International Journal of Advanced Information Science and Technology (IJAIST) ISSN: 2319:268
Vol.3, No.3, March 2014 DOI:10.15693/ijaist/2014.v3i3.112-119

Sea Port efficiency: the case of Tunisian maritime ports

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***Abstract*—The purpose of this paper is to assess the Tunisian ports 'efficiency/ inefficiency via the DEA Window approach. The main contribution of this methodology is to help determine the degree of ports' efficiency and observe how it evolves over a six year period ranging from 2005 to 2010. The econometric exercise has unsurprisingly revealed a noticeable inefficiency of almost all ports.**
This result confirms the state of the country's infrastructure *e.g.* shallow draft, filled-land scarcity and low linear dock platforms. In addition, our reached findings can serve to rationalize the system's recent reform i.e. the reform undertaken during the review period: 2005-2010.

***Index terms -Tunisian Maritime ports, Port efficiency, DEA Window*.**

I. INTRODUCTION

The economic globalization and trade liberalization have led to introduction of profound changes in the strategic and technological features of the global shipping system. Unsurprisingly, however, this constitutes a competitively challenge for all links constituting the port supply chain. Indeed, it is a well shared view that the port constitutes a key link in the international supply chain and a major strengthening force in the support of the economy (Monacco et al., 2009). It is commonly known that in addition to the traditional services it offers, such as handling, storage and distribution, the port also provides all types of inherent activities pertaining to customs clearance, insurance, trading transactions and banking. Ports also accomplish such continental dependence functions as the industrial activity. Naturally, however, the main services that ports provide are offered to vessels and ships, most of which pertain to ship construction and naval repair (*e.g.* piloting, towage, mooring, etc.).

It follows that for the freightage and cargo handling activity at terminals to be standard facilities, port authorities are required to have the capacity of improving the quality of service and frequently increasing the terminal's capacity as years go by. Consequently, investments in port infrastructures, along with the implementation of restructuring development plans for the modernization of ports turn out to be crucially necessary requirements (Hlača et al., 2008).

Recognizing the major role ports play in the economy, most countries undertake to set appropriate development strategies fit to rehabilitating the port area, e.g. investment programs, reshaping each involved actor's role, pre and post-forwarding connection chains, etc.

In this respect, Tunisia does not seem to escape such a phenomenon. Its ports, located along a coast line extending over 1298 kms, are often regarded as the country's main access to the global economy and to foreign trade through multimodal transport chains. Yet, such a competitive advantage has not so far been valued due to delays in productivity, reliability and consistency affecting the entirety of the country's ports. Hence, an urgent need for a new governance pertinent to the port structures, dictated by the efficiency principle, seems imposed. However, data on ports' productivity and efficiency are very scarce and even ill-perceived by the public authorities, due to the fact that they considered quasi-confidential by the operators.

Paradoxically, studies on ports efficiency (inefficiency) abound despite the inexistence of an agreed consensus as to the productivity indicators and the efficiency estimation- method to be adopted (parametric versus nonparametric) (Pjevčević et al., 2010; Tongzon and Heng, 2005). Nevertheless, the nonparametric approach, often equated with the DEA (Data Envelopment Analysis) method, seems suitably imposed. This method has been widely recognized for a number of advantages it presents.

Above all, it does not require a particular specification of the production function, needs fewer restrictive hypotheses, enables to capture the productive inefficiencies and, thereby, implementing comparative analyzes.

Indeed, measuring port efficiency through the DEA method has been the subject of numerous works over the last three decades. Actually, two types of analysis have emerged in accordance to the applied data, i.e. whether the gare cross-sectional or panel. Essentially, these works aspire provide a special ranking pertaining to the port systems in terms of efficiency (inefficiency), particularly measured with respect to the European, Asian, American and Australian economies (Lee et al., 2005; Cullinane et al., 2005).

Still, to our knowledge, no study has been concerned with the ports located in the southern Mediterranean area. Our work comes very timely to measure efficiency (inefficiency) of Tunisian seaports via the DEA Window approach. The latter has provided us with the appropriate and necessary means to determine the ports degree of efficiency and observe how it evolves over a six-year ranging from 2005 to 2010. The econometric exercise has unsurprisingly revealed the inefficiency of almost the entirety of ports. We attempt to show that this result testifies to the state of the country's infrastructure, *e.g.* shallow draft, filled-land scarcity and low linear dock platforms. In addition, our results seem to rationalize the recent reform undertaken during the review period (2005-2010).

Noteworthy, the present research plan is divided into four parts. The first part paves the way for the work's theoretical aspect. The work's methodology constitutes the subject of the second part. As for the third section, it deals with the Tunisian seaport system, namely, its infrastructure and traffic. Regarding the last section, it is devoted to depict the empirical analysis in its strict sense, including efficiency (inefficiency) estimation results of the Tunisian seaport sector.

II. LITERATURE REVIEW

The recent years have been marked by the DEA method's successful application in the analysis of container terminals in seaports. More particularly, in a testing study administrated on 20 seaports, Hayuth and Roll (1993) have recommend using cross-sectional data, on the ground that they provide a better efficiency assessment relative to the various port-service organizational modes. As input elements, the authors have chosen to apply the number of employees, annual investment per port, the uniformity of port facilities and cargo traffic. As for the outputs, they have applied the number of containers, the level of service, customer satisfaction and the number of ship stop-over.

In this context, on using data relevant to four Australian ports and twelve international ones for the year 1996, Tongzon (2001) has concluded that the most pronounced inefficiency has been inherent in the under-utilization of inputs in certain ports, for instance, the number of cranes, the number of container terminals, the number of tugs, land surface and the full-delay time.

In terms of method, Valentine and Gray (2001) argue that the DEA technique proves to be a useful tool in measuring the container terminals' efficiency. Their study has specifically been concerned with the efficiency of container traffic in the North American ports and 31 European ones.

Using cross-sectional data (for the years 1999-2000), Barros (2003) assessed the technical and allocative efficiency of five Portuguese ports through an analysis of the port-regulation potential impact on port productivity. The author argues that the reglementation incentive, designed to boost effectiveness and improve productive efficiency has not yielded the desired results and, therefore, recommends revising the port management related policy in a bid to further enhance efficiency. Barros and Athanassiou (2004) have further refined the analysis by examining the relative efficiency of Portuguese and Greek ports via the DEA method. The authors have come to the conclusion that only privatization would be liable to lead to an economically-efficient allocation.

Using two types of databases, cross-sectional and panel, along with the DEA Window approach, Cullinane et al. (2004) have undertaken to measure the efficiency score of the major world-leading container ports. Their work reached results have highlighted that the cross-sectional data diagnosis has not been able to provide an accurate measurement of port efficiency. However, the DEA Window technique applied to panel data has enabled to identify the temporal efficiency variation for each port and to compare it with that observed in other ports.

Similarly, Min and Park (2005) have used the DEA Window technique to examine the efficiency evolution of the eleven container terminals over a four-year period.

As for Cullinane and Wang (2006), they have studied the efficiency of 69 container terminals in Europe with an annual capacity exceeding 10,000 TEUs. The cross- section DEA technique has allowed them to demonstrate the inefficiency pertaining to most terminals. Notably, the container terminals' average efficiency has proven to differ proportionately from one region to another.

In their turn, Kaiser et al. (2006) have studied the productivity of ports using the DEA approach. They have managed to set a definition of efficiency frontier as being the ports' best practices, which must be implemented in inefficient ports. Based on the assumption that the container ports efficiency largely depends on equipments, communication techniques as well as port competitively, the purpose of the study was primarily targeted to minimize the use of inputs (total length of wharves and docks gantry) and maximize outputs (container traffic).

III. PORT EFFICIENCY : THE DEA WINDOW APPROACH

Literature relevant to port efficiency is very scarce. However, some recent studies have been conducted with respect to port efficiency and productivity. These studies refer, more or less, to two major approaches. The first concerns the nonparametric approach, often equated with the DEA technique (Data Envelopment Analysis). The latter allows the empirical construction of production frontiers based on mathematical optimization models and linear programming techniques. As for the second approach, it deals with the parametric approach and uses econometric models of stochastic frontier production.

It is also worth noting that the DEA approach, in its both versions, is usually applied to cross-sectional data and envelops an annual based data set, useful for distinguishing between the efficient and inefficient observations. It goes without saying that for the sake of avoiding the risk of having all observations on the border, such an analysis requires a fairly high number of observations.

In case the number of observations is too limited, one can generally have recourse to panel data. Henceforth, three options have been retained for the frontier to be constructed (Tulkens, 1995), namely:

i) constructing a frontier for the data set (NT observations). In this case, the DEA technique is readily and easily applicable. It provides convergent scores, but inputs and outputs do not allow to observe the efficiency shift over time.
ii) constructing a frontier envelope per year (N observations per year).The problem likely to emerge here consists in having a limited number of observations available, in which case, all observations would fall on the frontier through construction. Besides, the technical efficiency scores obtained might be biased.
iii) constructing a frontier relevant to each sub panel i.e. the Window method.

Noteworthy, however, although constructions i) and ii) use a standard DEA program, construction iii) turns out to be more delicately difficult yet pertinent.
Hence, the panel available to us will be divided into subsets (sub-panels) of observations periods and to each Window are associated N DMUs and a period p inferior to the considered period T, with p representing the Window length. Each Window is moved over the entire period and a DEA Window frontier is constructed for each sub panel before evaluating the DMUs efficiency for each case.
More precisely, if we consider the period composed of the years 1,2,3 and N DMUs to establish the first window, the second will be constructed by substituting the first year by the fourth, i.e. of periods 2,3,4 and N DMUs. The standard DEA technique is then applied to the first Window, as well as to the other, system until the T^{th} year, while enveloping the N DMUs relevant data.

After a brief presentation of the DEA Window approach, we train to focus on some of its formalization.

The whole set of production possibilities refer to two types of analysis namely:
i) cross-sectional data or
ii) temporal data.
In the first data set, all DMUs are observed at the same point in time. In the second, the different production plans can be obtained from temporal series. But once, the two situations (cross-sectional data and temporal series) have been considered, we would encounter a situation in which the data are of panel type. Consequently, the problem of constructing the border is imposed.
Thus, the whole set of production possibility corresponding to period t is written as follows:

$$p_t^h X^{ht} = \left[\left(x^{ht}, y^{ht} \right), y_s^{ht} \leq \sum_{h=1}^{N} \lambda^{h,t} y^{h,t}, s = 1,\ldots,M; \sum_{h=1}^{N} \lambda^{h,t} x_n^{h,t} \leq x_n^t, \right]$$

$$n = 1,\ldots,N; \lambda^{h,t} \geq 0, h = 1,\ldots,N$$

Where λt is a vector intensity and h is the firm index. The DEA Window method's interest consists in setting up intertemporal production subsets. Each subset is constructed from N DMUs and p periods relevant data, with p <T. The panel is then sub-divided into successively less short overlapping subpanels.

It follows that the first Window (under panel) consists of N DMUS and {1 ...... p} periods, the second consists of NDMUs and {2 .... p+1} periods and so on and so forth, till reaching the last Window which consists of N DMUs and {T-P+ 1 ... T} periods.

Thus, a Window of a length p (p = T -(T-P+1)+ 1), at time t, is defined as being a subset of adjacent points in time:
In this respect, the inherent observations are used to construct an inter-temporal set of production possibilities with a reference that is exclusively related to the period [t, t+p]. Thus a set of successive Windows defined for t = 1, ..., T-p would provide a referential set of production possibilities in sequence. The latter will be displaced in time, which would enable to detect the technical- efficiency changes over time for the whole set of DMUs making the panel.

In addition, the method provides us with the suitable means to envelop the appropriate data relevant to each production subset (Window) and, then, compare each DMU to itself as well as to other DMUs forming the sample. So, through the Window construction, each DMU is compared not only to itself over (p) period, but also to other DMUs which are also required to change their technical efficiency over time. Thus, for the technical efficiency to be measured, the mathematical programming problem (output oriented) has to be solved again NP times, as follows:

$$\underset{\varphi,\lambda}{Max\varphi}$$

$$Sc - \phi Y_{it} \geq \sum_{i=1}^{N} \lambda_i^t Y_i^t$$

$$X_{it} \geq \sum \lambda_i^t X_i^t$$

$$\lambda_I^T \geq 0$$

with, Y_{it} = [Y_{it}, ..., Y_{Mit}], being a vector of outputs produced by the DMU (i, i = 1, ... N) over period t (t = 1, ..., T) and X_{it} = [X_{1it}, ..., XM_{iT}], the vector of inputs used by the i th DMU to produce the output vector Y_{it}.

Actually, through the set of Windows offset, this program enables to increase the number of available DMUs from N to NP

The approach consists in solving the supra-enveloping problem for each constructed production subset. Thus, each DMU must have a single technical efficiency score during the first {1, ..., p} period, two technical efficiency scores during the second period {2, ..., p +1}, before being compared to itself and to other DMUs, etc..
In addition, each DMU observed in every Window will be treated as if it were several different DMUs, as it is successively observed p times. Noteworthy, however, p must too small in respect of T.

Eventually, the DEA method provides us with the tools and means necessary to administrate a panel-data type of analysis. The interest is twofold: static and empirical. Indeed, the technique helps:

i) increase the sample size;

ii) monitor the stability of the obtained technical efficiency scores;

iii) detect the change in temporal efficiency without enhancing the model with any particular form pertinent to the DMUs efficiency evolution over time.

Moreover, the use of such a technique enables to compare the parametric technique inherent results as well as those stemming from the nonparametric approach. This type of comparison is justified by the fact that the frontier-construction parametric methods on panel data necessitate the imposition of strong assumptions regarding the efficiency evolution over time. So, one might well wonder in this respect:

How to determine each window's length and number?

There is usually no specific rules to determine the length. Actually, this choice is arbitrary. Based on three or four-year length (p), the technical efficiency scores obtained are convergent (Charnes et al, 1985). In practice, different lengths have to be attempted with should the temporal dimension justify the panel. Once the window length is fixed, we have to proceed as follows:

The first window consists NDMUs over the period {1,..., p}. The second covers the period {2,...,p +1}. This procedure will be repeated several times until reaching the last WINDOW composed of the period T = {p +1, ... T}.

	1993	1994	1995	1996	1997	1 998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Bizerte	4147	4729	5085	5323	5908	5288	5308	4905	5165	5116	4711	4397	4381	4790	5035	5308	4706	3989
CP Tunis	3929	4031	4293	4012	4594	4806	4859	5368	6023	5620	5422	6087	6077	6557	6835	6758	6168	7093
Sousse	604	548	609	412	511	624	780	896	1172	1427	1378	1430	1592	1692	2126	2351	1805	2243
Sfax	4291	4954	4996	4712	5149	4823	5062	5411	4773	4889	4484	4243	4528	4573	5145	5092	4550	5018
Skhira	3974	5097	5017	5951	4901	4387	5464	5313	5484	6058	7026	7547	6043	6249	5402	6661	4112	5878
Gabès	2794	3422	3627	3192	3576	3459	3658	3961	4133	4402	3956	4049	4249	4425	4261	4155	5909	4773
Zarzis	350	243	229	229	179	287	271	249	482	563	650	803	853	736	704	796	1028	1355
Total	20089	23024	23856	23831	24818	23674	25402	26103	27232	28075	27627	28556	27723	29022	29508	31121	28278	30349

The next step consists in to determining the number of Windows (NW): NW = T-p+1 where T denotes the Window length.

After presenting the DEA Window method, we focus, as an initial step, on the Tunisian port infrastructure. In a second step, we present the traffic structure.

IV. THE TUNISIAN PORT SYSTEM

A. The infrastructure

The Tunisian Port' chain consists of seven ports open to international trade: the port of Bizerte - MenzelBourguiba, the port complex of Tunis (La Goulette port, the port of Tunis, Rades port), the port of Sousse, Port SfaxSidiYousef, the Skhira port, the port of Gabes and that of Zarzis. With the exception of the Skhira port, managed by a national oil company, all the other ports are managed by the Office of Merchant Navy and Ports "OMMP".Owing to its strategic position on the axis of the Gibraltar-Suez shipping services and its proximity to the South of Europe, the port of Bizerte-MenzelBourguiba has a major role to play in the socio-economic and cultural development of the region which makes of it a corner stone to conquer the European and Mediterranean markets.Thanks to its strategic geographic location, the Tunis port complex of would constitute vital stop-over insofar as it constitute a major crossroad of the country's important road and rail networks. This port is characterized mainly by the proximity of the Rades port which constitutes a geographical extension of the La Goulette one (passenger and cruise lines trafic), which would make of it one of the strongest links in the chain of national maritime transport

The geographical position and the various freight of goods make of the port of Sousse one of the most dynamic commercial ports.

Founded in 1905, making it one of the country's oldest trading ports, the port of Sfax is very polyvalent and versatile (general cargos, grain and cereals, minerals, etc.). Hence, it ranks first in terms of traffic and second in terms of value.

Not far from the industrial port of Gabès (chemicals and bulk solids), that of Skhira is distinguished by its traffic in chemical and petroleum products.

As for the port of Zarzis, it is dominated by oil tanker traffic, due to particularly its proximity to the oil fields of the extreme southern of Tunisia. Noteworthy, the activity of this port would be linked to the creation and development of a free exchange zone in the region.

B.Structure of the traffic

Maritime traffic consists of four broad categories liquid bulk, dry bulk solids, diverse break bulk units and conventional variety. In our analysis, the applied traffic data have been extracted from the OMMP reports relevant to the period 1993 to 2010.

Table 1.
Evolution of the Tunisian ports' total traffic 1993 – 2010 (000 Tones)

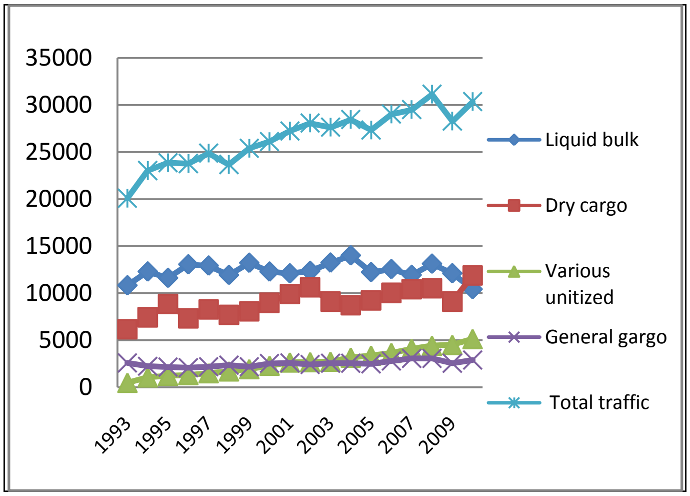

Figure 1.Evolution of the Tunisian ports' total traffic by categories 1993 – 2010 (000 Tones).

During the period 1993-2010, the Tunisian seaports traffic has undergone deep changes. The bulk liquids rose from 53.90% of the traffic volume in 1993 to 34.34% in 2010. The share of bulk solids amounted to 30.74% of total traffic in 1993 to reach 39.18% in 2010. The conventional products represented, on average, 10% of the traffic during the same period. As for the unitized miscellaneous products, they have increased from 2.43% in 1993 to 16.89% in 2010. This has its explanation in the containerization phenomenon, which has nowadays reached considerable dimensions.

Year	Share of VL	Share of VS	Share of DU	Share of CONV
1993	53,90%	30,74%	2,43%	12,92%
1994	53,39%	32,34%	4,59%	9,69%
1995	48,68%	37,17%	5,15%	9,01%
1996	54,77%	30,77%	5,51%	8,71%
1997	52,06%	33,33%	5,51%	8,78%
1998	50,38%	32,54%	7,17%	9,91%
1999	52,03%	31,77%	7,61%	8,57%
2000	47,06%	34,42%	8,81%	9,73%
2001	44,42%	36,42%	9,70%	9,47%
2002	44,00%	37,85%	9,54%	8,62%
2003	47,90%	32,99%	9,86%	9,25%
2004	49,05%	30,56%	11,06%	8,95%
2005	44,11%	33,36%	12,15%	8,99%
2006	43,24%	34,58%	12,59%	9,60%
2007	40,43%	35,33%	13,85%	10,38%
2008	42,15%	33,84%	14,17%	9,88%
2009	42,81%	32,25%	15,92%	9,02%
2010	34,34%	39,18%	16,89%	9,60%

Table2.The traffic structure evolution considering the national level 1993 – 2010 (000 Tones).

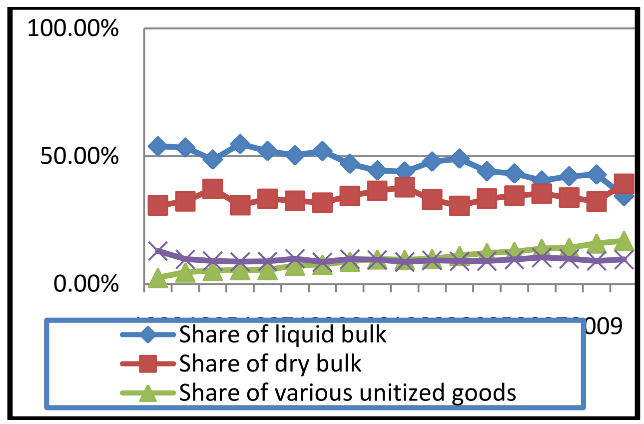

Figure 2.Traffic structure evolution considering the national level1993 – 2010 (000 Tones).

V. MEASURING THE TUNISIANPORT'S EFFICIENCY

A. Data and variables

The available data pertain to six ports and cover the period ranging from 2005 to 2010. The concerned ports are those of: Bizerte, Tunis complex, Sousse, Sfax, Gabes and Zarzis.

In this framework, the DEA Window technique will provide us with the necessary means to assess, in the first stage, the technical efficiency of the Tunisian port sector in its entirety and, in the second stage, compare each port to the others. Furthermore, this technique helps indicate the temporal variation in port efficiency by treating it as a separately-different entity in each time period. Thus, technical efficiency scores for the various ports are estimated via a DEA software program as developed by Coelli (1996), i.e. DEAP version 2.1.

It is worth recalling that the study of ports efficiency refers to two types of DEA models: the model with the constant returns to scale (CRS) hypothesis, and that with the assumption of variable returns to scale (VRS). Regarding our case, the variable returns to scale DEA model, with output orientation (BCC), has been applied. This choice, we reckon, is the most appropriate, to the current context of Tunisian port sector. Moreover, we have advanced the hypothesis that the port production technology of the port is reduced to three major inputs, namely, capital" K", the number of employees" L", and the number docks" Q", along with a single output (i.e. the containers' relevant tonnages).

Noteworthy, in this regard the variables applied do not have the same unit of measurement. Besides, and for the sake of preventing the achieved results' sensitivity to the measurement units, each variable has been deflated by its arithmetic mean.

B. Technical efficiency estimation results

Annual efficiency scores estimated via the DEA Window approach are reported in Tables 3 and 4 below.

Port	2005	2006	2007	2008	2009	2010	Mean
Bizerte	0,85	0,96	0,91	0,83	0,64	0,5	0,78
Tunis	0,8	0,87	0,83	0,75	0,61	0,71	0,76
Sousse	0,51	0,55	0,63	0,63	0,44	0,54	0,55
Sfax	0,68	0,69	0,71	0,64	0,51	0,57	0,63
Gabès	0,96	1	0,88	0,79	1	1	0,94
Zarzis	0,74	0,60	0,48	0,46	0,62	0,7	0,6

Table 3. Annual evolution of the Tunisian ports technical efficiency over the period (2005-2010)

Window	2005	2006	2007	2008	2009	2010	Mean
W1	0,759	0,787	0,811				
W2		0,771	0,797	0,822			
W3			0,620	0,644	0,666		
W4				0,588	0,608	0,670	
Mean	0,759	0,779	0,743	0,685	0,637	0,700	0,712

Table 4. Annual evolution of the Tunisian ports' annual technical efficiency of over the period (2005-2010)

As can be deduced from Table 5 and 6, the technical efficiency scores for the entire period are about 71.12%. This result indicates that, on average, the ports subject of our sample appear to be inefficient. This implies that the outputs can be increased to the level of 28.88%, while maintaining the same amount of inputs, should the most efficient technology be applied. Over the entire period, the Tunisian ports have witnessed their technical efficiency decline, with an inefficiency rate varying between 22% and 36%.

Table 5 below depicts a ranking range of the consecutive ports with respect to the change in their efficiency levels over time.

Year / Port	2005	2006	2007	2008	2009	2010	Mean
Bizerte	2	2	1	1	2	6	2
Tunis	3	3	3	3	4	2	3
Sousse	6	6	5	5	6	5	6
Sfax	5	4	4	4	5	4	4
Gabès	1	1	2	2	1	1	1
Zarzis	4	5	6	6	3	3	5

Table 5. Evolution of the Tunisian ports' range over the period (2005-2010)

On examining the technical-efficiency evolution of the Tunisian ports in their entirety, one can notice that the three types of efficiency, i.e. technical, pure and scale, have significantly decreased between 2006 and 2009, before recording a slight increase in 2010, with an average annual score of total technical efficiency ranging between 0.6 and 0.8.

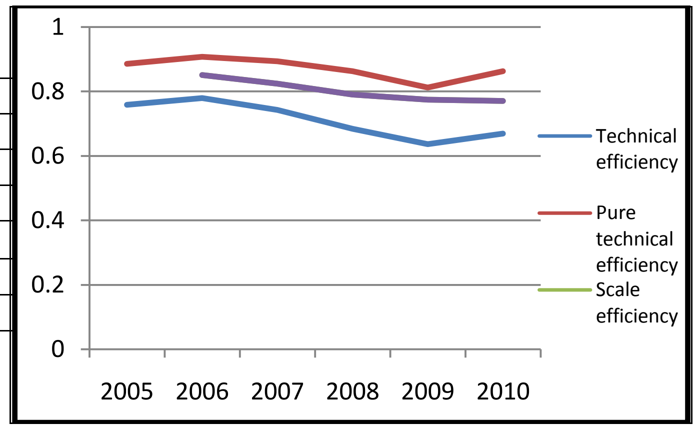

Figure 3. Technical efficiency evolution of the entire Tunisian sea ports (2005-2010)

Actually, the port sector witnessed its best performance in terms of technical efficiency in the years 2005 and 2006, with average annual scores of 0.758 and 0.779 respectively. The year 2009 has been marked with the lowest annual mean score of (0.636). This indicates that in that same year, traffic decreased and those ports could have increased the traffic size by 37% in constant returns to scale while using the same resources.

The pure technical efficiency shows an annual average score comprised between 0.8 and 0.9. The port sector had its best performance in terms of pure technical efficiency in 2006 (0.908), with the year 2009 witnessing the lowest mean score (0.812).

Regarding scale efficiency, it began to decline in 2009, reaching the lowest score in 2010 (0.770). The best performance was witnessed in 2005 with an average annual score of 0.852. With an average annual score of scale efficiency ranging between 0.7 and 0.8, the entire ports' technical inefficiency would be more likely due to scale inefficiency than to pure inefficiency.

The inefficiency noticed in the Tunisian ports has its explanation on the one hand, in the decline of handling traffic, thus conforming the results achieved by Pjevčević et al. (2010) regarding the Serbian river-ports' case. On the other hand, this inefficiency could be explained by the transition from a purely-competitive situation, mostly suitable and perfect for the handling business activity, to a situation of monopoly in the first stage, then of duopoly as a second stage. Effectively implemented on January 1, 2008, the shift undertaken through this reform has led to the creation of a public corporation dubbed STAM (the Tunisian handling and storing company), as a monopoly regarding the ports of La Goulette and Rades, and handling groups (Bahria, GMC, GMS, GMGA, GMZ) along with the STAM concerning the other ports, thus forming a duopoly. This seems consistent with the hypothesis advanced by Cullinane et al. (2005), Stating that a greater private sector involvement in the ports 'sector would inevitably lead to a greater efficiency, and, also, confirms the results reached by Barros (2003), according to whom, the incentive regulation carried out by a governmental regulatory body has not been able to achieve its intended objectives.

Above all, the inefficiency affecting Tunisian sea ports might also be due to unused capital stock and the high number of workers employed in every port following the 2008 reform. This reflects the prevalence of a remarkable waste in terms of capital (handling equipments) and overstaff regarding the number of executive officers and civil servants.

A further source of inefficiency is related, mainly, to the infrastructure which suffers from a shallow water draft preventing the entrance or reception of large vessels (with a maximum capacity of no more than 40,000 tones). In addition, the lack of vast platform makes the merchandise- storage operation very difficult, thus increasing the ships' waiting time in the harbor.

Furthermore, the reform undertaken by the Tunisian-port authorities has led to inverse results. For a potential improvement of efficiency, greater private sector involvement in this area, as recommended by Cullinane et al. (2005), seems imposed.

It goes without saying that a better efficiency of the Tunisian port sector would certainly necessitate the existing of more diversified non–specialized ports. This is even more true that the public authorities have initiated to undertake certain reforms aimed at providing the sector with special necessary equipments designed to be the suitably fit for all types of cargoes. Eventually, specialization implies (unsurprisingly) an underutilization of capital.

VI. Conclusion

This paper has been concerned with the efficiency (inefficiency) of Tunisian ports. Six ports have been examined, whose diagnosis has covered the period ranging from 2005 to 2010.

For the most part, the results achieved via the use of the non-parametric DEA Window refer us to the variability of the Tunisian seaports efficiency, with an average technical efficiency score regarding the entire period being of the order of 71.18%. However, the technical inefficiency of all ports, in their entirety, would be more due to the inefficiency of scale rather than pure inefficiency. Port authorities seem to be in a position to redefine an action plan or even an appropriate strategy, in a bid to boost and rehabilitate the ports' performance. Actually, the Tunisian port infrastructure consists of six ports pertaining to the first generation, characterized by a shallow water draft and low-linear platforms, constituting a major obstacle to receive large-capacity containing vessels. To develop trans-shipment ports on the major maritime routes, Tunisia is expected to modernize its ports' infrastructure, a prerequisite for a better application of capital and labor resources and an enhancement of the traffic volume.

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