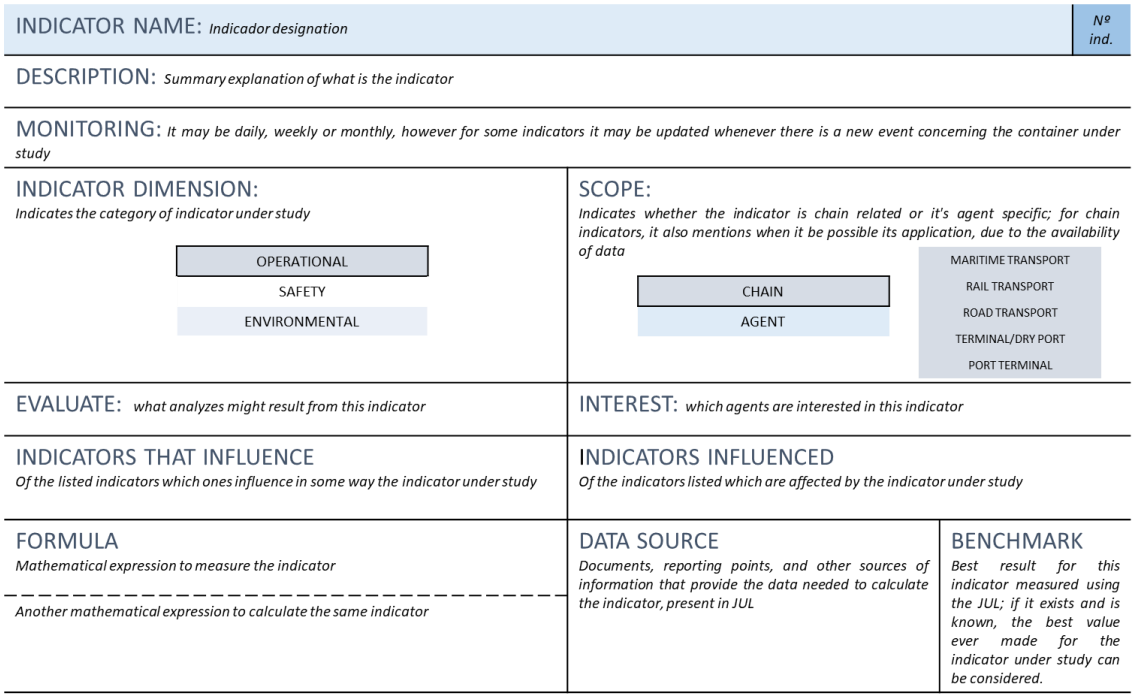

Figure 3 - Individual sheet for performance indicators

Table 1 - Framework to evaluate the intermodal transport chain

Nº IP	PERFORMANCE INDICATOR		DESCRIPTION	FORMULA
1	TOTAL ROUTE TIME	O	Time since the container enters the jurisdiction of a national port aboard a ship given by the crossing of the border line (CBL) until it reaches its final destination on national soil, in the case of an import. Or the time from the container out of its origin in Portugal until it crosses the CBL of a national ports for export. Also some origins/destination in Spanish territory, provided there is a report in JUL, in case of the legal concept of dry port.	1) Date/time of arrival at final destination – Date/time of CBL entered into portuguese port (IMP.) 2) Date/time of CBL exit from a national port – Date/time of departure from origin (EXP.) 3) Sum of haulage times, time spent at terminals and time in loading/unloading operations
2	CARBON DIOXIDE EMISSIONS	E	Total CO_2 emissions produced during the journey of the container from leaving the port of origin (previous port) until it reaches its final destination screened by JUL in the case of an import. When it comes to na export, it's the emissions produced from the container leaving a source known by JUL to the port after national port. The calculation of this indicator requires several data, which JUL doesn't have, being necessary to use the estimated and maximum value	Sum of CO_2 emissions produced during the container journey, which includes the emissions caused by each mean of transport used and those resulting from its stay in terminal, which comprises the loading/unloading and handling movements within the park.
3	PERCENTAGE OF DAMAGE	S	Damage can be applied to all terminals and transport services, with the exception of shipping by the lack of information and road transport in the final stride if it does not join the service sheet. This information can be found in the physical check of the container at the terminal gate, registered by the terminal operator.	Number of damaged containers/Total number of containers
4	PERCENTAGE OF THEFTS	S	Like the previous indicator, this indicator is also calculated for the terminal and transport services, with the exception of shipping and the last part of road transport for the same reasons. This indicator is calculated through physical verification information about the state of the container seal.	Number of containers with seal violation/Total number of containers
5	DELIVERY DEVIATION FROM SCHEDULED TIME	O	This indicator reflects delays/advances in transportation services. For maritime transport the report is made at least two hours before the ship arrives at the port, by modes of the Scale Announcement - Arrival Advice containing the ETA (*Estimated Time of Arrival*). ETA can be updated throughout the trip so it will be considered the first. ETA is considered in imports and is compared to the date/time given by the "PLF - entry" reporting point. For rail transport, this indicator will only take into account the actual dates/times and the estimated arrival dates/times of the container under study at the station where it is unloaded. Finally, in road transport, when the destination of the container is a port/terminal/dry port facility, delivery is scheduled in a time window and the date/time of truck entry through registration in the gate (gate-in). For another destination, referred to as the final destination, the expected delivery date/time may only exist if the road hauliers adhere to the service record. If there is an ETA of the container, this date/time will be compared to the delivery date/time recorded in the "proof of delivery" reporting point.	Sum of all deviations in container transport services under study Maritime transport: Date/time of arrival of the ship translated by the reporting point "CBL – Entry"– Expected date/time of arrival of ship (first ETA of arrival announcement) Rail transport: Date/time of train entry to terminal, recorded in the gate – Expected date/time of train entry to terminal. Road transport: Date/time of truck arrival at terminal, registered at the gate – Expected date/time of arrival at terminal (finish date/time of combined time window in Scheduling). Date/time of delivery of container at final destination (Proof of Delivery) – Expected date/time of delivery (Service Sheet) Advances (-) Delays (+)
6 (1.4)	CONTAINER WAITING TIME AT TERMINAL	O	Time from the container being checked in at the terminal (in the landing report/unloading report/inbound guide) until the container is checked out (boarding report/loading report/outbound guide).	Date/time of container exit from terminal that appears in the Bill of Lading/Cargo Report/Inbound Guide – Date/time of container entry into terminal (Landing Report/Unloading Report/Entry Guide)

O – Operational; E – Environmental; S – Safety

Continued from Table 1 –- Framework to evaluate the intermodal transport chain

Nº IP	PERFORMANCE INDICATOR		DESCRIPTION	FORMULA
7 (1.10)	TRANSFER TIME	O	Container residence time at port/terminal/dry port facility when customs authority exit clearance is not required when it has already been cleared at another customs office. Time since container is unloaded at the terminal (Landing Report/Unloading Report/Inbound Guide) and date/time when logged at terminal exit (Boarding Report/Loading Report/Exit Guide).	Date/time of container check out (Boarding Report / Cargo Report / Exit Guide) – Date/time of container check in (Unloading Report / Unload Report / Inbound Guide)
8 (1.4.1)	TIME CONTAINER DELAY AVAILABLE FOR CARRIER	O	The biggest difference between the container entry check-in in the landing report/unloading report/entry guide and the time when the customs authority release is granted or when the customer's authorization is reflected in the shipping order /loading instructions/uprising authorization.	Maximum {Date/time authorization of the Customs Authority; Date/time customer authorization (Loading Instruction/Shipping Order/Uprising Authorization)} – Date/time of container entry into terminal (Landing Report/Unloading Report/Inbound Guide)
9 (1.4.1.1)	CLEARANCE TIME WITH PYSICAL INSPECTION	O	Time that elapses since the container has been checked in at the terminal in the landing report / unloading report / entry slip until the moment that Customs Authority gives the exit. This indicator is applied when the container is physically inspected, that information is contained in the container residence.	Date/time of release of Customs Authority – Date/time entry of container at the terminal (Landing Report/Unloading Report/Inbound Guide)
10 (1.4.1.2)	CLEARANCE TIME WITHOUT PYSICAL INSPECTION	O	Time that elapses since the container has been checked in at the terminal in the landing report / unloading report / entry slip until the moment that Customs Authority gives the exit. This indicator is applied when the container is not physically inspected, that information is contained in the container residence.	Date/time of release of Customs Authority – Date/time entry of container at the terminal (Landing Report/Unloading Report/Inbound Guide)
11 (1.4.2)	TIME FROM WHICH THE CONTAINER IS AVAILABLE TO BE LISTED AND WHEN FACTLY COLLECTED BY THE CARRIER	O	Time elapsed since the last exit authorization given by the Customs Authority or the authorization given by the customer (Shipping Order / Loading Instructions / Uprising Authorization) and when container leaves the terminal, that is contained in the Bill of Lading / Cargo Report /Inbound Guide.	Date/time terminal container exit (Boarding Report/Cargo Report/ Inbound Guide) - Maximum {Date/time Customs Authority Authorization; Date/time Customer Authorization (Shipping Order / Loading Instructions / Uprising Authorization)
12	PORT EFFICIENCY	O	Indicator for measuring the efficiency of the terminal operator in the loading/unloading of container ship. It is translated by the ratio of the number of containers moved by the operation time. Operating time starts when authorities gives the authorized by the loading/unloading license and ends on the end date/time reported in the operations report. Often the operation starts before the loading/unloading authorization is given and in such cases the start date / time considered in the ship's operations report.	Number of Containers Handled (Operations Report) / (Date/time of the end of operation (Operation Report) – Date/time of the load/unload license (OR Date/time of start of operation (Operation Report)))
13	RECOVERY RATE	O	This indicator can only be applied to rail because of data availability. At the train location almost all stations are reported with the expected arrival and departure date/time and the actual arrival and departure date/time. Through these data it is possible to calculate the delay or advance in various sections of the train journey.	(Late or Early Time / Estimated Travel Time) * 100
14	ACCURACY RATE	O	Like in the previous indicator, and adjusting to the available data for maritime transport, we can, through the moments when the agent updates the ETA and the ETA date/time, also know the accuracy coupled with the delays/advances on the maritime route.	[(Date/time of reporting point "PLF - Entry" - Expected date/time of Arrival (ETA))/(Date/time of reporting point "PLF - Entry" - Date/time of ETA Update)] * 100
15	TIME EARNED WITH APPLICATION LEGAL CONCEPT OF DRY CONCEPT OF DRY PORT	O	Indicator comparing total journey times to final destinations of similar containers using the same modes of transport but being dispatched at different customs offices. For example, between a container waiting at the Port of Sines for customs clearance to go to Lisbon versus a container leaving Sines towards Bobadela and only there is dispatched.	Travel Time 1 - Travel Time 2 Travel Time 1 - container is dispatched at the second customs office Travel Time 2 - container is dispatched at first customs office but has final destination in the vicinity of second customs office

O – Operational; E – Environmental; S – Safety

6 Improvement Suggestions

The difficulties in the construction of the reference frame are mainly due to the lack of data from the current PCS - JUL. It was necessary to do some adjustments due to the unavailability of essential data in order to build a reference framework with performance indicators that would apply throughout the entire container transport chain.

With the data currently available, operational indicators that measure the specific performance of which task are easily applied, specifically in the port. Such as the length of stay of a ship in port.

The following statements are topics for some performance indicator improvements:

- Total route time: To apply this indicator it is only necessary to know the start and end date/time of the intermodal chain, however, JUL has limitations. This indicator is given by the date of entry/exit of the container by the crossing of the border line (area of jurisdiction of the national port) and by the date/time of entry/exit of the container from the national territory, with a maximum coverage of some Spanish intermodal platforms. The scope of this indicator could easily be applied by incorporating the date/time of departure from the home port (pre-national port) or the date/time of arrival at the destination port (port-national port). Another important data would be the date/time of delivery/collection of the container at the destination/origin by the road carrier.
- Delivey deviation from scheduled time: To Include the delivery date / time at the final destination and the expected delivery date / time as mandatory data of the haulier and not only when the haulier uses the worksheet;
- Clearance Time with physical inspection: to include the start and end date /time of the physical inspection of containers, this information will allow us to know the real time of containers inspection by customs;
- Percentage of Damage and Percentage of thefts: to Include a physical check after unloading the container and moments before loading the container.

In order to increase service indicators role in the assessment of intermodal transport chains, loss information should be included. So, it is recommended that the shipping company share this type of occurrence during transport services at JUL.

Undoubtedly, the environmental indicator translated by carbon dioxide emissions is the most difficult indicator to calculate / estimate but also the most stimulating performance indicator, since in the future it will increasingly reward those who opt for more sustainable solutions. It is appropriate to carry out a further study on the calculation of the “Carbon Dioxide Emissions” indicator and what information is available and projects developed by the EU to make the emissions produced increasingly visible.

It would also be important for actors to turn financial information available about their transportation services in order to evaluate intermodal transport chains across all categories.

7 Conclusions

Nowadays the production and consumption points are increasingly distant, with transport assuming a high importance in the Supply Chain. Bearing in mind the long distances, intermodal transport is best solution for reconciling the advantages of major modes of transport. However, it still has inefficiencies that are mainly due to numerous participants, which in turn requires better coordination and commitment from the parties involved.

From the bibliography analysis, it was possible to check that most of the works are mostly concern with the performance of activities performed by each agent, and not the overall performance of the chain, or the impact that this agent has on chain performance. By that, it was considered important and relevant to construct a reference framework capable of assessing intermodal transport chains using data

available in the next Portugal PCS, which is the main purpose of this article.

As future work it is suggested that the selected performance indicators should be validated through their calculation and should also include declines of the indicators if necessary. Finally, to create a hierarchical structure that includes agent-level indicators and that allows the assessment of the correlation between the delivery of a given agent and overall chain efficiency.

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