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Determinants of seaport efficiency: An Analysis of European container ports

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ABSTRACT

The present work is aimed to investigate the determinants of the thirty largest European container ports' efficiency, observed during the time period ranging from 2005 to 2018, using a two-step methodology. Initially, the Window Data Envelopment Analysis was applied to measure each single seaport associated efficiency scores. Then, we proceeded with studying the competition and environmental factors relating effects on seaport efficiency via bootstrap truncated regression modeling, through incorporation of time-effects procedure. The attained results turn out to reveal that, contrary to GDP per capita, the number of ship calls, logistic services' quality and quays' length factors prove to display a positive impact on the relevant efficiency scores.Our reached results also indicate well that these European seaports' efficiency tends to decrease with inter-port competition level, owing mainly to over-investment strategies oriented to attract additional users' requests.

1. Introduction.

The recent decades have been marked with noticeable changes affecting several European countries' economic and political situations (Niavis and Tsekeris, 2012). In turn, the transport sector has been subject to several changes, mainly associated with cargo boats shipment capacities and processes. In this respect, as an integral pillar of an increasingly globalized economy, maritime transport is estimated to account for approximately 70% of the world trade value and 80% of its volume (Matekenya and Ncwadi, 2022). Indeed, the European international maritime trade almost doubled in weight between 2005 and 2018, given the relatively lower costs it procvides in respect of the other modes of transport, mainly, air freight (Elmi et al., 2022). In effect, most seaports tend to display a high level of competitiveness by striving to offer the lowest costs, taking advantage of such factors as strategically adequate maritime connexion, experimenting with innovative technologies and effective reputation, enabling them to maintain their existing traditional customers and attract new ones (Kammoun and Abdennadher, 2022). An unpredicted channel and container terminal congestion, for instance, might well culminate in increasing waiting time at ports, therefrom, raising port charges and the cargo total transportation cost, likely to overburden the customer (Abioye et al., 2020). Hence, a high service maritime strategy should entail the implementation of effective liner container shipping operations, through deploying appropriate ships on different routes, applying efficient operation models, and designing well determined schedules fit for all the stopover ports visitor ships (Wang and Wang, 2021). In this regard, shipping lines should operate collaboratively with marine terminal agents to opt for the appropriate terminals available at the container port, request a convenient ship arrival time margin and effective cost handling schemes (Dulebenets, 2022).

With noticeably raised funds put at its disposal, the European seaport system is undergoing a wide range of restructuring and investment strategies, relating mainly to the construction and enlargement of port terminals, along with the installation of innovative equipment to improve the logistics performance, in a bid to compete effectively within the European context (Barros et al., 2016). Thus, improving port efficiency and/or reduc-

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ing inefficiency could greatly help in minimizing port charges, therefrom, reducing the overall transport costs (Wilmsmeier et al., 2006).

According to the relevant literature, several intervening factors appear to affect seaport technical inefficiency, mainly, the institutional environment (Serebrisky et al., 2016; Le and Nguyen, 2020; etc.), differences in scale efficiency and macro-economic factors (Bergantino and Musso, 2011; Wanke and Barros, 2016; Sun et al., 2017; Saky and Immurana, 2021; etc.) and inter-port competitive environment (Yuen et al., 2013; etc.). In this respect, two striking conditions appear to stand as main determiners of competitiveness. First, as recommended by the economic theory, the intensification of inter-port competition induces container ports to be performant. Second, because of increasingly competition, container ports may well overinvest, thereby, reducing technical efficiency (De Oliveira and Cariou, 2015). Consequently, an excessive implementation of inputs (yard area, number of machines, number of staff, storage area) proves to represent a major issue in port rehabilitation process. To resolve this problem, the Data Envelopment Analysis (DEA) stands as a widely useful technique, adequately fit for identifying the persistence of any input surpluses and/or output shortages (called slacks).

It is in this context, this work is designed to identify and measure the major determinants of efficiency in regard to thirty Europe based seaports, concerning the period ranging from 2005 to 2018. To do this, we consider adopting the DEA-Window under constant return to assess the technical efficiency level and identify the main elements causing technical inefficiency. Then, we proceed with implementing the truncated regression to examine the competition and environmental factors (GDP per capita, number of ship calls, logistic services' quality, quays' length and the distance to the nearest port Hub) related effects on seaport efficiency.

The remaining of this paper is planned as follows: Section 2 is devoted to providing a comprehensive overview of the seaport-efficiency affecting dimensions study area. Section 3 deals with highlighting the used two-step technique. As to the used variables, they are discussed in section 4, while the reached empirical results are detailed in section 5. Finally, section 6 involves a depiction of the study major reached conclusions.

2. Seaport efficiency : Literature survey.

The seaports and terminals associated efficiency has often been assessed through a large array of frameworks designed to compute and optimize the cargo handling operational productivity at berth and terminal area levels (Cullinane et al., 2006). In this respect, the DEA and SFA (Stochastic Frontier Analysis) approaches as two major techniques widely deployed to investigate the seaports and terminals production and performance features (e.g, Liu, 1995; Serebrisky et al., 2016; Wanke and Barros, 2016; etc.). Worth mentioning, in this regard, is the study conducted by Liu (1995) that pioneered the Translog production function, and applied it to examine the efficiency and ownership binding association regarding the efficiency of 28 British seaports throughout the period 1983-1990. He concluded that privatized seaports appear to operate more efficiently than the public sector held ones. Serebrisky et al. (2016) used the SFA method to estimate the seaport efficiency determinants of 63 Latin America and the Caribbeans (LAC) sited seaports. Their findings revealed the persistence of notiveable improvements in the LAC based seaports' average efficiency scores. They also examined a number of seaport technical efficiency determinants, including ownership, corruption and per-capita income. The translog production function highlighted the remarkable roles displayed by both of the ship-to-shore cranes and length of quays inputs, in relation to the terminal area and mobile cranes inputs. They also discovered that private operations turn out to display a positive impact on the seaports' efficiency scores. Using random-effect and fixed-effect stochastic models, Wanke and Barros (2016) evaluated the cost and operational variables' effects on China's largest ports, over the time period 2002 - 2012. They reached the result that a noticeable heterogeneity appears to persist among the Chinese ports, displaying a significant effect on seaport cost efficiency scores. In addition, remotely located seaports are discovered to demonstrate lower efficiency rates, while larger ports proved to operate rather efficiently. 9

Applying the DEA approach for port efficiency evaluation purposes has been the concern of a large number of researchers. In this regard, Roll and Hayuth (1993) pioneered the employment of the DEA method to assess the technical efficiency of twenty ports. Rios and Maçada (2006) used the DEA-BCC approach to measure the container terminals' efficiency level of the Mercosur seaport, over the time period lapsing from 2002 to 2004[2]. Accordingly, 60% of the studied container terminals were discovered to be efficient over the review period. On applying the bootstrapped DEA technique to analyze the effeciency levels of Vietnamese seaports, and by comparing the attained results to the SFA and standard DEA reached findings, Nguyen et al. (2015) found that the bootstrapping DEA scores proved to be non-biased. As to the standard DEA and SFA techniques, they ended up providing rather noticeably large-scope efficiency scores. In turn, Sun et al. (2017) implemented a non-radial DEA preference technique to examine the effect of environmental factors on Chinese seaport efficiency. Their achieved regression results revealed that the berth quantity, port assets and geographical location appeared to display significant impacts on the studied seaports' environmental efficiency. Their study also categorized the entirety of ports into four classes according to performance and cargo throughput.

Some authors, particularly Itoh (2002), applied the Window Data Envelopment Analysis to assess the operational efficiency of eight worldwide leading seaports during the time period 1990-1999. Their findings revealed that the Yokohama, Osaka, and Kobe seaports' recorded efficiency scores proved to be low, highlighting that the Kobe seaport is required to apply extra measures to draw more customers and maintain previ-

[2] The authors used the number of cranes, amount of yard equipment, number of births, terminal area and number of workers as inputs, while the average number of handled containers was used as output.

ous ones following the Great Hanshin earthquake. Similarly, Cullinane and Wang (2010) considered applying the window analysis to examine 25 major international container ports' efficiency throughout the period 1992–1999[3]. Their reacched empirical results validated the need to apply panel data, and highlighted the persistence of a significant waste marking container port production. Concerning Pjevčević et al. (2012), they implemented a window analysis to investigate the efficiency scores of five Serbia based river ports regarding the time period 2001-2008. On using the number of cranes, the area of stores and the total berths length as inputs, and total volume of goods as outputs, they concluded that these ports need to enhance production to attain efficiency. Zarbi et al. (2019) employed DEA-Window to estimate efficiency of ten Irani seaports during the period 2012-2018[4]. They concluded that the average efficiency of the Khorramshahr, Bushehr, Bandar Imam Khomeni and Chabahar seaports proved to score noticeable improvements over time. With respect to Seth and Feng (2020), they implemented a four-year window analysis to estimate the efficiency scores of fifteen USA sited seaports. They outlined that seaport efficiency scores are too critical for port authorities to help specify the appropriate seaport investment areas, likely to boost their potential commercial activity and trade operations.

In addition to this, and based on a two-stage methodology, a large number of researches undertook to analyze the effects of environmental factors on seaport efficiency area. In this respect, Barros and Managi (2008) applied the bootstrap truncated regression methodology to explore the effect of environmental factors (as the population density, yearly trend, country's GDP and hub status) on Japanese container ports effeciency. They highlighted that the hub status and GDP proved to display a positive help noticeably in enhancing seaport efficiency. To investigate the Asian container terminals' efficiency over the period 2004–2007, Yeo (2010) used a parametric statistics analysis, using such factors as operating capacity, connectivity level, convenient installations and electronic documents processing capacity. Their attained results indicated that both of the container terminal facilities and service quality factor variables tended to positively impact seaport efficiency. As for Niavis and Tsekeris (2012), they used the DEA-CCR model and bootstrapped truncated methods to explore the determinants of the south-east Europe based seaports' efficiency. Their major efficiency covariates were: port area, population, per-capita GDP, distance from suez and privatization. They concluded that some ports recorded low efficiency are related to the lack of management skills along with the effects of scale. They also noted that the distance separaing each port to the Suez canal, along with the territorial population and GDP per capita helped in raising the efficiency scores. On investigating the impacts of competition, privatization and hinterland on the container ports' efficiency, using the two-stage DEA and data relating to 21 major Chinese container ports, observed from 2003 to 2007, Yuen et al. (2013) discovered that Chinese ownership modes proved to impact the container ports' efficiency in different ways. If a minority of equities are held by Chinese entities, port performance turns out to be enhanced, while the impact of Chinese equities' majority is discovered to be reversal. The authors concluded that both of the intra-port and inter-port competitions proved to stand as important factors liable to increase seaport efficiency. For the purpose of estimating the Brazilian ports' performance, and by accounting for ship frequency as intermediate input/output, Wanke (2013) appealed to the network DEA model. Their reached results showed that both of the hinterland size and handling operations of both types of merchandise cargoes (solid bulk throughput and container frequency) tended to be positively associated with the shipment efficiency-consolidation levels, while the private administration factor appears to be a positively connected with the physical-infrastructure efficiency level. As for De Oliveira and Cariou (2015), they used the Simar and Wilson (2007) advanced two-step methodology to analyze the impact of competition, port city population, gateway or hub and market share on 200 container ports associated inefficiency. They discovered a significantly negative relationship binding HHI and seaport inefficiency. They also noted that the relationship binding the dummy variable and seaport inefficiency tended to improve significantly and positively throughout the study period. Such relationships could have their explanation in the strong competition exerting ports to over-invest, theeby, further reducing technical efficiency. By introducing a number of environmental factors in their analysis of the Chinese ports' efficiency, along with the distance direction function, Sun et al. (2017) concluded that port size proved to have a negative effect on environmental efficiency, yet, a positive effect on operational efficiency. Moreover, the Northern area based ports demonstrated noticeable differences to the Southern region sited ones in terms of efficiency, owing mainly to the noticeable variations in climate and industrialization conditions. Concerning Saky and Immurana (2021), they opted for the Generalized Method of Moments (GMM) to study the relationship binding the Africain seaports' efficiency and trade balance, over the period 2010-2017. Their findings demonstrated that seaport efficiency helps in boosting the trade balance over the long run as well as the short run. Using the Double-bootstrap DEA approach along with univariate and multivariate analyses, Le and Nguyen (2020) examined the impacts of government policy, operational and market conditions on the efficiency of 41 Vietnamese seaports. Their achieved results indicated that the reform policy, regional location and production factors participated well in enhancing seaport efficiency. In turn, Adler et al. (2022) investigated the effects of competition, specialization, ownership and regulation on the Indian seaports' performance, during the time period 1995 - 2015, by implementing the fixed effects regressions to the DEA scores. Their findings suggested that inter-port competition proved to be significantly and negatively correlated with seaport efficiency, while the external stakeholder participation and specialization demonstrated a positive correlation with

[3] As outputs, the authors used container throughput, terminal length and terminal area, while berths, cranes, yard gantry and straddle yard were used as inputs.

[4] As inputs, they applied the number of berths cranes, total quay length, yard space, and container throughput as output.

seaport efficiency. With respect to Kammoun and Abdennadher (2022), applied the DEA-CCR model along with the Principal Component Analysis (PCA) to assess the efficiency and competitiveness of thirty European container ports. The authors concluded that handling costs is the key measure for achieving effective competitiveness. Their findings also revealed that the Northern Europe based seaports are discovered to be highly competitive and inefficient thanks to over-investment and effective use of inputs. Worth citing also is the study conducted by Ayesu et al. (2022 a), who applied the gravity method to examine the seaport efficiency effect on the trade performance of 33 African countries, regarding the period 2006-2018. They conluded that seaport efficiency helps greatly in boosting trade performance. On applying the generalized moments' method in their analysis, Ayesu et al. (2022 b) stressed that seaport throughput and efficiency could well have a significantly positive effect on economic growth in Africa. In a recent study conducted by Ju et al. (2023), wherein they applied the DEA technique to compute the efficiency scores of fifteen Chinese coastal ports, the authors further justified their reached scores by implenting the panel data model. They ended up concluding that intense competition helps noticeably in enhancing seaport technical efficiency.

Based on the above cited analyses, one could well deduce that inspite of the wide range of literature dealing with seaport efficiency and the relevant determinants, the impacts of competition and other relating factors on port efficiency remain still unthoroughly treated, requiring further investigation.

3. Research Methodology.

For the purpose of estimating the hypothesis positing that the European seaports' efficiency is predominated by competition and environmental factors, we consider retracing the steps of Niavis and Tsekeris (2012), De Oliveira and Cariou (2015) as well as Le and Nguyen (2020), and proceed with estimating the two-step analysis, as put forward by Simar and Wilson (2007). As an initial step, we undertake to evaluate the efficiency level through implementation of the nonparametric linear framework. In the following step, we reckon to treat the issue of environmental factors as affecting seaport(in)efficiency, by opting for the bootstrap truncated regression methodology.

3.1. Measuring efficiency scores: DEA-Window.

Dubbed DEA, this non-parametric linear programming technique applies a number of resources and outputs to estimate the decision-making units (DMUs) respective efficiencies. It is worth recalling that the DEA is usually applied for the purpose of estimating the efficiency of a set of DMUs, wherein, each single DMU involves a production system englobing multiple inputs and outputs. The choice of DMUs rests heavily on the homogeneity principle, since comparisons among entities and production units could not be established on the basis of highly differing sectors of economy. In this regard, Charnes et al. (1978) set up the basic rules of the DEA approach under the form of the CCR model, in such a way that the DMUs respective efficiencies could be compared, allowing for input level increases to be introduced, thereby, proportionally increasing the output levels.

Additionally, this model stands as highly commonly useful for estimating the overall technical efficiency of each single firm or entity, by enabling to combine both of the pure technical efficiency and scale efficiency into a single value (Gollani and Roll, 1989). By implementing the CCR model, the analysis can be either input-oriented, considering each firm as employing a minimum of inputs while maintaining the available amount of throughput, or output-oriented, by proceeding with maximizing the amount of each firm produced throughputs while maintaining the available level of inputs. Accordingly, such an analysis applies the input-oriented procedure to retrieve any excessive utilization of the seaport available resources. The input orientation, associated with the DEA-CCR method, is provided by the bellowing linear program:

$$\theta^* = \min \theta \tag{1}$$

$$s.t. \sum_{j=1}^{n} x_{ij}\lambda_j \leq \theta x_{i0} \qquad i = 1, 2, \ldots, m \tag{2}$$

$$\sum_{j=1}^{n} y_{rj}\lambda_j \geq y_{r0} \qquad r = 1, 2, \ldots, s \tag{3}$$

$$\lambda_j \geq 0 \qquad j = 1, ..., n \tag{4}$$

Where

θ^* is the relative efficiency of seaport under evaluation (referred to by DMU_0),

y_{r0}, x_{i0} stand for the quantity of the r^{th} output and i^{th} input for seaport under evaluation (DMU_0), and λ_j designates the decision variables representing, respectively, the weights of i^{th} input and r^{th} output of DMU_j.

According to the above cited dual linear programming model, the efficiency index of a focal seaport is estimated by reducing the objective function, subject to two inequality sets. In the first inequality, the weighted sum of inputs of the non-focal terminals'/ seaports' need be equal or inferior to the seaport subject of the evaluation inputs. As to the second inequality, it stresses that the weighted sum of the seaports' throughputs need be equal or superior to the seaport under evaluation. To move an inefficient firm to the efficient frontier, Cooper et al. (2007) considered adding the slack variables s_i^- (input) and s_r^+ (output) into the linear programming model, so that its appropriate formulation turns out to be:

$$\theta^* = \min \theta - \varepsilon(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+) \tag{5}$$

$$s.t. \sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = \theta x_{i0} \qquad i = 1, 2, \ldots, m \tag{6}$$

$$\sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ = y_{r0} \qquad r = 1, 2, \ldots, s \tag{7}$$

$$\lambda_j \geq 0 \qquad j = 1, ..., n \tag{8}$$

$$s_i^- \geq 0 \qquad \imath = 1, ..., m \tag{9}$$

$$s_r^+ \geq 0 \qquad r = 1, ..., s \tag{10}$$

Where s_i^- and s_r^+ denote, respectively, the quantity of input i excesses and the quantity of output r shortfalls in seaport under evaluation.

The three prerequisite conditions, imposed by the DEA-CCR model, are summarized as:

-if $^*< 1$; the seaport is noted as inefficient.

-if $^* = 1$; the inputs and outputs associated slack values turn out to be equal to zero, i.e. $s_i^-= s_r^+= 0$; and the DMU_0 is then ranked as fully efficient;

-if $^*=1$ and some of the inputs and outputs related slacks are nonzero, i.e. $s_i^-\neq 0$ and/or $s_r^+ \neq 0$ for some input and output, the DMU_0 then the seaport turns out to be inefficient.

For our designed model to be liable to treat cross sectional and time-varying data, a variation of the traditional DEA method is adopted in our study case. Labeled DEA-Window analysis, this technique was initially devised by Klopp (1985), to help capture the organization's performance trend over time (Seth and Feng, 2020). Accordingly, each DMU is treated on a separate basis so that the seaport's various associated data, referring to different time periods, are introduced into the model while considered as referring to different seaport entities. In this way, the number of DMUs will be increased, thereby, increasing the discriminating power once a limited number of DMUs is provided (Pjevčević et al., 2012). The DEA-Window technique proceeds with selecting the window width D prior to mesuring the n*D efficiencies relevant to each window. The number of windows is $WI{=}K{-}D{+}1$, wherein, n denotes the number of seaports, and K the number of time periods. Then, the consecutive windows overlap is the equivalent of $(D - 1)$ periods. It is important to note, at this level, that this overlapping process, peculiar to this technique helps greatly in enhancing the data analysis quality, while improving the dynamic property evaluation procedure. A conveniently robust window width, fit for estimating efficiency, is provided by the following formula:

In the case when K proves to be an odd number:

$$D = \frac{k+1}{2}, \tag{11}$$

Else, for the case when K turns out to be an even number:

$$D = \frac{K+1}{2} \pm \frac{1}{2} . \tag{12}$$

3.2. Second-stage regression analysis of determinants of seaport efficiency.

The initial stage computed and drawn efficiency index could be explained by environmental factors. Applying an econometric analysis at this level, the second-stage turns out to be formulated as:

$$\theta_j = \beta Z_j + \varepsilon_j \qquad j = 1, 2, 3, \ldots, n \tag{13}$$

$$s.t.\theta_j \geq 1 \tag{14}$$

Where

θ_j denotes the efficiency index of the jth entity;

zj designates the vector of environmental factors likely to affect the seaport's capability level in effectively combining the consumed ressources to produce the achieved throughtput;

β stands for the vector coefficient, and

ε_j for the error term.

The parameters relevant to this regression analysis are usually estimated by means of the Ordinary Least squares (OLS), truncated (Niavis and Tsekeris, 2012) and Tobit (Yeo, 2010) models. As for Simar and Wilson (2007), they argued that these conventional regression models raise two major issues. On the one hand, the efficiency score θ_j, analyzed in the second stage, is serially correlated. On the other hand, a correlation between the environmental factors (Z_j) and the error terms would certainly ensue as a result of the environmental factors' correlation with the first stage deployed inputs and outputs. These issues lead to actually invalidating the standard approaches to inference.

For Simar and Wilson (2007), the bootstrap procedure could help surmount these shortcomings by setting up a valid confidence interval. In this framework, equation (7) incorporates the maximum likelihood truncated estimation to draw $\widehat{\beta}$ and $\widehat{\sigma}$, and for each firm, an artificial error ε_k is drawn from the N (0, σ_ε^2) with truncated distribution from the left at 1- βZ_j to estimate $\widehat{\theta}_j = \widehat{\beta} Z_j{+}\varepsilon_j$. The maximum likelihood method is introduced to estimate the truncated regression of $\widehat{\theta}_k$ and Z_k. Throughout this second step, this proceeding is reiterated 1000 times, and the bootstrap values sequence is applied to get a valid inference for β.

4. Data selection procedures.

The study sample, investigated in the present work, involves data relating to thirty European seaports based in France, Germany, Belgium, Netherlands, Sweden, Spain, and Italy. Our dataset includes 420 observations relevant to the time period ranging from 2005 to 2018. Our data set was gathered from various sources, including Lloyds database, the website of seaports, annual statistical reports and European statistical database (Eurostat).

4.1. Variables used in the first-stage efficiency analysis.

The input and output variables selected to conduct the first-stage analysis should help in reflecting the seaport's production process (Cullinane et al., 2004). In this regard, Wu and Goh (2010) insist that the terminals' production need be closely connected to the effective deployment of infrastructure, labor and equipment. Given the distinct features characterizing terminal production, the terminal area and the storage area represent the most convenient proxies fit for depicting the infrastructure input factor. As to the number of yard handling machines and the number of cranes, they represent two proxies that correspond well to the equipment input factor. Finally the number of employees and the number of port authority workers prove to be suitably fit to stand for the labor input factor (Wu et al., 2010

; Le and Nguyen; 2020). Hence, the inputs selected to execute our first-stage analysis turn out to be: the number of yard gantry cranes, the number of tugs, the number of direct employees and the total area of terminals. In fact, the input variables we have opted for to conduct the present study have been frequently applied in most of the already elaborated research works (Tongzon, 2001; Rios and Maçada, 2006; Wanke, 2013; Van Dyck, 2015; Zarbi et al., 2019; Munim , 2020; etc.). As regards the output variable, it involves cargo throughput per annum (tons). This variable is also widely applied in the literature, as an indicator depicting seaport production (Estache et al., 2002; So et al., 2007; Munisamy and Singh, 2011; Nwanosike et al., 2012, etc.).

A summary of the variables relating statistics is reported on Table 1. It is important to highlight that the implemented inputs' corresponding growth rates have been set to range from 5 % to 48.66% throughout the period under review (2005 - 2018), while the throughput level has been set at 21.19%.

4.2. Factors used in the second-stage regression.

As a second stage of our analysis, seven explanatory variables have been applied to explain the dependent variable efficiency scores attained in the initial stage. The first of these indicators is the seaport quays length, selected to help determine the port's ship reception capacity, defined by a number of authors, like Li and oh (2010), Musso et al. (2020), and Adam Kaliszewski et al. (2020), as a seaport competitiveness factor. Following Niavis and Tsekeris (2012), Serebrisky et al. (2016), our second selected criterion refers to the gross domestic product (GDP) per capita. It is aimed to identify the economic status of the seaport territorial area per person and is calculated by dividing the GDP of a port-city by its population (http://www.citypopulation.de). Already used by De Oliveira and Cariou (2015), our third indicator is a dummy variable equal to 1 if the seaport resources allowed for attracting investment over the period ranging between 2005 and 2018. Extensively explored in a number of already conducted studies, mainly, by De Oliveira and Cariou, (2015), Elbayoumi and Daood (2016) as well as Peter et al. (2018), our fourth factor refers to the seaport industry concentration.

It is estimated by means of the Herfindhal – Hirschman Index (HHI $= \sum_{i=1}^{n} (throu_i / \sum_i^n throu_i)^2$), wherein, $throu_i$ refers to the throughput of the ith container port, and n corresponds to the number of ports involved in the system. The HHI generally varies between 0 and 1. Decreases in the index generally denote a strong competition, and its increases denote a lower competition. Considering the entirety of Europe's largest thirty container ports, the HHI has been discovered to range between 0.0677 and 0.084, gradually growing over the years, as highlighted in Figure 1. One might well state, therefore, that concentration of total freight traffic turns out to be low, and that competition among European seaports proves to be strong. As to the fifth factor, that of ship calls, it is widely recognozed to represent a key competitiveness factor by several authors, such as Tongzon (1995) as well as Omoke and Onwuegbuchunam (2018). In regard to the port logistic services' quality, it is considered by Kammoun and Abdennadher (2022) as a major seaport competitive factor, as highlighted by the World Bank released data. This indicator reflects highly positive perceptions of a port's logistics, translating the efficiency of the customs clearance processes, the quality of logistics services, the quality of trade and transport infrastructure, easy disposition to handle shipments at highly competitive costs, noticeable shipping tracking and logging capacities, as well as the frequency rates of ships' timely arrivals and receptions. The index scores are set to range from 1 to 5, with high indexes denoting highly effective logistic services. With respect to our final variable selected, we retraced the stages of De Oliveira and Cariou (2015), who suggested a proxy that relies on the United Nations (2007) ratio of 0.12 TEU produced per one million of population. In our study, this factor corresponds to the distance between a seaport and its nearest competitor Hub port and is measured in kilometers. Accordingly, a port is ranked as a hub gateway whenever the number of port-crossing TEUs turns out to be twenty times greater than the traffic carried out by its port-city dwellers (TEU >20* 0.12* Population of the city port). Under this assumption, 57% of ports out of 30 are considered as Hubs as far as the study period[5] is concerned.

5. Results and Disscussion.

This section is devoted to presenting and discussing the two-stage efficiency analysis achieved results regarding the thirty container ports, subject of study. The of the seaport competition intensity along with other factors' effects on the container ports' efficiency have been examined via a truncated bootstrapped regression. We start with estimating the thirty seaports related efficiency over the time period 2005–2018 (30 container ports x 14 years period = 420 observations). Then, the slack variable analysis has been applied to examine each inefficient seaport associated characteristics.

5.1. Seaport efficiency scores.

The seaports respective efficiency was measured via a DEA-Window methodology, namely, through the input - oriented constant - return-to-scale framework (DEA-CCR). The fourteen-year period collected data, relate to the time lapse ranging from 2005 to 2018. For the study observations to be raised to a reasonably high amount, without noticeably extending the period and exceeding the plausibility realms, a seven-year window interval has been selected in such a way that: D = 7 and WI=8.

Owing to the results ensuing huge amount of information, we account for displaying the Algeciras port relevant efficiency scores, as an illustrated on Table 2. The average yearly efficiency results (column view), achieved through the DEA-Window framework, have been calculated for each single seaport, as shown on Table 3. The average annual efficiency index for each container port usually range from 0 to 1. Evidently, no

[5] The seventeen Hub seaports, as classified by city, are: France (Havre, Dunkerque), United Kingdom (Immingham, Hartlepool, Felixstowe, and Southampton), Germany (Hamburg, Bremerhaven, Duisburg, and Wilhelmshaven), Belgium (Antwerp), Netherlands (Rotterdam), Spain (Algeciras), Portugal (Sines), and Italy (Genova, Trieste, and La Spezia).

port, could actually achieve an efficiency rate of 100%. As could be noticed, only five container ports turned out to exhibit average efficiency scores ranging between 0.6 and 0.95; seven container ports recorded scores varying between 0.4 and 0.57, while and the remaining ports' scores were inferior to 0.36. Indeed, Felixstowe, Algeciras, Hartlepool and Sines proved to be the most efficient ports, recording average efficiency scores of 0.9444, 0.7118, 0.6984 and 0.6847, respectively. Such findings do actually coincide with the results released by Bergantino and Musso (2011), highlighting that the Algeciras' seaport is operating highly efficiently.

Out of the total sample's thirty container ports, sixteen seaports have registered a decline in technical efficiency level over the period 2005-2018. Based on our collected database, this fall in efficiency is owed mainly to remarkable investments failing to enhance sea traffic to an expected level. The seaports of Dunkirk and Harterpool, for instance, have gone through a declining process in their efficiency levels over the review period. Such a decline is mainly due to the rise in the number of their employees relative to a decrease in container traffic, which dwindled down by 12 million tons and 27 million tons, respectively, during the review period. Similarly, the seaports of Las Palmas and Wilhelmshaven scored a fall in their efficiency records in relation to a rise in the cranes number, which increased respectively by nine and eight units in 2009 and 2011.

The same state is also true in regard to the Gothenburg seaport, whose efficiency level went down from 0.7508 in 2010 to 0.3160 in 2018 despite a rise registered in the cranes' number by 25 units and the construction of a new APM terminal in 2011, counterbalanced with a drop by 8 million tons in general cargo terminal traffic. Similarly, the Southampton seaport efficiency score witnessed a noticeable decrease in 2016, due to the rise in the number of its cranes relative to a three million-tons drop in production during the three-year period 2015-2018.

The average DEA-CCR index recorded for the sample's thirty container ports is of the rate of 0.3899. On average, such a finding shows that these seaports could well improve their efficiency levels by minimizing their current resources' level to a rate of 61.1 % = (1–38.99%). To pinpoint the causes of inefficiency, it is necessary to look into the slack values of the used input and output. In fact, slacks exclusively represent the remaining left out parts following the process of inputs' minimization and outputs' maximization process undergone to an inefficient firm (Ozcan, 2014). Table 4 details the average ressource excesses and throughput shortages recorded for the year 2018.

Regarding the seaport of London, it displayed the lowest efficiency score of 0.1348 in 2018, indicating the persistence of a surplus in two inputs. Indeed, the seaport is required to reduce not only the number of its employees, but also its terminals area to the thresholds of approximately 98.359 employees and 908.528 m^2, respectively. The seaports of Le Havre, Immingham, Genova and Trieste exhibited a similar situation to that of London, though with varying magnitude levels. For the other inefficient seaports, such as Gothenburg, the results show that the port suffers from a surplus in input variables and a shortage in the output related ones. The cited port is required to reduce its yard gantry cranes by 2.45 units and its labor force by 2011.2714 employees. Contrarily, however, for the efficiency level to be attained, the Gothenburg seaport needs to raise its merchandise handling volume by at least twenty tons. Similarly, the Dunkirk and Taranto seaports displayed a similar state, but with varying magnitude degrees.

Noteworthy, however, is that the seaport of Algeciras has been discovered to record zero slacks in input as well as in outputs, and was operating efficiently notably in 2018. Based on the above-discussed results, one might well notice that an excessive use of inputs appears to lie at the origin of most of the European seaports associated inefficiency. For efficiency to be effectively enhanced, new strategies could be developed, through which, a full use of inputs and an increased throughput could be maintained. In what follows is an assessment examination of the investment and efficiency binding relationship, as a second stage of our analysis.

Predominantly, most of the ports appear to apply massive resources in a bid to boost their cargo traffic. Yet, an excess in inputs, mainly in the number of employees, proves to be a major factor lying at the origin of most of the European seaports prevalent technical inefficiency.

5.2. Determinants of seaport efficiency.

The second stage of our analysis involves implementing the bootstrap *Truncated* regressions model to examine each of the explanatory variables associated impact on the container ports respective efficiency, through incorporation of time-effects procedure. The major reached results, drawn following execution of our analyses, are depicted by respective P-value (Table 5). As can be noted, each explanatory variable turns out to bear a p-value that is inferior to the rate of 0.05, which stands as a statistically significant measure.

The achieved empirical results revealed well that the length of quays turns out to display a significantly positive effect on the container ports respective efficiency. Indeed, one could well deduce that seaports with important length quays tend to enjoy rather favorable efficiency levels. As a major factor reflecting the capacity of the seaport (Wu and Goh, 2010) is the length of quays, which has always been consudered as a significantly determinant of port productivity and competitiveness (Musso et al., 2020). For simplicity reasons, seaports with important quay lengths are accessible by a large number of container vessels transporting large shipments and cargo volumes, therefrom, contributing in intensifying seaport throughput traffic, thus, enhancing efficiency (Talley, 1990; Meyler et al., 2011).

It is also worth highlighting that the logistic services' quality index is positively correlated with the seaport efficiency scores, by recording statistically significant coefficients. It is , therefore logical, that seaports characterized with efficient customs clearance processes, adequate transport and robust logistic infrastructure, low shipping costs, and shipment tracking could attract more customers. Such results are actually consistebnt with those reached by Kammoun and Abdennadher (2022). It is not strange, therefore, that the Felixstowe port, considered efficient throughout the first-stage of our research, turns out to be one of the major ports that detain excellent port logistic services in Europe, accounting for 4,04 of this index in 2018. It is recorded that the quality of logistics services reflects a distinctive competitive advantage, liable to help attract greater interest from the part of major shipping companies.

The number of ship calls is also positively correlated with seaport efficiency scores that reveals a statistically significant coefficient. In effect, increased calls' frequency stnds as an attractive factor for shipping companies that reflects the volume of cargo likely to be handled by a port. Indeed, high ship-call frequencies contribute noticeably in intensifying port traffic, thereby, improving efficiency.

Concerning the GDP per capita variable, it has been discovered to display a negative relationship with seaport efficiency scores, displaying statistically significant coefficients. This results corroborate well the argument put forward by Merkel and Holmgren (2017) and Munim and Schramm (2018), maintaining that a large number of developed countries undertake to invest heavily on enlarging the seaports' capacities to account for any potential world trade growth, as a factor highly connected to the GDP growth ratio. Over-investing on seaports might therefore culminate in decreasing their technical efficiency.

Moreover, the investment variable, which corresponds to an increase in the inputs used during the analysis period (2005-2018), is discovered to be negative and statistically significant. Based on the achieved results, it can be deduced that the seaports that have allocated investments to boost the seaport sector tend to be rather inefficient. Such inefficiency is partly due to the relatively long lapse of time necessary for the investment process to achieve production enhancement strategies.

The coefficient associated with the Herfindhal–Hirschman Index, which is positive and statistically significant, leads us to deduce that the ports' efficiency rates turn out to be reduced with fierce inter-port competition. These results are consistent with the findings reached by De Oliveira and Cariou (2015) who investigated a data sample involving a set of worldwide based container ports. Moreover, this relationship might also have an explanation in the noticeably high investments made by the major ports in a bid to attract and meet additional users' requests.

In regard to the distance to the nearest hub seaport variable, it has been demonstrated display a negative relationship with container port efficiency scores displaying statistically significant coefficients. Such a finding seems to be very logical since a short distance separeting a port and the nearest competing hub seaport makes the intended port more attractive to world carriers, in their efforts to avoid dwell time in a hub port (Talley, 2009; Meyler et al., 2011). As a matter of fact, a seaport would be rather enticed and liable to overinvest in infrastructure and superstructures, by constructing specialized terminals, maintaining well-developed services, and installing modern state-of-the-art handling machines to cope with their users' needs. Nevertheless its efficiency would be liable to fall as a result of the erected unused space and equipment. From the above displayed results and discussed arguments, both port Hubs of Valencia and Algeciras turn out to stand as noticeably efficient following the initial stage of our elaborated analysis. They owe their efficiency to the large distance separating them (i.e. about 763 kms). The same applies to the two hub ports of Hartlepool and Felixstowe satisfactory results recorded in terms of efficiency, given the long distance separating them (i.e. about 452 kms). As the short distance between the two hub seaports of Bremen-Bremerhaven and Wilhelmshaven, it stands as a main reason for their displayed technical inefficiency (i.e. about 82 kms).

Finally, the time effects have proved to be positive and statistically significant ever since the year 2010. This result is attributed to the increasing logistic services' quality marking the study sample seaports. This can be clearly illustrated through the average values scored by the logistic services' quality indexes, which went up from 3.29 in 2010 to 3.89 in 2018. These seaports have been able to attract further customers, which enabled them to boost their total freight traffic rates by 420 million tons during the 2010-2018 time interval, thereby, further enhancing their overall efficiency.

Conclusions.

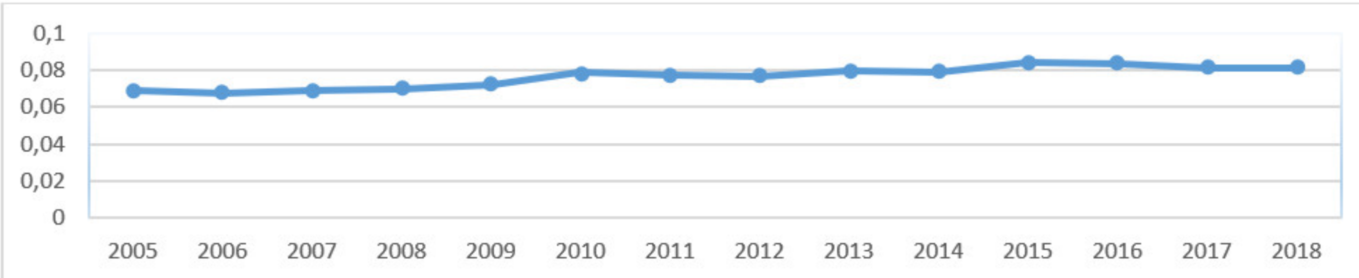
Container ports play a critical role in improving the economic growth rate of countries. Enhancing technical efficiency is therefore necessary to facilitate the exchange and handling of goods in a highly competitive modern world environment of nowadays. Many studies have tried to find out the impacts of fierce inter-port competition and environmental factors on technical efficiency (Yuen et al., 2013 ; Merkel and Holmgren, 2017 ; etc.). Theoretically, however, it has been widely assumed that intensified inter-port competition stands as a noticeable enhancing factor, significanly contributin in boosting seaports' achieved efficiency. Nevertheless, subject to increasingly fierce competition, seaports might well engage in over-investment strategies, yet, remain inefficient (De Oliveira and Cariou, 2015).

The contribution of this research paper to the literature consists in attempting to estimate and highlight the impacts of port competition and environmental factors on the efficiency scores of thirty European container ports, observed throughout the time lapse ranging from 2005 to 2018. For this purpose, a two-stage analysis process has been implemented, wherein, the non-parametric technique has been jointly applied with the truncated regression model to yield the achieved results.

The findings achieved following conduction of this work seem to be interesting as we found that both of the number of ship calls, logistic services' quality and quays' length factors turn out to positively impact seaport efficiency. We have also been able to conclude that, in addition to production deficits and excessive input, seaport inefficiency could have an explanation in other intervening factors. More particularly, fierce inter-port competition and the short distance to Hub seaport are likely to noticeably decrease the seaport's technical efficiency. Such a relationship provides an explanation as to the seaports engagement in over-investment, thereby, creating a reserve of capacity. This finding corroborates the results achieved by Cariou and De Oliveira (2015).

Nonetheless, it should be noted that the main shortcoming associated with this study lies in the data shortage issue. The main shortcoming relates to the data shortage issue. It

Figure 1: HHI of European seaport system, 2005 - 2018.



Source: Authors.

Table 1: Descriptive statistics of container port.

			Obs	Min	Max	Mean	STD
First-Step	2005	Annual traffic	30	14050000	345819000	57888087.7	61042144.52
		Number of yard gantry cranes	30	11	50	25.32	26.5844
		Number of tugs	30	3	90	19.3	20.4081627
		Number of employees	30	183	130000	20388.6	32907.531
		Terminals area	30	7392	6227200	693635.936	1250934.804
	2018	Annual traffic	30	13000000	467354000	70156362.27	85741266.92
		Number of cranes	30	18	89	54.12	56.45
		Number of tugs	30	7	340	142	158.365
		Number of direct employees	30	183	358000	30311.7	69188.671
		Terminals area	30	7392	6832000	731790.603	1340903.164
Second-Step	2005	DEA-CCR	30	0.0004	0.8256	0.2663	0.2381
		Quays' length	30	2003	151000	27170.5	37072.191
		GDP per capita	30	0.0041	0.9525	0.1911	0.2804
		Investment	30	0	1	0.7	0.466
		HHI	30	0.0692	0.0692	0.069162	0.00E+00
		Distance	30	90	1587	397.77	365.873
		Logistic services' quality	30	3.1904	4.25	3.8033	0.3023
		Vessel calls	30	41240414	461240414	251121817	261137894
	2018	DEA-CCR	30	0.004	1	0.2856	0.3012
		Quays' length	30	2003	172000	28492.53	39815.195
		GDP per capita	30	0.0059	0.9367	0.2460	0.3235
		Investment	30	0	1	0.7	0.466
		HHI	30	0.0815	0.0815	0.0815	0.00E+00
		Distance	30	90	1587	397.77	365.873
		Logistic services' quality	30	3.6550	4.3106	3.9372	0.2129
		Vessel calls	30	47426476.1	530426476	288790090	300308578.12

Source: Authors.

is therefore recommended that we expand the port sample to incorporate extra seaports based in other regions. A potential study might well involve other seaports mainly located in Africa, Latin America, and the Middle East. The latter might provide further evidence likely to consolidate our study objective regarding the investigation of seaport efficiency determinants. Still, a future work could investigate the impact of privatization on these respective transshipment ports, taking into account the fact that ongoing privatization trends should increase the container ports' overall efficiency.

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Table 2: Algeciras seaport efficiency scores using DEA-window approach (based on CCR).

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
W1	0.6337	0.6893	0.7134	0.7104	0.5810	0.6093	0.7170							
W2		0.6893	0.7134	0.7104	0.5810	0.6093	0.7170	0.6751						
W3			0.7134	0.7104	0.5810	0.6093	0.7170	0.6751	0.6310					
W4				0.7104	0.5810	0.6093	0.7170	0.6751	0.6310	0.7060				
W5					0.5810	0.6093	0.7170	0.6751	0.6310	0.7060	0.7407			
W6						0.6093	0.7170	0.6751	0.6310	0.7060	0.7407	0.7785		
W7							0.7170	0.6751	0.6310	0.7060	0.7407	0.7785	0.7792	
W8							0.7170	0.6751	0.6310	0.7060	0.7407	0.7785	0.7792	1.0000
mean	0.6337	0.6893	0.7134	0.7104	0.5810	0.6093	0.7170	0.6751	0.6310	0.7060	0.7407	0.7785	0.7792	1.0000

Source: Authors.

Table 3: Efficiency scores mean value recorded for the thirty European seaports (2005-2018).

Container port	Town	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Mean
Le Havre	France	0.2029	0.2005	0.2118	0.2168	0.1984	0.1885	0.1749	0.1635	0.1777	0.1695	0.1737	0.1656	0.1824	0.1979	0.1874
Dunkirk	France	0.7914	0.8222	0.8198	0.8234	0.6188	0.5925	0.6664	0.6586	0.5978	0.6350	0.6022	0.6015	0.6378	0.6420	0.6792
Nantes	France	0.4279	0.4261	0.4213	0.4165	0.3686	0.3852	0.3797	0.3237	0.2990	0.3113	0.2747	0.2759	0.3236	0.3520	0.3561
Marseille	France	0.4584	0.4741	0.4547	0.4545	0.3922	0.4049	0.4149	0.4021	0.3746	0.3656	0.3806	0.3754	0.3715	0.3959	0.4085
Immingham	United Kingdom	0.3617	0.3678	0.3808	0.3749	0.3143	0.3104	0.3288	0.3452	0.3597	0.3411	0.3395	0.3125	0.2910	0.2994	0.3377
London	United Kingdom	0.1373	0.1324	0.1345	0.1351	0.1159	0.1226	0.1245	0.1116	0.1102	0.1127	0.1151	0.1276	0.1264	0.1348	0.1243
Hartlepool	United Kingdom	0.9996	0.9562	0.8923	0.8144	0.7020	0.6398	0.6309	0.6088	0.6747	0.7087	0.6426	0.4817	0.5099	0.5162	0.6984
Southampton	United Kingdom	0.4508	0.4576	0.4944	0.4624	0.4201	0.4442	0.4274	0.4300	0.4039	0.4140	0.4250	0.4067	0.3890	0.3893	0.4296
Felixstowe	United Kingdom	0.8256	0.8827	0.9493	0.9140	0.9030	0.9721	0.9752	0.9560	0.9344	0.9905	0.9886	0.9932	0.9744	0.9626	0.9444
Hamburg	Germany	0.1465	0.1564	0.1600	0.1609	0.1258	0.1388	0.1519	0.1508	0.1601	0.1673	0.1596	0.1598	0.1577	0.1813	0.1555
Bremen-Bremerhaven	Germany	0.0760	0.0920	0.0998	0.1260	0.1099	0.1183	0.1438	0.1500	0.1403	0.1381	0.1281	0.1346	0.1269	0.1882	0.1266
Duisburg	Germany	0.3573	0.3907	0.1812	0.0833	0.0671	0.0450	0.0500	0.1887	0.1863	0.1825	0.1855	0.1593	0.1617	0.1699	0.1720
Wilhelmshaven	Germany	0.3452	0.3237	0.3202	0.3045	0.2521	0.1823	0.1798	0.1935	0.1821	0.1777	0.2020	0.1804	0.2080	0.2086	0.2329
Antwerp	Belgium	0.3609	0.3755	0.4096	0.4238	0.3359	0.3782	0.3319	0.2919	0.3051	0.3201	0.3373	0.3525	0.3476	0.3585	0.3521
Bruges-Zeebruges	Belgium	0.2045	0.2334	0.2488	0.2485	0.2653	0.2933	0.2776	0.2575	0.2533	0.2516	0.2266	0.2236	0.2194	0.2371	0.2458
Rotterdam	Netherlands	0.4825	0.4934	0.5221	0.5361	0.4938	0.5522	0.5533	0.5717	0.5760	0.4811	0.4959	0.4902	0.4918	0.5304	0.5193
Amsterdam	Netherlands	0.2318	0.2600	0.2807	0.3266	0.2863	0.3006	0.2954	0.3041	0.3115	0.3247	0.1643	0.1649	0.1845	0.1845	0.2586
Gothenburg	Sweden	0.6379	0.6979	0.7056	0.7402	0.6808	0.7508	0.3222	0.3209	0.2994	0.2873	0.2949	0.3196	0.3182	0.3160	0.4780
Algeciras	Spain	0.6337	0.6893	0.7134	0.7104	0.5810	0.6093	0.7170	0.6751	0.6310	0.7060	0.7407	0.7785	0.7792	1.0000	0.7118
Valencia	Spain	0.2935	0.3418	0.3854	0.4210	0.4056	0.4453	0.4548	0.4548	0.4486	0.4618	0.4829	0.4874	0.5043	0.6428	0.4450
Barcelona	Spain	0.1503	0.1551	0.1664	0.1683	0.1456	0.1432	0.1428	0.1392	0.1393	0.1669	0.1542	0.1585	0.2017	0.2752	0.1648
Las Palmas	Spain	0.3639	0.3839	0.4029	0.3951	0.3079	0.3363	0.3798	0.3753	0.3147	0.3450	0.3147	0.2845	0.2542	0.2505	0.3363
Bilbao	Spain	0.3588	0.4016	0.4147	0.4100	0.3877	0.4129	0.3892	0.3551	0.3689	0.3804	0.3925	0.4048	0.4170	0.4288	0.3945
Tarragona	Spain	0.5483	0.5548	0.6357	0.5834	0.5540	0.5768	0.5616	0.6242	0.4956	0.5642	0.5846	0.5548	0.5965	0.5678	0.5716
Lisbon	Portugal	0.5258	0.5245	0.5594	0.5851	0.5293	0.4501	0.4621	0.4145	0.4502	0.4437	0.4334	0.3838	0.4581	0.4865	0.4790
Sines	Portugal	0.5424	0.5860	0.5650	0.5337	0.4964	0.5146	0.5175	0.5706	0.7598	0.7294	0.8577	0.9998	0.9666	0.9457	0.6847
Genova	Italy	0.4339	0.4521	0.4921	0.4729	0.4346	0.4216	0.4312	0.4320	0.4155	0.4416	0.5111	0.5071	0.5514	0.5516	0.4678
Taranto	Italy	0.4760	0.5058	0.4896	0.4924	0.3786	0.3401	0.4099	0.3501	0.2436	0.2315	0.1838	0.2086	0.2003	0.1999	0.3364
Trieste	Italy	0.4351	0.4356	0.4168	0.4356	0.4471	0.4797	0.4107	0.4189	0.3915	0.4024	0.4184	0.4198	0.4697	0.4700	0.4322
La Spezia	Italy	0.3470	0.3901	0.3926	0.3765	0.2897	0.3629	0.3450	0.3121	0.3143	0.3132	0.3051	0.2868	0.3231	0.3255	0.3346

Source: Authors.

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Table 4: Average excess inputs and output shortages recorded in 2018.

	Number of yard gantry cranes	Number of tugs	Number of employees	Terminals area	Throughput
Le Havre	0	0	3826.6612	7700.332	0
Dunkirk	8.02	0	135.5132	0	25.32
Nantes	0	6.23	18.4254	352.569	0
Marseille	7.25	0	414.182	0	0
Immingham	0	0	200.6048	378.616	0
London	0	0	98.359	908.528	0
Hartlepool	0	5.25	106.3622	169.7785	0
Southampton	0	8	6344.4188	0	0
Felixstowe	0	4	0	0	0
Hamburg	0	0	7946.5856	916.5885	95.58
Bremen-Bremerhaven	0	5.12	7892.8592	659.3475	0
Duisburg	4.89	9.23	0	9062.805	0
Wilhelmshaven	0	4.25	0.4838	0.106	0
Antwerp	0	0	165.7302	0	0
Bruges- Zeebruges	0	4.85	2327.0042	0	0
Rotterdam	0	3.45	5578.2526	8.674	0
Amsterdam	0	7.78	726.7414	0	0
Gothenburg	2.45	0	2011.2714	0	20
Algeciras	-	-	-	-	-
Valencia	0	3.51	0	3013.33	14.12
Barcelona	0	6.49	4946.1498	0	0
Las Palmas	6.15	5.87	0	915.9665	0
Bilbao	4.54	7.22	0	819.865	0
Tarragona	3.61	4.12	0	42.193	0
Lisbon	0	2.16	11.8818	627.5545	0
Sines	6.37	0	0	4336.9615	22
Genova	0	0	967.0834	3085.3035	0
Taranto	5.82	0	870.7334	0	58.36
Trieste	0	0	63.8944	1035.1535	0
La Spezia	0	9.01	1103.0148	0	0

Source: Authors.

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Table 5: Regression Results.

	Coefficient	P-value
Quays' length	5.4348	0.000***
Logistic services' quality	0.0608	0.000***
Vessel calls	0.2350	0.000***
GDP per capita	-0.9730	0.000***
Investment	-0.3860	0.000***
HHI	0.0529	0.012**
Distance	-1.6434	0.020**
	Time-effects	
2005	0.0267	0.115
2006	0.0032	0.779
2007	0.0258	0.113
2008	0.0032	0.781
2009	-3.4354	0.000***
2010	0.5659	0.000***
2011	0.2492	0.000***
2012	0.5659	0.000***
2013	0.7723	0.039**
2014	0.5903	0.000***
2015	0.7812	0.029**
2016	0.2585	0.000***
2017	0.2492	0.000***
2018	0.7812	0.028**
cons	0.8400	0.016**
/sigma	0.1893	0.000***
N	420	
Note : Significance levels are respectively 1% (***). 5% (**) and 10% (*).		

Source: Authors.

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