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The Impact of Privatization on Terminal Efficiency: A Case Study of Tema Port

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Abstract

Port and terminal efficiency are of utmost importance to the container shipping industry due to their significance in enhancing the competitive advantage of ports within a region. Consequently, there have always been notable variations of studies around it. This paper analyzes the impact of privatization on terminal efficiency using the Port of Tema as a Case Study. The main objective of this paper is to analyze the efficiency trends of the public and private terminals in the port over the years. To achieve this objective, DEA-CCR methodology was employed to calculate the annual technical efficiency trends of the private and public terminals using four input variables and three output variables. The main results of the paper indicated that the public and private terminals were efficient for multiple years. However, the efficiency scores over the years demonstrated inconsistency, exhibiting notable fluctuations. The findings of this study will aid policymakers across the region on policies relating to the efficiency and ownership structure of ports and terminals.

Keywords

Privatization, Terminal Efficiency, DEA, Tema Port

1. Introduction

The growth in containerized cargo has led to a surge in the growth in maritime shipping globally therefore, innovative measures are being put in place by many seaports to satisfy demand [1]. Studies on port and terminal efficiency have dated way back and it's still predominant in current research due to its impact on the various stakeholders of maritime trade [2] [3] [4]. The Port of Tema which doubles as the largest port in Ghana faces stiff competition from neighboring ports such as Lomé, Abidjan, and Cotonou to gain the status of a trans-

shipment hub of the region. Therefore, the government of Ghana signed an agreement with the private sector to build and operate a containerized terminal for 35 years aimed at gaining a competitive advantage over its neighboring ports following the private sector's successful operation in the port since 2007 [5]. The current structure of the port includes terminals controlled by the public authority as well as the private sector.

Container terminals which are well operated contribute immensely to the general efficiency overview of the port therefore it is important to relatively analyze the efficiency of the terminals against one another [6]. Terminals are considered efficient when they produce maximum results with the least amount of financial and infrastructure expenditure [7]. Consequently, port and terminal management endeavors to complement their infrastructural investments with service strategies geared toward satisfying the various stakeholders of the port [8]. This is because several underperforming or inefficient terminals within a port could adversely impact the port's reputation, rendering it less appealing and diminishing its competitive position against its neighboring ports.

Past studies have employed the DEA methodology to measure the efficiency of ports within selected regions [9] [10]. However, analyzing the efficiency at the port level may be misleading because the performance of individual terminals in the port has different impact levels on the total efficiency of the port [11]. Highly efficient terminals could cover up for underperforming or inefficient terminals in the same port therefore, this study adopts DEA methodology to analyze the efficiency trends of public and private container terminals in the same port. By evaluating the efficiency trajectory of the terminals in the port, it becomes possible to analyze the level of consistency exhibited by these terminals. This analysis provides valuable insights for the implementation of necessary adjustments and strategies aimed at attaining sustainable objectives.

Most studies that have focused on this research area typically employ several input variables and one output variable, usually cargo throughput when calculating port or terminal efficiency [12] [13]. However, there are other performance indicators or output variables that should be considered when analyzing efficiency therefore, this paper factors in other output variables in determining the efficiency scores and trends of the private and public terminals in Tema port and how it could affect the general output of the port.

This study extends the frontiers of knowledge by broadening the terminal efficiency literature with the introduction of privatization. Also, West African ports have received less attention regarding studies on privatization and efficiency therefore this paper focuses on the private and public terminals in Tema Port and the findings shall guide the policy implementations within the region. The justification for using DEA as a tool for modeling the efficiency of ports and terminals was confirmed by Krmac and Rostamzadeh [14] [15].

The rest of the paper shall consist of the literature review, followed by the methodology which includes the data, variables, and the Data envelopment analysis (DEA) model. Subsequent sections covered the empirical studies of the

paper which highlights the descriptive statistics of the various terminals, the discussion on the relationship between privatization and terminal efficiency, and the policy implications based on the findings. The concluding chapter shall summarize the study and highlight the future research orientations around the topic.

2. Literature Review

The related literature can be divided into two major streams namely, terminal privatization and efficiency.

According to [16] privatization has its costs and benefits therefore, [17] examines how the privatization process has influenced the growth of the functional structure of the Constanta port, using a theoretical model of port organization. The findings helped to explain some of the present anomalies in this field of work. [18] also sought to validate the theoretical claim that privatization improves economic efficiency and operational performance. The study concluded that privatization serves as a partial cure to what ails the ports and is less effective when implemented in isolation. [19] expressed that ownership, regulation, utilities, and operations, coupled with autonomy, efficiency, and competitiveness, are the most important issues in port privatization. [20] also expressed that port privatization which in most cases spans for extended period is detrimental to port competitiveness and has negative effects on port users and the public.

Past studies have employed different methodologies in trying to investigate and rank the efficiency of various ports across the globe. Studies have focused on Data Envelopment analysis methodology when dealing with port efficiency and productivity [2] [12] [21] [22] [23]. Other studies combine two models to reduce the margin of ambiguity and inaccuracy. In most instances, researchers combine the DEA model with other methodologies to answer their research questions. [24] [25] [26] combined DEA with Malmquist Total Factor Productivity, Stochastic Frontier Analysis, and MPI model specifications to answer the research questions relative to port efficiency. [27] also investigated the scale and technical efficiency of container port terminals in 32 ports situated in nine (9) counties across Europe using the sophisticated frontier analysis (SFA) model. The model was developed to examine the elements that make up the container port and terminal industry. [6] investigated the efficiency of major container terminals in China by employing a super-efficiency data envelopment analysis (SE-DEA) methodology. The researcher justified the use of this approach over the normal DEA model because it can be used to classify and rank the efficiency of container terminals more correctly and thoroughly. [28] studied the relationship between port privatization, efficiency, and competitiveness of various container ports. The study employed a stochastic frontier with a technique in efficiency effects to prove the impact of port privatization on the competitive advantage of ports. The study concluded that to some extent, the private sector can help improve

operational efficiency and the competitiveness of a port. [29] also sought to establish the relationship between Data envelopment analysis (DEA) estimate analysis. The hypothesis that an increased private sector involvement in the container port sector inevitably results in increased efficiency is refuted in the paper's conclusion. [30] investigated the impact of privatization on port efficiency and effectiveness. The study selected specific ports from Panama and the United States of America and accessed them using specific econometric techniques. The model was used to analyze the port performance under the government as against the private sector and concluded that there were effective gains and savings from the time the private sector took charge. [31] studied and evaluated the effects of PPPs on significant Brazilian public ports. The study selected specific inputs and output variables to calculate the DEA efficiency estimates. Next, a truncated bootstrapped regression analysis was performed to assess different contextual variables. Results show that public-private partnerships have a significant positive impact on port scale efficiency.

Previous literature has contributed immensely to issues relating to port privatizations and efficiency. However, there are a few gaps that this paper seeks to address as far as contributions to the subject area are concerned. This paper deals with both private and public terminals within the same port to identify and analyze how efficient the terminals are under public and private authority and administrations. Also, this paper deals with terminals in Ghana, situated in the West African region hence all policy recommendations shall be relevant and could be applied in ports across the region. Finally, the study also introduced variables that have not been considered by past studies hence giving fresh perspectives to the port and terminal efficiency literature.

3. Model

This section deals with the Data Envelopment Analysis—Charnes, Cooper, and Rhodes (DEA-CCR) model employed in analyzing the efficiency trends of private and public terminals in the Tema port. The Input and output variables employed in the model are also highlighted in this section. Past studies on port efficiency used cargo throughput as the sole output variable. However, this research will expand the empirical study by using four (4) input variables and three (3) output variables to determine the efficiencies of the public and private terminals. This study used a 15-year data span to calculate the efficiency scores.

Table 1 below indicates the inputs and output variables necessary for analyzing the efficiency of ports and terminals. It highlights the variables, measurement, and relevant sources. This study introduced waiting time as a variable because it's a very important performance indicator in measuring port efficiency as indicated in [48] to address the gap in previous literature. Regarding the waiting time of vessels within the Tema port, the data was adjusted and translated to meet the DEA characteristic that larger output values are better. Emphasis was placed on increasing the decreases and decreasing the increases [49]. This was

achieved by subtracting the actual waiting time values from the closest higher value to the highest waiting time value which in this case is six (6) to achieve the DEA principle of bigger numbers being better for output variables. For example, the best average waiting time for vessels waiting to berth at the private terminals between 2017 to 2021 was 0.89 days in the year 2017. However, because the DEA methodology requires higher output figures to be better, the value was adjusted by subtracting 0.89 from 6 to get 5.11. Also, the private terminal achieved its worst waiting time in the year 2013 with an annual average of 3.73 days which was adjusted by subtracting 3.73 from 6 to get 2.27. This made the waiting time for 2017 bigger than 2013. This adjustment was applied to all the terminals under consideration to make the years with lower waiting times have higher values and the years with higher waiting times have lower values as indicated in **Table 2**.

Table 1. Input and output variables.

Indicator	Input/Output	Measurement	Relevant References
Number of Berths	Input	The total number of berths	[32] [33] [34] [35]
Quay Length in General	Input	The length of the quay in the terminals measured in meters	[36] [37] [38] [39]
Maximum Draught	Input	The maximum draught in meters	[40] [41] [42]
Number of Quay Cranes	Input	Total number of quay cranes	[37] [43] [44] [45]
Container Throughput	Output	Annual Cargo throughput in TEUs	[10] [32] [43] [46]
Container Ship Calls	Output	Annual total calls	[9] [43] [47]
Waiting Time	Output	Total time spent at Anchorage in Days	By authors.

DEA Model

The DEA model used for this study is the Data Envelopment Analysis—Charnes, Cooper, and Rhodes (DEA-CCR) or constant returns to scale (CRS). The model used more input variables than output variables hence it is termed an input-oriented DEA methodology. DEA-CCR is known to be a pioneer in calculating and comparing the relative efficiencies of ports and terminals to guide policy implementations. The model also highlights the departments with inefficiencies which gives a pathway on where and when to deal with the inefficiencies hence the justification for choosing DEA-CCR for this study.

The questions and objectives of this study are addressed using a quantitative benchmarking technique. Panel data was employed in setting up the DEA-CCR model as has been used by previous port efficiency studies [43] [50]. The model reviewed the efficiency trends of the terminals for 15 years. The 15-year efficiency span ranged from the year 2007 to 2021 for both private and public terminals. In technical terms, the total number of DMUs for analyzing the terminal efficiencies was 15 years with four input variables and three output variables. The input variables are number of berths, quay Length in general, maximum draught, and number of quay cranes. The output variables also include container throughput, container ship calls, and waiting time as highlighted in Table 1.

To proceed with analyzing the data, the efficiency for each terminal under the public and private administrations was calculated annually using the DEA frontier software with the input and output variables. Professor Joe Zhu created the DEA Frontier program to decrease DEA code mistakes. In using this program, the secondary panel data collected for the private and public terminals were imported into the Excel sheet after the Macros for DEA frontier had been enabled. For this study, an input-oriented model was selected to display the efficiency results of the DMUs.

4. Terminal Efficiency

This section deals with the descriptive analysis of the terminals, the efficiency trends, and discussions on privatization and efficiency.

Table 2. Descriptive statistics of terminals at Tema port (public and private) from 2007-2021.

Ownership	Variables	Minimum	Maximum	Mean	Standard Deviation
Public Terminals	Number of Berths	12.00	14.00	12.13	0.52
	Quay Length (m)	1873.00	2447.00	1911.27	148.21
	Maximum Draught (m)	10.00	11.40	10.09	0.36
	Number of quay Cranes	1.00	7.00	3.40	2.29
	Container throughput	197603.00	496198.00	361326.53	91895.46
	Container Ship Calls	16.00	131.00	85.53	27.84
	Waiting Time	0.57	3.11	2.25	0.82
Private Terminals	Number of Berths	2.00	4.00	2.33	0.72
	Quay Length (m)	574.00	1274.00	695.73	259.01
	Maximum Draught (m)	11.40	16.00	12.32	1.90
	Number of quay Cranes	3.00	9.00	4.07	1.98
	Container throughput	32806.00	1044848.00	486954.47	249706.19
	Container Ship Calls	272.00	719.00	480.40	116.66
	Waiting Time	2.27	5.11	4.21	0.89

Table 2 presents the statistics of the terminals under public and private authorities from 2007 to 2021. It gives a summary of the available data that was used to calculate the efficiency of the terminals based on the input and output variables for the DEA model. The public terminals had several berths over the period under consideration ranging from 12 to 14 while the private terminals ranged from 2 to 4. Over the years, the maximum draught for the public terminals ranged from 10 meters to 11.40 meters while the private terminals ranged between 11.40 meters and 16.0 meters. The length of quay for the public terminals ranged from 1873 meters to 2447 meters and from 1274 meters to 574 meters for the private terminals after one of the private terminals was transferred back to the public authority. The number of quay cranes ranged from 1 to 7 for the public terminals and 3 to 9 for the private terminals. Regarding the output variables, the container throughput for the public terminals over the years under consideration was able to handle a maximum of 496,198 TEUs per year while the private handled 1,044,848 TEUs. The maximum number of container ship calls over the years for both public and private terminals were 131 and 719 respectively while their waiting time figures ranged between 0.57 to 5.11. The descriptive statistic for the terminals is done by calculating the maximum, minimum, mean, and standard deviation of the data.

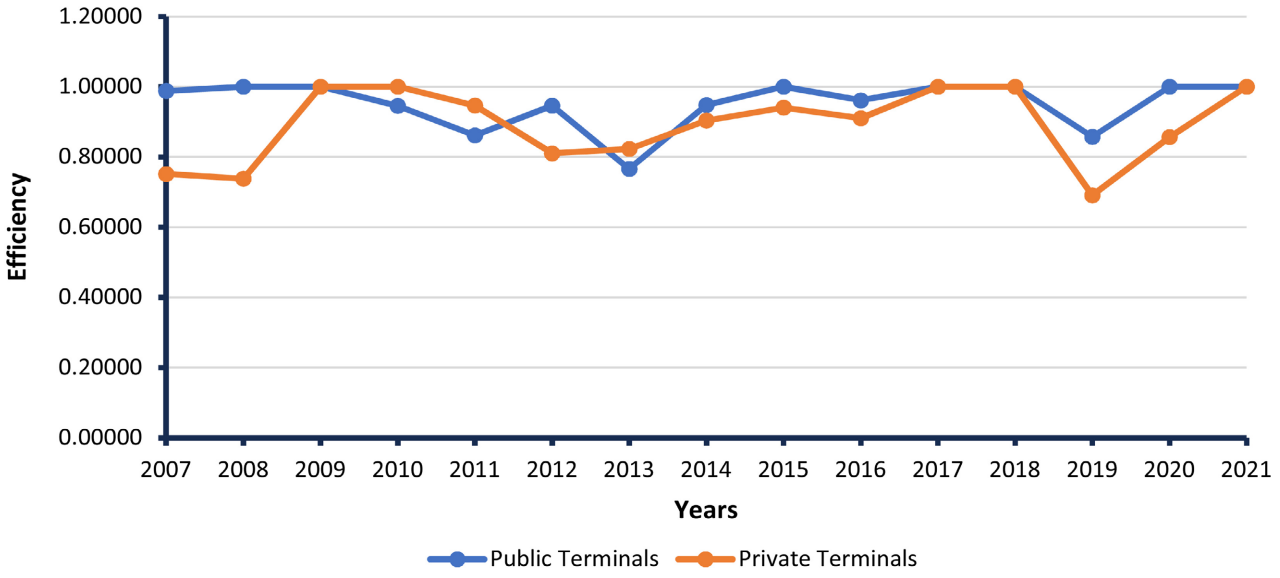

Figure 1. Annual efficiency scores and trends of public and private terminals at Tema port.

Figure 1 above illustrates the annual efficiency scores and trends of the terminals under the public and private administrations over the years. The efficiency score for terminals that are on the efficiency frontier is 1 (or 100%) are considered efficient. On the other hand, terminals that are below the frontier have efficiency scores below 1 (or 100%), which means they have the potential to increase performance in the future [51]. Relative to Figure 1 above, the return to scale from 2007 to 2021 of the public terminals indicated that there was a con-

stant and lambda sum of 1 for the years 2008, 2009, 2015, 2017, 2018, 2020, and 2021. However, there was an increasing return to scale (IRS) for the years 2007, 2010, 2011, 2012, 2013, 2014, 2016, and 2019 which indicates that the sum of the lambdas is less than 1% or 100% therefore there is room to improve these efficiency scores. The IRS efficiency scores for the public terminal over these years are 98.8%, 94.5%, 86.2%, 94.6%, 76.6%, 94.8%, 96.1%, and 85.8% respectively.

The terminals under private authority and administration achieved a constant or a sum of lambdas of 1 for the years 2009, 2010, 2017, 2018, and 2021 and achieved IRS or less efficient scores in the years 2007, 2008, 2011, 2012, 2013, 2014, 2015, 2016, 2019 and 2020 with efficiency percentages of 75.14%, 73.81%, 94.63%, 81.01%, 82.29%, 90.37%, 94.05%, 91.01%, 69.08% and 85.68% respectively. The 2019 efficiency score is the lowest, and that could partly be attributed to the phases of the terminals still under construction and the uncertainty on how the terminals will be optimally operated going forward. However, the private terminals increased their efficiency the following year during the Pandemic as a result of the increase in import of containerized cargo in 2020. The terminal attained an efficiency score of 1 in 2021 after the industry had adjusted well to the immediate shocks of the COVID-19 pandemic and to the uncertainty surrounding the newly constructed private terminal as indicated in **Figure 1**.

Despite attaining certain levels of efficiency, both the public and private terminals lacked some degree of sustainability and exhibited inconsistent patterns relative to their efficiency scores over the years under consideration. These inconsistencies could be attributed to the infrastructural investments, construction of the new terminals, transfer of an old terminal from private to public control, adjusting to the immediate shocks of the pandemic, and application of strategies to minimize and maximize inputs and outputs respectively.

4.1. Privatization and Efficiency

Privatization and efficiency have been studied by a handful of researchers with diverging findings. [29] established that theoretically there is no clear-cut relationship between privatization and terminal efficiency and that was supported by the empirical presence in the study. This is because although the private terminals recorded efficiency scores for some years, there were also notable inefficient years. [52] [53] also cited that privatization has positive impacts on ports after ownership change as it is reflected in the efficiency and satisfaction of the port users. This study supports that claim because based on the available data, privatization leads to massive infrastructural developments which places the port in a position to compete with neighboring ports relative to becoming a transshipment hub within a region. However, the empirical results indicated that both the private and public terminals within the Tema port exhibited similarly inconsistent efficiency trend behaviors over the past few years. In simple terms, although the private terminals had similar efficient years as compared to the public terminals within the port, the public terminals yielded slightly more effi-

cient scores over the years than the private terminals hence the findings align with the findings in [29] which indicated that increased private involvement does not automatically lead to increased efficiency.

4.2. Policy Implications

This paper seeks to give policy implications on situations involving terminal privatization and efficiency. The paper's findings and results are relevant for West African Ports and Terminals, the policymakers, port authorities, and researchers. This paper gives a blueprint for future decisions on the ownership structures of ports.

Factors affecting port efficiency are apparent in each terminal as the variables relevant to port performance have been expressly stated by UNCTAD. The variables considered in this study were limited to a few but important variables such as the number of berths, maximum draught, number of cranes, length of quay, container throughput, container ship calls, and waiting time. These variables play combined roles to determine the efficiency and sustainability of ports and terminals due to their ability to analyze how well the port is doing and also serve as insulation to negative effects that may arise due to the highly elastic nature of the port industry.

Given the fact that many port authorities are inviting the private sector for joint investments and collaborations, this paper will be relevant to policymakers on investment strategies and the nature of ownership agreements. To achieve the status of a hub port, below are some policy recommendations enumerated based on the empirical findings.

1) The private terminals must deploy various strategies to maximize their top-tier infrastructural developments to attain consistent efficiency results.

2) The public terminals need to invest in increasing their draught and other infrastructure for the accommodation of larger vessels to attain sustainable efficiency results in the future.

3) Port authorities should collaborate with the private sector by entrusting them with the responsibility of overseeing the daily administration and operations of the terminals to enhance customer satisfaction while the government or the landowner focuses on regulation and infrastructural investments.

5. Conclusions

This study seeks to analyze the impact of privatization on the efficiency of terminals using Tema Port as a case study. The Port has terminals under both public and private control therefore the purpose of this study is to analyze the technical efficiency trends of these terminals over the years.

The study employed an input-oriented DEA-CCR methodology to analyze the efficiency trends of the terminals. Panel data from 2007-2021 consisting of four (4) input variables and three (3) output variables was employed in analyzing the technical efficiency trends of the terminals under both administrations. The in-

put variables used for this study are the number of berths, quay length, maximum draught, and number of quay cranes while the output variables are container throughput, container ship calls, and waiting times at anchorage.

The study concluded that although privatization comes with positive benefits like infrastructural development, it does not immediately translate into higher efficiency, and comparatively, the efficiency trends are similar to the public terminals which have relatively lesser investments in port infrastructure. Both private and public terminals exhibited efficiency fluctuations over the years by attaining efficiency scores for multiple years and inefficient scores in other years.

However, the private terminal's huge infrastructural development relative to maximum draught, quay length and number of cranes propels the port to achieve the status of a transshipment hub within the region therefore a slight consistency in efficiency trends shall give the port a competitive advantage over neighboring ports.

For future research studies relative to this study, emphasis must be placed on other performance indicators or output variables of terminals to add more insight to the existing literature. Also, future studies should focus on efficiency at the terminal level instead of the port level because by calculating the efficiency scores of terminals separately, there will be clarity on the contributions of each terminal to the general efficiency of the port. Finally, future studies should employ updated data when analyzing the efficiency of terminals because this paper used a limited available data set up until 2021 to analyze the efficiency trends.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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