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ABSTRACT

Technical efficiency (TE), allocative efficiency (AE) and productivity measures were calculated using Data Envelopment Analysis (DEA) and Malmquist Total Factor Productivity (TFP) indexes for panel data of eight government seaports in Mindanao over six-year period, 2001 to 2006. Ports under the Southern Mindanao port district are Davao, General Santos and Zamboanga while ports belonging to Northern Mindanao port district are Cagayan de Oro, Iligan, Nasipit, Ozamiz and Surigao. Test of difference between the operating efficiencies of the two port districts was also computed.

Output variables are shipcalls, cargo throughput and container traffic; input variables are berth length and vessel's average service time (in calculating for the TE) and capital outlay and operating expenses (in the case of AE calculation).

The ports of Cagayan de Oro, Ozamiz and Davao emerged as the technically efficient ports relative to the rest of the sample. These three ports were also the top performers in terms of having the greatest volume of cargoes, shipcalls and container traffic respectively. The two least efficient ports were Iligan and Surigao, which, based on actual performance, serviced the least number of shipcalls and the least number of cargoes and containers for the period in review.

All the ports in the sample experienced productivity growth and regression at varying degrees during the six-year period. These changes in productivity were attributed to both technical and efficiency adjustments. The ports which registered full technical efficiency like the ports of Davao, Cagayan de Oro and Ozamiz pointed to technology adjustments as the primary mover of their productivity changes.

At 5 percent level of significance, there were no significant differences in the technical efficiency and allocative efficiency scores of the ports when analyzed according to the port district where they belong.

I. Introduction

In a borderless world, trade exchanges flow from one region to another with ease and facility giving great advantage to those regions that consummate the exchange in the most efficient way.

No trade-oriented economy can strategically formulate its development objectives without highlighting and evaluating the capacities of its own seaports by the fact that maritime trade continues to dominate the world transport chain as the cheapest, most appropriate and practicable mode of transport.

Port is a shore-based installation for the transfer of goods from and to the ships. Its function is to serve as gateway to an industrialized hinterland, to provide an outlet for its products and an inlet for the raw materials it needs. It is the vital link in the long chain of transportation that binds the producer to the consumer (Oram, 1985).

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More than 80 percent of the global international trade is conducted by way of maritime transportation (Lin and Tseng, 2005). It being so, a nation's international trade competitiveness and consequently, its economic development are largely defined by the efficiency of its ports. Thus, port authorities have increasingly been under pressure to improve port efficiency by ensuring that port services are provided on an internationally competitive basis (Poitras, Tongzon and Li, 1996).

Transport costs, according to Herrera and Pang (2006), to a large extent, are determined by the efficiency of port infrastructure. Poor port efficiency will increase import prices and reduce the competitiveness of the country's exports in world markets. Poorly-performing ports have a greater dampening impact on trade for small, less-developed countries than many other trade frictions. No single cause contributes more to the cost of living of a maritime country than the speed at which ships are turned round in her (country) ports.

Therefore, in the global trading arena, the dominant are the competitive economies which boast of, among others, their efficient transportation sector infrastructure, primarily the seaports.

In the Philippines, due to its archipelagic physical configuration, maritime transport is the major means by which the islands are connected and the movement of commodities and people are facilitated. Almost 98 percent of materials and products imported and exported by the country are facilitated through maritime exchanges (Innovation Norway 2004 as cited by Llanto et.al., 2005).

The financing, management, and operation of public ports of the country are within the mandate of the Philippine Ports Authority (PPA), a government-owned and controlled corporation created under Presidential Decree 857 on July 11, 1974. Under its charter, the PPA has jurisdiction over all the government ports of the country, except for some ports that are under independent port authorities, like the Subic Bay Metropolitan Authority (SBMA), which operates and manages the Subic Bay Freeport in Zambales; the Cebu Port Authority (CPA), which is in-charge of all ports in the province of Cebu; the Cagayan Economic Zone Authority (CEZA), which oversees the operation of the Port Irene; the Phividec Industrial Authority (PIA), which operates and manages the Mindanao Container Terminal (MCT) located in Cagayan de Oro; the Autonomous Region of Muslim Mindanao (ARMM), which manages the devolved PPA ports in Polloc, Jolo and Bongao; and the Bases Conversion Development Authority (BCDA), which supervises the port in San Fernando, La Union and the former US facility in Clark Field, Pampanga.

Philippine exports show continuous bright performance in Mindanao. Mindanao export products primarily consist of banana, coconut oil, fresh pineapples, tuna and iron ore agglomerates. It also grows most of the country's major crops such as rubber, cacao, coffee and corn.

To further strengthen the position of Mindanao as a premier trading economy, both in the domestic and international markets, provision of reliable and efficient transport links such as seaports is indubitable. Along this vein, it has become imperative to determine the efficiency level of the operation of major government ports in Mindanao thus, this current investigation.

The study covers the eight PPA-managed and operated government seaports in Mindanao cutting across the five administrative political regions of IX, X, XI, XII and Caraga. The eight ports are Davao, General Santos, Zamboanga, Cagayan de Oro, Iligan, Ozamiz, Surigao and Nasipit.

These ports all cater to both domestic and foreign vessels and handle all types of cargoes, i.e., bulk, breakbulk and containerized. They are, as they say, in a similar operating environment.

The efficiency performance of the eight ports is investigated based on the following indicators – berth length, vessel's average service time, capital outlay, operating expenses, shipcalls, cargo throughput and container traffic. More specifically, measures of these indicators for the years 2001 to 2006 are the ones subjected to test and analysis. Six-year performance proves substantial to generate reliable and dependable results.

Efficiency Defined

Efficiency is defined by the Steering Committee for the Review of Commonwealth/State Service Provision (1997) as "*the success with which an organization uses its resources to produce outputs, that is the degree to which the observed use of resources to produce outputs of a given quality matches the optimal use of resources to produce outputs of a given quality. This can be assessed in terms of technical and allocative efficiency.*"

Technical efficiency, according to the same source, is the conversion of physical inputs (such as the services of employees and machines) into outputs relative to best practice. Thus, a firm or an organization operating at best practice is said to be 100 percent technically efficient. If operating below best practice levels, then the firm's technical efficiency is expressed as a percentage of best practice.

Allocative efficiency on the other hand is the ability of a firm to use the inputs in optimal proportion (Coelli, 1996 citing Farrell, 1957). Thus, a firm is allocatively efficient when the inputs, given their prices, are used in a proportion that minimizes the cost of production. Allocative efficiency is also expressed as a percentage score, with a score of 100 percent indicating that the firm is using its inputs in optimal proportion.

Approaches to Efficiency Measurement

Herrero and Pascoe (2002) cite that the Farrell's (1957) definition of technical efficiency led to the development of methods for estimating the relative technical efficiency of firms. The common feature of these estimation techniques is that information is extracted from extreme observations from a body of data to determine the best production frontier. From this, the relative measure of technical efficiency for the individual firm can be derived. Despite this similarity, the approaches for estimating technical efficiency can be generally categorized under the distinctly opposing techniques of parametric and non-parametric.

Stochastic estimations incorporate a measure of random error. This involves the estimation of stochastic production frontier, where the output of a firm is a function of a set of inputs, inefficiency and random error. An often quoted disadvantage of the technique, however, is that it imposes an explicit functional form and distribution assumption on the data. In contrast, the linear programming technique of data envelopment analysis (DEA) does not impose any assumptions about functional form, hence, it is less prone to mis-specification.

Further, DEA is a non-parametric approach so it does not take into account random error. Likewise, it is not subsequently subject to the problems of assuming an underlying distribution about the error term. But since DEA cannot take account of such statistical noise, the efficiency estimates may be biased if the production process is largely characterized by stochastic elements (Herrero and Pascoe, 2002).

DEA Characteristics

Lertworasirikul (2002) summarizes some key characteristics of DEA as follows:

- DEA is used to measure efficiency of homogenous units called decision making units (DMUs), which consume the same type of inputs and produce the same type of outputs.
- DEA is a nonparametric approach; hence, there is no restriction on the functional form that relates inputs to outputs.
- DEA is a fractional mathematical programming technique. However, it can be converted into a linear programming model and solved by a standard LP solver.
- DEA generalizes the concept of the single-input, single-output technical efficiency measure of Farell to the multiple-input and multiple-output case by computing a relative efficiency score as a ratio of a virtual output to a virtual input. Specifically, efficiency is defined as a ratio of a weighted sum of outputs to a weighted sum of inputs.
- DEA is an approach focused on frontiers instead of central tendencies. It evaluates the efficiency of each DMU relative to similar DMUs. Thus, it provides an efficiency frontier or envelop for all considered DMUs rather than fitting a regression plane through the center of the data.
- DEA determines the relative efficiency of one DMU at a time over all other DMUs by finding the most favorable weights from the viewpoint of that “target” DMU.
- Alternative for making each inefficient DMU efficient can be seen by projecting them onto the efficient frontier.
- DEA offers the following three possible orientations to efficiency analysis:
    - Input-Oriented. With this orientation, input usage is minimized to produce given output levels for each DMU.
    - Output-Oriented. With this orientation, highest possible output is produced for a given input usage for each DMU.
    - Base-Oriented. With this orientation, the optimal usage of inputs and the optimal production of outputs are simultaneously achieved. Both inputs and outputs can be controlled in a Base-Oriented model.

Productivity Growth

As cited by Bayda (2003), Lovell (1993) defines productivity of a production unit as the ratio of its output to its input. He states that productivity of an individual firm depends on differences in production technology and differences in the efficiency of the production process, as well as on differences in the environment when and where the production occurs. Due to these three factors, productivity changes over time. At a given moment of time, when technology and the production environment are essentially the same, production units may exhibit different productivity due to differences in their production efficiency. Thus, in order to achieve valid productivity measures, a DMU must be compared to itself at different time points as well as with other DMUs at the same point in time.

Grosskopf (1993) as cited by Bayda (2003) characterizes productivity growth as “*the net change in output due to change in efficiency and technical change, where the former is understood to be the change in how far an observation is from the frontier of technology and the latter is understood to be shifts in the production frontier”.* Approaches to productivity growth measurement can either be non-frontier or frontier and in turn, each category can be subdivided into parametric and nonparametric models.

A popular nonparametric frontier approach to measuring productivity growth is the Malmquist productivity index calculated using linear programming techniques.

The Malmquist Total Factor Productivity (TFP) Index

The theoretical derivation of the Malmquist index and its properties was introduced by Caves et al. The index was based on defining an efficiency frontier that can be identified in terms of minimizing input requirements per unit of output. The output-based and input-based productivity indexes were named for Stan Malmquist, who proposed constructing input quantity indexes as ratios of distance functions (Bayda, 2003).

An input distance function characterizes the production technology by looking at a minimal proportional contraction of the input vector, given on output vector. An output distance function considers a maximal proportional expansion of the output vector, given an input vector (Coelli and Rao , 2003).

The Malmquist TFP index measures the TFP change between two data points (e.g., those of a particular DMU in two adjacent time periods) by calculating the ratio of the distances of each data point relative to a common technology.

The Malmquist index reveals values greater than unity if improvements in productivity occur. A decline in performance is indicated by a Malmquist index of less than one. The same arithmetic holds for each of the components of the Malmquist index. Since the product of the efficiency and technical change defines productivity growth over adjacent time periods, each of these components may show opposite results (Schmiedel, 2002).

DEA Application in Measuring Port Efficiencies

The various researches on measuring port efficiency can be classified either by the method or by the sample they use. They use either the stochastic frontier methods or non-parametric methods. The samples are either coming from a single country or they can include ports of different countries. One thing evident however is the fact that most of the studies cover developed nations (Herrera and Pang, 2006).

In this paper, related studies chosen to be presented are those which adopted DEA as the methodology in measuring port efficiency. So far, materials gathered pertain only to container ports, highlighting the dominance of container operation over breakbulk or bulk operation in the global port arena.

Poitras, Tongzon and Li (1996) studied on “Measuring Port Efficiency: An Application of DEA” covering five Australian and 18 other international container ports. The authors measured the relative efficiency of the subject ports using CCR and Additive DEA models. The outputs were (1) total number of containers loaded and unloaded, and (2) the speed of moving cargoes off and onto ships at berth, measured as the amount of cargo handled per berth hour. The inputs, on the other hand, were (1) number of shipcalls, (2) number of gantry cranes, (3) container mix, which referred to the proportion of 40 ft. and 20 ft. container, (4) work practices, measured as the difference between the time the ship is at berth and the gross working time, (5) quay crane efficiency, and (6) port charges.

The authors found out that those ports judged to be inefficient with variable returns to scale were also inefficient with linear production relations but not the converse. The two most inefficient ports identified with the additive model, Fremantle and Manila, were also found to be the most inefficient using constant returns to scale.

Further, the study showed that the primary characteristic of the four ports judged to be inefficient with both DEA models is size, measured in terms of number of containers handled. The 10 out of 23 ports found to efficient using CCR, the group of most efficient ports, did not have any discernable characteristics.

Another study was by Wang and Cullinane (2006) on "The Efficiency of European Container Terminals and Implications for Supply Chain Management". The study covered 104 of Europe's container terminal with annual throughput of over 10,000 TEUs (twenty-foot equivalent units). Adopting input orientation, the single output variable was container throughput while the input variables were (1) total quay length, (2) terminal area, and the (3) aggregate annualized expenditure associated with terminal equipment, as a proxy for the capital input.

The primary finding of the study was the significant inefficiency that generally pervaded most of the terminals under study. Likewise, taking into account the scale properties of the container terminal production, it was found out that in most container terminals, large production scale was more likely to register higher efficiency scores. The paper also found out the average efficiency of container terminals located in different regions differed from each other, either to a large or small extent.

The finding that larger ports tend to be more efficient than the smaller ones is supported by the study of Herrera and Pang (2006) entitled "Efficiency of Infrastructure: The Case of Container Ports" covering a sample of 86 container ports all over the world. Variables of the study were the container throughput as the single output variable and the terminal area, number of ship-to-shore gantries, number of quay, yard and mobile gantries and the number of tractors and trailers as the four input variables. Said authors also inferred that most ports in the developing countries would reduce scale inefficiency by increasing the scale of operation, while about one-third of them would reduce scale inefficiency by contracting the level of input consumption.

"An Application of DEA and SFA on the Measurement of Operating Efficiencies for 27 International Container Ports" was another study by Lin and Tseng (2005). The study aimed to measure the operating efficiencies of 27 international container ports from 1999 to 2002 by applying both DEA and SFA models with three inputs and single output. The inputs were (1) container gantry cranes, (2) container quay length and (3) stevedoring equipment. The single output was the container throughput.

The authors found out that the total average of operating efficiency scores of SFA_{TR} model is highest followed by SFA_{CB} model, DEA_{BCC} model and DEA_{CCR} is the smallest. It is found that the total average scores model SFA_{CD} is larger than other models, so SFA_{CD} model is better than other models and SFA method is better than DEA method in measuring port efficiency. Port of Hongkong demonstrated the best performance in the four models, while the other ports showed variation of performance in different models.

Cullinane et.al. (2005) also ventured in comparing the two approaches of data envelopment analysis and stochastic frontier analysis in estimating technical efficiency of the world's largest container ports. The study found out a high degree of correlation between the efficiency estimates derived from all the models applied, suggesting that results are relatively robust to the DEA models applied or the distributional assumptions under SFA. The study further found out that the high levels of technical efficiency are associated with scale, greater private-sector participation and with transshipment as opposed to gateway ports.

Treading a different path from the commonly used cross-section data analysis, another study entitled "An Application of DEA Windows Analysis to Container Port Production Efficiency" (Cullinane, Song, Ji and Wang, 2004) adopted panel data to determine the efficiency of the 25 world's leading container ports using DEA windows analysis. The study concluded that the efficiency of the different container ports can fluctuate over time to different extents. Most ports exhibited constant returns to scale, indicating that production scale is not the main source of inefficiency. A qualitative analysis of some ports in the sample showed that the ports measured as being highly efficient appeared to be those that do not invest actively over time, in contrast with their low efficiency counterparts which invest actively in either port equipment or infrastructure in order to be competitive in the long term.

This implies that port competition and competitiveness may have a major and direct impact on the measured levels of relative efficiency within container ports. Some other possible reasons that may explain empirical estimates of inefficiency in port production include differences in port ownership or governance, locational attributes and the form and level of competition faced (Cullinane et.al., 2004).

Another study which extended the DEA methodology is the one by Park and De (2004) where the authors employed the alternative four-stage DEA model. Basic differences between general DEA and the alternative four-stage DEA were, first, unlike conventional DEA method where overall efficiency is usually measured by using specific input and output variables, the alternative DEA divides the overall efficiency into several stages by transforming the inputs and outputs in each stage. Second, the four-stage DEA method also shows the role of the inputs and outputs according to the stages differently. Third, policy planners can analyze a situation correctly, and suggest a solution for enhancing the efficiency of each DMU. In this particular study, the four-stage DEA method was introduced to measure the productivity, efficiency and marketability of a port and the authors claimed that this model is a useful tool in measuring seaport efficiency.

Port Efficiency and Productivity

Wang and Cullinane (2006) put it so explicitly when they say that in a competitive environment, ports should efficiently utilize their existing facilities in serving their customers. The corollary of this logic is that ports should ensure that existing infrastructure and equipment are utilized to maximum economic and technical efficiency in order to optimize the [container] port production process. In so doing, actual and perceived service quality is enhanced by reducing the time that vessels need to stay in port and this translates into indirect, but very real, cost savings to the main customers of [container] ports - the shipping lines.

Ports are complex organizations where multiple activities take place, with a large variety of agents like the port authorities, cargo handling operators, pilots, shippers and consignees, etc. Furthermore, port activities and services differ from each other in aspects such as the nature of operation, the degree of competition in which they take place or the level of regulation to which they are subject to. Being such, it is not advisable to study ports as a whole but rather to focus the center of analysis on a concrete activity (Gonzalez and Trujillo, 2007).

De Monie (1987) echoes that port performance and productivity cannot be determined by only one indicator or by a single all-encompassing value. The complexity of port operations, and in particular the interaction between various essential elements such as the efficiency with which ships, berthing space, equipment and labor are utilized, make it compulsory to rely on a set of indicators if one wants to arrive at an accurate and meaningful evaluation of a port's performance.

In this investigation, the analysis focuses on one that is carried out by the port authority, the Philippine Ports Authority. This revolves around the provision of infrastructure to achieve efficiency and productivity.

Model Specification and Orientation

The objectives of a port are of crucial import to the definition of variables for efficiency measurement. Input and output variables should reflect actual objectives and the process of port production as accurately as possible. DEA models can be distinguished according to whether they are input- or output-oriented. The former is closely related to operational and managerial issues, while the latter is more related to planning and strategies (Cullinane et.al., 2005).

The PPA operates within the parameters of prudent expenditure program. Towards this end, it focuses on the use of its resources on vital core services, in this case the development and maintenance of infrastructure and facilities. The ability of ports to efficiently utilize their infrastructure and facilities will ultimately benefit most port users in terms of a reduction in their costs, which is one of the corporate priority objectives of the PPA.

In this instant case, the model adopted is input oriented, that is, given the same level of output, the objective of the decision making unit (DMU), in this case the Port Management Office (PMO) shall be to minimize the input(s).

Identification and selection of output and input variables is based on a standpoint of looking at the port as a multiple-output organization or decision making unit (DMU) unit. In this current investigation, however, the analysis revolves in determining the efficiency of the provision of infrastructure services as well as the management and operation by the port authority. The survey of previous studies conducted on port operating efficiency using the DEA method as summarized by Lin and Tseng (2005), Gonzales and Trujillo (2007) and Estache, et. al. (2001) also served as guide in identifying the variables under study. The following table shows the variables of the study:

Table 1. Description of Variables

Variables	*Unit*	*Description*
Outputs	Shipcalls (Units)	Number of ships berthing at a port per year
	Cargo Throughput (Metric Tons)	Volume of cargoes passing through the port, both outbound and inbound, domestic or foreign for a year's period
	Container Throughput (Twenty-Foot Equivalent Units, TEUs)	Number of containers loaded and unloaded onto/from ships for a year
Inputs	Berth Length (Linear Meter)	The part of the wharf or pier where vessels dock or tie up
	Average Service Time (Hours)	Duration the vessel stays at berth computed by finding the difference between the vessel's arrival at and departure from berth.

Capital Outlay (Pesos)	Amount spent in construction, rehabilitation and maintenance of port facilities and structures like berthing, storage and lighting facilities.
Operating Expenses (Pesos)	Amount spent to sustain port operation, which includes personnel services and maintenance & other operating expenses.

Technical Efficiency of Mindanao Seaports

Technical efficiency (TE) refers to the ability of a firm to obtain maximal output, or combination of outputs from a given set of inputs.

The TE scores of the eight Mindanao ports were calculated with shipcalls, cargo throughput and container traffic as output variables and berth length and service time as the input variables. Adopting input orientation, the TE score indicates the potential to reduce the quantities of inputs used in producing given quantities of outputs. As reference in the succeeding discussion of the TE scores for each port, Table 2 below presents the rank of each port in terms of aggregate output production during the six-year period in review.

Table 2. Rank of Mindanao Ports According to Output Production, 2001-2006

Rank	*Shipcalls*	*Cargo Throughput*	*Container Traffic*	*Total Output*
1	Ozamiz	Cagayan de Oro	Davao	Cagayan de Oro
2	Zamboanga	Davao	Cagayan de Oro	Davao
3	Surigao	General Santos	General Santos	General Santos
4	Cagayan de Oro	Ozamiz	Zamboanga	Ozamiz
5	General Santos	Zamboanga	Nasipit	Zbo
6	Nasipit	Nasipit	Ozamiz	Nasipit
7	Davao	Iligan	Iligan	Iligan
8	Iligan	Surigao	Surigao	Surigao

Of the eight ports under investigation, the port of Cagayan de Oro and the port of Ozamiz appeared to be consistently technically efficient from 2001 to 2006 (Table 3).

Attaining a technical efficiency score of 1.00 means that the port of Cagayan de Oro and the port of Ozamiz, relative to the performance of all the other six ports in the sample, have been calculated by the DEA model to be operating at efficient (best practice) frontier. It further implies that for the period in review, these ports were able to realize the highest potential or optimal quantity and combination of outputs for a given quantity and combination of inputs. These ports emerged as the peer port or the "role model" port of all the inefficient ports in the sample. DEA model identifies a peer group which consists of efficient port(s) from which an inefficient port could benchmark its performance. Following the ports of Cagayan de Oro and Ozamiz as the most technically efficient ports is the Port of Davao with a mean TE of 0.985.

For the less technically efficient ports, or those ports whose TEs are less than1.00, the results indicate that inputs may have been reduced without diminishing the outputs. Since berthing facility could not be physically and literally reduced, reduction of this input to attain technical efficiency would mean that its utilization has to be improved and optimized in such a way that the "excess" berth length would be eliminated. Reducing service time on the other hand, may mean improving cargo handling productivity thus enabling the vessels to stay shorter time in ports.

A thorough scrutiny of the ports' actual performance shows that the ports measured as being highly efficient appear to be those that produce the biggest number of outputs. In this current study, the port of Ozamiz serviced the most number of shipcalls, the port of Cagayan de Oro handled the most volume of cargoes and the port of Davao moved the most number of containers. In contrast, the least efficient port, the port of Iligan, serviced the least number of shipcalls and the second to the least volume of cargoes and number of containers. The port of Surigao, the second least efficient port, handled the least volume of cargoes and least number of containers.

These observations associating large production with higher efficiency scores go consistent with the findings of Herrera and Pang (2006) and Wang and Cullinane (2006). The former stipulates that larger ports tend to be more efficient than the smaller ones while the latter, looking into the scale properties of container terminal production, posits that large production scale is more likely to be associated with higher efficiency scores.

Table 3. Technical Efficiency Scores and Input Slacks

	2001	***2002***	***2003***	***2004***	***2005***	***2006***	***Mean***
Port of Davao							
Efficiency Score	0.956	0.951	1.000	1.000	1.000	1.000	0.985
Input Slacks							
Berth Length (m)	0	0	0	0	0	0	
Service Time (hrs)	26.221	5.231	0	0	0	0	
Port of Gen. Santos							
Efficiency Score	0.930	0.782	0.815	0.724	0.675	0.906	0.805
Input Slacks							
Berth Length (m)	0	0	0	0	0	0	
Service Time (hrs)	11.182	10.543	10.781	1.803	7.834	19.796	
Port of Zamboanga							
Efficiency Score	0.513	0.470	0.481	0.438	0.456	0.576	0.489
Input Slacks							
Berth Length (m)	0	0	0	0	0	0	
Service Time (hrs)	1.527	1.802	0	0	0	0	
Port of Cagayan de Oro							
Efficiency Score	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Input Slacks							
Berth Length (m)	0	0	0	0	0	0	
Service Time (hrs)	0	0	0	0	0	0	
Port of Iligan							
Efficiency Score	0.300	0.213	0.212	0.303	0.253	0.215	0.249
Input Slacks							
Berth Length (m)	0	0	0	0	0	0	
Service Time (hrs)	5.029	1.789	4.575	0	0	0	
Port of Nasipit							
Efficiency Score	0.629	0.597	0.757	0.698	0.800	0.852	0.722
Input Slacks							
Berth Length (m)	0	0	0	0	0	0	

Service Time (hrs)	6.068	5.71	8.733	14.581	9.523	5.231	
Port of Ozamiz							
Efficiency Score	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Input Slacks							
Berth Length (m)	0	0	0	0	0	0	
Service Time (hrs)	0	0	0	0	0	0	
Port of Surigao							
Efficiency Score	0.361	0.284	0.234	0.235	0.213	0.249	0.263
Input Slacks							
Berth Length (m)	0	0	0	0	0	0	
Service Time (hrs)	2.767	2.484	2.529	3.253	2.948	1.966	

Allocative Efficiency of Mindanao Seaports

A decision making unit (DMU) is said to be allocatively efficient when for a certain level of production, inputs are used in the proportion which minimizes the cost of production, given input prices (SCRCSSP, 1997). In this investigation, allocative efficiencies of the eight ports were calculated using the three output variables – shipcalls, cargo throughput and container traffic, and two input variables – capital outlay expenditures and operating expenses. Table 4 shows the Allocative Efficiency (AE) scores of the eight ports.

Table 4. Allocative Efficiency Scores

Port	***2001***	***2002***	***2003***	***2004***	***2005***	***2006***
Port of Davao	0.614	0.359	0.617	1.000	1.000	0.998
Port of Gen. Santos	1.000	1.000	1.000	0.931	1.000	1.000
Port of Zamboanga	0.429	1.000	1.000	1.000	0.499	0.496
Port of Cagayan de Oro	0.821	0.340	0.785	1.000	0.337	0.412
Port of Iligan	0.402	0.779	0.935	0.760	0.507	0.417
Port of Nasipit	0.932	0.786	0.693	0.299	1.000	0.740
Port of Ozamiz	1.000	1.000	1.000	1.000	1.000	1.000
Port of Surigao	0.545	0.958	0.952	0.785	0.519	0.445

Analyzing the overall performance of the ports in terms of their relative allocative efficiency scores from 2001 until 2006, the general picture is the pervading inefficient utilization of capital outlay and operating expense budget in a proportion that would minimize the cost of production. Only the port of Ozamiz achieved full AE during the six-year period. It is worth to mention though that the ports of Davao and General Santos both attained full AE also in 2005 and 2006. These ports may therefore use as benchmark their 2005 and 2006 performance in decision making particularly in annual budget preparation. As to the other ports with less than 1.00 AE scores, their scores imply that subject ports may have cut their budget without adversely affecting their outputs.

Productivity Growth of Mindanao Seaports

Productivity growth of the ports was estimated and examined by calculating the Malmquist total factor productivity (TFP) indexes. Changes in average port productivity and its components (i.e., technical change and efficiency change) for all ports in the data set and for each port are reported in Table 5. The results indicate that over the 2001 to 2006 time period, there has been a rather low productivity growth (TFPCH) of approximately 1.2% per year for all the Mindanao ports under study. This growth was primarily attributed to technology improvement (TECHCH) of 1.8% juxtaposed the very minimal regression in efficiency (EFFCH) by .7%.

Over the six-year period, four ports namely, Davao, General Santos, Cagayan de Oro and Nasipit experienced an average single-digit TFP growth, two ports - Iligan and Surigao recorded an average single-digit regression, while the other remaining two ports – Zamboanga and Ozamiz had their progress and regress almost totally canceling out each other resulting to near-zero net effect.

Table 5. Changes in Average Port Productivity and Their Components

Port	Time Period	Total Factor Productivity Change (TFPCH)	Technical Change (TECHCH)	Efficiency Change (EFFCH)
Davao	01-02	1.143	1.149	0.995
	02-03	1.057	1.005	1.052
	03-04	1.100	1.100	1.000
	04-05	1.029	1.029	1.000
	05-06	1.146	1.146	1.000
	Mean	*1.094*	*1.084*	*1.009*
Gen. Santos	01-02	0.966	1.149	0.841
	02-03	1.004	0.963	1.043
	03-04	0.986	1.109	0.888
	04-05	0.945	1.014	0.932
	05-06	1.277	0.950	1.343
	Mean	*1.029*	*1.034*	*0.995*
Zamboanga	01-02	1.088	1.189	0.915
	02-03	1.067	1.041	1.025
	03-04	1.020	1.122	0.910
	04-05	1.009	0.968	1.042
	05-06	0.832	0.659	1.262
	Mean	*0.999*	*0.976*	*1.023*
Cagayan de Oro	01-02	1.192	1.192	1.000
	02-03	0.934	0.934	1.000
	03-04	1.080	1.080	1.000
	04-05	0.999	0.999	1.000
	05-06	0.925	0.925	1.000
	Mean	*1.021*	*1.021*	*1.000*
Iligan	01-02	0.818	1.152	0.710
	02-03	0.973	0.976	0.997
	03-04	1.569	1.101	1.425
	04-05	0.849	1.016	0.835
	05-06	0.891	1.048	0.850
	Mean	*0.989*	*1.057*	*0.935*
Nasipit	01-02	1.095	1.153	0.950
	02-03	1.184	0.934	1.267
	03-04	0.987	1.070	0.922
	04-05	1.039	0.906	1.146
	05-06	0.946	0.888	1.065
	Mean	*1.047*	*0.985*	*1.063*
Ozamiz	01-02	1.403	1.403	1.000
	02-03	1.255	1.255	1.000
	03-04	1.119	1.119	1.000
	04-05	0.918	0.918	1.000
	05-06	0.550	0.550	1.000
	Mean	*0.999*	*0.999*	*1.000*
Surigao	01-02	0.937	1.192	0.786
	02-03	0.916	1.114	0.822

	03-04	1.079	1.071	1.007
	04-05	0.873	0.963	0.906
	05-06	0.833	0.713	1.168
	Mean	*0.924*	*0.995*	*0.928*
All Ports	01-02	1.067	1.195	0.893
	02-03	1.043	1.023	1.020
	03-04	1.106	1.096	1.008
	04-05	0.995	0.976	0.979
	05-06	0.901	0.838	1.076
	Mean	1.012	1.018	0.993

Test of Difference in the Efficiency Scores Between Port Districts

All government ports nationwide are clustered by port districts for purposes of carrying out their management, supervision and operation. The eight ports under study are managed and supervised by the Port District Office of Northern Mindanao (NoMin) and the Port District Office of Southern Mindanao (SoMin). SoMin ports include Davao, General Santos and Zamboanga while NoMin ports cover Cagayan de Oro, Iligan, Nasipit, Ozamiz and Surigao.

To determine whether or not there is significant difference in the operating efficiencies of the ports under the two districts, t-test for independent samples was undertaken. Table 6 shows the results of the t-test on the technical efficiency scores between the ports under NoMin port district and SoMin port district from 2001 to 2006. At 5 percent level of significance, the p-values were all greater than .05, thus, there were no significant differences in the technical efficiency scores between the two groups. The results, therefore, fail to reject the null hypothesis.

Table 6. Test of Difference in the TE Scores Between Port Districts

Year	Mean Technical Efficiency (TE) Score		t-value	p-value
	NoMin	SoMin		
2001	0.65800	0.79967	-0.627	0.554
2002	0.61880	0.73433	-0.468	0.657
2003	0.64060	0.76533	-0.480	0.648
2004	0.64720	0.72067	-0.295	0.778
2005	0.65320	0.71033	-0.219	0.834
2006	0.66320	0.82733	-0.747	0.483

In the same way, Table 7 shows the results of the t-test on the allocative efficiency. At 5 percent level of significance, the p-values were all more than .05 which means that there were likewise no significant differences in the allocative efficiency scores of the ports when analyzed according the port district where they belong. The results, again, fail to reject the null hypothesis.

Table 7. Test of Difference in the AE Scores Between Port Districts

Year	Mean Allocative Efficiency (AE) Score		t-value	p-value
	NoMin	SoMin		
2001	0.74000	0.68100	0.301	0.774
2002	0.77260	0.78633	-0.062	0.952
2003	0.87300	0.87233	0.006	0.996

2004	0.76880	0.97700	-1.214	0.271
2005	0.67260	0.83300	-0.729	0.494
2006	0.60280	0.83133	-1.154	0.292

The absence of significant differences in the technical and allocative efficiencies between NoMin and SoMin ports may be attributed to first, PPA's sustained efforts to ensure that its policies, particularly on resource allocation and management, are uniformly and consistently implemented in all ports nationwide, regardless of their geographical location; second, being all located in Mindanao, the types of vessels calling at the ports, the cargo mix being handled, and the economic environment within which these ports operate do not differ much and finally, the cargo handling operators and shipping companies involved in the port operation naturally and expectedly aim to reduce cost and maximize their profit such that they have to push the port authority to enhance port operating efficiencies under the resource restrictions of port infrastructure and financial availability. Operating within comparable milieu, the ports are most likely to respond with parallel actions.

Conclusion

Attributed to the data set used and assumptions made while estimating the technical and allocative efficiencies and productivity, the following conclusions are drawn from the results of the study. First, the findings of some authors attributing technical efficiency to production level are affirmed in this study. The ports of Ozamiz, Cagayan de Oro, and Davao which emerged as the technically efficient ports relative to the rest of the Mindanao ports under study were likewise the top performers in terms of the number of shipcalls, volume of cargo and number of containers respectively. On the other hand, the two least efficient ports – Iligan and Surigao were servicing the least aggregate number of shipcalls, cargo and containers.

Second, the allocative efficiency scores computed in this paper revealed that the margin for cost reduction is significant. The most inefficient ports used financial resources for capital outlay and operating expenses in excess of about 20 to 40 percent of the level used in the most efficient ports. The ports of Ozamiz and General Santos were the only allocatively efficient ports and the other six were not.

In distinguishing efficient ports from the inefficient ones, it is important to point out though that the DEA approach which was used in the research combines statistical noise (e.g., weather, luck, machine breakdown and other events beyond the control of the firm) in the data set with inefficiency and identifies it all together as inefficiency.

Third, productivity performance of the eight ports did not establish a trend over the six-year period. Improvements as well as decline in productivity in various years were both observed in all ports. Variations in productivity were attributed to both changes in technology and in efficiency.

Finally, notwithstanding the varying levels of technical and allocative efficiencies recorded by the eight ports, test results showed that these have not been statistically influenced by their geographical location (i.e. northern Mindanao vs. southern Mindanao) as well as their administrative subordination under two different port district offices. Based on t-test results, there were no significant differences on the technical and allocative efficiency scores between the northern Mindanao ports (Cagayan de Oro, Iligan, Nasipit, Ozamiz and Surigao) and the ports in southern Mindanao (Davao, General Santos and Zamboanga).

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