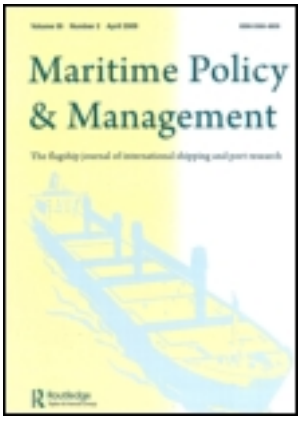

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Does ISO 9000 series certification matter for the financial performance of ports? Some preliminary findings from Europe

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Does ISO 9000 series certification matter for the financial performance of ports? Some preliminary findings from Europe

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This article investigates the role of ISO 9000 certification on the financial performance of the port authorities. The financial and scale efficiency of 18 European port authorities, some certified and some not, have been reviewed and results derived using data envelopment analysis. The inputs and outputs used in the analysis were selected following the literature and after employing regression analysis on the whole data set and the results reveal that ISO certified ports are more efficient financially than their non-certified competitors. By further using the efficiency slacks from the frontier, an indicative estimation of the magnitude of this inefficiency has been also calculated. The method followed may provide the impetus for a research agenda aiming explicitly on the exact contribution of certification on the financial 'below the line' results of the companies.

1. Introduction

Economic and market globalisation have led to an increasingly important role of transportation. About 90% of goods are transported by sea, while the commercial mobility of ports – which constitute the essence of the sea transport system as *the basic means to satisfy sustainable mobility* [1] – has increased by about 3% per year [2]. In the European Union, there are more than 1000 ports managing about 3.5 billion tons of cargo every year, while 350 million passengers pass through European ports annually, almost 70% of the total European population. Located at the vital interface of sea and inland transportation, the significance of ports and their production capabilities cannot be ignored [3].

Within such a competitive environment, port 'financial performance' and 'efficiency' measurement are not only a powerful management tool for port administration, but also constitute essential input for informing regional and national port planning and operations [4]. Based on its strategic role, efficiency is of major importance for ports and has been the focus of intense research in the recent years. For example, many researchers [5–12] have devoted their efforts to measuring port sector efficiency. The development of an efficient port is crucial, as emphasised in the literature, given the relationships between ports and their commercial clients, who focus strongly on competition and pricing issues [13, 14].

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On the other hand, bearing in mind the various new trends in sea transportation and improvements in port infrastructures, ports are forced to meet ship operator requirements in order to maintain a competitive advantage [15].

Consequently, in order for port managers to deal effectively with the needs of their customers, new process-focused practices that underlie a progression of popular quality improvement programmes including Total Quality Management (TQM), Business Process Reengineering, the Malcolm Baldrige Award Criteria and the ISO 9000 certification programmes have been adopted in ports. These process management practices cite the expectations of port managers to improve quality and efficiency, and in the long term to increase revenue, reduce costs and ultimately higher profits [16, 17]. One of the quality standards which has already been applied to a few European ports is ISO 9000. This directive is *a series of international standards which sets out requirements and recommendations for the design and assessment of management systems* [18] and specifies how management operations must be conducted. The basic objective is to prevent nonconformity ([19], p. 936). However, only a few ports in the European Union have been certified to ISO 9000, due to the associated difficulties, such as the rather complex character of the port 'product'. Quality standards, such as ISO 9000, are implemented at one unit level, while the production of the port product and supporting services are carried out by more than one production unit. Consequently, it is very difficult to implement a single standard in different production units.

In the literature, the results from the adoption of ISO 9000 in the financial performance of service firms have been equivocal. Besides the fact that ISO 9000 certification has been globally pursued and implemented, just a handful of studies in any financial sector [20] have explored certifications' impact on financial performance with unclear results [21]. While some researchers demonstrate an improvement in financial results of certificate companies [22–24]), others have not found better business performance after certification [25–28].

In the port industry, a major issue arises since no research, to the best of our knowledge, answers the question, *Is port financial performance affected by the adoption of quality standards, such as ISO 9000?*

Moreover, previous studies on ports have tended to focus on infrastructure development, costs and port efficiency from the production view in which efficiency attempts to describe the production process that makes optimal use of its resources with existing technology (Table 1). Little attention has been paid so far to the *relationship* between efficiency and financial performance in the port sector.

Accordingly, the main purpose of this research is to identify and compare the financial performance of ISO 9000 certified ports with noncertified ones. The structure of this article is as follows. First, the theoretical background is discussed, after which research hypotheses are presented, followed by methodology and analysis of results. Finally, the research conclusions and limitations are reported.

2. Literature background

2.1. *Port efficiency*

Performance and the factors affecting it have been discussed extensively in the literature [29, 30], as well as the immediate relationships to the variables measuring it, such as efficiency. In general, the concept of 'efficiency' can be considered as the relationship between a system's 'outputs' and the respective 'inputs' used for

Table 1. Literature review.

References	Method	Units	Inputs	Outputs
Roll and Hayuth [5]	DEA–CCR model	Hypothetical numerical example of 20 ports	Manpower Capital Cargo uniformity	Cargo throughput Level service Consumer satisfaction Ship calls
Martinez-Budria *et al.* [6]	DEA–BCC model	26 Spanish ports, 1993 to 1997	Labour expenditure Depreciation charges Other expenditure	Total cargo moved through docks Revenue obtained from rent of port facilities
Tongzon [7]	DEA–CCR additive model	4 Australian and 12 other international ports for 1996	Number of cranes Number of container berths Number of tugs Terminal area Delay time Labour	Cargo throughput Ship working rate
Valentine and Gray [40]	DEA–CCR	31 container ports out of the world's top 100 container ports	Total length of berth Total investments	Number of containers Total tons throughput
Itoh [41]	Window	8 ports of Japan	Terminal area Number of berths Number of cranes Number of employees	TEUs handled
Serrano and Castellano [42]	DEA–BCC	9 ports of Spain	Berth size Terminal area Number of cranes	TEUs handled Total tons throughput
Barros [43]	DEA-allocative and technical efficiency	5 Portuguese seaports, 1999 to 2000	Number of employees Book value of assets	Outputs: Ships, movement of freight Gross tonnage Market share Break-bulk cargo Containerised cargo Ro-Ro traffic

(*continued*)

Table 1. Continued.

References	Method	Units	Inputs	Outputs
				Dry bulk Liquid bulk Net income Prices: Price labour measurement by salaries and benefits divided by the number of employees Price of capital measured by expenditure on equipment and premises divided by the book value of physical assets
Barros [44]	DEA-Malmquist index and Tobit model	10 Portuguese seaports 1990 to 2000	Number of employees Book value of assets	Ships, movement of freight Break-bulk cargo Containerised freight Solid bulk Liquid bulk
Park and De [45]	DEA–CCR and BCC	11 Korean seaports for the year 1999	Berthing capacity (number of ships) Cargo handling (tons)	Cargo throughputs Number of ships calls Revenue Consumer satisfaction
Barros and Athanassiou [9]	DEA–CCR and BCC	2 Greek and 4 Portuguese	Labour Capital	Number of ships Movement freight Cargo handled Container handled
Turner *et al.* [10]	–	26 North America container ports	Berth size Terminal area Number of cranes	TEUs handled
Cullinane *et al.* [4]	Window, CCR and BCC	25 of 30 biggest terminals in the port	Berth size Terminal area Number of berth cranes Number of yard cranes Number of straddle carriers	TEUs handled

Liu [46]	Translog production function	28 British port authorities 1983 to 1990	Movement of freight (tons)	Turnover
Coto Millan *et al.* [47]	Translog Cost model	27 Spanish ports 1985 to 1989	Cargo handled (tons)	Aggregate port output (includes total goods moved in the port in 1000 tons, the passenger embarked and disembarked and the number of vehicles with passengers)
Estache *et al.* [48]	Translog and Cobb–Douglas production frontier model	14 Mexican Ports 1996 to 1999	Container handled (tons)	Volume of merchandise handled
Cullinane and Song [33]	Stochastic Cobb–Douglas production frontier: half normal, exponential, truncated models	15 Asian containers ports observed in 10 years 1989 to 1998	Number of employees	Annual container throughput in TEUs
Cullinane and Song [49]	Stochastic Cobb–Douglas production frontier: half normal, exponential, truncated models	5 container terminals, Korean and UK different years of observations (65 observations)	Fixed capital in Euros (1998=100)	Turnover derived from the provision of container terminal services, but excluding property sales
Cullinane *et al.* [12]	DEA–CCR, DEA BCC and DEA–FHD models	57 international container seaports in 1999	Container throughput	Terminal length, terminal area Quayside gantry Yard gantry Straddle carries
Tongzon and Heng [50]	Stochastic Cobb–Douglas model and a competitiveness regression. We restrict the analysis to the frontier equation	25 international container seaports	Container throughput	Terminal quay length Number of quay cranes Port size measure by a dummy which is one for port which exceed one million TEU Private participation in the port

(*continued*)

Table 1. Continued.

References	Method	Units	Inputs	Outputs
Barros [51]	Stochastic Translog cost frontier	10 Portuguese seaports, 1990 to 2000	Price of labour Price of capital Ships Cargo Trend	Total cost
Cullinane *et al.* [52]	Stochastic Cobb–Douglas and DEA model	28 International container seaports, observed from 1983 to 1990	Container throughput	Terminal length Terminal area Quayside gantry Yard gantry Straddle carries
Rios LR and Macada ACG [39]	DEA–BCC model	23 Container trerminals in Mercosur 2002 to 2004	Number of cranes Number of berths Number of employees Terminal area Amount of yard equipment	TEUs handled Average number of container handled per hour ship
Wang and Cullinane [11]	DEA–CCR and BCC	104 European container terminals	Total birth length Terminal area Equipment costs	Container throughput

their generation. The existing literature refers to efficiency as a relevant measure that depicts the variations from the best possible output for a given level of input [31, 32].

Efficiency is a central issue in contemporary port economics, as mentioned by Cullinane and Song [33], due to the ports' strategic position in connecting different countries in a globalised world. Furthermore, according to Haralambides *et al*. [34], the need for ports to compare their performance against that of their competitors through benchmarking, confirms that efficiency is of major importance for port managers and, accordingly, researchers should devote sufficient attention to this issue.

In order to measure efficiency, certain methods have been developed. Regression analysis, single productivity factor estimation and data envelopment analysis (DEA) are some of the efficiency measurement techniques. Compared to traditional approaches such as multiple regression analysis [35], and estimation of a single productivity factor [36], the DEA technique has the advantage that it can accept multiple inputs and outputs. The DEA is the most standard deterministic nonparametric technique and has subsequently been analysed and extended by Charnes *et al*. [37].

The DEA technique has been applied many times in the maritime and port sector literature to measure port efficiency from the production view. Table 1 summarises the literature reviews and presents the studies using DEA technique in ports. The literature review provides a set of examples including those of Martinez-Budria *et al*. [6], who have conducted an important project on Spanish ports, Tongzon [7] on 16 terminals in various countries, Cullinane *et al*. [12] in 57 container seaports, Wang and Cullinane [11] in 104 European container terminals and Valentine and Gray [8] in 31 container ports out of the world's top 100 container ports. For an extensive review of the productive efficiency in seaports, see Barros [38] and Rios and Macada [39].

3. Hypotheses formation

3.1. *ISO 9000 and performance*

The ISO has developed a set of quality standards, ISO 9000, as a model for quality assurance standards in design, development, production, installation and service. The ISO 9000 is a series of internationally accepted guidelines as to how companies should establish quality assurance systems. Focusing on procedures, controls and documentation, the standards are designed to help a company identify mistakes, streamline its operations and guarantee a consistent level of quality [53]. Meeting the ISO 9000 standard requirements ensures that the products or services have been produced according to certain specifications and that any potential errors have been detected and eliminated [54]. The standards are not specific to products or services, but apply to all processes. They are generic and therefore can be used by manufacturing and service organisations [53]. They have been described as the 'one size fits all' standards [55].

The two most common benefits of ISO 9000 certification reported in the literature are an increase in productivity and access to overseas markets [20]. Numerous companies have experienced an increase in overall sales after certification [56]. Calingo *et al*. [57] confirm that ISO 9000 certified companies yield better quality systems, customer satisfaction, competitive advantage and a reduction in quality problems. Rao *et al*. [58] surveyed companies in China, India, Mexico and the

United States and concluded that ISO 9000 certification exerted a significant impact on quality management practices such as leadership, strategic quality planning, supplier relationships and customer satisfaction. They also report that ISO certification was significantly related to rework, throughput time, productivity and market share. Elmuti and Kathawala's [59] study of two manufacturing plants in a large American organisation showed that the plant with ISO 9000 certification had a better and improved quality of work life compared to the noncertified plant. They also found that ISO 9000 certification increased employee productivity, goal congruence and morale, while it decreased defects and rework. Chittenden *et al*. [60], in line with Elmuti and Kathawala [59], confirm that British firms attaining ISO 9000 certification report similar benefits after ISO certification. Analogous results have been observed in Northern Ireland [61], Norway [62] and North America [63]. Gotzamani and Tsiotras [64] identify six benefits of ISO 9000 certification, including increased staff retention, greater opportunity for exports, waste reduction and increased efficiency, greater customer satisfaction, greater competitive advantage and finally, an improvement in profitability. Brown *et al*. [65] also identify seven benefits of certification, such as greater quality awareness, better customer service, greater staff retention, greater opportunity for exports, reduction in waste and inefficiency, greater expansion to international market and an increase in market share. For an extensive review of ISO 9000 certification benefits, see Chow-Chua *et al*. [20].

3.2. *ISO 9000 and financial performance*

While many studies have reported better business performance arising from ISO 9000 certification, very few actually measure financial performance [20] and with contradicting results.

Some researchers note the negative effect of ISO 9000 certification in company benefits and profitability [21, 66, 67], while others mention low levels of customer satisfaction with the implementation of the standards [68]. It is important to note that all the above studies collect evidence over a short period of time (3 years) after certification. This finding probably means that the short-term results for a company's business performance are not as impressive as the long-term ones [21]. Martinez-Costa and Martinez-Lorente [21] collected data from 713 Spanish manufacturing companies that were ISO 9001 certified. The results indicate that these companies obtained considerably less earnings and return on assets (ROA) during the 3 years following registration. They also had a noticeable increase in operational costs over the same period. However, sales and personnel expenses remained unchanged. In other words, the effect of ISO 9001 certification was an increase in operational costs that was not compensated for by an increase in sales turnover and profitability. Simmons and White [63] studied 126 American companies in the electronics industry and investigated whether three financial performance measures (ROA for profitability, sales/equity for operational performance and foreign sales) were significantly different between the 63 ISO certified and the 63 non-ISO certified companies.

Other scholars argue in support of the positive role of ISO certification in financial results [64, 69–72]. Quazi and Padibjo [73], for example, state that certified companies improve their quality and increase their sales and market share, while Haversjo [74] notes that an increase in sales also increases the rate of return for certified, as opposed to noncertified companies. His results, based on 664 companies,

showed a significantly higher rate of return for ISO 9000 certified companies than their size-matched counterparts. The difference in performance between ISO companies and non-ISO companies was 20% in the year prior to certification and approximately 35% 2 years after certification.

Furthermore, Naveh and Erez [75] and Naveh and Marcus [76], state that the improved 'performance' of ISO 9000-certified firms also means an increase in profits, total revenue and a greater market share. Feng *et al*. [66] surveyed 613 ISO 9001 certified manufacturing and service organisations in Australia and New Zealand, exploring the relationships between the various approaches to implementing the quality standard and the resulting organisational performance. Organisational performance was measured in two dimensions, namely operational performance (related to an organisation's internal operation, such as productivity, product quality and internal customer satisfaction) and business performance (related to financial and marketing, such as sales growth, profitability and market share). The results yielded both a positive and significant relationship between the certification practices (implementation, organisational commitment and planning) and operational performance.

From the above analysis, it can be concluded that there is no a clear position on the benefits of ISO certification in the literature. Moreover, the lack of any study in the ports industry raises a profound question:

Does ISO 9000 series adoption exert a direct impact on ports' financial performance?

4. Sample

The research was conducted in 22 European ports (Port Authorities) whose financial data is both published and accessible. Moreover, this study is driven not only by the availability of information, but also by the conviction that port authorities provide a good proxy for the performance of overall port activities, as mentioned by Trujillo and Tovar [2].

Only 18 were finally used, based on their compatible financial and operational structure (e.g. year of publication, similarity of operations etc). Of these 18 ports, 9 had been certified according to ISO 9000, while the remainder are either not yet certified or employ other certification methods or standards (Table 2).

Table 2. Selected ports.

ISO 9000 certified	Non-ISO 9000 certified
Barcelona	Antwerp
Koper	Hamburg
Tallinn	Piraeus
Dublin	Helsinki
Turku	Malmo
Thessaloniki	Belfast
Malaga	Amsterdam
Kotka	Sines
Bilbao	Rotterdam

5. Analysis

As Norman and Stoker [77] and Wang *et al*. [78] suggest, an effective and reliable way to select variables (input–output) for analysing efficiency, is the use of regressions.

Regarding port performance and efficiency measurement, some previous studies have recognised total revenue as an output in the service production function [45, 46, 49]. Inputs to this function are total cargo traffic in tons [46], fixed capital [49] and the number of vessels stevedored at a particular port [45]. On the other hand, operating profits, to the best of our knowledge, have not been used to measure port efficiency. A set of 14 variables were selected, including the number of bulk carriers in–out, number of container ships in–out, total gross registered tonnage (GRT) in–out, depreciations, GRT tankers in–out, GRT bulk carriers in–out, GRT container ships in–out and total twenty-foot equivalent units (TEUs) in–out, total tons in–out, passengers and cruise passengers and tangible fixed assets represent the inputs of the production function. The selection of these inputs is both grounded in the literature and based on the availability of information (Table 3).

For an extensive review, refer to Barros [38] and Rios and Macada [39].

The use of dependent variables as outputs, and independent variables as inputs, seems to overcome the inefficiencies of DEA, since the data have already been studied. In this way, before the DEA method implementation, a set of competing variables, based on the literature, is first selected. Bivariate correlation was then used and variables yielding high scores on the Pearson correlation index were identified as strong candidates for exclusion from subsequent analysis. All variables that are essentially uncorrelated or present a very low correlation, form the pool of input (or independent) variables, whereas their high Pearson correlation to outputs (profits and revenues) constitutes a further criterion for input variable selection (Table 4).

A step-wise regression followed, in order to justify which variables would be the inputs in the system and which would be excluded from further analysis, as nonstatistically significant. Step-wise regression was applied twice, once with total revenue being the dependent variable and once with operating profits. It should also be noted that, when operating profits were used as a dependent variable, total revenue and expenses were first added to the independent variables, and then finally excluded from the step-wise regression model, as nonstatistically

Table 3. Variables those were previously used in the literature.

Depreciation	Martinez-Budria *et al*. [6]
Revenue	Martinez-Budria *et al*. [6]; Park and De [45]
TEU handled	Valentine and Gray [40]; Itoh [41]; Serrano and Castellano [42]; Cullinane and Song [33]; Cullinane *et al*. [4]; Turner *et al*. [10]; Liu [46]
Total tons in-out	Serrano and Castellano [42]; Park and De [45]; Roll and Hayuth [5]; Martinez-Budria *et al*. [6]; Tongzon [7]; Valentine and Gray [40]; Barros [43, 44]; Barros and Athanassiou [9]
Ship movement	Barros [43]; Barros [44]; Barros and Athanassiou [9]
Expenses	Barros [51]
Passengers in-out	Coto Millan *et al*. [47]
Tangible fixed assets	Barros [43]; Barros [44]; Cullinane and Song [49]

Table 4. Correlations.

	Number of vessels in general	Number of tankers	Number of bulk carriers	Number of container ships	Total GRT	GRT tankers	GRT bulk carriers	GRT container Ships	Total TEU	Total tons in-out	Passengers + cruise passengers	Tangible fixed assets	Operating profit	Revenue	Depreciation
Number of vessels in general					0.841(**)									0.717(**)	
Number of tankers					0.862(**)	0.964(**)	0.824(**)	0.797(**)	0.780(**)	0.963(**)		0.822(**)	0.914(**)	0.845(**)	
Number of bulk carriers							0.724(**)								
Number of container ships					0.770(**)			0.959(**)	0.969(**)	0.785(**)		0.759(**)		0.860(**)	
Total GRT	0.841(**)	0.862(**)		0.770(**)		0.843(**)	0.759(**)	0.844(**)	0.823(**)	0.893(**)		0.886(**)	0.923(**)	0.927(**)	
GRT tankers		0.964(**)			0.843(**)		0.913(**)	0.742(**)	0.720(**)	0.955(**)		0.851(**)	0.929(**)	0.807(**)	
GRT bulk carriers		0.824(**)	0.724(**)		0.759(**)	0.913(**)		0.723(**)	0.707(**)	0.903(**)		0.789(**)	0.833(**)	0.749(**)	
GRT container ships		0.797(**)		0.959(**)	0.844(**)	0.742(**)	0.723(**)		0.993(**)	0.879(**)		0.839(**)	0.763(**)	0.937(**)	
Total TEU		0.780(**)		0.969(**)	0.823(**)	0.720(**)	0.707(**)	0.993(**)		0.871(**)		0.807(**)	0.743(**)	0.907(**)	
Total tons in–out		0.963(**)		0.785(**)	0.893(**)	0.955(**)	0.903(**)	0.879(**)	0.871(**)			0.881(**)	0.934(**)	0.892(**)	
Passengers + cruise passengers															
Tangible fixed assets		0.822(**)		0.759(**)	0.886(**)	0.851(**)	0.789(**)	0.839(**)	0.807(**)	0.881(**)			0.936(**)	0.925(**)	
Operating profit		0.914(**)			0.923(**)	0.929(**)	0.833(**)	0.763(**)	0.743(**)	0.934(**)		0.936(**)		0.880(**)	
Revenue	0.717(**)	0.845(**)		0.860(**)	0.927(**)	0.807(**)	0.749(**)	0.937(**)	0.907(**)	0.892(**)		0.925(**)	0.880(**)		
Depreciation															

Note: **Correlation is significant at the 0.01 level (two-tailed).

Table 5. Revenue.

Unit	Efficiency score	Slack ↑ (%)
U1	100	37.69
U2	100	160
U3	100	197
U4	37.27	313
U5	52.83	188
U6	55.88	271
U7	100	146
U8	72.37	281.8
U9	100	0
U10	49.11	106.52
U11	100	0
U12	100	0
U13	100	123
U14	100	263
U15	100	0
U16	73.46	186
U17	100	0
U18	100	0

significant variables. The results of the step-wise regressions for both the profit and the revenue functions are presented below:

$$f(\textit{Operating Profit}) = 4054.8 + 0.569\ (\textit{Tangible Fixed Assets}) + 0.446\ (\textit{Number of Tankers})$$

$$f(\textit{Revenue}) = 22563.525 + 0.313\ (\text{Total GRT}) + 0.365\ (\textit{TEU}) + 0.353\ (\textit{Tangible Fixed Assets})$$

As noted from the above, total revenue depends on the total gross registered tonnage of vessels that enter or arrive in a port, the total TEUs stevedored and the company's tangible fixed assets. An adjusted R^2, explaining 93.7% of overall variance of 'Revenue', confirms the good fit of the introduced variables. Moreover, operating profits may well be explained (adjusted R^2 of 93.2%) by the company's tangible fixed assets and the total number of tankers. All regression tests (tolerance and VFI tests) easily exceed the recommended thresholds. Finally, when 'revenues' were used as inputs to total profits, step-wise regression identifies it as nonstatistically significant and excludes it from the final model.

Based on the results of step-wise regressions, the DEA technique was then applied. The multi-attribute value expressions for total revenue and operating profit, with the independent variables indicated by the step-wise regressions as inputs, constitute our objective functions. The DEA method is employed to define the 'production possibility set', which contains all feasible input–output correspondences of the production process operated by the port in question. The efficiency ratings are then estimated, based on the output-maximisation method under variable returns to scale. The tables below (Tables 5 and 6) present the efficiency scores of 18 ports under study, compared with one another in terms of revenue and profit outcomes and the effort (distance) they require in order to become efficient (frontier).

In order to obtain support for our second hypothesis, a straightforward run of all 18 ports was then performed. The x-efficiency targets were added for both profit

Table 6. Operating profit.

Unit	Efficiency score	Slack ↑ (%)
U1	61.60	161.6
U2	90.41	142
U3	100	175
U4	69.84	84.1
U5	67.62	163
U6	99.3	32.1
U7	51.3	315
U8	100	0
U9	100	0
U10	59.72	67.3
U11	–	–
U12	100	0
U13	74.88	102
U14	100	123
U15	28.68	528
U16	100	11.9
U17	68.86	107
U18	100	0

maximisation and revenue maximisation objectives-inefficient cases. Finally, in order to identify the contribution of ISO to port performance, corresponding targets (distances) were specified for each case, and two virtual ports (not really observed in practice) are then created out of the summation of all cases. Both virtual ports correspond to the ISO and non-ISO-certified ports, by summing all revenues and profits of the constituting ports, as well as their corresponding levels (slacks or targets) for improvement. The assumption of variable returns to scale prevented the model from yielding targets exceeding the maximum feasible scores for each case. Following our previous line of thought, the gap rate in targeted improvement (%) for each case and for all ports was then estimated. Note, however, that these targets refer to the average ones that an ISO and a non-ISO port should seek, in attempting to be *x*-efficient.

The following observations are evident from the analysis:

(a) Regarding the efficiency measurement based on total revenue, a 145% improvement target is proposed for certified ports and a 174% improvement target for noncertified ones. This 16% difference in improvement may be attributed to the certification to ISO 9000.
(b) Regarding the efficiency measurement based on operating profits, a 90% improvement is proposed for certified ports and a 133% improvement for noncertified ones. This 32% difference is due to the ISO 9000 certification.

6. Discussion

The main purpose of this article is to prove that ISO 9000 certification has a positive impact on port authority financial performance. The results indicate clearly that ISO 9000 certification does exert a positive impact on port financial efficiency, either in terms of profit or revenue. This claim is supported with the use of the *x*-efficiency

targets and the fact that efficiency gaps narrow for ISO certified ports, compared to noncertified ones. These efficiency targets were defined as the percentage improvement (slack) of a virtual unit, incorporating all port inputs, compared with the examined outputs, in this case, either profit or revenue. This process eliminates any differences (managerial inefficiencies) between the ports and allows a comparison of slack. Because ports are selected after a careful screening process, it is expected that outliers or extreme cases would not seriously distort the results. Finally, as the regression analysis suggest, all inputs are grounded in the literature and selected according to their significance and the explanatory ability of the dependent variable.

The results reveal another rather interesting finding, based on the fact that the efficiency benchmarking within the two groups (profit and revenue maximisers) produce different outcomes and rankings. These diverging rankings may be attributed to the differential effect ISO certification has on profit and revenue. The different slacks in operating profits (32%) amount to almost double the difference in total revenue (16%). In itself, this provides a strong indication that certification to ISO 9000 contributes more to the increased profitability of these ports than to total revenue. This finding indicates evidence that the certification impacts on customer choice or behaviour and thus, the resulting revenues are not immediately apparent. Resources consumed may be better organised and developed, additional or unnecessary expenses avoided for several reasons, and reduced cost leads to higher profits. Certification to ISO 9000 evidently fosters profitability more than revenue. The contribution of ISO 9000 certification to customer satisfaction, employee satisfaction and increased market share, and thus to revenue improvement, is perhaps limited. This finding is in line with previous research [20, 79], which suggests that, while the profitability of certified companies has improved significantly, the above-mentioned aspects yielded either no change or even a negative impact.

In conclusion, taking into account all the positive effects of certification already mentioned in the theoretical part of this article, the adoption of ISO 9000 is, to all intents and purposes, necessary, especially in a period in which ports, as the main transport nodes, circulating the bulk of cargo and goods worldwide. Certification to ISO 9000 creates an additional competitive advantage that is presently necessary for ports to compete successfully with one another.

Future research could usefully examine the contribution of ISO with a larger sample. The limitations imposed by the sample size used in this study entailed keeping the number of variables in the DEA analysis as low as possible. We expect that larger samples may favour the use of thick-frontier approaches to port ranking and a comparison of results. Finally, it may also be worthwhile to investigate and examine the contribution of other certification standards or quality initiatives with ISO.

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