A Study of Efficiency of Container Terminals: A Case Study of Ports in Tanzania

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Abstract: The objective of this study is to evaluate efficiency of container terminals in Tanzania. Relative efficiencies between terminals are imperative to identify the potential areas of improvement for the inefficient terminals. Tanzania is often excluded from literature about port operation and performance since many studies focused on Asia and Europe. In order to enhance understanding about Tanzanian port efficiency, the present study is highly demanded. However, traditional studies on container terminal efficiency tend to focus on partial productivity measures such as TEUs per crane. These instruments do not assess the overall efficiency of terminal operations, as they are focusing only at specific aspects of the terminal operation process. This study uses a measurement of container terminal efficiency based on Stochastic Frontier Analysis (SFA). It is found that the lowest score is 0.430, and the highest score is 0.997 of technical efficiency among container terminals. On average, a typical container terminal in the sample during the study periods has an efficiency level around 0.821, meaning that the terminal operating at 82.1%, of efficiency, which is below the maximum potential output on the frontiers. However, there is a possibility for terminals to increase efficiency by 17.9%. The most efficient terminal ever found is at Zanzibar, and the least is at Mtwara. The urgency of automation to reduce inefficiency level is required to fulfil the timely submission, timely delivery, and higher quality services.

1 INTRODUCTION

Seaport is a potential link of international supply chains between sea and land transportation and therefore enhances international trade. Following the expansion of sea transportation technology, 80% of world total imports and exports were conducted by way of maritime transportation (UNCTAD, 2017) and remains the most common mode of international freight transport (AfDB, 2010). It is the principal foundation to smoothing world trade, offering the most economical and reliable way to move goods over long distances. The growth of world trade was due to the world container ports improvement with enough infrastructures and handling equipment (UNCTAD, 2018). However, many ports experience a shortage of facilities and investment, long delays, and dwelling time, causing congestion, affecting import prices, and export competitiveness (Carine, 2015).

The amount of delay and dwelling time in Tanzanian ports became significant challenges that affected the production level due to inefficient services provided. The efficiency of the container terminal is an influential factor toward competitiveness and became indicator of a country's development. Therefore, the Seaports authorities are under the pressure of improving efficiency by ensuring that the services level offered on the container ports is on a competitive basis.

There is no doubt that technological changes significantly influence the efficiency of container terminals and competitiveness. The inefficiency of a container terminal would be evidenced by several performance indicators including physical design, equipment, and container stacking capacity, quality and connectivity of landsides transport connections, links to the main shipping lines routes, vessel size, quality of port or terminal infrastructure as well as container handling, government process, and custom charge. These factors are accountable in linear relationships with economic scale since they build a positive reputation for the customers and, indeed, lead more attractive. Therefore, in the less matured container port including ports of Tanzania, the study of comparing one terminal with another in terms of

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their relative efficiency is vital for economic reformation.

The economic value of maritime transportation are facilitated by high-level efficiency that guarantees timely submission, timely delivery, and high-quality services, which are less bureaucratic. Headed to the improvement of efficiency and productivity in the container port or terminal, comprehensive maritime management information systems support is needed. These systems are automatic identification systems, vessel traffic management systems, and port operating systems.

In the country with a less-matured port system, the development of port infrastructure and facilities should be paid special attention to the port to accommodate business activities. In Tanzania, the ports performance has deteriorated and already exceeded maximum capacity planned since 2013. Therefore, container ports in Tanzania will suffer progressive declines in operational effectiveness unless both capacity and terminal efficiency issues should adequately be well addressed. However, little is known about the container terminals' efficiency of Tanzanian ports. This study aims to bridge the gap.

In addition, there are extensive researches in the literature that have been conducted in examining factors that influence performance and efficiency of container terminal, most of them focused in Europe, Asia, and Middle East ports (Almawsheki et al.,2015; Zheng et al., 2016; Liu, 2010; Yang et al.,2011; Wang, 2004), few have focused on African ports (Ago et al., 2016; Carine, 2015). There are limited studies focused in Tanzanian ports. Therefore, there is a need to enhance an empirical-driven understanding of efficiency issue to Tanzanian ports' performance in efficiency perspective. This study plays an essential role in creating this perspective. The significance of this study is to provide support to managers and operators of the container terminal in decision making to improve the operating system in order to produce the best potential output. It contributes knowledge to the literature in the carrier while helping students, researchers, and practitioners for further development. Also, it contributes to efficiency theories by offering an empirical model that can be used as a decision support tool for container terminals' efficiency in Tanzania.

The authors designed this study with the primary objective of evaluating the efficiency of container terminals in ports of Tanzania with a special interest in technical efficiency. However, approaches of technical efficiency estimation vary depend on the target of the researcher want to achieve. The technical efficiency herein estimated based on output-oriented approaches via the Stochastic Frontier Analysis.

2 LITERATURE REVIEW

Operational efficiency and effectiveness of ports or terminals are critical to success, and considered the best way to maintain competitiveness. Inefficient operation and physical factors (including water depth, mooring facilities, land, equipment, access, and so forth) can reduce port throughput. Technological factors have a significant impact on the availability of real-time information for stakeholders and the streamlining of both import and export value chains of the business (Kahyarara & Simon, 2018). Although port size and infrastructure, private sector participation, and quality of both cargo-handling and logistics services are essential determinants of efficiency, the inputs such as quay length, terminal area, and quay cranes have significant effects on production (Yang et al., 2011). Similarly, the input (length of the quay, the number of berth-side cranes, the number of births) are shown a significant influence on port production efficiency (Ago et al., 2016). In the study of world major container terminals, the variables such as terminal berth length, alongside quay depth, terminal area, and draft, have proven to significantly affect the production efficiency (Hlali, 2017).

On average, container port terminals in Sub-Sahara Africa have witnessed inefficiency indeed rather than technical efficiency (Carine, 2015). The study conducted at North Mediterranean Sea for both ports and terminal operation efficiency revealed that 90% of the container ports included in the study have their technical efficiency lower than 0.80, while 95% of the container terminals have their technical efficiency lower than 0.80 (Liu, 2010). From an economic scale perspective, both container ports in Korea and China, on average, revealed similar scores of efficiencies about 0.886 and 0.887, respectively (Zheng et al., 2016).

Numbers of studies have displayed different approaches to investigate the efficiency of the ports or terminals. Table 1 evidenced that recently, the Stochastic Frontier Analysis (SFA) has become a popular method in evaluating the efficiency of container terminals. In this study, we use SFA to evaluate the efficiency of container terminals of Tanzania due to the available data characteristics. The goodness of SFA is that it addresses the issue of error and less bias as compared with analytical techniques. Stochastic frontier analysis has not yet been used to

Table 1: Review of port/container terminals efficiency study.

Author	Title	Technique	Variables
Almawshaki et al., 2015	Technical efficiency of container terminals in the Middle EasternRegion	DEA	Berth throughput, berth length, yard area, quay crane, yard equipment, and maximum draft
Carine, 2015	Analyzing the operational efficiency ofcontainer Ports in Sub-Saharan Africa	DEA	Throughput, terminal area, quayside crane, berth length, and yard equipment
Demirel, 2012	Container terminal efficiency and private sector participation	Tobit	Throughput, private sector,hub port status, logisticperformance index, and deviation distance
Hlali, 2017	The efficiency of the 26 major container ports in 2015: Comparative analysis with different models	SFA	Throughput, quay length, alongside depth, terminal area, and storage capacity
Hlali, 2018	Efficiency analysis with differentmodels: The case of container ports	SFA	Throughput, quay length, alongside depth, terminal area, and storage capacity
Liu, 2010	Efficiency analysis of container ports and terminals	SFA	Berth length, quayside crane, yard crane, yard area, crane spacing, tradevolume, terminal size, and throughput
Lopez-Bermudez et al., 2018	Efficiency and productivity of container terminals in Brazilian ports (2008 - 2017)	SFA	TEUs, frequency of call,gantry crane, and mobile crane
Liu, 1995	The comparative performance of public and private enterprises: the case ofBritish ports	SFA	Turnover, labour, capital, ownership, size, capital intensity, and location
Notteboom et al., 2000	Measuring and explaining the relative efficiency of container terminals employing Bayesian Stochastic Frontier Models	BSFM	Quay length, terminal surface area, gantry crane, and container traffic in teus
Suárez-Alemán et al., 2015	When it comes to container portefficiency, are all developing regions equal?	SFA	TEUs, terminal area, berth length, mobile crane, and gantry crane
Wang, 2004	Analysis of the container port industry using efficiency measurement: A comparison of China with its international counterparts	SFA, DEA	Quay length, yard area, quayside, and yard gantry cranes, and straddle carriers
Yang et al., 2011	Seaport operational efficiency: Anevaluation of five Asian port using stochastic frontier production function model	SFA	Berth length, quayside crane, yard crane, yard area, and throughput
Zheng et al., 2016	A study of container terminals efficiency of Korea and China	DEA	Berth length, quayside crane, yard area and berth throughput

build an efficiency model of container terminals in Tanzania ports. This situation leads to authors' decision on using SFA approaches as paramount techniques for studying production efficiency in container terminals of Tanzania ports.

3 METHODS

3.1 Variables

The measurement of container terminals efficiency of Tanzanian ports used stochastic frontier models. The output variable that was considered in this study is berth throughput (in TEUs) from 2010-2018. Also, the input variables selected were quayside crane, the terminal area in meter square, and berth length in meter. However, other exogenous variables in binary form were also included, such as quality of cargo handling and private sector participation.

3.2 Modelling

The stochastic frontier analysis technique is used to build the container terminals' efficiency model of Tanzania. The stochastic frontier model is a statistical-based modelling used to analyze the efficiency, which identifies the frontier through the regression method with a composed error term. The method was first proposed by Aigner et al. (1977) and later was improved by Meeusen and Van den Broeck (1977), which requires the specification of distribution assumptions in order to estimate the efficiency. The presence of stochastic elements makes the models less vulnerable to the influence of outliers than with deterministic frontier models. In general, stochastic frontier model, also called Potential Production Function, is defined as follows:

$$Y_i = f(X_i)e^{(v_i - u_i)} \tag{1}$$

Where:

X_i , Y_i	:	Observed inputs and output for an individual container terminal
U_i	:	Non-negative random variable associated to technical inefficiency
V_i	:	White noise due to random shock

The composed error terms (V and U) are distributed independently of each other. In the literature, the error (V) is always normally distributed, and (U)is specified by several one-sided error distributions. The density function U can be evaluated under the Half Normal, Exponential, Truncated Normal, or Gamma distributions.

In this study, the Authors adopted the truncated normal distribution assumption of Battese and Coelli (1992) as well as Battese and Coelli (1995) models to analyze dataset with the Cobb-Doulas function, since the Translog function failed to accommodate the data set accurately. The model specified in coded form such that the first code digit represent functional form (1= Cobb- Douglas function), second digit represents model type (1 = (Battese and Coelli, 1992), and 2 = (Battese and Coelli, 1995)) and the third digit represents number of variables specification (1= three inputs variable with exogenous variables, and 2 = three inputs variable with trend and/or exogenous variables).

According to Battese and Coelli (1995), the estimation of a stochastic production frontier function depends on the validity of variance parameters as follows:

$$\sigma^2 = \sigma_v^2 + \sigma_u^2 \tag{2}$$

Then, the shared variation of inefficiency is defined as follows:

$$\sigma^2 = \frac{\sigma_u^2}{\sigma_v^2 + \sigma_u^2} \tag{3}$$

The shared variance ratio reflects the total variation from the frontier level of output attributed to the technical inefficiency. It is normally used to test the null hypothesis that the technical inefficiency is not present in the model. If that is the case the value of variance, σ_u^2, is close to zero, and the inefficient term must be removed in the model, and hence the model will be constantly be estimated using the Ordinary Least Square (OLS) method.

Furthermore, the hypothesis test for the parameters of the stochastic production should be diagnosed using the generalized likelihood ratio (LR) statistic defined as follows:

$$\lambda = -2\left[\ln\left(L(H_o)\right) - \ln\left(L(H_1)\right)\right] \tag{4}$$

Where:

$L(H_o)$	:	Value of log-likelihood function restricted to OLS
(H_1)	:	Value of the unrestricted function

If the value of LR-statistic is significantly asymptotically distributed as a mixed Chi-square random variable lead the critical area with a certain degree of freedom, the null hypothesis should be validly rejected and potential conclusion provided. The production model of Cobb-Douglas function in this study is specified as follows:

$$\begin{aligned} \ln Y_i = \beta_o + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 \\ + \beta_4 T_4 + V_i - U_i \\ U_i = \delta_o + \delta_1 Z_1 + \delta_2 Z_2 + W_i \end{aligned} \tag{5}$$

Where:

Y_i	:	Berth throughput of container terminal i
X_1	:	Number of quayside crane
X_2	:	Area of the terminal area
X_3	:	Berth length among container terminal
Z_1	:	Private participation
Z_2	:	Quality of cargo handling
β_o, δ_o	:	Intercept
$\beta_{1\ldots4}, \delta_1, \delta_2$	:	Slope coefficients of independent variables
W_i	:	Error term needs to be estimated
T	:	Trend variable
V_i, U_i	:	White noise and inefficiency error term, respectively

4 RESULTS AND DISCUSSION

4.1 Output of Container Terminals

During the period of 2010-2018, the majority of container handling occurred in Dar es Salaam terminal out of the total container handled, followed by Zanzibar terminal (Figure 1). Besides, the Tanga and Mtwara have shown relative lower operating container trade.

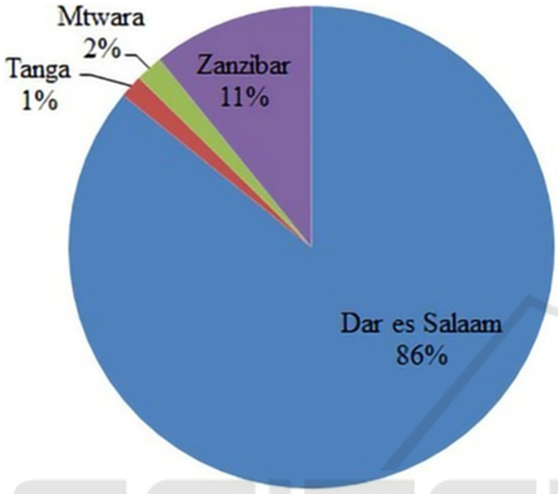

Figure 1: Berth throughput 2010-2018 share.

4.2 Correlation of Variables

Correlation measures describes the relationship between two variables. It measures the strength and direction of linear relationships among variables. The value of correlation in Table 2 obtained using Microsoft Excel.

All variables are accepted since there are no negative correlations among them. The dependent and independent variables are reasonably correlated and provide a venue toward analysis. whereas quay crane has the lowest correlation with berth output. This finding suggests relatively lower importance of quay crane to the influence throughput of container traffic. Among the three inputs themselves, berth length, terminal area, and quay cranes are strongly positively correlated to each other.

4.3 Maximum Likelihood Estimate

Table 2: Correlation among terminals characters.

	Y	X_1	X_2	X_3
Y	1			
X_1	0.871	1		
X_2	0.967	0.951	1	
X_3	0.975	0.929	0.998	1

In general, all elasticity coefficients (beta) are empirically found significant at a 5% level, showing that all three inputs (quay crane, terminal area, and berth length) have a significant effect on berth throughput among container terminals. This result is consistent with those observed by (Zheng et al., 2016; Hlali, 2018; Yang et al., 2011). However, the berth length and quay crane are not relevant since their coefficients have a negative sign, the results are not differently found in the study of (Lopez- Bermudez et al., 2018 and Hlali, 2017). It is not surprising due to sample composition in which difference of quay crane and the length of the berth are too large among terminals.

For both inefficient models (1.2.2 and 1.2.1), the intercept and parameter of the exogenous variable (private participation and quality of cargo handling) have experienced negative signs except for the private sector involvement in model 1.2.2. The negative sign is indicating that private participation and quality of cargo handling reduces inefficiency to the terminals but not statistically significant. The result suggests that both variables are not relevant in improving operating efficiency among container terminals in Tanzania.

For private sector participation, it is concluded that the container terminals can operate efficiently without private participation. These results are proven contrast with previous results reported by (Yang et al., 2011; Liu, 2010; Demirel et al., 2012). These studies evaluated efficiency significant level of technical efficiency under private sector participation. In the present study, Figure 3 shows that the highest efficient container terminal is public operating than its counterpart. The results provide criticism for economic argument that private sector involvement in the operation of container terminals associated with high efficiency.

For the quality of cargo handling, the results experienced an insignificant effect on the technical efficiency among terminals. It means that the quality of cargo handling is not associated with inefficiency among terminals. However, the terminal of Zanzibar and Dar es Salaam observed with high quality of cargo handling, which is reflected their average efficiency scores. There is another possibility of improving technical efficiency among terminals if port authorities would focus on improving the cargo handling services. In the evaluation of container terminals, economics of scale became a potential aspect in the running process of any container terminal. The Authors are backing to the production elasticity on the selected model herein, the results displayed, thus comparing them with the previous study.

The sum of elasticity coefficients of the inputs variables appeared to be lesser than 1, which indicates that container terminals of Tanzanian ports shifts the situation of constant returns to scale towards decreasing returns to scale. The results were supported by the study of five major container ports that were conducted using Cobb-Douglas and Translog function.

The summation of coefficients variable recorded as 0.46 which is less than 1 (Yang et al., 2011). However, the results differ from the study of (Notteboom et al., 2000; Hlali, 2017; Suárez-Alemán et al., 2015; Liu, 2010). The revealed behavior of decreasing return to scale means that among the terminals, the tendencies of using few resources of input factors against the level of output produced have been experienced. Therefore, the government of Tanzania should be responsive to the port infrastructures, investments, and policies to enhance cargo handlings services.

In contrast with the study herein, the container ports among 26 major ports appear to be increasing return to scale for both model distributions (Hlali, 2017). These results suggest that 26 major ports reached extremely usage of input factors in the production process against the level of output produced. The same result was observed from the study conducted in container port of developing countries using Cobb-Douglas function and Translog function that tends to increased scale among the container ports (Suárez-Alemán, et al., 2015). However, the constant return to scale in production process was experienced by full efficient terminals (Almawsheki, 2015).

Management effort is required to maintain the efficiency of handling container cargo as the results of this study suggest that the characters of the input among terminals are not sufficient to handle the container cargo. Traditional inputs would surpass the output of the production and will remain attractive to the customers. Hence, the terminals' authority need to review their quality services level offered to the customers and maintain their loyalty.

In order to decide if the model would provide more accurate data representation in the container terminals, several tests of the hypothesis concerning the nature of the product function, and inefficiency effects. The relative higher considerable value of the log-likelihood function is satisfactory, indicating that the model is a good fit for the dataset. This is due to the log-likelihood is higher enough to surpass critical value at a certain level of significance. Three null hypotheses were assessed, and the results are presented in Table 4.

Starting with the first null hypothesis, "There is no technical inefficiency in the estimated model of container terminals." The null hypothesis was fully rejected. That means the method used justifies the accuracy results of the methods used.

The second hypothesis, "Technical inefficiency of container terminals of Tanzania, is not affected by independent variables included in the model." This hypothesis was also rejected, meaning that the

Table 3: Production frontier of container terminals for 2010-2018.

Variables	Estimated Parameters	1.1.2	1.2.1	1.2.2
Constant	β_o	290.223 (0.044)*	-13.793 (0.000)	-40.315 (0.000)
Quay crane	β_1	-7.385 (0.000)	-4.916 (0.000)	-4.641 (0.000)
Terminal area	β_2	8.018 (0.000)	4.701 (0.000)	4.319 (0.000)
Berth length	β_3	-10.669 (0.000)	-3.204 (0.000)	-2.292 (0.000)
Trend	β_4	-0.144 (0.000)		0.012 (0.000)
Constant	δ_o		-5.411 (0.533)	-2.467 (0.362)
Private participation	δ_1		-1.093 (0.797)	0.098 (0.965)
Quality of cargo handling	δ_2		-1.885 (0.634)	-1.659 (0.438)
Total variance	$\sigma^2 = \sigma_v^2 + \sigma_u^2$	0.023 (0.000)	1.664 (0.000)	0.828 (0.000)
Gama ratio	$\gamma = \sigma_u^2 / \sigma^2$	0.374 (0.000)	1.000 (0.000)	1.000 (0.000)
Mu	μ	0.251 (0.000)		
Eta	η	0.240 (0.000)		
Log-likelihood		16.87	15.866	17.985
Wald chi2		1667.280	2.75×10^7	2.99×10^8

* Maximum likelihood estimated parameter values obtained using STATA, at 5% level of significance with 100 iterations, the p-value showed in the bracket. The panel data models with total observations 36 in four-container port terminals.

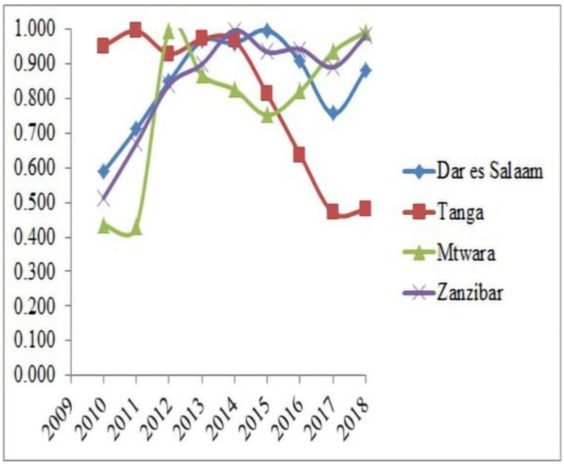

Figure 2: Individual technical efficiency among container terminals for 2010-2018.

exogenous variables influence inefficiency among container terminals in Tanzania.

The third hypothesis was developed to check if the technical efficiency among container terminals in Tanzania during the periods of study varies over time. The postulate is full rejected since the likelihood ratio test has been surpassing the critical area.

These hypotheses were valid to our entire models in the study. As we have seen in Table 3, the model specified as model 1.2.2 revealed that it is the most correct estimation of the parameters. It is chosen as a suitable model in this study because the value of log-likelihood function displays higher enough than remaining model that reflects better. Therefore, in any piece of discussion of this study, we choose to reference the model 1.2.2 as the best model among all for container terminals studied and therefore proposed to the authority of the terminals for policy implication.

4.4 Technical Efficiency

In general, operating efficiency among container terminals in Tanzania has shown a reasonable effort in improving the handling of container cargo over periods shows the pattern of terminals' efficiency improvement across time under the study.

If technological changes effect was considered, both Zanzibar and Dar es Salaam container terminals are found to be gradually increasing technical efficiency. Though, Zanzibar terminal might surpass Dar es Salaam terminal just after 2016.

Tanga terminal, the pattern movements of operating efficiency have showed relatively fluctuated efficient at the beginning until 2014, in which it starts constant decline its' relative efficiency. Mtwara terminal, starting with high efficiency in 2012 and start to operate inefficiently until 2015 before starting to improve its efficiency and surpass the Zanzibar terminal just before 2017. To conclude on the efficiency movement observed herein, there is inconsistent with the efficiency pattern among terminals. The ranked terminals efficiency was also displayed.

On average, the most highly technical efficiency terminal has been ranked, with Zanzibar terminal at the first place, surpassing the Dar es Salaam terminal for the substantial difference of 0.6 percent, while the last place terminal was Mtwara terminal with worth value 0.784 of average operating efficiency during the nine periods. However, all terminals have deviated far from the potential production frontier. This result shows that during the periods under study those terminals were not able to maximize output to close the potential output on the frontier curve during the production process (see Figure 2).

To compare the results with similar application in the literature, it was found that the container port of Shanghai, Singapore, Shenzhen, Ningbo, and Dalian are the most efficient container ports among 26 major ports which represent the higher number of Containers handling (Hlali, 2017; Hlali, 2018). These results are shown in contrast with all container terminals in Tanzania which are almost efficient with small number of container handling. The best efficiency port was upholding the mean efficiency 0.876, while in the present study the best terminal was sustained to the mean efficiency of 0.852. The results

Table 4: Hypotheses testing of the production frontier function.

Null hypothesis	Log-likelihood function	Test Statistic (λ)	Criticalvalue (5%)	Decision
$H_o: \gamma = 0$	17.985	36.380	2.706	Rejected
$H_o: \delta_1 = \delta_2 = 0$	17.985	36.380	5.138	Rejected
$H_o: \eta = 0$	16.870	34.150	2.706	Rejected

Note: approximate critical value at p = 5% has mixed Chi-square and obtained from Table 1 of (Kodde and Palm, 1986). The log-likelihood function value obtained directly from the estimated maximum likelihood model (see Table 3), the test Statistic value found from the application of Equation (5). The decision was made by comparing the difference between loglikelihood value and test statistics with critical area.

illustrate that five ports among 26 have better management practices compared with the container terminals of Tanzania ports.

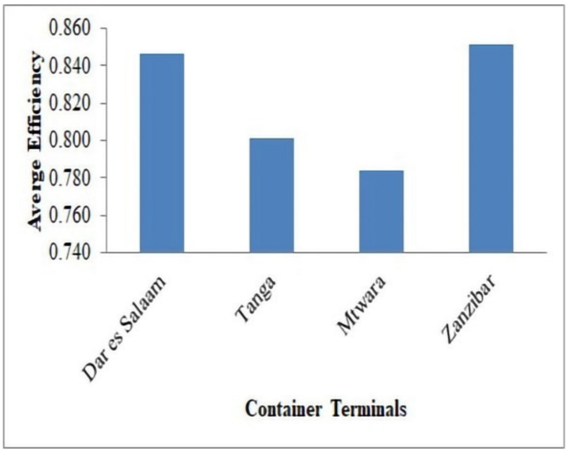

Figure 3: Technical efficiency per terminals, 2010-2018.

The estimation of the efficiency revealed that no single port in the sample of developing economies had reached a full efficient input combination. The highest-ranked port reached a technical efficiency score of 85 percent over study periods between the years 2000 - 2010 (Suárez-Alemán et al., 2015). The results in supporting the results found in the present study such that the highest-ranked terminals have reached the efficiency of scores 85.2 percent. The exciting results found in the Dar es Salaam port the efficiency was relative intermediate by score 0.660, while Tanjung Perak Port, was found lower than of about 0.550 scores of efficiency (Suárez-Alemán et al., 2015). It is noted that the most efficient port in this study are San Juan - Puerto Rico, Nanjing - China, Puerto Limón - Costa Rica, Puerto Cortés - Honduras, Jawaharlal Nehru - India all from developing countries while the first six ranked port Rades of Tunisia from Africa. Note that the best model suggested in this study is model 1.2.2, which describes the data much more precise.

Table 5 summarises a statistical description of technical efficiency among models. It shows that on average a typical container terminal in the sample during the periods has an efficiency level about 0.821, meaning that the terminal was operating at 82.1%, which is below the maximum potential output on the frontier. Similarly, by holding the input factors constant there was possibility of container terminal to increase the efficiency level by 17.9%.

Table 5: Descriptive of technical efficiency 2010-2018.

Model	Observation	Mean	Std. Dev.	Min	Max
1.2.2	36	0.821	0.179	0.430	0.997
1.2.1	36	0.811	0.182	0.397	0.999
1.1.2	36	0.780	0.074	0.715	0.904

The minimum efficiency level among container terminal is 0.430, indicating that the typical terminal operating at 43%, which is below the maximum potential output. There was a possibility of increasing the efficiency by 57% if the inputs factors were held constant. The maximum technical efficiency level among terminals was recorded at about 0.997, which implies that the common terminal in the sample during the period of study operating at 99.7% close to the maximum potential output in the frontier. Therefore, if the terminals holding the input factors would increase to full efficiency by 0.3%.

5 CONCLUSIONS

This study builds an empirical model under the stochastic frontier analysis framework (1.2.2) to study the technical efficiency of container terminals in Tanzania ports. The model is built upon the recent panel data covering nine years (2010-2018). The empirical model evaluates the technical efficiency of four container terminals. The following are conclusions and suggestions for further studies.

5.1 Conclusions

The main findings of the study are summarized as follows:

- Only terminal area was found to be relevant factors of production among container terminals in Tanzania, while berth length and quay crane did not.
- Few operating resources are still used among terminals (decreasing return to scale), which indicates that shortage of container handling infrastructures faces among terminals.
- Private contribution and quality of cargo handling are insignificant factors to technical inefficiency. Technical efficiency among terminals in Tanzania does not have a linear relationship with private participation and quality of cargo handling. The highest efficient terminal operates without private contributions.
- As the best selected model 1.2.2, the lowest efficiency index was 0.430, and the highest was 0.997, among terminals across the period of study.

- On average, the most highly efficient terminal in container cargo handling is Zanzibar, and the least is Mtwara terminal.

Terminals of Zanzibar and Dar es Salaam have emerged extremely efficient technically, even though it is well known that they are faced with congestion. In fact, port congestion in container terminals is unavoidable.

5.2 Suggestions

The following suggestions are provided for future studies:

- The effects of different ownership structures of container terminals efficiency and productivity should be the focus on the future research on the container terminals in ports of Tanzania.
- In the future, the study can be extended to scale and allocate efficiency to observe if the input resources employed with lowest cost lead to increases the economic profit in the container terminals.
- It is strongly suggested that in the future study, the comparative analysis with regional container port countries can be carried out to understand the level of efficiency in container handling services of each presented terminals to maintain competitive advantage.
- In the future study, the information systems usage and services quality levels should be a prioritized factor to be included in the investigation of container terminal efficiency since it currently plays a critical role in container handling services.
- An improved estimation methodology must be paid attention on the future study regarding container terminals efficiency.

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