Performance Evaluation of the Portuguese Seaports
Evaluation in the European Context

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A global reform of the Portuguese port sector favoured the involvement of private operators in the provision of port services. The port system comprises five major ports, each managed by an independent Port Authority. These were set up as limited liability companies with all their shares held by the State. Port services are gradually being passed on to private operators through concession contracts. The Portuguese and three other countries port sectors were analysed in terms of regulatory policy, governance model, institutional setting and scale and type of operations. These countries are Spain, because it is our main competitor, the Netherlands and the UK, whose ports had the top scores in the performance measurement procedure carried out. In this evaluation reliability and coherence were stressed in order to achieve realistic and useful results. Thus, all the options in the performance analysis were thoroughly discussed and justified. Forty one ports from eleven European countries were included in the sample. The study relied on input oriented Data Envelopment Analysis (DEA) models with Operational Expenses (OPEX) and Capital Expenses (CAPEX) as inputs. Five types of cargo throughputs (conventional, containerized, roll on-roll off, dry and liquid bulk) and passenger traffic were the outputs. All the Portuguese ports had very low efficiency scores except for Lisbon which was deemed as efficient due to a very high volume of passenger traffic. The possible cost reduction if the Portuguese seaports had performed efficiently adds up to 64 million euros in 2005.

Keywords: Seaports, regulation, DEA, performance, Portugal

1 Introduction

The importance of maritime transportation for the global economy is paramount. In terms of weight, about 96% of the world trade is carried by sea, according to Rodrigue *et al*. (2006). Measuring seaports performance is a complex task because they provide a wide range of services and operate in significantly diverse contexts. Most of the analysed countries were reformed or under a reform processes aiming to increase the participation of the private sector. Nevertheless, the form and the extent of private sector participation varies widely from country to country.

This study aims not only to provide relevant and reliable analysis of the Portuguese and international seaport sectors, but also to establish a robust performance evaluation methodology standard. In order to do so a holistic approach was undertaken in the implementation of the performance measurement procedure since non operational issues such as the regulatory policies, governance model, institutional setting and scale and type of operations may significantly affect the performance level of seaports. All these perspectives were considered in this study in order to provide an analysis as relevant and realistic as possible.

2 Seaport sector analysis

2.1 Portugal

With the end of trade barriers in the European single market, Portuguese seaports have been subject to higher levels of competition. Nowadays, it is indifferent to load or unload cargo in any of the seaports inside the European Union. Besides, the external trade share with other EU countries has

been growing, mainly with Spain, at the cost of extra-EU countries trade share as evidenced by Afonso and Aguiar (2004). Trading more with closer countries means that Portuguese seaports are now facing fierce competition from other transport modes, mostly road haulage. Aiming at a higher competitiveness in a globalized market, a port sector reform was initiated and has been gradually implemented. Port Authorities were set up as limited liability companies with all their shares held by the State. Leixões, Aveiro, Lisbon, Setúbal and Sines, the five major Portuguese seaports, are now operating with their own independent Port Authorities. The Port and Maritime Transport Institute (IPTM) established as the national regulator for the seaport and maritime transport sector. However the administration of the secondary continental ports and the navigability of the Douro River have also been delegated to the IPTM. This situation is questionable since, in theory, regulators should be independent from the interests they are regulating.

Nowadays service provision in ports is threefold: directly through Port Authority operational resources, by private companies under short term license agreements or through concession contracts where private operators perform under long term agreements. Private sector participation has been accomplished mainly through BOT (build, operate and transfer) contracts. Usually, as the port industry has become a capital intensive one, contracts have long time-spans of 20 or more years. At the end of the contract period both the infrastructure and the superstructure should be transferred back to the Port Authority in perfect operating and security conditions. Dedicated terminals, i.e., terminals for the exclusive use of a liner service, are not allowed under the current legislatory framework. Nevertheless, a private entity may entail the exclusive use of a terminal for a specific industrial facility, under a private concession use, if public interest is recognized by the Cabinet, as stated by Dias (2005). Concerning other services besides cargo handling, only in 2001 was the possibility of licensing or concession for other port services legally set.
Table 1 describes the way of provision of each type of port services.

Table 1 - Service provision in Portuguese ports

Service	Provider
Cargo handling	Private concessionaires and licensed operators or the Port Authority in exceptional situations
Pilotage	Port Authority albeit concessions or licenses are established under legislation in force
Towage	Port Authority or concessionaires depending on the port
Mooring and Unmooring	Port Authority or concessionaires depending on the port
Fuel supply	Concessionaires in general
Warehousing	Concessionaires, licensed private enterprises and Port Authorities

Port tariffs are established under the Decree-Law no. 273/2000 that sets out the Continental Ports Tariff System. It stipulates the formulas for each and every tariff a Port Authority may charge to cargo shippers and/or vessel owners. Based on these legally set formulas Port Authorities annually define coefficients in order to calculate each tariff. Concessionaires subject to public service contracts must submit their tariffs to the Port Authority. However, they may freely offer rebates solely based on their commercial policy.

2.2 Other countries

The United Kingdom is in the most advanced stage of port sector privatization worldwide. In terms of economic regulation a *laissez fair*[1] policy is pursued. Currently three models of port governance coexist in the United Kingdom. Ports may be under private ownership, municipal control, or managed by a trust. All of them are open to market forces, and are run independently as stand-alone, self-financing enterprises, free from Government support or subsidy hence relying on the dues charged to the port users. Port tariffs are not subject to any kind government intervention or regulation. In terms of labour there is no other regulation to port labour besides the one applicable to the labour market in general. Each port has the ability to define its own labour policies. Port Authorities are responsible for the enforcement of regulations concerning labour, safety and environmental issues in the scope of the port state control conventions.

The Netherlands coast lies in the middle of the Hamburg - Le Havre range where inter port competition levels are very high. According to the National Port Council[2] statistics, in 2005 the Dutch ports handled 471 million tons of cargo. The port of Rotterdam is by far the busiest European port. Most of the smaller port administrations are integrated in the municipalities. Municipalities may form partnerships between themselves and regions and jointly manage seaports. These partnerships[3] are usually formed when the socio-economic significance of the seaport largely expands over more than one municipality. The Port of Rotterdam is managed by an independent company since 2004. The Rotterdam municipality is the main shareholder, while the State has a third of the company's shares. Beside the seaport itself, usually Dutch Port Authorities also manage vast logistical and industrial areas. Private operators are in charge of providing cargo handling, tuggage, mooring and warehousing services. A reference set of prices for each service is available but commercial operators are free to negotiate going rates with their clients. There are a few private ports in the Netherlands though in a much smaller extent than in the United Kingdom. The Dutch State has a significant intervention in the seaport market by granting funds to port developments and subsidizing infra-structure maintenance. Besides it establishes differentiated funding priorities to certain areas.

The Spanish port system comprises 44 ports of public interest. These are controlled through 28 Port Authorities. 'Puertos del Estado' is responsible for carrying out the government port policy and coordinating the entire national port system, namely with the several state bodies which have jurisdiction over port areas. It has its own revenue sources and controls the Interport Compensation Fund[4]. This fund is mainly used to support maritime signalization maintenance expenditure and investments. Port Authorities are autonomous public entities with legal ability and their own patrimony. The Autonomous Communities[5] appoint the president of the Port Authority and the majority of the members of the board. Tariffs paid to Port Authorities for the provision of services are negotiable but

[1] Deregulation, non interference.
[2] 'National Havenraad'.
[3] 'Havenschappen'.
[4] 'Fundo de Compensasion Interportuaria'.
[5] 'Comunidades Autonomas'.

must not be lower than the cost of providing the services. Private operators have reference tariffs specified by the Port Authority but have freedom to establish their own commercial policy offering rebates and discounts. Manzano *et al*. (2004) claim that the Spanish Port Authorities set of incomes is based on two pillars. Firstly, port service fees and, secondly, rents from concessions, commercial and industrial activities within the harbour precinct. Despite seeking for self financing, most of Spanish Port Authorities are still partly supported by the State through compensation for operating losses and grants. In addition, the European Cohesion Fund provides significant financial support for maritime infrastructures development.

3 Performance measurement

3.1 Literature review

While Data Envelopment Analysis (DEA) has been extensively applied in several fields, it has been scarcely used in the port sector. Only sixteen papers were found applying DEA methodology to this sector. The first study was published by Roll and Hayuth (1993) but it should only be regarded as a theoretical exploration of the applicability of DEA to the seaport sector since only hypothetical data was used. Tongzon (2001) analyses the efficiency of 4 Australian and 12 other ports with high throughput levels of containerised cargos. Itoh (2002) analysed the container operation of eight ports in Japan by means of a DEA 'window' application. Their efficiency was measured between 1990 and 1999. Turner *et al*. (2004) measured productivity trends on the top 26 continental U.S. and Canadian container ports. Park and De (2004) go beyond the traditional DEA methodology and proposed a four stage approach where productivity, profitability, marketability and overall efficiency were separately measured. Cullinane *et al*. (2004) applied a DEA-window analysis to 25 of the world's top 30 container ports. An extensive analysis of European container terminals efficiency was accomplished by Wang and Cullinane (2006). A benchmark of Italian seaports was accomplished by Barros (2006) where 24 Italian Port Authorities were analysed over the years of 2002 and 2003.

There are three papers focusing on Portuguese ports. Barros (2003a) analyses both technical and allocative efficiency of the Portuguese Port Authorities. Models for these two efficiencies were run considering both constant returns to scale (CRS) and variable returns to scale (VRS) models for the years of 1999 and 2000. Only one port was found to be inefficient under the VRS model. With the CRS model two ports were found to be inefficient but one only in terms of allocative efficiency. Barros (2003b) implemented a DEA Malmquist index to ten Portuguese seaports in the 1999-2000 period. The multipurpose nature of national seaports was depicted with output measures of various types of cargo (movement of freight, break bulk cargo, containerised freight, solid bulk and liquid bulk). The number of ships was also considered as an output. The number of employees and the book value of assets were the adopted inputs. In the most recent paper, Barros and Athanassiou (2004) benchmarked major Portuguese and Greek seaports. Leixões, Lisbon, Setúbal and Sines were compared against Thessaloniki and Piraeus. Setúbal and Thessaloniki were found to be inefficient under the CRS model. However the former presented only scale inefficiency.

3.2 Variable definition

Performance measurement is extremely important in the development of an organization. Dyson (2000) claims that it plays an essential role in evaluating production because it can define not only the current state of the system but also its future, as shown in figure 1. Performance measurement helps moving the system in the desired direction through the effect exerted by the behavioural responses towards evaluation results. Miss-specified performance measures, however, will cause unintended consequences, with the system moving in the wrong direction.

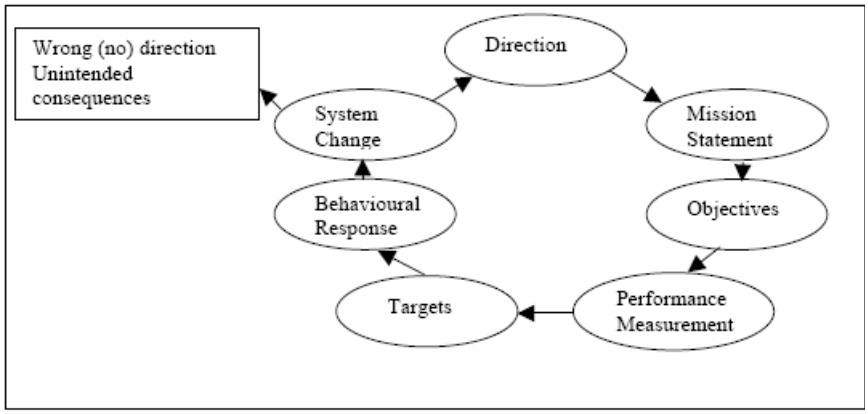

Figure 1 - Performance measures and organisational development
Source: Dyson (2000)

The choice of inputs and outputs is a critical decision with DEA. Different variables originate different results. One must ensure that the model results are actually pointing in the right direction. An incorrect or less strictly scrutinized choice of variables may induce totally biased results. In this study this choice was especially difficult because the previous literature is scarce. In addition, this literature focuses mainly on container terminals efficiency and not on the port as a whole as this study does. Cullinane *et al*. (2004) state that the objectives of a port should be considered when defining inputs and outputs. For instance, if the objective of a port is to maximize its profits, then the number of employees can be an input variable. Nevertheless, if the objective of a port is to increase employment, then labour can be regarded as an output. The analysed seaports have different objectives but, given that this study concerns the performance measurement of the Portuguese seaports, it was established that variables should be defined accordingly with the objective of the Portuguese seaports. It is assumed that, given the public nature of the national seaport system, its objective is to support economic growth at the national level by maximizing cargo and passenger traffic while maintaining the lowest possible costs.

Total cargo throughput is one of the two most frequent output measures found on previous literature. Besides, it is consistent with the objective definition above. However it has some drawbacks because Portuguese seaports handle several different types of cargos, usually through different terminals. Using total cargo throughput would encourage seaports to handle only the cargo types that are less costly to move, in order to achieve higher efficiency scores. This indicates that total cargo throughput was not an adequate variable. Therefore, it was established that the cargo output ought to be measured on a disaggregated basis.

Terminal area and the number of equipments such as berth cranes, yard cranes and straddle carriers were the two most frequent inputs adopted in previous studies. This is due to the fact that the majority of these studies focus only on container cargo. These variables are not so relevant to other types of cargo or passengers. Terminal area is irrelevant in terms of liquid bulk cargos. In addition only counting the number of equipments fails to capture important characteristics of these inputs such as age and cost.

Given the objective statement of reducing costs it was decided to deem costs as inputs. This option has several advantages, being the most important that it correctly reflects several inputs without favouring certain managerial options that are not directly related to performance. For example, considering costs instead of labour or the number of cranes only favours outsourcing or using one large yard crane instead of two smaller ones if these managerial options actually promote cost reductions. It was chosen to aggregate costs in operational expenses (OPEX) and capital expenses (CAPEX). This study did not include taxes in any of the inputs as it was found that the different national taxation systems would unfairly affect the evaluation results. When it was not objectively possible to separate extraordinary costs in the capital and operational costs, they were pondered and added to the regular operational and capital expenses. European Central Bank bilateral exchange rates, of 30 December 2005, were used to convert non euro currencies into euros. It is assumed this is not an uncontroversial option and a PPP input converted model was run for comparison purposes.

3.3 Models, Orientation and Data

This study aims to develop a standardized methodology for seaport performance evaluation. For this to be achieved the methodology should be as robust and reliable as possible. Nevertheless the core analysis was performed using only the most validated models, Charnes, Cooper and Rhodes[6] (CCR) which assumes CRS and Banker, Charnes and Cooper[7] (BCC) which assumes VRS. However in the results discussion a Super-Efficiency model was used in order to provide a deeper insight. All models were run using the DEA Excel Solver software, Zhu (2003).

Seaports should act in a demand responsive way and not the opposite, that is they should provide for the existent and potential demand of port services instead of creating new infrastructure in the hope to create new demand by themselves. Therefore, it is assumed that ports should focus in cost reduction. Based on this rationale an input orientation was chosen.

Forty one seaports from eleven European countries were analysed, all of them belonging to the European Union except Norway. The UE countries were Portugal, Belgium, Denmark, France, Greece, Poland, Spain, Sweden, the Netherlands and the United Kingdom. In terms of data collection a great care was put on gathering data as reliable as possible. Most of the data was directly gathered from the annual reports of the respective Port Authorities. However, for some of the seaports it was

[6] Charnes *et a.l* (1978).
[7] Banker *et al.* (1984).

not possible to find some of the required cargo or passenger figures. In these few cases missing figures were withdrawn from the EUROSTAT webpage.

4 Results

The VRS model highlighted fourteen ports as efficient (Lisbon, Amsterdam, Antwerp, Calais, Dover, Ferrol-San Cibrao, Larvik, London, Milford Haven, Piraeus, Rotterdam, Szczecin-Swinoujscie, Valencia and Zeeland). However the CRS model results showed Amsterdam and Rotterdam to be inefficient Therefore only the other 12 ports turned up to be efficient under this model. Both the average and the median of the VRS scores are superior to the CRS ones as shown in Table 2. This was expectable since VRS scores disregard scale efficiencies. Otherwise it would indicate inconsistent results. A small skewness and close mean and median values indicate an approximate symmetrical distribution. There is a high linear association between both model results, as the correlation coefficient is near 1, due to relatively high scale efficiencies.

Table 2 - Descriptive statistics of the efficiency scores

	VRS	CRS
Average	0.723	0.644
Median	0.765	0.641
Std. Deviation	0.261	0.287
Skewness	-0.194	0.061
Minimum	0.244	0.216
Maximum	1.00	1.00
Pearson correlation	0.980	

From the Portuguese ports only Lisbon was found to be efficient. The results discussion below showed that this was mainly due to the high volume of passenger traffic. Other ports with significant passenger traffic are Piraeus, Dover, Calais and Stockholm.

DEA provides efficient targets both for inputs and outputs. Targets for the Portuguese ports are listed in Table 3. Every port, except Lisbon, which was deemed as efficient, presented significant potential cost reductions both in OPEX and CAPEX. If all the Portuguese seaports had performed efficiently, savings would amount to 64 million euros annually.

Table 3 - Efficient input and output targets under the VRS model

Seaport	OPEX	CAPEX	Convent. general	Contain. cargo	Ro-ro cargo	Dry bulk	Liquid bulk	Passengers
	10^3 euros	10^3 euros	10^3 tons	10^3 tons	10^3 tons	10^3 tons	10^3 tons	10^3 pass.
Aveiro	3222 (7072)	1941 (4786)	1376 (1376)	527 (0)	739 (0)	2669 (1416)	2717 (536)	558 (0)
Leixões	9142 (23775)	5257 (13672)	2022 (487)	3539 (3539)	1259 (9)	4315 (2309)	7714 (7714)	465 (18)
Lisbon	29390 (29390)	16652 (16652)	438 (438)	4040 (4040)	11 (11)	5202 (5202)	1608 (1608)	29929 (29929)
Setúbal	5199 (14273)	2276 (6247)	1212 (1212)	570 (113)	716 (379)	3224 (3224)	1980 (1717)	1442 (1442)
Sines	7382 (18863)	6190 (15816)	4466 (29)	777 (658)	1886 (0)	11712 (5801)	18552 (18552)	255 (0)

Note: inside the parenthesis are the 2005 actual values

4.1 Geographical analysis

Ports were grouped on the basis of their geographical location and average efficiencies were computed. Based on these results it was verified that Southern European ports had lower scores than Northern European ones. South Europe had averages of 0.60 and 0.50 for VRS and CRS respectively while Northern Europe had 0.93 and 0.88.

In a national perspective, both the United Kingdom and the Netherlands were deemed as benchmarks. All UK ports scored as efficient under both models. Conversely to what might have been expectable, Spanish insular ports presented a higher efficiency average than the country as a whole. Figure 2 compares the average efficiencies under VRS and CRS of European regions, countries and insular ports.

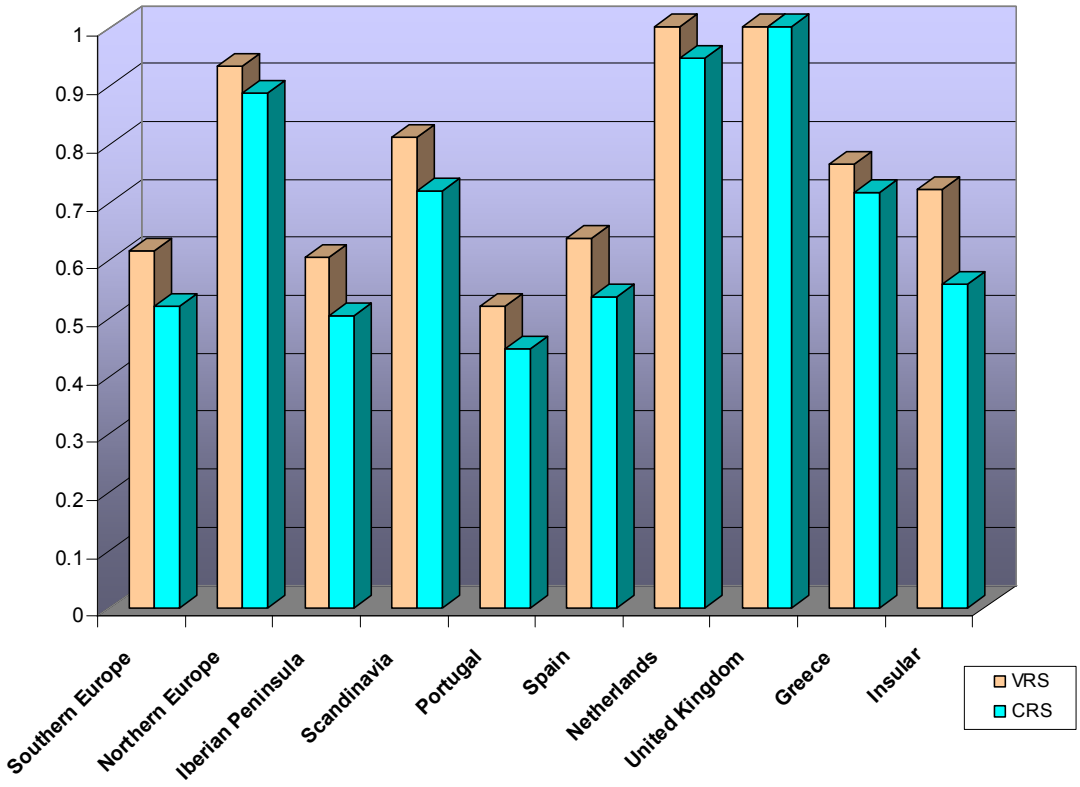

Figure 2 – Average efficiencies under VRS and CRS of European regions, countries and insular ports.

4.2 Super efficiency, peer count and variable sensitivity

In the Super Efficiency VRS input oriented model four efficient DMUs were found to be infeasible, namely Lisbon, Antwerp, Calais and Rotterdam. Peer count indicates the number of times an efficient DMU was found to be efficient when benchmarked against another DMU. In a certain perspective one may say that an efficient DMU is as much more efficient as the number of times it has proven to be efficient. A sensitivity of efficient ports to each one of the variables was tested by running models without each one of the variables and it was recorded if any of the efficient ports was sensitive to a specific variable. Table 4 shows the super efficiency scores; peer count and the variable sensitivities of the fourteen efficient DMUs.

Table 4 - Super efficiency scores; peer count and variable sensitivities of efficient seaports

Seaport	Super Efficiency	Peer Count	Variable
Lisbon	infeasible	12	Passengers
Amsterdam	1,813	1	Dry bulk
Antwerp	infeasible	5	-
Calais	infeasible	8	Ro-ro
Dover	1,214	2	CAPEX;Ro-ro; Passengers
Ferrol-San Cibrao	1,472	10	OPEX; CAPEX; Dry bulk
Larvik	1,981	23	-
London	2,637	7	CAPEX
Milford Haven	4,583	12	Liquid bulk
Piraeus	2,023	4	CAPEX
Rotterdam	infeasible	1	-
Szczecin-Swinoujscie	2,598	6	CAPEX
Valencia	1,686	10	OPEX; Containerized
Zeeland	11,507	23	-

5 Conclusions

5.1 Concluding remarks

Portuguese seaports have been facing growing competition. Aiming at the improvement of the seaports competitiveness a wide port sector reform was initiated in the late nineties promoting service provision through private operators. After almost a decade since the beginning of the reform it is now timely to evaluate its results.

Most of the previous literature applying DEA to the port sector focused only in containerized traffic. Since Portuguese seaports are usually multipurpose, this study undertook a broader perspective by considering all types of cargo plus passengers. Forty one seaports of eleven European countries were analysed. Fourteen ports were found to perform efficiently with VRS and twelve with CRS. Efficiency scores of the Portuguese seaports were all very low except for Lisbon. All of the other seaports were in the 10 least performing group. Lisbon was deemed as efficient because of the very high level of commuter passenger traffic. If performing efficiently the major Portuguese seaports would have saved about 64 million euros during 2005. Scale efficiency can not be seen as a cause for inefficiency since most of the Portuguese seaports had relatively high scale efficiencies.

On a regional analysis it was found that the Iberian Peninsula seaports presented low efficiencies in general. Portugal was underperforming relatively to Spain. In contradiction with previous studies insular Spanish ports were found to have better results than continental ones. In terms of national averages the United Kingdom and the Netherlands were found to have the best performing ports. These countries have significantly different degrees of private involvement in seaports. While the UK may be taken as the example that private ports do perform efficiently, the Netherlands show that a full scale port privatization is not necessarily a pre requisite to achieve high performance levels.

5.2 Further research

This study regards seaports as independent Decision Making Units (DMU). Country performance results were computed as the mean of the seaports performance results in each country. It would be interesting to consider the whole country as a DMU by using national public spending in the seaport

sector as input and the national annual throughputs and passenger traffic as outputs. Public spending should encompass not only direct expenditure with Port Authorities and infrastructure but also expenditure with public bodies with attributions related to the seaport sector, such as regulators. This analysis would allow to identify the best practices in terms of public policies for the seaport sector, based on empirical evidence.

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