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Contribution to the assessment of the economic performance of container ports in the Mediterranean & Tangier-Med

Azzelarab Zaoudi, Abid Ihadiyan, Hassane Zouiri

Abstract— currently, container ports operate in a highly competitive environment. The viability of the port sector depends mainly on their degree of performance. In this context, an assessment of their performance proves to be an exam of a major consideration. This research seeks to assess the economic performance of container ports in the Mediterranean, including Tangier-Med. For this, we will apply the econometric method of Stochastic Frontier Analysis (SFA). The sample includes 22 container ports in the Mediterranean region. According to the SFA method, technical inefficiency dominates the performance models of the ports of the region. According to the parameter μ, a representation of the efficiency according to a half-normal distribution falls perfectly adequate for the port industry. The impact of China's trade on the prosperity of Mediterranean ports is crucial. On the other hand, the relationship is strong between capacities - demand and efficiency in port industry. Employment and underemployment of port resources are constantly alternated following the expansion projects. The intensity of port technical capital is considered within the framework of the particular strategies carried out by the different ports, our research distinguishes 5 types of port strategy: leader, follower, moderation, rationalization of resources and mere attendee strategy.

Index Terms— Economic Performance, Technical Efficiency, Productivity, Container port, Stochastic Frontier Analysis, Technological change, Data Envelopment Analysis

1 Introduction

Currently, container ports and terminals operate in a highly competitive environment. They are now key players in the global logistics chain and in international trade. The viability of the port sector depends mainly on their degree of performance. In this context, an assessment of their economic performance proves to be an exam of great interest. This research aims to assess the economic performance of container ports in the Mediterranean and Tangier-Med port. For this, we will apply the econometric method of Stochastic Frontier Analysis (SFA).

2 Terminology

Two concepts underlie the analysis of economic performance, the concept of productivity and efficiency.

2.1 Productivity

The productivity is defined as the ratio of the production output on total of used factors, it reports the result obtained to the observed consumption of factors. So it means merely "the ratio of outputs on inputs". In economics, productivity is the ratio of output of goods or services to the quantity of inputs used (including capital and labor) to produce these goods or services. Productivity is a measure of performance. The concept of Total Factor Productivity (TFP) aims to synthesize the overall productivity of the production process. It aims to measure approximately technical progress. Malmquist index is one of the indices of this measure. The notion of productivity is sometimes broad and complex considering its implications in economics and management. Although it is difficult to estimate its impact on management, several studies continue to demonstrate its positive impact on performance. Nicholas Bloom leads with his team of researchers an experience in India in which they have provided management consulting to a number of companies drawn at random and comparing the performance with a company of "control" of which they did not offer this consulting service. They concluded that companies that benefited from management consulting perform better.[1]

2.2 Effeciency

Efficiency is a relative concept, the ability of an individual, group, or organization to achieve its goals with a minimum of waste of time and effort. Henry Mintzberg in his book reveals that "efficient management is the very essence of management".

2.3 Economic performance

The performance, idem, is a very relative concept, it refers to the two previous concepts, in general, the performance, as that, refers to the concept of benchmarking, there are several methods and approaches to measuring economic performance. We will review the SFA and DEA method. However, there is no consensus on the concept of economic performance. In transport literature two main categories of measures are considered: productivity/efficiency and technological change (Oum, Trethways and Waters 1992). The widely exploited measures are those of linear regression, productivity index, ordinary least squares, corrected least squares (COLS), maximum likelihood, envelope data (DEA) and stochastic frontier (SFA) methods.

2.4 Data Envelopment Analysis method

The DEA method evaluates the relative efficiency of comparable production units and generates efficiency scores based on

[1] Nicholas Bloom, Benn Eifert, Aprajit Mahajan, David McKenzie and John Roberts, "Does Management Matter? Evidence from India", The Quarterly Journal of Economics, vol. 128, no 1, 2013, p. 1-51

information of inputs and outputs (Kobou et al., 2009). This method is based on mathematic linear programming as well as on microeconomic theory principles in order to compare all similar units simultaneously taking into account several dimensions. It determines the efficiency frontier coming up from the "best practices" of the production units. Inputs are resources used to create outputs of a given quality. Each unit is considered as a Decision Making Unit (DMU). In other words, it is a linear programming method that limits the observations by sections so as to find a frontier. This method does not require an explicit specification of the form of the underlying production relation, that is to say, the "a priori" function of production or cost.

2.5 Stochastic Frontier Analysis method

This approach is known as the econometric frontier, it specifies a functional form of production or cost often by the translogarithmic or Cobb-Douglas function that we will try to apply in this work. Unlike the non-parametric approaches as DEA, the SFA allows the presence of random error which it tries to measure by one of the available techniques like the maximum likelihood or least squares method. However, the determination of the frontier is different in comparison with nonparametric approaches it includes two random terms, one for statistical noise and other for technical inefficiency, in this sense the gap to the frontier does not result only from the system error but it is also partially due to the inefficiency of the economic unit, the optimization margin is considered without adjusting the regression line at the frontier as in the case of the conventional linear regression methods. 1) It has the same advantages as the COLS method, but 2) it adds the consideration of the terms of the error, which makes it possible to test the validity of some hypothesis, 3) it is flexible in the use of the function of production technology (shape of the function), 4) finally, it makes it possible to take into consideration and to estimate the exogenous factor in the given model. It has the disadvantage 1) of requiring a priori the structure of production or the function of cost; 2) it imposes to take into account the hypotheses of distribution of the term of the error in order to decompose it.

3 Literature Review

The analysis of the performance of a port or terminal requires taking in consideration a number of mandatory criteria, two criteria to be evoked at this stage, 1) the port is not the simple collection of its terminals. 2) Output presents some issues that only a broad understanding of the field can alleviate. Assumptions are strictly related to the objectives of the research. Economic performance, that is, productivity and efficiency, can be measured quantitatively by parametric and non-parametric methods, including the SFA and DEA method. These methods are characterized by their advantages of comparing several units, so it is the application of the benchmarking technique that makes it possible to distinguish between the leader units that represent the best practices of the market or a geographical area. The question of the objectives of the production units is necessary to clarify since a port is looking for objectives different from those pursued by a container terminal.

Indeed, many port studies evoke the port by reference to its port authority, and evoke the terminal by reference to its stevedore. Several organizations are present in the port area and their activities although under the control of the authority, their objectives are obviously different. The role of the port authority itself can be distinguished from one zone to another or from one country to another. Estache, Gonzales and Trujillo (2002), Barros (2005), Trujillo and Tovar (2007), Gonzales and Trujillo (2008) have explicitly revealed that the activities studied are on the accountability of the port authority, Tovar and Trujillo 2007) analysis cover 22 European port authorities, while in other works, the authors remain silent, Liu (1995), Coto-Millan, Banso-Pino and Rodriguez-Alvarez (2000), Cullinane, Song and Gray (2002) do not reveal any specification to the port's activities, the latter studied the performance of 15 Asian ports.

The multiplicity of actors and agents within a port makes the task of studying the port as a homogeneous organism very difficult if not impossible. On the other hand, studies on port terminals reveal the activity in question, mainly container transfer and exclude agents and other actors within the port, Notteboom, Coeck and Van den Broech (2000), Cullinane and Song (2003), Tongzon and Heng (2005), Sun, Yan and Liu (2006), Tovar and Trujillo (2007). The relative performance of a port or a terminal is measured by its potential to generate output through the combination of inputs it possessing, the specification of output and input variables sometimes is problematic. Performance can be measured by quantitative methods, mainly via the Stochastic Frontier Models (SFA), Tongzon and Heng (2005), Cullinan et al (2005) or via DEA, Roll and Hayuth (1993), Liu 1995), Tongzon (2001), Valentine and Gray (2001), Cullinan et al (2004, 2005).

The debate on the choice of the method of estimating efficiency is still ongoing. A survey carried out by A. Pallis, T. Vitsounis, Peter de Lange, and E. Notteboom on the different performance measures published in the journal of port economics indicates that port and terminal studies have been developed since the 1990s, they concern the economy of port / terminal operations or the economy and management of the organizations that operate it, the studies mainly discuss efficiency and productivity, whereas previously it were simply matter of partial measures of productivity (ship turnaround time, yard and wharf productivity, drivers productivity, etc.).

Currently, studies start to use sophisticated regression methods such as SFA and DEA, Lun and Carriou (2009) have used the regression analysis as a statistical tool to highlight the relationship between the variables which they combined with the DEA method to develop a reference for the stevedore operators in order to provide an appraisal of their performance. Tongzon and Heng (2005) combine traditional regression with the SFA method to investigate the quantitative relationship between port ownership structures and its effectiveness. The DEA method is renowned for its adaptation to multiple output production measures in the port sector, it is now possible to estimate the margin for improvement of inefficient ports (Barros 2006), the DEA method made sense of the performance measures (efficiency or productivity) that compares several terminals (Gonzalez and Trujillo 2009, Cullinan, Song, Ji and Wang 2004). SFA as

DEA are deemed to be of interest for the benchmarking between performance of several ports / terminals. According to the objectives of each researcher and his conception of performance, the choice of the method is established. Notteboom et al (2000) were pioneers in applying the SFA parametric method, introducing the Bayesian approach to the SFA for the Container Terminal context, 36 European CTs were assessed. Cullinan, Song and Gray (2002) compile a database of 15 Asian ports, while Liu (1995) assessed the turnover of 28 major ports in Great Britain. Tongzon and Heng (2005) show that privatization is a necessary port strategy to gain the competitive advantage. Barros (2005) evaluates the performance of 10 Portuguese ports by estimating the stochastic translog frontier during the period 1990-2000. Rodriquez-Alvarez et al (2007) also use the translog function in their econometric model to calculate the technical and allocative efficiency of 3 ports of the Canary Islands and mainly of the port of Las Palmas in Spain. Gonzalez and Trujillo (2008) highlight the relationship between institutional reform and terminal efficiency.

They assess the performance of 5 Spanish port authorities by estimating the distance of the translog function, thus demonstrating that the port reform improves significantly the technological change, but with a "light" and "mild" change in technical efficiency. Bergantino and Musso (2011) use a stochastic frontier method where regional GDP, employment rate, population density and accessibility are used to assess the efficiency of 18 Southern European ports for the period between 1995 and 2007.

They conclude that these factors play a positive role with the exception of the level of employment. Finally, Niavos and Tsekeris (2011) identify the main determinants of the technical efficiency of container ports in the South-East Europe region and reach the same outcome as Cullinan and Song (2003), Estache and al (2002), Tongzon and Heng (2005), which means that large ports tend to perform better and privatization improves performance.[2]

4 Research Methodology

A production function gives the maximum output that can be realized from a vector of inputs x. The technology is defined by the production function f (x): y = f(x, β) + ε

The SFA method is distinguished by its approach of decomposing the error, the estimation of the efficiency in this instance requires the specification of the distribution hypothesis.

The error is break down as follows: ε = v - µ with:

v: represents the residual term (statistical noise or random term)

µ: represents the inefficiency

v and µ are distributed independently of each other

ε measure the difference between the observed output y and the maximum output reached by the efficient technology, the model is deterministic if ε represents only µ in this case, y = f (x, β) - µ The model takes only one effect is the inefficiency which in this line of thought attributable to factors assumed under the control of the management (wrong investment decision, poor technological choice, lack of competence, bad Management ...), µ would be zero for technically efficient units. In this case the estimation of the efficiency of Farell is simply carried out by the quotient: $y_i/f(x_i, \dot{B})$ and Ḃ is an unbiased estimator of β

If we add to the deterministic specification a random term v, the model becomes stochastic. This model takes into account not only the factors subject to management but also factors beyond its reach, such as adverse weather conditions, political atmosphere (strike) or economic crisis. The model also takes into account the exogenous factors. In the literature v is always distributed "normally" and µ is specified according to one-side distribution.

The density function of µ is may be half-normal, truncated normal, exponential or gamma. Kumbhakar and Lovelle (2000) present the distribution hypothesis. In this research two models are tested, the model of Battese and Coelli 1992 and that of 1995, the first considers the deterministic model and the second envisages the stochastic model:

4.1 Model B and C (1992):

The Battese and Coelli model 1995 proposes to estimate the production function as in (1)

$$\ln y_{it} = \beta_0 + \sum_{n=1}^{5} \beta_n \ln x_{nt}^i + v_t^i - u_t^i \qquad (1)$$

$$u_{it} = u_i + e^{(-\eta(t-9))}$$

y et x: explained and explanatory variables respectively
β_n, β_*: unknown parameter to be estimated
v_t^i: symbolize symmetric random noise
and supposed to be i. i. d, according $N(0, \sigma_v^2)$
u_t^i: non negative random variables, u_i are asymmetric (≥ 0)
supposed to be i. i. d, with a truncation to zero, according $N(m_t^i, \sigma_u^2)$
η: Eta parameter and to be estimated, if $\eta = 0$

The model B and C (1992) utilizes the parameterization of Battese and Corra (1977) who replace σ_v^2 and σ_u^2 by $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma^2 / (\sigma_v^2 + \sigma_u^2)$. This is done by the maximum likelihood technique.

4.2 Model B and C (1995):

The Battese and Coelli model 1995 proposes to estimate the production function and to predict the efficiencies of the firms, then regress the efficiencies on exogenous variables in order to detect other reasons that may affect performance, in this case we shall apply the two-stage estimation procedure. The first phase of the frontier is estimated using the OLS method (ordinary least square). In the second step, the maximum likelihood method is tested. The model is expressed as (2)

$$Y_{it} = X_{it}\beta + (v_t^i - u_t^i) \qquad (2)$$

$$m_t^i = z_t^i \quad \delta$$

$$u_t^i \sim N(m_t^i, \sigma_u^2)$$

i = 1…... N & t = 1…... T

where : *the parameters as difined earlier*
z_t^i: p x 1 vector of exogenous variables

[2] Pierre Carriou, Gabriel Figueiredo de Oliviera, Les déterminants de l'efficience portuaire : une analyse des ports à conteneurs méditerranéens, Région et Développement n°41-2015, Toulon, 2015.

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u_t^i: *non negative random variables,* u_i *are asymmetric* (≥ 0) *supposed to be i.i.d, truncated at zero, following* $N(m_t^i, \sigma_u^2)$

5 Data and Variable Specification

Our sample includes 22 Mediterranean ports. we have collected their physical information specifying 5 variables inputs which are endogenous to the production process where the technical (in)efficiency derives and an exogenous variable to the production process, the China's trade in dollars (see Table 1). The database is constructed for a panel of 9 years that covers the period from 2006 to 2014 (included). We have built our database from the various official reports and notes of the port authorities, statistics of governments and international institutions, reports of companies and consulting agencies as well as research and private reliable works.

TABLE 1
Specification of the Variables

Output	*y*	*Throughput teus*
Input	*x1*	*Berth Lenght*
	x2	*Port area*
	x3	*Draft*
	x4	*Storage cap*
	X5	*Quay crane nbr (QC)*
Exogenous factor	*z*	*China's trade (exp/imp volume)*

TABLE 2
Descriptive Statistics

Statistics	Yi Throughput	x1 B. Lenght	x2 Port. Area	x3 Draft	x4 Stor. Cap	x5 QC Num	zi China's Trade
Observations	196	196	196	196	196	196	196
Minimum	12202	200	6	7,2	0,15	0,2	1,76807E+12
Maximum	4555000	4214	166	18	5	36	4,30184E+12
Range	4542798	4014	160	10,8	4,85	35,8	2,53377E+12
Mean	1512759,8	1751,1	66,309	14,329	2,141	12,113	3,09252E+12
Standard dev. (n-1)	1262575,4	1115,9	48,748	2,839	1,477	9,852	8,90992E+11
Variation Coef.	0,832	0,636	0,733	0,198	0,688	0,811	0,287
Skewness (Fisher)	0,689	0,536	0,656	-0,853	0,292	0,642	-0,013

We observe in Table 2 a positive Fisher skewness parameter for all variables except for the draft (x3) since its distribution is spread out to the left, thus, for x3, the left skewness (-0.853) means that the large observed values are more frequent than the small values. Other variables lie to the right, thus small values overcome larger ones. The spread on the right is less strong for the variable (x4), the skewness (0.292) approaches the value zero, so the distribution is approximately close to the symmetry.

6 Models Definition

According to the data of our sample we define 8 models (3):

TABLE 3
Models of Performance Analysis of Ports

Model specification / Factor parameters	Cobb-Douglas		Translog	
	Endogenous effect model	Exogenous effect model	Endogenous effect model	Exogenous effect model
	Truncated Normal B - C 1992	Truncated Normal B - C 1995	Truncated Normal B - C 1992	Truncated Normal B - C 1995
Basic model	1.1		2.1	
Basic model and trend	1.2		2.3	
Basic model, trend and trade volume	1.3	1.4	2.5	2.6

Table 3 illustrates the different models and their mathematical assumptions, the first line represents the basic model which include 5 input factors, the second line comprises the basic model plus the trend for the time (1,2, ..., 9), the third and the last represent the basic model, the trend in addition to the exogenous variable: the trade volume of China. The values are expressed in logarithms. The columns represent the mathematical hypothesis, first the form of the function, Cobb-Douglas and the translogarithmic functions are used in the deterministic part, secondly the model with endogenous or exogenous effects, depending on whether the exogenous variable is included in the deterministic part or in the stochastic part and finally the distribution hypothesis for the random variables u and v, we opt for technical (specific to the model) reasons for the normal truncated hypothesis.

In the model 1.3 we have inserted, in addition to the trend, the variable of China's trade as an endogenous variable even if, in fact, this variable is not directly influenced by the given port, we have taken it into account as an additional factor (input) in attempt to measure the effects of China's trade on the efficiency system of the Mediterranean ports, in this case the volume of trade is included in the deterministic part of the model, it affects inefficiency in an indirect way, the variable is considered as one input among others, in this sense market conditions are integrated into the decision-making process of the given port, whereas the Model 1.4, unlike models with endogenous effects, aims to measure the impact of China's trade on the port efficiency system in the sense that port management does not support the external factor , That it is external to it, that it undergoes its variations, the external factor is considered in the stochastic part, so the market conditions affect the efficiency of the ports directly, the external factor is unsteady and unpredictable, we assume, unlike models with endogenous effects, that ports cannot build their knowledge and technologies on market conditions (unsteady and unpredictable).

7 Results of Assessment

For our sample, the function Trans-logarithmic have generated irregular values, we chose the Cobb-Douglas function.

TABLE 4
Null Hypothesis for Cobb-Douglas Models

Null hypothesis	*Interpretation*	*Maximum likelihood*	*Decision*
Tests given Model 1.1			
H0: $\gamma = 0$	*Ports are fully technically efficient*	0.940658	*Reject*
H0: $\mu = 0$	*The effects of technical inefficiency are represented by a half-normal distribution*	-2.237335	*Accept*
H0: $\eta = 0$	*The effects of technical inefficiency does not change over time (time-invariant model)*	0.089442	*Reject*
Tests given Model 1.2			
H0: $\gamma = 0$	*Ports are fully technically efficient*	0.892113	*Reject*
H0: $\mu = 0$	*The effects of technical inefficiency are represented by a half-normal distribution*	-0.837112	*Accept*
H0: $\eta = 0$	*The effects of technical inefficiency does not change over time (time-invariant model)*	0.123264	*Reject*
Tests given Model 1.3			
H0: $\gamma = 0$	*Ports are fully technically efficient*	0.892083	*Reject*
H0: $\mu = 0$	*The effects of technical inefficiency are represented by a half-normal distribution*	-0.833003	*Accept*
H0: $\eta = 0$	*The effects of technical inefficiency does not change over time (time-invariant model)*	0.122873	*Reject*
Tests given Model 1.4			
H0: $\gamma = 0$	*Ports are fully technically efficient*	0.998251	*Reject*
H0: $\delta_0 = 0$	*The effects of market conditions are represented by a half-normal distribution*	59.353540	*Reject*
H0: $\delta_1 = 0$	*Market conditions do not affect port inefficiencies*	-3.399944	*Reject*

7.1 Endogenous effect model: Input variables

We have specified the models with endogenous effects with a mean μ according to a truncated half-normal. When μ is equal to 0, the distribution of the inefficiency is half-normal (without a truncation to zero), our models present μs not significant (negative), the alternative hypothesis is accepted, so the inefficiencies of ports can perfectly have a specification with a half-normal distribution.

We have specified the endogenous effects models with parameter η. The latter represents technological change over time in the sector of activity which is port industry. When η is 0, the port efficiency model is not affected by technological change over time. Our models, always with endogenous effects, have a positive and significant Eta η, which means that the port sector (for our sample) presents a slow and steady technological change (0.12): model 1.3 as a reference (see table 4).

We tested the gamma γ parameter for our models. The parameter γ is between 0 and 1. When γ approaches 0, the model is economically efficient, γ in this case indicates that the distance to the frontier is due almost to the error of the system, so depending on factors that take care of the environmental conditions of each production unit, here, ports, for example, geographical conditions or climatic conditions, etc. On the other hand, if γ approaches 1, the model presents technical inefficiencies, the distance to the frontier is due to endogenous factors, so to those under management control. Economically, the parameter γ traces the relation between the standard deviation of the two terms of the residue, u (for inefficiency) and v (for error), with: $\gamma = \sigma_u^2/(\sigma_v^2 + \sigma_u^2)$. In our models the parameters γ are 0.9 indicating that the technical inefficiency dominates the port system for our sample. Our data compilation accepts rather a deterministic frontier to describe the technique of port production. In this wave of idea, the deterministic frontier includes only the random term of inefficiency u, and it does not take into account the error term v.

7.2 Exogenous effect model: China's trade

In fact, the intercept and the parameter to be estimated of the exogenous variable play the same role as μ and η in the models with endogenous effects. We observe that the intercept and the parameter of the exogenous variable δ0 and δ1 respectively are significant. The parameter δ1 representing the exogenous variable is negative, indicating that an increase in trade flow from China somehow undermines port inefficiency. The economic performance of ports (in terms of TE) seems steady in models with endogenous effects (see table 6) and evolving over time, when the exogenous variable is taken into account in the model with exogenous effects (see table 7) the model performs otherwise the performance of the ports is irregular. Trade flow plays a crucial role in the inefficiency and development of port infrastructure and directly influences the economic performance of ports. However, we noticed that models with endogenous effects 1.1, 1.2 and 1.3 have the same steady and increasing efficiency model, although for model 1.3 we have taken into account the trade flow as input but has not changed so far the model, which proves that the exogenous variable directly influences the performance of the ports, efficiency is real rather than nominal.

7.3 Production elasticities

The elasticity reflects the relative variation in port throughput caused by a variation in one of the parameters of the model, all things being equal. We find it useful to measure the partial variation production elasticities of the ports relative to the geometric mean. It should be noted that the geometric mean works perfectly for the rates of variation and elasticities.

Statistics	Yi	x1	x2	x3	x4	x5
Mean	1512759.87	1751.17	66.30	14.32	2.141	12.113
Geome-tric mean	880705.69	1367.97	46.35	13.99	1.449	6.504

The Cobb-Douglas equation estimates Beta (β) parameters in terms of the number of xi that can be interpreted as output elasticities for the different ports of the study. The table below (Table 5) comprises βs parameters for the 5 variables of our model:

TABLE 5
MAXIMUM LIKELIHOOD ESTIMATION RESULTS

Variable	Param	Model 1.1	Model 1.2	Model 1.3	Model 1.4
Stochastic Frontier					
Intercept	β_0	8.71	7.88	6.21	12.85
		(8.47)	(7.31)	(0.97)	(12.87)
B. Lenght (m)	β_1	0.93	1.08	1.07	0.46
		(5.90)	(7.14)	(6.88)	(3.68)
Area (ha)	β_2	0.12	0.16	0.16	0.19
		(1.11)	(1.50)	(1.54)	(2.09)
Draft (m)	β_3	-0.63	-0.59	-0.60	-1.13
		(2.42)	(2.05)	(2.12)	(4.22)
Storage (teu)	β_4	0.09	0.13	0.13	0.49
		(0.78)	(1.27)	(1.25)	(6.46)
Qc (nbr)	β_5	0.04	-0.08	-0.08	0.08
		(0.54)	(0.86)	(0.81)	(1.53)
Year	β_6	-	-0.05	-0.05	0.01
		-	(3.23)	(1.83)	(0.65)
Trade	β_7	-	-	0.06	-
		-	-	(0.26)	-
Intercept z	δ_0	-	-	-	59.35
		-	-	-	(1.01)
Trade (z)	δ_1	-	-	-	-3.40
		-	-	-	(1.04)
Variance Parameters					
	σ^2	1.33	0.68	0.68	23.21
		(1.62)	(0.67)	(0.65)	(1.13)
	γ	0.94	0.89	0.89	0.99
		(23.32)	(5.53)	(5.40)	(560.47)
	μ	-2.24	-0.84	-0.83	
		(1.68)	(0.32)	(0.30)	
	η	0.09	0.12	0.12	
		(5.76)	(7.20)	(7.04)	

According to the basic model 1.3 (model of reference in this discussion), berth lenght, area and storage capacity elasticities were estimated around 1.07, 0.16 and 0.13 respectively, although a 1% increase in The berthing lenght (about 13 meters) leads to a 1.07% increase in the throughput about 9250 teu. In the same way, an expansion of the area of 0.5 ha leads to an increase of the port traffic of 1409 teu, an increase in the capacity will lead to a growth of 1145 teu. Other production elasticities are not significant. The elasticity of QC is considered positive and significant in model 1.1 and 1.4, whereas it is not positive in models 1.2 and 1.3 following the introduction of the time variable, this can be explained by making investment in equipment generally take longer to show its benefits on performance. We can conclude that investment in the quay length must be a priority.

7.4 Trend factor

The trend factor highlights the importance of time on the output of a given port. It is the percentage change in output due to technological change over time (given the period of the study). On the other hand, Eta η represents the parameter related to time that marks the change in technical efficiency over time. Confusing the two concepts is a potential source of error.

Reference to our models, we observe that the estimated parameter of the trend is negative (-0.05), several reasons can be advanced at this stage:

-We can argue that the port industry is suffering from the overcapacity which means that there is more supply of maritime carriers than demand for goods of customers.

-The management of the ports is listening to the tendency (of the market of the maritime carriers), as answer the ports anticipate offering more capacity (container ships), this explains the negative trend parameter, so as far the response of the output to the technological change is not synchronized.

-Ports continue to offer infrastructure and equipment in spite of a very slow rate of return on investment in an attempt to foreclose the port market, the ports practice "land occupation strategy", in order to eliminate competition and set up barriers for new entry.

-Some ports find opportunities in excess of capacity to the extent that this attracts customers, here ship-owners, it is a sign of confidence and notoriety. This strategy is therefore of prime importance for the protagonists of the port industry.

-The hub and spoke system: hub ports have capacity to accommodate large size container vessels (mother vessels) as well as small vessels of feeders, spoke ports can accommodate only small ships (feeders), this implies that hub ports have the necessary resources to manage operations for container ships of different sizes and in this context the provision is not always exploitable. Some economic underperformance is inherent to the hub and spoke system.

-Transshipment and gateway traffic are not without impact on the economic performance system of container ports. Transshipment ports require large spaces in area that the gateway ports, the transshipment ports are not fully exploitable. The transhipment consists of the operation process: ship- port - ship, while the process of a gateway port is: ship - port - land, the gateway process occupies the land which is requiring various spaces in the port. When the proportion of transhipment rises, the inefficiency of the given port decreases.

-Other factors can trigger a negative trend parameter such as port ownership, port exclusivity, and port investment:

-Ownership, the performance of the private sector is generally higher than that of the public sector. The private port tends to exploit the maximum of its resources in infrastructure and equipment than a public port.

-Port exclusivity refers to the port's contract management system, some ports contract with their different customers on the basis of resources by dedicating a proportion of them such as quay and storage yard. In case of non-respect of the traffic negotiated a priori with a given customer, this last will be forced to pay the penalties. This revenue optimization strategy protects ports from market volatility, but on the other hand, this strategy weakens the efficiency of ports.

-The port investment system can contribute to the negativity of the trend insofar as demand adjustment differs from ports in the Mediterranean region from one country to another. Emerging countries such as those in Africa are beginning a new phase in their economic development history, so they commence several port projects in restructuring and developing, for these African countries the investment comes first and traffic second. However, for the European countries present in the Mediterranean region, the growth rate of traffic is slow involving wide operating cycles. Finally, for Asian countries mainly China, the growth rate is high implying that new infrastructure investments are starting in the immediate future, for these countries traffic arrives at first and investment follows. Client attraction strategies for countries in the region require the provision of infrastructure resources involving a negative rate of annual technological change in relation to port output.

7.5 Technical efficiency assessment

The efficiency indices shown in Table 6 (see appendix) mean that large ports have a higher level of economic performance than small ones.

The port Tangier Med (2014: 0.95), Algeciras (2014: 0.97) and Barcelona (2014: 0.94) as having a very high index. The port of Annaba (2014: 0.25) and Tarragona 2014: 0.31) are ports of small sizes. These ports have a lower efficiency index. Another point deserves to be revealed, the port of Algeciras was considered to have the best score at the level of technical efficiency index in model 1.3 with endogenous effects (0.97 against 0.95 for Tanger-Med) , While in the evaluation according to model 1.4, the Tanger-Med port is considered to have the best score (0.93 vs. 0.89 for Algeciras), this is due to the use of resources, Algeciras has more unexploited resources than his peer Tanger-Med.

-The ports of Turkey Mersin (2014: 0.6) and Ambrali (0.6) have a medium level of efficiency while they are very well equipped in infrastructure and equipment, we believe that their disappointing performance has a relationship with the port management, the absence of a real port authority is perhaps the cause ?!

- The port of Alexandria should improve its calculations, we expected a higher score, this port has significant capacity with a quay length of about 2500 meters and 16 QCs.

- The ports of Algeria Annaba and Bejaia have a very low efficiency index, these ports are poor in capacity, while they have a very good position on the Mediterranean. The port of Tunisia has a great margin of improvement, this port initiates cycles of investment recently.

- Surprising the index of efficiency for the ports of Italy for which we have expected a higher rate, Gioia Tauro, one of the largest ports of the Mediterranean, is a medium indexe and even lower in the previous years with enormous capacities (3400 meters of linear, 4.2 million teu and 22 porticos among others).

- Similarly, the port of Valencia in Spain, which is the largest port in the Mediterranean with pharaonic capacities (4300 linear quays, 161 hectares and 36 QCs among other characteristics), its index is medium and even lower in the period considered. In general, we can conclude that the efficiency index has been maintained steady and progressive during the period for all ports studied, regardless of their size (in terms of throughput), their capacities and effectiveness levels.

The efficiency scores reveal the investment strategy of the given port which we will try to outline in the following grid:

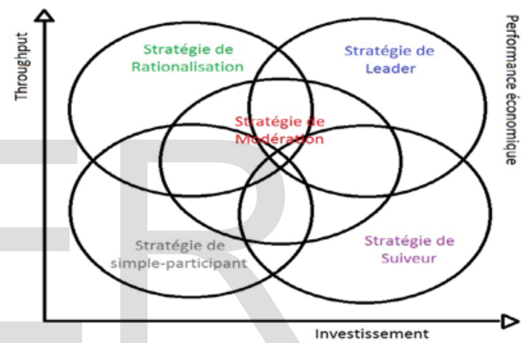


Fig.1: Economic Performance Grid (Investment and Port Performance Relationship). **Source: Grid set up by us**

The cut-off point between the types of investment evoked by the grid is blurry, sometimes it is complicated to determine the strategy of a port, the grid remains silent as to the cycles of return on investment, we have Alex in the group of followers, whereas this port unlike the other two (Barcelona and Alicante) has experienced a fairly large increase in its traffic, true its capacity is even more important, we have to wait yet time to see if the demand continues to increase, consequently the traffic will increase again and again to fill its additional capacity and its efficiency would be better or to the contrary, the port would maintain his position of follower.

The situation of the port of Alger deserves to be mentioned, the port has taken advantage of the demand because of its strategic location, it is positioned in the heart of the Mediterranean, the port has led light investments and its traffic keeps increasing. It may be necessary to inject more technical capital if traffic continues to increase. Port Said and Valencia, although they are leading ports in the basin, they still have margin of performance in front of them. The ports of Barcelona and Alicante are led to undertake commercial actions in order to catch more traffic. The majority of Italian ports have not carried out expansion projects, these ports are in the rationalization phase. As we have seen, we can conclude that there is a relationship between capacity and demand that is reflected in the variation in traffic. The efficiency score according to the model with exogenous effects is different from the models with endogenous effects, allowing a better reading on the effect of the technological change on the economic performance of the port. On the other hand, the relationship between capacity - demand and efficiency is strong following the implementation of investment projects, when demand increases without trigging investment process, this leads to overexploitation as well as a drastic increase of efficiency until reaching a level of technical obsolescence where the renewal of technical capital becomes necessary. When the port generates new capacities, the underemployment of this additional capacity installs, leading by induction and temporarily the efficiency to fall. Over-employment and underemployment are constantly occurring as a result of the start-up of capacity extension projects at ports level.

8 CONCLUSION

Technical inefficiency dominates the economic performance model of Mediterranean ports. According to the parameter μ, a representation of the efficiency according to a half-normal distribution falls perfectly adequate for the port industry. The variation in quay length input significantly influenced port output. The efficiency score according to the model with exogenous effects is different from the models with endogenous effects, allowing a better understanding of the effect of technological change on the economic performance of a given port. The relationship between capacity - demand and efficiency is strong following the investment projects decision by the management. Ports envisage the market with different strategies. We have identified 5 types of strategy, those of: leader, follower, moderation, resource rationalization and simple-attendee.

APPENDIX 1

TABLE 6

TECHNICAL EFFICIENCY OF PORTS ACCORDING TO MODEL 1.3

Noms des ports	2006	2007	2008	2009	2010	2011	2012	2013	2014
Tanger-Med	n/a	n/a	0,90	0,91	0,92	0,93	0,94	0,94	0,95
Algésiras	0,94	0,94	0,95	0,95	0,96	0,96	0,97	0,97	0,97
Valencia	0,44	0,48	0,52	0,56	0,60	0,64	0,67	0,70	0,73
Tarragona	0,04	0,06	0,08	0,11	0,15	0,18	0,22	0,26	0,31
Las Palmas	0,25	0,29	0,34	0,38	0,43	0,47	0,51	0,55	0,59
Alicante	0,56	0,59	0,63	0,66	0,70	0,73	0,75	0,78	0,80
Barcelona	0,84	0,86	0,87	0,89	0,90	0,91	0,92	0,93	0,94
Alger	0,56	0,60	0,63	0,67	0,70	0,73	0,75	0,78	0,80
Annaba	0,03	0,04	0,06	0,08	0,11	0,14	0,17	0,21	0,25
Bejaia	0,17	0,21	0,25	0,29	0,34	0,38	0,43	0,47	0,52
Radès	0,48	0,53	0,57	0,60	0,64	0,67	0,71	0,73	0,76
Alexandrie	0,17	0,21	0,25	0,29	0,34	0,38	0,43	0,47	0,51
Port Said	0,80	0,82	0,84	0,86	0,87	0,89	0,90	0,91	0,92
Mersin	0,29	0,34	0,38	0,43	0,47	0,51	0,55	0,59	0,63
Ambarli	0,28	0,33	0,37	0,42	0,46	0,50	0,55	0,58	0,62
Genova	0,47	0,51	0,55	0,59	0,63	0,66	0,70	0,73	0,75
Las Spezia	0,70	0,73	0,75	0,78	0,80	0,82	0,84	0,86	0,87
Cagliari	0,20	0,24	0,29	0,33	0,38	0,42	0,47	0,51	0,55
Gioia Tauro	0,45	0,50	0,54	0,58	0,61	0,65	0,68	0,71	0,74
Piraues	0,63	0,66	0,70	0,73	0,75	0,78	0,80	0,82	0,84
Thessaloniki	0,29	0,34	0,38	0,43	0,47	0,51	0,55	0,59	0,63
Marsaxlokk	0,59	0,63	0,66	0,69	0,72	0,75	0,78	0,80	0,82
Moyenne	0,33	0,38	0,44	0,48	0,52	0,56	0,60	0,64	0,67

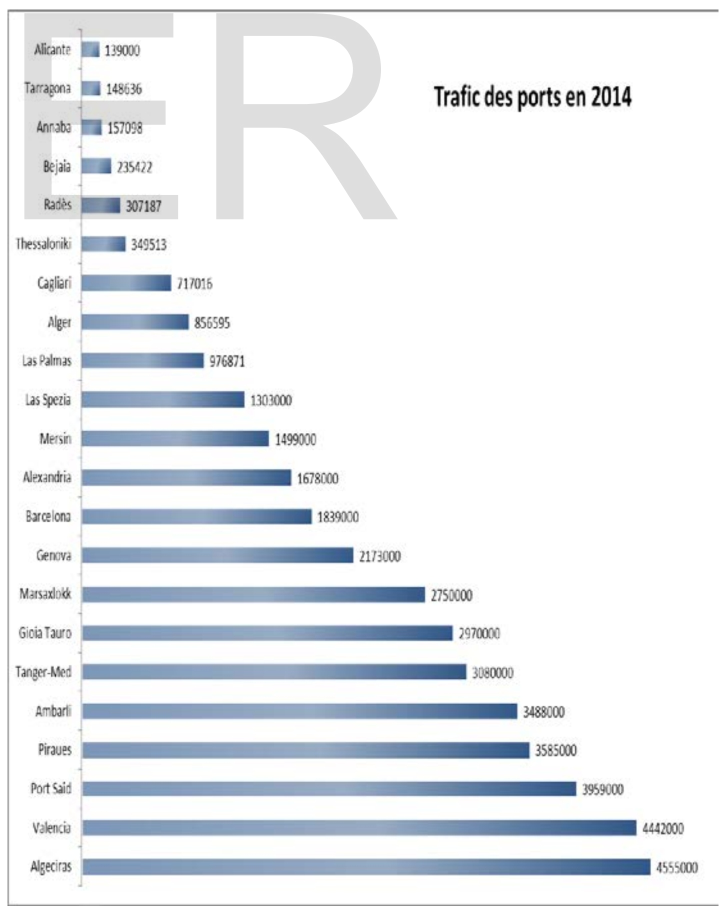
APPENDIX 2

TABLE 7

TECHNICAL EFFICIENCY OF PORTS ACCORDING TO MODEL 1.4

Noms des ports	***2006***	***2007***	***2008***	***2009***	***2010***	***2011***	***2012***	***2013***	***2014***
Tanger-Med	n/a	n/a	0,67	0,61	0,86	0,87	0,83	0,91	0,93
Algésiras	0,92	0,92	0,92	0,91	0,89	0,83	0,87	0,89	0,89
Valencia	0,74	0,60	0,70	0,70	0,77	0,78	0,80	0,78	0,79
Tarragona	0,03	0,13	0,13	0,59	0,49	0,43	0,34	0,27	0,30
Las Palmas	0,70	0,70	0,70	0,52	0,62	0,69	0,64	0,48	0,50
Alicante	0,77	0,78	0,75	0,67	0,73	0,75	0,76	0,72	0,68
Barcelona	0,90	0,92	0,92	0,84	0,86	0,87	0,49	0,48	0,51
Alger	0,66	0,76	0,82	0,84	0,83	0,86	0,86	0,87	0,90
Annaba	0,03	0,05	0,06	0,08	0,09	0,13	0,41	0,44	0,48
Bejaia	0,23	0,30	0,35	0,45	0,48	0,55	0,46	0,55	0,47
Radès	0,85	0,89	0,92	0,92	0,92	0,89	0,88	0,88	0,84
Alexandrie	0,36	0,28	0,32	0,24	0,24	0,44	0,43	0,44	0,49
Port Said	0,77	0,79	0,84	0,85	0,83	0,83	0,76	0,81	0,80
Mersin	0,37	0,45	0,48	0,47	0,57	0,62	0,65	0,67	0,72
Ambarli	0,51	0,67	0,58	0,46	0,63	0,65	0,72	0,76	0,77
Genova	0,69	0,75	0,72	0,63	0,71	0,73	0,77	0,75	0,79
Las Spezia	0,77	0,79	0,81	0,72	0,81	0,82	0,80	0,81	0,81
Cagliari	0,50	0,46	0,26	0,61	0,52	0,49	0,51	0,57	0,58
Gioia Tauro	0,74	0,81	0,81	0,72	0,71	0,59	0,68	0,75	0,72
Piraues	0,85	0,84	0,31	0,16	0,21	0,58	0,80	0,85	0,88
Thessaloniki	0,34	0,44	0,24	0,27	0,27	0,29	0,31	0,31	0,34
Marsaxlokk	0,67	0,79	0,76	0,77	0,79	0,78	0,81	0,84	0,84
Moyenne	**0,46**	**0,53**	**0,50**	**0,52**	**0,56**	**0,61**	**0,63**	**0,64**	**0,65**

APPENDIX 3



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