THESIS-MN185401

A STUDY OF EFFICIENCY OF CONTAINER TERMINALS: A CASE STUDY OF PORTS IN TANZANIA

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Tesis disusun untuk memenuhi salah satu syarat memperoleh gelar
Magister Teknik (MT)
di
Institut Teknologi Sepuluh Nopember
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Tanggal Ujian: 14 Januari 2020
Periode Wisuda: Maret 2020

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ABSTRACT

The objective of this study is to evaluate the efficiency of container terminals in Tanzania ports. The relative efficiencies encouraged to identify the potential areas of improvement for the inefficient terminals. However, Tanzania is much excluded from literature toward port/terminal operation performance since many studies focus on Asia and Europe. To enhance understanding of Tanzania port or terminal efficiency, the present study is full demanded. However, the traditional studies on container terminal efficiency tend to focus on partial productivity measures such as *TEU per crane*. These instruments do not assess the overall efficiency of terminal operations, as they only look at specific aspects of the terminal operation process. The study uses measurement of container terminal efficiency based on Stochastic Frontier Analysis (SFA). It is found that the lowest score is 0.430 while 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 efficiency level about 0.821 meaning that the terminal operating at 82.1% which is below the maximum potential output on the frontier. Therefore there is a possibility of terminals to increase efficiency by 17.9%. The most efficient terminal found is Zanzibar, and the least is Mtwara terminal. The promotion of private sectors contribution and mechanization to reduce inefficiency level indeed are required to fullfill the timely submission, timely delivery, and higher quality services.

Keywords: *Container Terminals, Technical Efficiency, SFA*

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SEBUAH STUDI EFISIENSI TERMINAL PETIKEMAS: STUDI KASUSI DALAM PELABUHAN DI TANZANIA

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ABSTRAK

Tujuan dari penelitian ini adalah untuk mengevaluasi efisiensi terminal kontainer di pelabuhan Tanzania. Namun, Tanzania banyak diabaikan, karena literature yang ada lebih banyak di wilayah Asia dan Eropa. Untuk meningkatkan pemahaman tentang efisiensi atau efisiensi terminal di Tanzania, studi ini sangat dibutuhkan. Namun, studi tradisional tentang efisiensi terminal kontainer cenderung berfokus pada langkah-langkah produktivitas parsial seperti TEU per crane. Instrumen-instrumen ini tidak menilai efisiensi keseluruhan operasi terminal, karena mereka hanya melihat aspek-aspek spesifik dari proses operasi terminal. Penelitian ini menggunakan pengukuran efisiensi terminal kontainer berdasarkan *Stochastic Frontier Analysis (SFA).* Hasil analisis menunjukan bahwa skor terendah adalah 0,430, sedangkan skor tertinggi adalah 0,997 efisiensi teknis di antara terminal kontainer. Rata-rata terminal petikemas yang diamati memiliki tingkat efisiensi sekitar 0,821 yang berarti bahwa terminal beroperasi pada 82,1% di bawah potensial maksimum. Oleh karena itu ada kemungkinan terminal untuk meningkatkan efisiensi sebesar 17,9%. Terminal paling efisien yang ditemukan adalah Zanzibar sedangkan yang paling terendah adalah Mtwara. Keterlibatan sektor swasta dan mekanisasi untuk mengurangi tingkat inefisiensi sangat diperlukan untuk meningkatkan waktu penyusunan document dan pengiriman barang serta meningkatkan kualitas layanan secara umum.

Kata kunci: *Terminal Kontainer, Efisiensi Teknik, SFA*

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ACKNOWLEDGEMENT

Alhamdulillah, thanks to Allah who has given me the opportunity to complete this thesis, during the Master studying in the Institut Teknologi Sepuluh Nopember (ITS). I gained a lot of valuable knowledge comes from scientists, researchers, and developers in addition to the huge knowledge and help I have been got from my supervisors during my research implementation. With completion of this thesis I would like to thanks to Dr. Eng. I. G. N. Sumanta Buana, S. T., M. Eng. and Dr. Ir. I Ketut Suastika, M. Sc., as supervisors. They have guided me patiently to be on right truck and always encouraged to complete this work. Thanks to their guidance and advice.

Also I would like to thank sincerely to Ir. Tri Achmadi, Ph.D., Dr. Ing. Setyo Nugroho, and Dr. Ir. Heri Supomo, M.Sc. as examiners. They play role a lot in shaping my thesis technical as required. My family, my mother, father, wife and children, who never tired of supporting praying and encouraged to finish this thesis. Finally, KNB scholarship for covering most of the cost during my study and implementation of this research as well as International Office for smoothing my ways of study

Surabaya, January, 2020
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CHAPTER 1
INTRODUCTION

1.1 Background

It is believed that seaport is a link of international supply chains between sea and land transportation, and therefore entrance of the import and exit door of the export to the international market. However, due to the expansion of sea transportation technology (unitization or containerization), 80% of world total imports and export volume 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 world trade trend was shown slightly increases for all types of loaded cargo as well as international container loaded cargo from 2016 to 2017 as shown in Figure 1.1. This result has shown positive growth in the world container trade which contributed from the world container ports with sufficient infrastructures and handling equipment (UNCTAD, 2018).

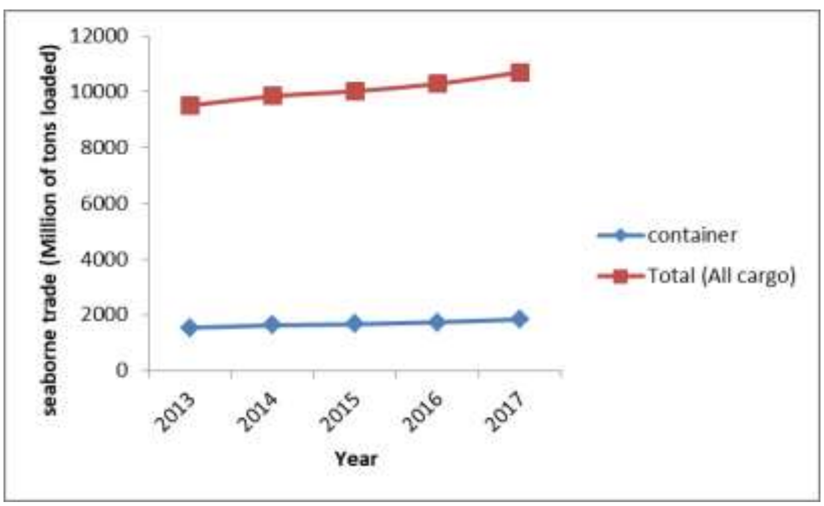

Figure 1.1 International Seaborne Trade (2013-2017)

Sources: (UNCTAD, 2018)

There is no doubt that role of technological changes (containerization, informatics), introduction of regional market, and privatization affects the ports and intensified the ports competition and efficiency. Regarding Tanzania ports, technological changes in informatics, as well as large size container ships still is a barrier in container terminals. However, many ports experience a shortage of facilities and investment, long delays, and dwell time, causing congestion, which affecting import prices and export competitiveness (Carine, 2015). During the current era of global intensive competition of ports, the most efficient way to enhance the effectiveness of the container terminal is improving its service level. This can be realized with full invested resources such as dock, berth, yard, and equipment (Zheng et al., 2016). Therefore, it is necessary for Container terminals of Tanzania to examine relative performance to identify whether they are efficient in the utilization of resources not only in facilities and equipment but also in terms of people and management process.

Ship requires potential infrastructure investments (sufficient dock, handling equipment) at the seaports area. Currently, ship size in competitive edges of shipping trade cannot be accommodated by most seaport of Africa because of insufficient infrastructures and facilities (AfDB, 2010). Longer berth lengths, wider ship turning circles, and deeper access channels alongside berths for modern ships are needed and must be reformed. However, different facilities in the port area expensive to run and purchases, but also under-utilization will result in capital loss, higher cost of running the port, and in turn lead to customer loss

The delay and dwell time in Tanzania port are significant challenges that affect the production level due to inefficient operational services. For the port of Dar es Salam the dwelling time is around 4 – 7 days and delay up to 20 days before ship getting a berth (TPA, 2016), while Malindi port of Zanzibar has dwelling time about 3 – 4 days and delay increased up to 15 days that cause shipping companies to impose emergency surcharge for long delay (CMA CGM, 2018). The situation is a terrifying businessman because some international companies decide to unload cargo to the port nearby which affects the import price and reduces the production output.

Technological changes adaptation and private sector contribution is very week; almost all terminals are conservative while Dar es Salaam terminal is just new to employ the informatics system for services provided and allow private investor (TPA, 2016). Less use of technology results in high dwelling time of container in the port area since container handling process consumes much time. The study is choosing to evaluate the efficiency of container port terminals because port efficiency is the most influential factor of competitiveness, and has a significant role in evaluating the production level that leads to defining the system of operation both now or future (Elferjani, 2015).

Following the East African region, the container ports have distinguished in services offered as some of them maintain goods performance in some aspects. The study used to refer East African container ports performance as a benchmark to justify performance of Tanzania container ports because of the following reasons

1 The economic growths among East African Countries (as an economic zone) are recorded not a big difference meaning that the same level of development can be appreciated among members

2 The East African container ports share almost the same hinterland mainly landlocked countries that servicing, so they experiencing the same challenge from their customers and competitive edge in service delivery should be valued among the service providers

Inefficiency of container terminal would be evidenced by several criteria including physical design, equipment and container stacking capacity of the terminal, quality and connectivity of landsides connections, links to main shipping lines routes and vessel size, the quality of port infrastructure and efficiency of container handling, government process, custom charge and freight logistic efficiency. These factors accountable in linear relationship with economic of scale since they can build positive reputation to the customers and indeed lead more attractive among terminals. The performance indicators have shown and provides support to prove on the problem faces the container terminals in Tanzania.

Table 1.1 Swot Analysis of Container Port in Tanzania

Strength	Weakness
• Dar es Salaam Container Terminals has exceeded its capacity design compared with actual throughput (PwC, 2018) • Tanzania Container Terminals has higher hinterland connectivity status (railways, and road). Third-ranked for East African Countries (PwC, 2018)	• Stacking capacity in container terminal of Tanzania much lower than the neighboring port of Kenya and Djibouti (PwC, 2018) • Vessel size is limited for which the channel depth less than 16 meters as international preferred • The freight charge is higher than other East African Ports (PwC, 2018) • Quality of infrastructures rating poor by 3.4 out of 7 scores compared with Kenya having scores 4.2 (WEF, 2016) • Dwelling time in the port is higher (about 7 days), then processing efficiency categorized poor (AfDB, 2010)
Opportunity	**Threaten**
• Tanzania Container Port servicing neighboring landlocked countries efficiently with access connection of hinterland hence increases output • A new port project in Bagamoyo approved project and expansion of old ports (berth and water depth) • New electricity standard gauge railways under construction • The security level is lower along the coastline of Kenya	• Slow of advanced technology adaptation • Cheap freight charge in Kenya Ports and other Sub-Saharan countries • Managerial conservative still constraints

Sources: (Developed by Author)

From the above discussion the study is seemed to be very critical because of the following noted point:

i. It creating better understanding of the operating efficiency and provide a support to managers and operators of the container terminals to improve the operating system in order to produce the best potential output
ii. It contribute knowledge to the literature in the carrier while helping students, researchers and practitioners for further development
iii. It contribute to efficiency theories by offering an empirical model that can be used as a decision support tool for container terminals' efficiency in Tanzania

To evaluate the port efficiency properly, a number of techniques have been suggested to estimation. Traditional studies on container terminal efficiency tend to focus on partial productivity measures, which offer performance indicators such as TEU per crane. These instruments do not assess the overall efficiency of terminal operations, as they only look at specific aspects of the terminal operation process (Notteboom et al., 2000). However, non-parametric methods have been much used (Wang et al., 2003; and Kim, 2012), and therefore the Data Envelopment Analysis (DEA) method is very famous in the literatures. However parametric method becoming sophisticated along stochastic frontier based on production function and cost function.

- Data Envelopment Analysis (DEA) is a non-parametric test, and it uses a linear programming in calculating efficiency. It is used for its ability to cover multiple inputs and outputs. it is not necessary to identify production function.
- Stochastic Frontier Analysis (SFA) is a parametric test that uses a statistical technique to calculate technical efficiency as long as the production function specified. It is care of white noise and exogenous variables.

In general, Stochastic Frontier Analysis provides better results especially when the panel data are used. The study focused on analyses of the efficiency of container terminals using Stochastic Frontier Analysis.

Based on the above references, it can be seen that there is no such model to calculate the efficiency of the container terminal in Tanzania.

1.2 Statement of the Problem

Cargo owners especially those from landlocked countries who receive the services in the container ports of Tanzania frequently are claiming that their cargo processing spend long time in the port at least two weeks before delivery. Since 2015 many of them option to use Mombasa ports in Kenya as the best choice for their cargo handling. According to Tanzania Port Authority high dwelling time is due to a shortage of infrastructure and facilities. However this reason is not empirical evidence yet. This study is intended to address the efficiency issue by focusing the technical efficiency of the container terminals of ports in Tanzania.

1.3 Research Question

From the above statement, the research questions derived in this study focus on

i. What is the level of efficiencies of container terminals of the seaports investment in Tanzania?
ii. What the factors that leads to the inefficiency of container terminals?
iii. Is technical efficiency varies over time?

1.4 Significance of the Study

The primary potential of the study is for the port authority to be able to run the ports efficiently; this will avoid the cost of other facilities or insufficient facilities invested in the port of container terminals. The proper allocation of resources will support the economic development of Tanzania. The results of this study (empirical model) will emphasize the need to improve support operational efficiency and indicate which characteristics should be given more attention

1.5 Scope and Limitation of the Study

i. The scope of the study is subjected to seaport container terminals in Tanzania port (Dar s Salaam, Tanga, Mtwara and Zanzibar) as a study area.
ii. The study focusing on input variables such as Quayside crane, terminal area, berth length, and berth throughput in TEUs
iii. The study is limited with production evaluation (container throughput) in the selected terminal while price and cost of production excluded due to financial and data availability
iv. The study is time constraint with maximum one semester of the academic year

1.6 Objectives of the Study

The primary objective of the study was to analyze the efficiency of container terminals in Tanzania. To achieve the objective of the study the following specific objectives created

i. To examine the factors that are influencing production efficiency in the container terminals
ii. To determine the technical efficiency of container terminals in Tanzania

1.7 Hypothesis of the Study

i. The technical coefficient parameter of the input factors are not significant to the production efficiency of container terminals
ii. Inefficient effects are not present in the production function of the estimated model among container terminals
iii. Technical inefficiency is not affected by the independent variable included in the model
iv. The second-order coefficients of Translog function are equal to zero
v. The fluctuation of technical efficiency of container terminal not due to the period

1.8 Study Variables

The suitability of results and estimation of the study depends on the rational choice of variables based on the objective. The choice of variables used herein based on different backed scientific observations, as shown in Table 2.3. This study aims to examine container terminals in their principal function from sea to land or back to sea again, the infrastructure and equipment as input variable was considered to evaluate the terminal production efficiency. Also, berth throughput used as an output variable. Infrastructure measures include berth length and terminal area, whereas equipment measures include number of handling equipment (quay crane/mobile crane).

- **Inputs variables**

The inputs variable have shown inconsistent conclusion in many pieces of research work. The literature argues that only the input factors: quay length, terminal area, and the number of quay cranes are relevant variables affecting container terminal operational efficiency (Zheng et al., 2016). It concluded that the port infrastructures are essential determinant of efficiency (Yang et al., 2011). For the most of Sub Sahara African countries, the infrastructures and handling equipment are the sources of inefficiency of container ports (Carine, 2015). The input factors such as quay length, terminal area, handling equipment, channel depth, turning area, truck, connectivity and many others are categorized as direct inputs variable which affect the efficiency of the ports. However other categories of inputs which have indirect impact to the port efficiency are referred as management operational factors or exogenous factors.

Indirect variables

These are factors that associated with more organizational side for production, how the efficiently ports use inputs to produce current output, and whether the technologies adopted by container terminal operators are most efficient. The factors such as port size, private sector participation, and quality of both cargo-handling and logistics services are noted as an essential determinants of efficiency (Yang et al., 2011), while terminal type, and operator type are input factors used in container terminal (Liu, 2010). The private investor always looking for maximizing profit, then there is higher possibility of influence the output of the terminal (Wang, 2004). These exogenous variables used to validate the economics theories of production in container terminals based on inefficiency model. Therefore in the present study the binary variable of private sector contribution and quality of cargo handling are chosen to identify their impact on operational efficiency among container terminals of the seaports in Tanzania.

Output Variables

One of the difficult tasks is to describe the output of container port or terminals in the normal circumstance. The trade volume, visiting vessels, and traffic volume are all considered as an output variable in the port or terminals depending the purpose and methods of study analysis. Based on the previous studies the choice of output variable in the study depend on the nature, technique, and the study requirement and also how well the researcher understand and relate it to the input variables

The container throughput is unquestionably the most important and widely accepted indicator of container port output, and almost all previous studies have treated it as an output variable (Liu, 2010; Yang et al., 2011; Almawsheki et al., 2015; Carine, 2015; and Zheng, et al., 2016). The constant conclusion provided in the literature that the total berth throughput in TEUs is a proper measurement of the output of a container terminal (Talley, 2015). The present study output variable is berth throughput in TEUs, which is the total number of containers loaded and unloaded in twenty-foot equivalent units

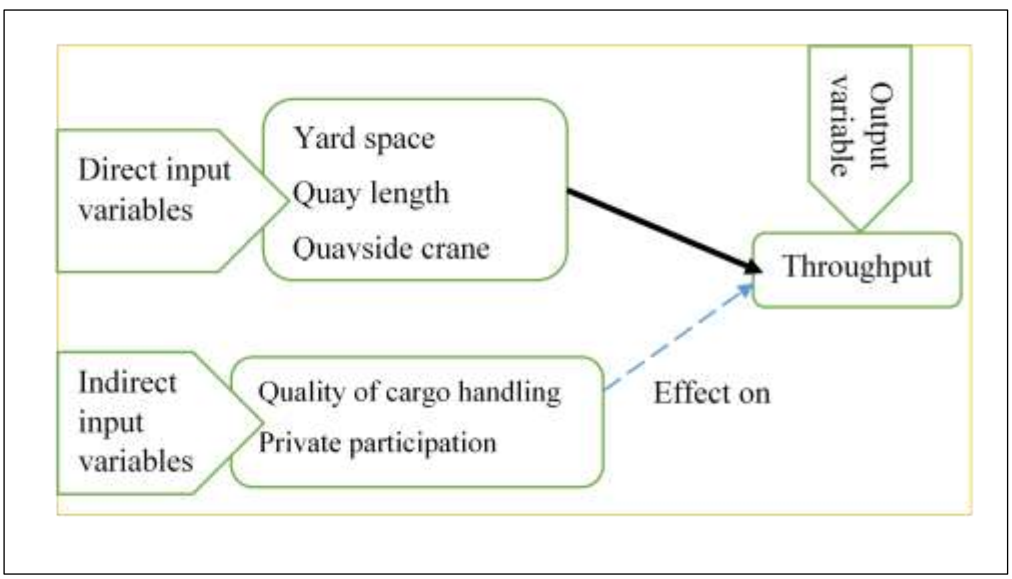

Figure 1.2 Research Variables Relationship

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CHAPTER 2

LITERATURE REVIEW

2.1 Overview of Tanzania Ports Terminal

The United Republic of Tanzania has three main seaports, namely, Dar es Salaam, Tanga and Mtwara ports. Other smaller seaports include Kilwa, Lindi, Mafia, Pangani, and Bagamoyo. The ports are overseen by the Tanzania Ports Authority (TPA), legislative organization built up on 15 April 2005. It regulates and licenses port and marine services and facilities. It manages vessel traffic in the port while ensuring safety and security. The authority also operates a system of ports serving the Tanzania hinterland and the landlocked countries of Malawi, Zimbabwe, Zambia, Democratic Republic of Congo (DRC), Burundi, Rwanda, and Uganda. Each port within have a terminal that is dedicated to container operating services

2.1.1 Dar es Salaam Port

The port of Dar es Salaam is one of East Africa's leading freight gateways, which is a growing entry and exit of goods for the local market and to many landlocked countries across East and Central Africa. The port is the Indian Ocean entry point of a sophisticated logistics network stretching much of central Africa. The port handles about 95% of Tanzania international trade across 11 deep-water berths.

Table 2.1 Location and General Information of Tanzania Port

Port Location and Contact			
Country	Tanzania	Tanzania	Tanzania
Nearest city	Dar es Salaam	Tanga	Mtwara
Port’s name/terminals	Port of Dar es Salaam	Port of Tanga	Port of Mtwara
Location	Nelson Mandela Road	Chumbageni port road	Port road
Managing company	Tanzania Port Authority	Tanzania Port Authority	Tanzania Port Authority
Nearest Airport	10.7km	7.4km	10.9km

Sources: (TPA, 2019)

In Tanzania, the Port Authority (TPA) operates seven berths while four are under consortium with Tanzania International Container Terminal Services (TICTS). Currently, the port of Dar es Salaam is prominent multipurpose port with a total berth length about 2,600 meters included 750 meters for dedicated container terminal. Container operations in the port of Dar es Salaam are dominated by private operator known as Tanzania International Container Terminal Services Ltd (TICTS), which handles about 500,000 TEUs each year at its two terminals (TPA, 2019). TICTS is the largest container terminal in Tanzania handles 75% of Tanzania's trade and services as a vital part of the supply chain to and from Tanzania. For the port of Dar es Salaam, the present study is subjected to container terminal.

Currently, the port consists of many barriers to trade, including insufficient infrastructures and facilities. However, the Government is racing to accommodate those barriers, including deepening water channels, expand quay length, and information technology infrastructures to facilitate trade and hence increase output. The port of Dar es Salaam is selected and included in the study due to its strategic position in international trade since it serves the rest of landlocked countries and it is in competitive edge of the neighboring container terminal

Figure 2.1 Dar es Salaam Container Terminal Layout

Sources: (TPA, 2016)

2.1.2 Tanga Port

The Port of Tanga is the second largest port in Tanzania and is a vital part of the regional and national development and economy. Tanga port is positioned on the northern coast of Tanzania near the Kenya border. It is one of the three main Tanzanian ports managed by the TPA which is ultimately Government agency, and hence private contribution in this port does not exist. The Port of Tanga was built in 1914 initially to serve the commercial and agricultural needs of northern Tanzania. In 1954 the original lighter age quay of 190 meters was extended to 381 meters with a capacity of 500,000 tons per annum.

The Tanga port consists of a terminal which is dedicated to service container with a total storage area for container and other cargo around 16,430 square meters and unpaved area of 5,200 square meters for general cargo. This port is selected and included in the study due to its potential in local trade and connection to the north and west region movement. Since the port is linked by a one meter gauge railway to Arusha via Moshi. It connects the trade in the northern part of Tanzania. Presently, the port has an annual capacity of 700,000 tonnes while the expected upgraded is 1.21 million tonnes (TPA, 2019).

Figure 2.2 Container Terminal of Tanga Port

Sources: (DLCA, 2019)

2.1.3 Mtwara Port

Mtwara port is one of the three major ports managed by the Tanzania Ports Authority, located 578 kilometers south of the commercial city of Dar es Salaam. The harbour at the Port of Mtwara was deepened in the year 1948 - 1954 during the colonial era. The drawback of the channel of the harbor basin around the port is narrow which limit large ship to enter as consequences effect ships traffic. However, the railway line was built to connect the port as part of the Tanganyika groundnut scheme. Due to the failure of the scheme, the port immediately lost value, and the railway line unconcerned. The port was functional, but underutilized for many years due to poor transport infrastructure and facilities. In the years 2010-2011, the increased activity in oil and gas exploration activity caused a surge of operations of this port.

The port of Mtwara consists of one continuous quay with a length of 385 meters and a maximum depth alongside 10.0 meters. For containers handling point of view, the port has an annual handling capacity of 200,000 TEUs with 27,500 square meters of stacking yard (TPA, 2019). The advantage of this port has enough reserves area whenever the development expansion required with total 80 hectors

Figure 2.3 Container Terminal Layout of Mtwara Port

Sources: (WPS, 2019)

2.1.4 Port of Zanzibar

The Port of Zanzibar at Malindi area was built in the 1920s as a modest lighter port to serve general cargo. In 1989, new construction of port (wharves) was dedicated to Cogefar Company and was supposed to construct the port to life span of 60 years. However, the port was again rehabilitated between 2004 and 2009, while the improvement was on the North and West wharves with a total quay length 382 meters. The target was to enhancement of safety at the port, building-dock structures, and improving the container operations. The port terminal consists of two berths for cargo servicing, and about 95 percent of Zanzibar imports and export passes through this Port. Currently port of Zanzibar is managed by the Zanzibar Ports Corporation (ZPC) as Government entity (100 percent publicly owned) due to Act of house of representative in 1997 while it is performing role as operator in terms of commercial activities (ZPC operate under the Ministry of infrastructures and communication).

Over the last several years, Malindi Port has operated at or above capacity and remains continuously congested. Water depth (average surrounding port area range from 8-13m) limits the size of vessels (13,000 DWT with 200m in length) that can call at the port, and limited equipment, including the absence of shore cranes, makes offloading cargo slow, adding further congestion (Nathan Associate Inc, 2014). The port has an area of about 75,000 m^2, out of this 12,000 m^2 used for container storage.

Table 2.2 Location and General information Zanzibar Port

Port Location and Contact	
Country	Zanzibar, Tanzania
Nearest city	Stone town
Port’s name/terminals	Malindi Port
Location	60km North of Dar es Salaam
Managing company	Zanzibar Port Corporation
Nearest Airport distance	1km

Sources: (Nathan Associate Inc, 2014)

However, recently the port area is limited and cannot allow any expansion for its developing purposes. Due to this problem that we found above the necessity of taking performance evaluation is unquestionable, which can support decision making in the port development process. This port terminal is included in the study just because for the best of our knowledge it is much undermined in literature. Since it is small port serve Zanzibar Island, this study will establish understanding the efficiency of the terminal for improvement of the required operations system in the port. Currently the ports' management authority is under the pressure of expand the container yard handling area by shifting the ports into new nearby area. However the project still does not in place for implementation since 2012, although the constructors from China has been yet sign the project contractors

Figure 2.4 Map of Zanzibar Port

Sources: (Nathan Associate Inc., 2014)

2.2 Production Theory and Port Operation

2.2.1 Basic Concept of Production Theory

Production refers to the process of converting input (labor, capital, raw material, and time) into output (value-added products). In the production carrier, inputs as factors of production categorized into fixed inputs (remain constant for a given level of output) and variable inputs (supply changes with the level of output produced). The production of entity frequently accessed in short periods, prolonged periods or very long periods depend on the target and objective of the entity.

Short-run refers to the production period where some of input factors are fixed, and others are variable, while long-run production the technology remains fixed and all others remain input became variables. The very long run is a period of production where all factors of production are variable. This situation means that technology also subjected to change in the production process.

Inputs are also independent variable and outputs are the dependent variables. The relationship between input and output variable basically can be represented in mathematically and graphically form and that is production function. However, the production function poses a constraint across the number of variables used in determining the changes in output. By the time two factors of input and one output used in the study, the production function can be represented graphically or mathematically. Besides, when exceeding three variables, it is no longer possible to display their relationship graphically instead mathematical equation should be preferred (Reker et al., 1990). The knowledge for using the production function became necessary in taking analysis to yield sound study results.

In maritime sectors especially in container terminals, production evaluation studies are not news concept even though the problematic poses due to the complex in nature of the sectors. It requires much knowledge and rational justification to identify required inputs and output variable which should be anticipated in the study for better results that can help and used as supporting tools in decision making in the seaport

2.2.2 Mathematical Representation of Production Function

Among others, the production function represented as Cobb-Douglas function, Exponential function, Gamma function, and Translog function. In this study we prefer to describe Cobb-Douglas and Translog function that will be used in our case study to evidence empirically efficiency of the terminals in case area. Cobb-Douglas function was introduced by Charles W. Cobb and Paul H. Douglas (1928). It is linear in logarithms, and thus we can use linear regression techniques.

$$\ln y = \beta_0 + \sum_{n=i}^{N} \beta_n \ln \mathrm{X}_n \quad \text{(2.1)}$$

The function represents decreasing/constant/increasing returns to scale when the coefficient of variables observed as $\sum_{n=1}^{N} \beta_n < 1, = 1, > 1$, respectively.

The elasticity of substitution between factors is always equal to 1. If sum estimated coefficient parameter of the model appear to be higher than one ($\sum \beta > 1$), the terminal productivity exhibit increasing return to scale in which more resources input are utilized against the total output produced and the vice versa of it ($\sum \beta < 1$) is valid decreasing return to scale behavior meaning that few resources of input factors are used in the production against the level of output produced. Likewise, if the totality of the value estimated coefficient parameters of the model are observed precisely equal to one ($\sum \beta = 1$) constant return to scale appreciated in which resources of input factors of maximum production usage equal to maximum level of output produced. At this point in production the firm exhibit full productive efficiency.

Therefore, the theory above is valid for any functional forms among all that are mentioned in the study; no matter the different forms exist. The Cobb-Douglas functional form frequently used in numerous studies due to its simplicity (linear equation) and good for trend prediction as long as assumption fulfilled.

2.2.3 Production Theory Based on Container Terminal

The economic theory of production has its basis in the study of the firm (Hooper, 1985). The firm refers to any entity that has capable of converting inputs to produce a new output. The output produced can be in the form of goods or services. Therefore the term production refers to the relationship between a set of inputs and the quantity of output produced by the firm (Reker et al., 1990). The question left in the growth of output produced in the entity. Although the change in productivity detected by examining the growth in output from time to time based on changes in the level of inputs (Hooper, 1985). When the technology changes and adopted for the business probable would improve the production of the entity. In the port sector, for container ports terminal, the output in production function is usually measured as TEU throughput (Talley, 2015).

Theoretical in the production, the assumption that the firm produces at the maximum capacity is appreciated. To measure the efficiency of the firms' technical efficiency index should be overlooked intentionally. If the firm's output achieved to the maximum output produced by a given level of resources, the firm is then technically efficient (Talley, 2015). Technical efficiency also defined as the relative production between the observed output and the best possible output (Liu, 2010). On other hand the difference between observed output and maximum output in production frontier curve (production disturbance) of the firm referred as technical efficiency. Similarly, the given set of inputs converted into output relative to the best level on the efficiency frontier (Farrell, 1957). In other words, a firm is assumed to be technically efficient if and only if that firm can produce maximum outputs from a given input without waste of resources when compared with its competitors.

In the port sector the production influenced by several factors, which are some direct and other indirect inputs. Deploying these factors create different production notion ineffectiveness and still not consistent in the literature. In container terminals, some literature displays that production efficiency is due to private participation in operation of the terminals (Yang et al., 2011). Likewise the notion that the production efficiency in the terminals is due to matured of the terminal (the more developed terminal with full equipment the higher efficiency of the terminal). Some scholar argues that higher productivities do not the means that the terminal operates efficiently (Talley, 2015). Some to terminal types that are multipurpose terminal are less efficient than specialized container terminal. There is no uncertainty that technological changes are factor input in production efficiency, but it does not always reflect the technical efficiency of the industry, mainly when some of inputs factors are misused. Production inefficiency of terminal also could be influenced by strategic location of the terminal. The more efficient terminal available in the dollar area and where the hinterland connection appreciated since operating of container terminal depends on the suitability of hinterland connection where maritime services providers are easily attracted and invest. Even though in practice it is difficult to justify these notions in production, this study is an effort to evidenced that production theory in container terminal by investigating the causes of inefficiency as factors of production

2.2.4 Concept of Productivity and Efficiency Measures

The efficiency and effectiveness of a port or terminals are critical to success, and the best way to maintain competitiveness. Performance in the port sector has a direct impact on the efficiency and reliability of the transport network in which the port is just a node for the transfer of goods. High quay productivity does not mean much when ships have to wait at anchorage, while cargo delivery processes are slow, and inland transportation networks are inadequate. Physical factors (including water depth, mooring places, land, equipment, and so on) can reduce port throughput and efficiency. The technological factors impact the availability of real-time information for stakeholders and the streamlining of both import and export value chains. With limited resources it is necessary to study the quality of production of firm associated with efficient use of input and amplifying output. This prompts raising measurement performance to describe the quality of production. The purpose of studying economic performance in the entity is to identify the gross measures productivity and shift measures of technical changes which describe business efficiency. However there are inconsistent idea about measurement of productivity and efficiency.

Gross productivity measured by ratio of output to the given inputs that usually estimated using index method to produce indicators measures of performance such as (berth throughput per crane per hour). In the literature, argue that gross measure productivity reflects a specific area (such as at berth) and not the whole terminal productivity (Notteboom et al., 2000). Efficiency measured by compared the productivity of the firm on the production frontier or cost frontier. It describes shift measures of technical changes in the production frontier. The situation of the firm shift from constant return to scale to increasing return to scale is an example of shift measures of efficiency. The inefficient firm also determined when operating either bellow or above the frontier.

Based on Figure 2.5, Gross productivity represents overall changes due to technical change over time. While efficiency represents part of productivity changes due to efficiency level of the performance. Also the technical changes represent part of productivity change due to technological modifications

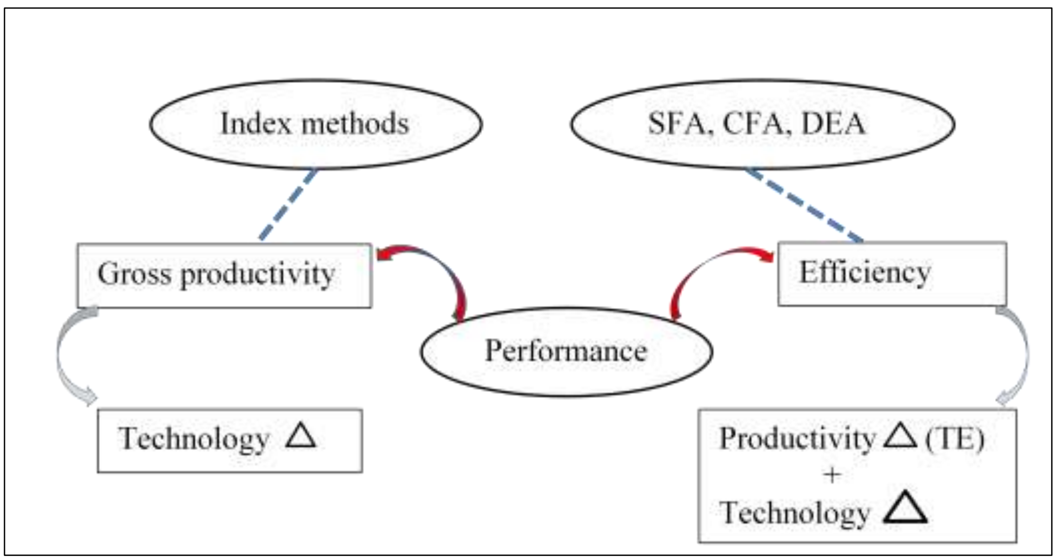

Figure 2.5 Productivity and Efficiency Relationship
Sources: Developed by author

Because the economic importance of maritime transportation facilitated by a high level of efficiency that guarantees timely submission, timely delivery, high-quality services, which are less bureaucratic. To improve efficiency and productivity, a comprehensive maritime management information systems supports are needed. These systems are automatic identification system (AIS), vessel traffic management system (VTMS) and port operating systems (POS)

Now we have already seen above that there is an active link between the efficiency and productivity in which efficiency measured by productivity. Therefore, to measuring efficiency the following appreciated in the operating terminal or port

i. Understand the most productive scale of the terminal or port
ii. The most scope for efficient saving in the use of resources
iii. The most suitable role model for the inefficient unit to stimulate improving its performance

In general, the efficiency of container terminal can be observed in seaside (quay transfer along the berth), terminal operation (storage systems in the container terminal yards), and landside operation as demonstrated here below

2.2.5 Sea Side Operation

The primary operations of container terminals are categorized as the ship to shore, transfer, storage, delivering and reception. The seaside operations concern with the operations of ship docking, pilotage, and tugging/towing services. In practice, the ship docking requires sufficient water depth to promote safety as well as suitable berths to allow flexible a ship's mooring. The situation is essential to enhance cargo-handling operations. The seaside area in container terminal is very potential due to have excellent influence port accessibility, which also affects port performance. Regarding their influence, the dimension of water depth, berth length, ship draft, and overall length are considered as an input variable in studying operational efficiency of port or terminals. There is no inconsistency in the literature about these dimensions used as input variables in the evaluation of port performance and efficiency.

For a port or terminal with qualified dimensions of its facilities has a good position of competitive edge in attracting port customers due to providing enough water depth and dock length that can able to accommodate more massive ship, maintain safety conditions and reduce ship dwelling time. This will enhance the growth of terminal production as the principal economic aim of the firm to maximizes production output with the minimum cost of production.

Turning circle, anchorage area, channel depth, and navigation device (buoy), as well as tagging, are among the services provided in the water area, which greatly enhance performance of the ports and lead customers' attractiveness. If the port fails to deliver better services in the water area its consequence losing customers and thus negative growth will experienced. Therefore, to provide better services port or terminal should maintain high quality of its necessary infrastructures and facilities.

2.2.6 Terminal Operation

Terminal operations include the entire operations of container handling from the ship's hold to the storage yard as shown by 2.6. Terminal operations depend on the superstructure, which includes all cargo-handling equipment used within the port or dedicated terminal for cargo-handling operations. The number and type of cargo-handling equipment play a vital role in the cargo handling, which also determinant of port efficiency. Cargo handling equipment influences the speed of cargo movement within the port, storage mode, and total operating time including ship turnaround time.

Inefficiency productivity is due to congestion that addressed as the primary sources in port production due to causal long waiting time for ships before getting services. Increasing cargo volume also leads to shifting cargo to barges which then increasing further pressures on the berth and internal movement. The maximum levels of terminal operations efficiency depend on the form of an operator and the level of terminals' development. Operator can be categorized as an international or local, private or public not surprising when they join together in operating terminal.

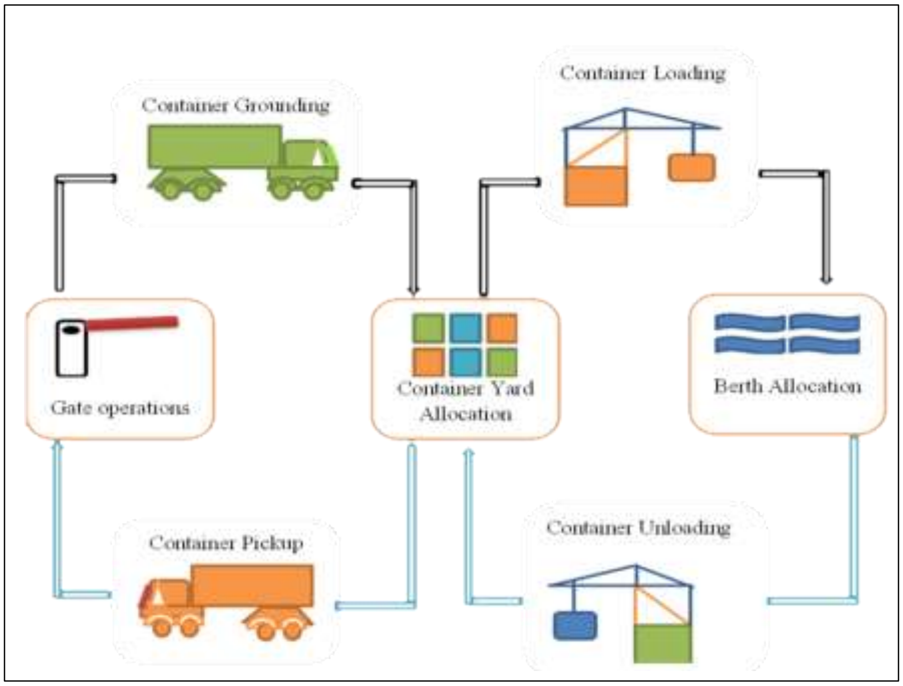

Figure 2.6 Container Terminal Basic Operations

Sources: (OPM, 2015)

2.2.7 Land Sides Operation

Landside operations concern landside accessibility to enhance the efficiency of container flow between a port and its hinterland. Landside accessibility to seaports has become one of the significant concerns of port authorities and public policymakers. As logistic services and supply chain accessibility is a crucial factor in port performance and for enhancing economic development.

When the port has a full intermodal connection, the customers will attract to use the port for the transfer of their goods and hence increase the port productivity. The operations and management strategies in the container yard ultimately influence the operational efficiency and operating cost of terminal operations as a whole by reducing congestion in the hinterland as well as adjustment on market structure for container terminal (ie privatization of container terminal). The transportation infrastructures connectivity (railways and tarmac road) in the hinterland area should be focused with special attention for port operates in productive efficiently. Therefore, the smoothness of the hinterland contributes more level of production efficiency especially for the hinterland characterized in dollar area.

In Tanzania most of all port has an advantage of railways connection as well as tarmac road and lead secure container handling when exit from or entry to the port area away or from the hinterland. Currently the Government of Tanzania is starting to implement the project for new railways building (electricity standard gauge railways) that will connect to the hinterland from commercial capital city (Dar es Salaam) to west north part of Tanzania where the most trading partners are located (Rwanda, Burundi, Democratic Republic of Congo).

2.3 Review of Container Port Efficiency

Several authors have been addressed container port operational efficiency and showed different results across many factors (input and output), region or country, and even methods used in the study analysis. Port type and size are indirect factors that have been cited in many previous studies with different conclusions. It was noted that terminal size is not the main factor of efficiency, as some terminals with the medium size are more efficient than larger terminals (Almawsheki et al., 2015). Moreover the comparative study has been proven that Chinese ports have little efficient than the ports in West Africa (Ago et al., 2016), even though ports from Chines are larger. This is not surprising because the main ports in China (Shanghai and Hongkong) was under consideration in the study are faced with higher congestion, which affects the production of the ports. In contrast, the study conducted in China and Korea based on container terminals evidenced the efficiency to major terminal (Zheng et al., 2016).

The inputs such as total quay length, terminal area, and quay cranes have significant effects on production (Yang et al., 2011). Similarly, the input factors such as length of the quay, the number of berth-side cranes, the number of births are shown the influence on ports to the production efficiency (Ago et al., 2016). On average, the container port terminals in Sub-Sahara Africa have observed inefficiency indeed rather than technical efficiency (Carine, 2015). The study conducted at North Mediterranean Sea for both ports and terminal operation efficiency reveals that 90% of container ports included in the study have their technical efficiency lower than 0.80, while 95% of container terminals have their technical efficiency lower than 0.80 (Liu, 2010). The guarantee of the inputs depends on the port or terminal operation system to the production efficiency. Hence direct inputs variables should be studied time to time to evaluate the production movement of terminal.

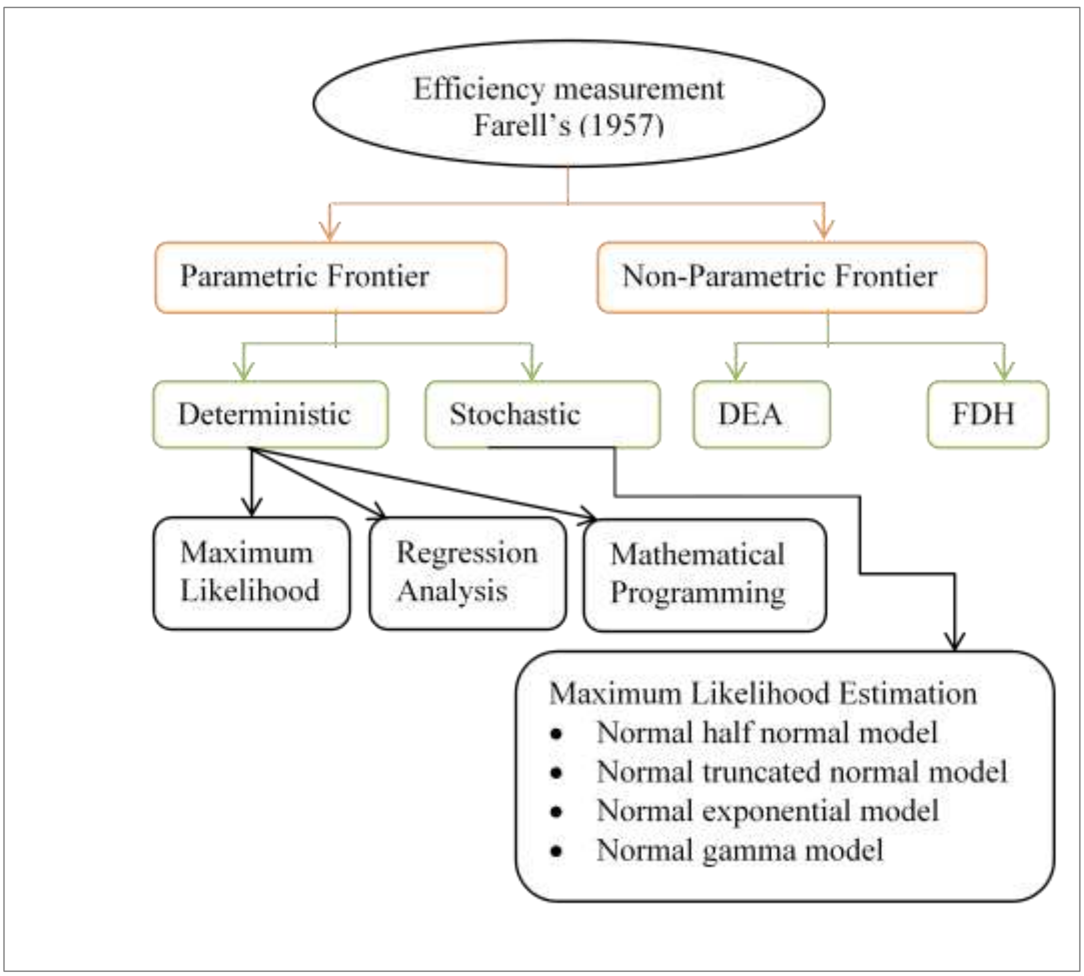

Figure 2.7 Efficiency Measurement Methods
Sources: Adopted from (Wang, 2004)

2.4 Review of Efficiency Measurement Method

Theoretical production function analysis uses econometric techniques in order to investigate growth of production in the port or terminal. However the role in evaluating production can define not only the current state of the system but also its future. Regarding container port efficiency number of previous studies have been employ different techniques to investigate the efficiency of the ports or terminals. The conventional methods used to evaluate efficiency cited in the literatures are grouped into parametric frontier, and non-parametric frontier approaches as shown by Figure 2.7. Among other methods, the efficiency of container port production efficiency can potentially be analyzed by DEA or by the Free Disposal Hull (FDH) Model (Wang et al., 2003). Many studies uses these methods to study container terminals efficiency (Almawsheki et al., 2015; Carine, 2015; Zheng et al., 2016; and Ago et al., 2016).

Besides, other studies uses parametric approaches which are either Stochastic frontier Analysis (SFA) or deterministic frontier or combination of both such as net-effect and gross-effect models (Liu, 2010). Inefficiency model based on SFA in the specification of the Translog function (Yang et al., 2011; and Reker et al., 1990). Based on the reference above, it can be seen that non-parametric frontier approaches are shown frequently used as compared to parametric approaches. The present study uses parametric approaches as the techniques for study production efficiency of container terminals in Tanzania to bridge the gap.

2.4.1 Stochastic Frontier Analysis (SFA)

The stochastic frontier analysis is a statistical modeling method used to analyze the efficiency of the firms and benchmarking, which identifies the frontier through a regression method with a composed error term. The method first proposed by (Aigner et al., 1977) and later was improved by Meeusen and van den Broeck (1977). The method requires specification of two errors term distribution assumptions to estimate the efficiency. The presence of stochastic elements makes the models less vulnerable to the influence of outliers than with deterministic frontier model. In practice the stochastic frontier analysis technique describes the relationship among observed production point (X_i, Y_i) and production function (f) which defined as

$$Y_i = f(X_i)\exp(V_i - U_i) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots... (2.2)$$

Where:

(X_i, Y_i) Observed input and output for unit i

(f) potential production function

U_i Non-negative arbitrary variable related to inefficiency; it is also a dependent variable explained by environmental factors (inputs variable) to the inefficient model.

V_i Statistical white noise due to the random shock

The composed error term (v, and u) are distributed independently of each other. In the many previous research works, white noise (v) is always normally distributed, and the inefficient error term (u) specified by several one-sided error distributions.

The one-sided error term (u) can be Half normal, Exponential, Truncated normal, or Gamma distribution as shown clearly by Figure 2.7. The accommodation of these depends on the nature of the dataset involved in the study. The reason why this study chooses to use the Stochastic Frontier Analysis technique in the analysis of datasets is demonstrated as follow:

i. The stochastic frontier analysis model comprises stochastic elements (white noise and inefficient error) which make the model less vulnerable with an outlier (it is less frequently affected with outlier value in the analysis of the data sets)
ii. Analysis of datasets is made based on the distribution assumption since the time series data usually are less normality and sometimes inconsistent in natures. Therefore to obtain suitable results that reflect the datasets need to handle data using SFA. In other hands, it makes possible to test assumption and hypothesis in production model
iii. It does not require much series of data to estimate the model and indices
iv. It is extensively used in many industries but less used in the port sector

2.4.2 Econometric Frontier Model

In neoclassical production theory, the frontier refers to a boundary function constructed from observed points. The production frontier reflects the current state of technology in the entity. Production function estimated with special attention of functional form without neglecting the assumption distribution of the composed error terms. Translog and Cobb-Douglas functional forms are the most commonly used in the literature, and therefore, we can compare our results with the previous literature when it is necessary. In this study these two functions was used because the Cobb-Douglas model (1) is a particular case of the Translog model (2) in functional form and mathematical properties (Meaning that if the value coefficient of interaction terms appear to be zero then the model (2) reduced to model (1) functional form).

Several models have cited in the literatures that can be used to estimate efficiency depending the distribution assumption required by model such as Greene (2005a), Greene (2005b), Battese and Coelli (1992), Battese and Coelli (2005), Kumbarhaka (1990), and so on as prevailing by (Belloti et al, 2012). The study model usually defined due to the distribution assumption of the inefficiency term as noted in (Section 2.4.1) depending on the objective of that study.

The present study will adopt a model developed by Battese and Coelli (1992) to estimate production frontier parameters and thereafter technical efficiency indecies of an individual firm in panel data which defined as:

$$\ln y_{it} = \ln \mathrm{X}_{it}\beta + (V_{it} - U_{it}) \qquad (2.3)$$

$$U_{it} = U_i \exp(-\eta(t - \mathrm{T})) \qquad (2.4)$$

Where,

y_{it} : The output of the ith firm at the period t

X_{it} : Vector of the input quantities of the firm ith during the period t

β: Vector of the unknown parameter needs to be estimated

V_{it} : White noise random errors assumed to be identical and independent distributed $\mathrm{N}(0,\sigma_v^2)$ normal distribution, independently distributed to U_{it}

U_{it}: Inefficiency assumed to be identical and independent distributed as truncation at zero of $\mathrm{N}\left(\mu_i, \sigma_u^2\right)$. When estimated $u_i \geq 0$ reflect the technical inefficiency

η: The scalar parameter needs to be estimated, if its value appear to be zero then the technical efficiency index does not varies over time.

Besides, the focus of this study not only determines frontier coefficients and the level of technical efficiency but also analyses factors that are determinants of technical inefficiency. Therefore more advanced panel model established, which considers exogenous factors to inefficiency distribution function as specified by Battese and Coelli (1995). A model is a one-stage approach that takes into account the endogenous (inputs, *x*) factors and exogenous (z) factors simultaneously and is given as:

$$\ln y_{it} = \ln \mathrm{X}_{it}\beta + \left(V_{it} - U_{it}\right) \qquad (2.5)$$

$$U_{it} = Z_{it}\delta + W_{it} \qquad (2.6)$$

Where:

$y_{it}, \mathrm{X}_{it}, \beta$, and V_{it} : the same as defined in equation (3) above

U_{it} : Inefficiency assumed to be identical and independent distributed as truncations at zero of the $\mathrm{N}\left(U_{it}, \sigma_u^2\right)$

Z_{it} : Vector of explanatory variables associated with technical inefficiency of terminals production over period

δ: Is a vector of unknown coefficients

W_{it}: Random error term need to be estimated

t: Represent each year in the period of analysis

In the model estimation, when the exogenous variables are included in the deterministic part, the model is called a *net* effect model. Similarly, when the exogenous variables are included in the random inefficiency term, the model is called a *gross* effect model. The *gross* effect model considers that the exogenous variable influence the efficiency directly, but do not directly influence the output (Liu, 2010).

2.4.3 Maximum Likelihood Function Estimation

Maximum likelihood estimation (MLE) is a technique used for estimating the parameters of a given distribution using some observed data. It is useful in a variety of contexts ranging from econometrics. Maximum likelihood estimation is estimate consistently the parameter needs to be estimated aiming to avoid bias. The parameters estimated are coefficient of variables, variance due to random shock, and variance due to technical inefficiency. Thereafter calculated the total shared varience in the model. According to Battese and Coelli (1995) estimation of stochastic production frontier depend on the validity of following parameters

$$\sigma^2 = \sigma_v^2 + \sigma_u^2 \quad \text{(2.7)}$$

Where

σ_u^2 is the variance due to inefficience disturbance, and σ_v^2 is the variance due to statistical white noise. Then, the shared variance of inefficiency is defined as

$$\gamma = \frac{\sigma_u^2}{\sigma_v^2 + \sigma_u^2} \quad \text{(2.8)}$$

The shared variance ratio (γ) is explaining the total variation in output from the frontier level of output attributed to technical inefficiency. It is usually 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 consistently be estimated using (OLS) methods. It is argued that these parameters are not enough to decide the correctness of the model. Furthermore, the hypotheses test for the parameters of the stochastic production function model should be diagnosed using the generalized likelihood ratio (LR) statistic defined as

$$\lambda = -2[\ln(L(H_0)) - \ln(L(H_1))] \quad \text{(2.9)}$$

$L(H_0)$ - The value of the log-likelihood function (restricted function to OLS)

$L(H_1)$ - the value of the unrestricted function

If the value of LR-statistic or (λ) is significantly asymptotically distributed as a mixed Chi-square, the random variable lead the critical area with certern degree of freedom, the null hypothesis should be validily rejected and conclusion provided, concluding the null hypothesis that technical inefficiency effects are present in the model.

In order to select the best specification of the production function for a given data set, the Coefficient of interaction variables should be significantly different from zero then the Translog functional form in favor of Cobb-Douglas functional form. Also, to determine the best model among model developed the log-likelihood function value should be compared. Therefore the most relative small value is appreciated. The most prefer function will reflect better off the results of our data set and generate rational prove of hypothesis in the study, which then evidenced the production theory cited in many previous literature. Nevertheless the model will be counted as the supporting tools for decision making to the administrative level in selected firm for operating improvement

2.4.4 Concept of Technical Efficiency

Technical efficiency represents either the ability of a firm to minimize the inputs used in the production for a given output vector, or the ability of the firm to maximize the output from a given input vector. Technical efficiency is also defined as relative productivity over time or space, or both (Wang, 2004). Therefore, there are two technical efficiency measures associated with this statement such as input-oriented measures and output-oriented measures.

Technical efficiency refers to output-oriented measures if the firm intends to maximize output to the frontier by employing the same inputs factor (input factors held constant) in the production process. Likewise the vice versa is true for input-oriented measures when firm aiming to modify inputs factors to maximizing the output to the frontier level. In both case the mathematical calculation of technical efficiency remain similar their difference input function in the expression

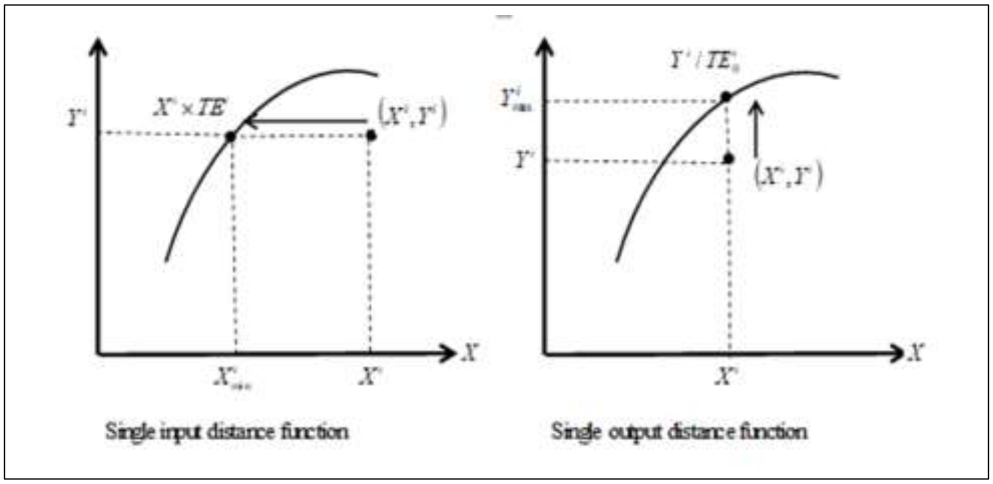

Figure 2.8 Input and Output-Oriented Efficiency Measurement
Sources: Adopted from (Liu, 2010)

Technical efficiency is used to estimate efficiency levels that can be used to rank producers, identify under-performing industry (inefficiency firm), and identify those at or close to efficiency frontier (efficiency firm). This study aims to examine the technical efficiency of container terminals as a comparable unit and which factors influence the production level. However, we prefer to appreciate technical efficiency in terms of output-oriented measures using Cobb-Douglas and Translog functional form. The output-oriented efficiency ratio of production point of industry i ($x_i\ y_i$) refer in Figure 2.8 can then be written as

$$\mathrm{TE} = \frac{y^i}{y^i_{\max}} \quad \text{...} \quad (2.10)$$

For the case of Cobb-Douglas production function as shown in the equation (2.4) above the model can be defined as

$$\ln y_{it} = \beta_0 + \sum_{n=1}^{N} \beta \ln \mathrm{X}_{in} + v_i - u_i$$

By applying the formula in equation (2.10) above, then

TE for terminal i, is $\mathrm{TE} = \frac{\beta_0 + \sum_{n=i}^{N} \beta \ln \mathrm{X}_{in} + v_i - u_i}{\beta_0 + \sum_{n=i}^{N} \beta \ln \mathrm{X}_{in} + v_i} = \exp(-u_i)$ …….……….. (2.11)

Likewise for the case of Translog production function in which model defined as

$$\ln y_{it} = \beta_0 + \sum_{n=i}^{N} \beta \ln \mathrm{X}_{im} + \frac{1}{2} \sum_{n=i}^{N} . \sum_{m=i}^{N} \beta_{nm} \ln \mathrm{X}_{in} \ln \mathrm{X}_{im} + v_i - u_i$$

$$\mathrm{TE} = \frac{\beta_0 + \sum_{n=i}^{N} \beta \ln \mathrm{X}_{im} + \frac{1}{2} \sum_{n=i}^{N} . \sum_{m=i}^{N} \beta_{nm} \ln \mathrm{X}_{in} \ln \mathrm{X}_{im} + v_i - u_i}{\beta_0 + \sum_{n=i}^{N} \beta \ln \mathrm{X}_{im} + \frac{1}{2} \sum_{n=i}^{N} . \sum_{m=i}^{N} \beta_{nm} \ln \mathrm{X}_{in} \ln \mathrm{X}_{im} + v_i} = \exp(-u_i) \quad \text{……….. (2.12)}$$

Therefore, in both cases, Cobb Douglas and Translog function technical efficiency observed as:

$$\mathrm{TE} = \exp(-u_i) \quad \text{……….…………………….………………………...…… (2.132)}$$

In the estimation of technical efficiency care should be taken to the analyst depending on the type of software applied, the technical efficiency (TE) normal estimated after estimate maximum likelihood parameter coefficients and satisfyed with the validity of the model. Then the prediction of technical efficiency index generated across the periods which then average index of each terminal or decision unit calculated.

2.4.5 Strength and Weakness of Stochastic Frontier Analysis

Rational choices of technique for study analysis depend on the objective of the study, data behavior, and knowledge of the expert. The strength of the method exists when they reduce business and reflect the analyzed results otherwise the truth is weak method. The following are the noted point of strength and weakness of SFA

The goodness of the Stochastic Frontier Analysis

i. The method has carefulness of statistical white noise in performing analysis
ii. It allows the analysis of exogenous variables (inefficient model is appreciated)
iii. It is not necessary to operate many data set in the analysis

Weakness and Limitation of Stochastic Frontier Analysis

i. It requires to impose specific structure when constructing a frontier function
ii. The assumption of the inefficiency term has to be imposed

iii. The method cannot deal with multiple outputs because the parametric production function is not defined in multiple outputs.

2.5 The Uniqueness of the Study

Although many studies of this particular carrier that intends to evaluate port efficiency for our best knowledge faced with the following constraints

i. In literature, studies have shown a lack of distinctness of port and terminal in performing an evaluation and hence misleading the targeted area of the particular studies along the results.
ii. The inclusion of variables (input and output), which are lacking with correctness. For instance, the inclusion of handling equipment of the whole path from each terminal and reflect the result for the terminals in comparison

The present study attempted to correct the listed faults to shape the study in objectivity by performing the following:

i. The Homogeneity selection of the decision-making unit will be considered, and simultaneously the relationship between input and output factors to improve the efficiency of targeted are being improved.
ii. The scope of comparisons of the subject constrained to terminal levels to provide a venue for best and detail seaport terminal operations efficiency attained and provided significant implications for operators and customers

2.6 Literature Review Conclusion

- In the literature, the Stochastic Frontier Analysis is recently technique and becoming famous in port sectors
- Most of the studies use berth throughput in TEUs as output variable, and physical variables as inputs.
- Most of the studies use cross sectional data while panel data are otherwise
- Most of the studies focusing on top container ports as well as a regional character
- The study of efficiency of container terminals in Tanzania is very limited

Table 2.3 Summery of Previous Studies on Port/Terminal Efficiency

Author	Title	Technique	Variables
Almawshaki et al., 2015	Technical efficiency of Container Terminals in the Middle Eastern Region	DEA	Berth length, Yard area, Quay crane, Yard equipment, maximum draft, and Throughput
Carine, 2015	Analyzing the operational efficiency of container 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, logistic performance 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 Different Models: The Case of Container Ports	SFA, 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, trade volume, 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 of British ports	SFA	Turnover, Labour, capital, ownership, size, capital intensity, and location
Notteboom et al., 2000	Measuring and explaining the relative efficiency of container terminals by means of 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 port efficiency, 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: an evaluation 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

CHAPTER 3
METHODOLOGY

Research framework designs used in this study's methodology follow the stages, process and evaluation procedures as depicted in figure 3.1 below

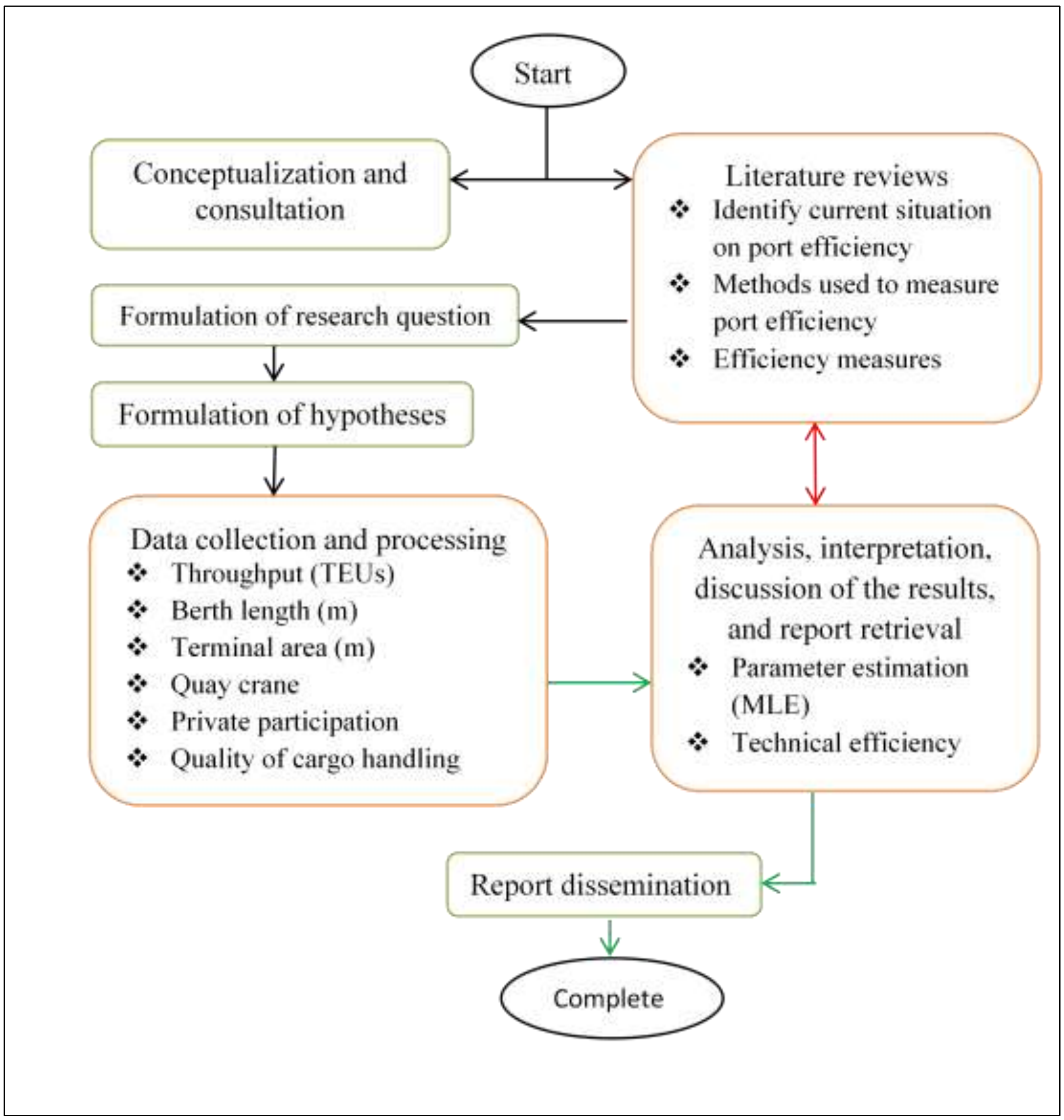

Figure 3.1 Flowchart of Research

The research design is the quantitative study starting to conceptualize the research concept, review of literature, formulation of research question and hypothesis, data collection and processing, analysis, interpretation, discussion, report retrieval, and dissemination.

The purpose of conduct a review of the literature was to obtain an overview of operation efficiency problems associated with container terminal in the maritime world especially Tanzania as case study. The reviewed literature outputs explained in chapter 2. This stage was held simultaneously with the conceptualization of the problem and design the way that we can solve it and make initial consultation with the various experience scholar including lecturers in the Institute Teknologi Sepuluh Nopember, Surabaya. Research questions and derived hypotheses have been achieved with the help of review literature as evidence of the problem that can help to answer the objective of the study.

3.1 The Research Design

The design of this research is a quantitative approach that uses numerical data in investigating the problem among the industries through statistics, mathematics, or computational technique. The importance of research design is to facilitate research operations, making yielding maximal information with minimal expenditure of effort, time and money. The target of quantitative approaches is to develop and employ mathematical models, theories, and hypotheses about phenomena and make justification for decision making. Quantitative approaches are flexible for cross-sectional data and panel data (historical data series)

In Figure 3.2, the research methodology structure design is presented and explains the detail about the designing of the research methodology in which the series of task was organized to accomplish the research goals. A series of tasks used as methodology of this research also described such as data collection methods, hypothesis validation, data analysis, and report writing.

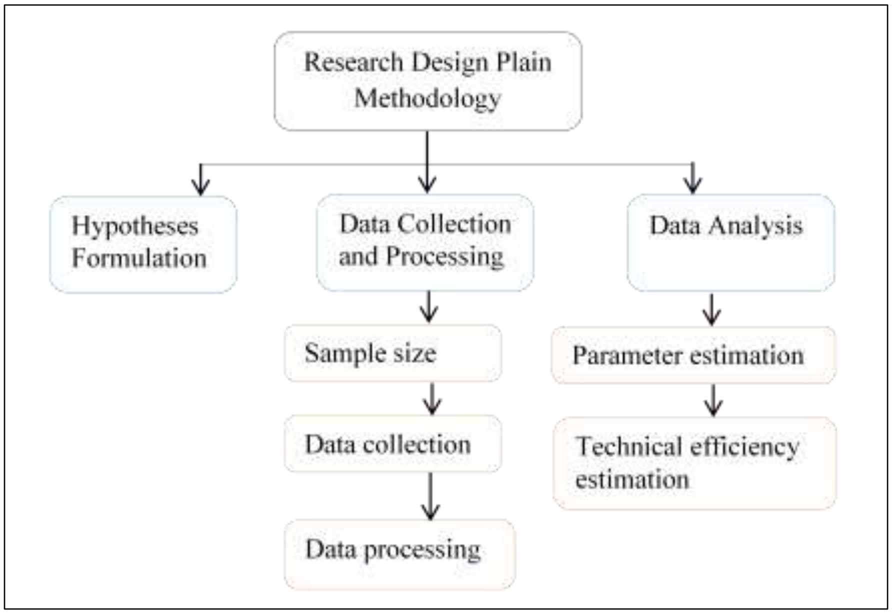

Figure 3.2 Research Design Plan of Methodology

3.2 Data Collection and Processing

3.2.1 Sample Size

A purposive sample of the study was a convenience, and preferred used in the study since the castles and riskless in time constrains. The sample size is crucial for reliable results. In this study the sample size designed lie under the rule of thumb given by various scholar. The sample should meet the criterion based on the argument that the number of firm should be at least more significant to the product between number of output variables and number of input variables (Boussofiance et al., 1991). However, the proper number of firms should be three times greater than input and output variables (Banker, 1984). Also the option says that the sample size of the study should be equal to or greater than three times the sum of output and input variables. Another rule of thumb, which is most convenience says that the number of observations in the sample for time series data, should be at least 30 for reliable results. This enhances the statistical confidence of the results reflected in the datasets used in the study

In this study, six variables were used as input variables, including exogenous factors. These include the quay length, terminal area, quay cranes (gantry/mobile), ship call, terminal size, and private participation. The single output variable used was berth throughput in TEUs, as shown in Table 4.1. The period of the study starts from 2012 to 2018, of which consists of seven spans in the production of the terminals.

This study employed the most restricted rule, which says that the sample size (observations) should be equal to or greater than 30 data points in the datasets. Even though the nature of the technique used in the study does not force to have many data sets, but the option is more convenient. Therefore, the required sample sizes are.

Sample size (n) = (Number of terminals*Length of span in production)

$$n = (4 * 9)$$

$$n = 36 \text{ Observations}$$

Accordingly, the total number of container terminals included in the study sample was 4, and the total observation was 36, which satisfies the requirement of the sample size. The reason factors for selecting the terminal are as follow:

(i) The terminal should be operated for at least eight years to fulfill the needs of sample size assumption

(ii) Significant data should be available on the official website or in official office

3.2.2 Data Collection

The types of data also are crucial in the determination of the specific objective of the study. The panel data set of about nine years collected from each terminal during the period of production. These dataset collected based on the selected inputs and output variables that are used to measure container terminals' efficiency as comparison units. Variables are explained in chapter 1 subsection 1.7 and then clearly shown by Figure 1.2; Figure 1.3; and Table 3.1. Therefore the primary sources of data are

i. Report approved by the terminal authority available in the official website of Tanzania Port Authority (TPA)
ii. Direct visiting to the port office in the case of missing or data problem found from the open sources

Table 3.1 Selected Variables

Output and input variable			Symbol
Throughput (TEUs)			Y
Quay crane (unit)			X_1
Terminal area (m^2)			X_2
Quay length m)			X_3
Quality of cargo handling	Binary	1 = Good, 0 = otherwise	
Private participation	Binary	1 = Private participate, 0 = otherwise	

It is common practice to categorize predictor variables when the data analysts want to find real results. The linear model doesn't really care if the predictor is continuous or categorical. Categorical variable coded with binary value, the model returns a parameter estimate that only really gives information about the response; the difference in the means of the response for the two groups. However, more than two categories of the variable provide detail information of response of the group variable. Also if the predictor consists many categories can provide meaningless information. The categorization process intend to grouping the response into groups which have similar properties.

In the present study categorization of quality of cargo handling used to analyses perceived services quality difference among terminals provided to the users. There is relative importance of examining the differences among container terminals rated with "Good = 1 and together Average and Poor = 0", since the average and poor categories found to have the same level of perception responses. It is really that there is no difference between user perception on Average and Poor categories in the rating results of those container terminals in Tanzania. To categorize average and poor individual will reflect the same meaning due to have the same weight. Therefore, in this study we decide to categorize the quality of cargo handling in to binary dimensions as the best way to explain the dependent variable (inefficient term) with respect to good services performed among the terminals compared with those average and poor terminal service performed.

The same case for the private participation predictor of inefficient term intend to explaining the inefficient term with respect to participation of private sector among the container terminals in ports of Tanzania.

3.2.3 Data Processing

Microsoft Excel and STATA version 15 software was used to prepare, processing, and analyze the dataset. The data first prepared in Microsoft excel and convert the values of the variable in natural logarithm before transferred in STATA software for running the proposed models. Therefore, several models of production efficiency thereafter established accordingly as shown in the sub-Section 3.4.2 with its specific efficiency index

3.3 Data Analysis

The production frontier reflects the current state of technology in the industry. In addressing this, stochastic frontier analysis employed under maximum likelihood estimate technique to examine the factors that are influencing production level of the terminals. The choice of function influences the shape of the frontier and the accuracy of the estimation and therefore two functional forms of the SFA model were selected. These functional forms are Cobb Douglas and Translog function and three models in each functional form were analyzed. Figure 3.3 has shown the modeling procedures of our dataset of container terminals in Tanzania.

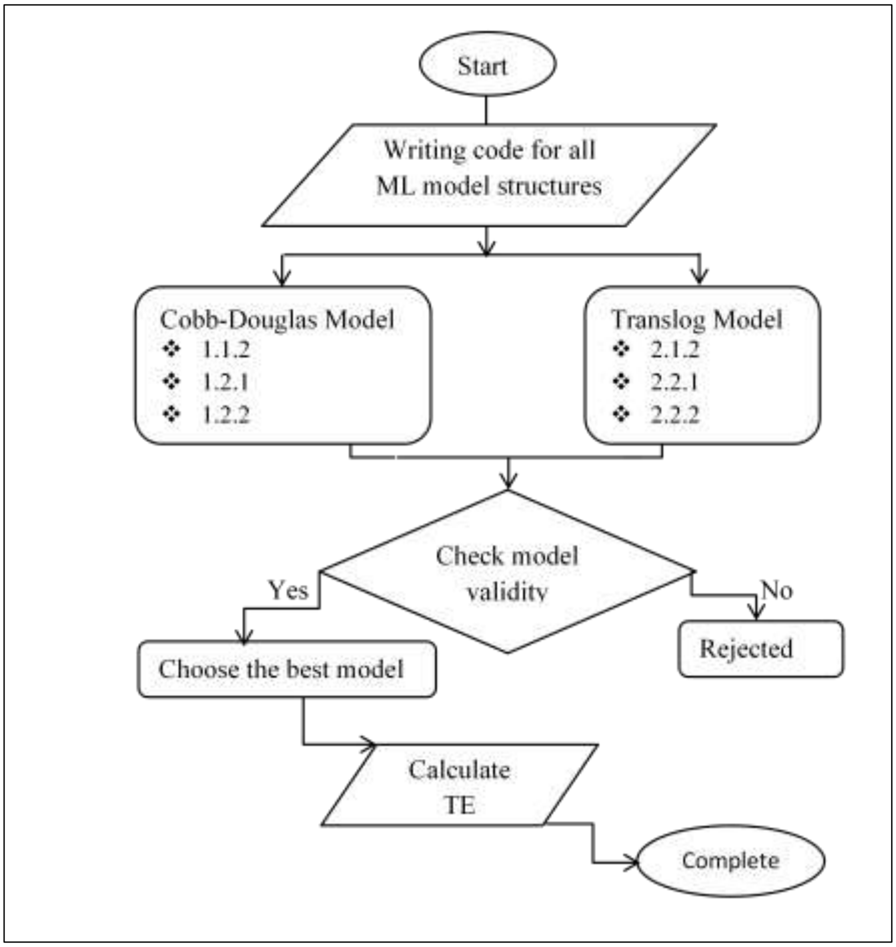

Figure 3.3 Modelling Algorithm

3.3.1 Parameter Estimation (MLE)

To estimate the parameters, the statistical methods used in order to fit the mathematical functional form to the dataset. Maximum likelihood estimation (MLE) was used to determine the parameters that maximize the probability (likelihood) of the observed data. Table 3.2 displays the estimated parameter models through Cobb-Douglas and Translog both under the truncated normal distribution assumption. The uniqueness of the model developed lie under the trend variable for both models (bc92) and (bc95).

Table 3.2 Model Specifications and Parameter Estimation

Model specification / Parameter estimated	Cobb-Douglas		Translog	
	Truncated normal (bc92)	Truncated normal (bc95)	Truncated normal (bc92)	Truncated normal (bc95)
3 input and 2 binary variable		1.2.1		2.2.1
3 input, trend and 2 binary variable	1.1.2	1.2.2	2.1.2	2.2.2

The consequence of the trend variable was to increase the explanatory power in the models.

Note: (bc92) and (bc95) are model equivalent with Battase and Colli (1992) and Battase and Colli (1995) respectively, see detail in Chapter 2.

In this study empirical model defined and identified by numerical coded with three-digit such that the functional form (Cobb-Douglas =1; Translog = 2), the model type with respect to its assumption distribution of inefficient error term (Truncated bc92 = 1; Truncated bc95 = 2) and number of variable due to varies of trend variables such that (3 input variables with trend variable and 2 exogenous variables = 1; 3 input variables without trend variable and 2 exogenous variables =2). However, all translog model (2.2.1; 2.1.2; and 2.2.2) have not been involved in this study because the data set behavior did not accommodated functional assumption

- Validation of Hypotheses

After estimating required parameters following with checking the hypothesis, postulate if rejected or accepted aiming to validate the theory underlying the model and production theory. The estimated variance parameters (σ) and total shared variance (γ) have been considered to validate the reality that if an inefficient present.

For the model fit and accuracy of data representation the likelihood function has been potential criteria. The likelihood ratio value (λ) used as compared with the critical value of mixed chi-square distribution with a particular value of the degree of freedom (restriction) as presented by kodde and Palm (1986). The hypothesis that needs to be validated explained in chapter 1; sub-section 1.6.

3.3.2 Technical Efficiency Estimation

Once the parameters are estimated, the terminal-specific efficiency can be calculated based on the inputs and output-oriented for that particular observation, see equation (8) and (9) in chapter 2 sub-section 2.5.3. The value of individual average technical efficiency reflects the efficiency level of the firm or terminal (how the good is the terminal in the production process). The values of technical efficiency lie between 0 and 1. The higher the value, the higher the efficiency of the terminal, likewise the vice versa is real for inefficiency terminal

The following are proposed production efficiency models of the container terminal in Tanzania ports, as suggested in the study.

- Technical efficiency model 1.1.2

The efficiency model 1.1.2 of Cobb-Douglas function form with three inputs variable and trend variables variable based on Battle and Coelli (1992) defined as

$$\ln(Y) = \beta_0 + \beta_1 \ln(X_1) + \beta_2 \ln(X_2) + \beta_3 \ln(X_3) + \beta_4 \ln(T) + V_i - U_i$$

For the case of technical inefficiency model with the assumption of the truncated normal distribution, the following are the inefficiency models based on Battle and Coelli (1995). The specific of this model consist two different models which estimated simultaneously and provides results for both model at once. It is more appreciated because it reduces the bias in estimating the parameters of the models

- Technical efficiency model 1.2.1

The inefficient model 1.2.1 of Cobb-Douglas function form with three inputs variable without trend variable and two binary variables defined as

$$\ln(Y) = \beta_0 + \beta_1 \ln(X_1) + \beta_2 \ln(X_2) + \beta_3 \ln(X_3) + V_i - U_i$$

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + W_i$$

- Technical efficiency model 1.2.2

The inefficiency model 1.2.2 of Cobb-Douglas function form with three inputs variable, trend and two binary variables defined as follow

$$\ln(Y) = \beta_0 + \beta_1 \ln(X_1) + \beta_2 \ln(X_2) + \beta_3 \ln(X_3) + \beta_4 \ln(T) + V_i - U_i$$

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + W_i$$

- Technical efficiency model 2.1.2

The efficiency model 2.1.2 of Translog function form with three inputs variable and trend variables as control variable defined as

$$\ln(Y) = \beta_0 + \beta_1 \ln(X_1) + \beta_2 \ln(X_2) + \beta_3 \ln(X_3) + \beta_4 \ln(X_1)^2 + \beta_5 \ln(X_2)^2 + \beta_6 \ln(X_3)^2$$
$$+ \beta_7 \ln(X_1)\ln(X_2) + \beta_8 \ln(X_1)\ln(X_3) + \beta_9 \ln(X_2)\ln(X_3) + \beta_{10} \ln(T) + V_i - U_i$$

For the case of technical inefficiency model with the assumption of the truncated normal distribution, the following are the inefficiency models based on Battle and Coelli (1995).

- Technical efficiency model 2.2.1

The inefficient model 2.2.1 of Translog function form with three inputs variable without trend variable and two binary variables defined as

$$\ln(Y) = \beta_0 + \beta_1 \ln(X_1) + \beta_2 \ln(X_2) + \beta_3 \ln(X_3) + \beta_4 \ln(X_1)^2 + \beta_5 \ln(X_2)^2 + \beta_6 \ln(X_3)^2$$
$$+ \beta_7 \ln(X_1)\ln(X_2) + \beta_8 \ln(X_1)\ln(X_3) + \beta_9 \ln(X_2)\ln(X_3) + V_i - U_i$$

$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + W_i$$

- Technical efficiency model 2.2.2

The inefficiency model 2.2.2 of Translog function form with three inputs variable, trend and two binary variables defined as follow

$$\ln(Y) = \beta_0 + \beta_1 \ln(X_1) + \beta_2 \ln(X_2) + \beta_3 \ln(X_3) + \beta_4 \ln(X_1)^2 + \beta_5 \ln(X_2)^2 + \beta_6 \ln(X_3)^2$$
$$+ \beta_7 \ln(X_1)\ln(X_2) + \beta_8 \ln(X_1)\ln(X_3) + \beta_9 \ln(X_2)\ln(X_3) + \beta_{10} \ln(T) + V_i - U_i$$
$$U_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + W_i$$

The comparison provided across the terminals that enabled to identify the least and most operating efficiency. Also, estimated coefficient parameters will enable us to distinguish factors that are more enhanced production across the terminal as compared to other factors among all studied factors. The final recommendation provided to the terminals authority to improve the production process current and future and achieve economic utilization of resources in the respected terminals

3.4 Study Plan

Since the study constraints only one semester within the academic year, the process of conducting the study divided into two quarters. The first quarter will cover the study design, data collection, and processing. The second quarter will involve Data analysis, report writing, and publications of the study results

Table 3.3 Work Plan of the Study

	3rd Semester	
	1st quarter	2nd quarter
Proposal design and consultation		
Proposal exam and working on the correction		
Data collection		
Data processing and analysis		
Report writing		
Thesis exam		

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CHAPTER 4

DATA PRESENTATION

4.1 Output Information

Tanzania is located on the eastern coast of Africa and has an Indian Ocean coastline approximately 1,424 kilometers long. The Figure 4.1 shows the position of container terminals in Tanzania indicated by a small circle along the coastal line of the Indian Ocean. Since the Zanzibar terminal has different authority from Tanzania Ports Authority, the data used in this study collected from two different sources. The berth throughput data of container terminals in Tanzania ports as output information have been collected in four different terminals, as shown by Table 4.1 for the span of nine years from 2010-2018. For three terminals (Dar es Salaam, Tanga, and Mtwara), data are collected from the annual and accountancy report of Tanzania Ports Authority via its official website and for Zanzibar container terminal collected directly at the port office, Malindi Zanzibar

Figure 4.1 Location of Container Terminals of Tanzania

Berth throughput data among container terminals in Tanzania prevailing significant differences of the terminals' production. As the Dar es Salaam terminal shows worth of higher production in TEUs than others across all year of production. It shows that Dar es Salaam terminal is the busiest for handling container cargo in Tanzania. However, some of the fluctuation containers handled observed across the study periods. In general the highest productivity among terminals observed in the year 2015, and afterward there was a tendency of decline in the production. It might be the consequence of operating overcapacity and creating congestion, which then affects the production. It is because the physical infrastructure played a significant role in pushing production and became a primary source of customs attractive. Failure of cargo handling in proper time the worse tendency on the prosperity of container terminals would observed. The worse situation experienced in two terminals (Dar es Salaam and Tanga) from 2015 – 2018, where the output was dropped

Table 4.1 Terminals Throughput in TEUs (2010-2018)

Year \ Terminals	Dar es Salaam	Tanga	Mtwara	Zanzibar	Total
2010	359,010	11,262	7,074	38,806	416,152
2011	439,464	11,922	7,076	51,344	509,806
2012	530,089	11,262	16,601	65,053	623,005
2013	610,503	11,922	14,609	70,592	707,626
2014	614,555	12,013	14,081	79,256	719,905
2015	645,561	10,207	12,982	75,161	743,911
2016	595,109	8,118	14,337	76,787	694,351
2017	501,690	6,057	16,528	73,351	597,626
2018	592,000	6,257	16,913	82,312	697,482

Sources: (TPA, 2019) and (ZPC, 2019)

4.2 Input Information

For the inputs information of container terminals in Tanzania ports, several data were also collected in four different terminals, as shown in Table 4.2. These data are collected from the annual handbook provided by Tanzania Ports Authority on its official website and for the Zanzibar container terminal (Malindi) collected at the port office, Malindi Zanzibar, via interview of staff personnel.

Each terminal's information collected was about berth length of the terminals in meter, number of quayside crane, and terminals area in squares meter. Also, the study uses the private participation information and quality of cargo handling as factors inputs to analyses the effect of private contribution in the production of the container terminals and the effects of cargo handling situation in terminals associated with inefficiency as presented in Table 4.2 in binary form

For the quality of cargo handling, information was available by rating the terminals through terminals/ ports users' perspectives (managers, terminal service provider, clearance and forwarding, and cargo owner). The question was distributed through an online Google form using WhatsApp.

Purposive sampling used due to time and cost constraints, which uses a snowball technique to collect the information required. After the first respondent interviewed was asked to facilitate to achieve another respondent, the process continues until the completion of data gathered

The question was on the Likert scale form having three scales, which are Good, Average, and Poor. For this study the scale was signed as 1, and both average and poor were signed as 0. It means that for the terminal, which has more than 50 percent of the average rating, good is given 1 and 0 otherwise. Finally, the variable information available showing that Dar es Salaam and Zanzibar terminals are worth in quality of cargo handling as compared with two others

The consequence of using binary categorization in developing this variable explained in detail in Chapter 3 sub section 3.2.2. However it is the one of the limitation of the study due to argue that the two categories did not provide detail information.

Table 4.2 Terminals Input Information

Inputs / Terminals	Quay length (m)	Quayside crane (number)	Terminal area (m^2)	Private participation	Quality of cargo handling
Dar es Salaam	725	6	187,500	1	1
Tanga	381	2	27,500	0	0
Mtwara	385	3	16,430	0	0
Zanzibar	382	1	12,000	0	1

Sources: (TPA, 2019) and (ZPC, 2019)

For the input factors we observe that the total area of container terminals in Tanzania was 143,430 meters square in which the Dar es Salaam terminal owns a larger part of that area, while Zanzibar occupies smallest area. For the quay length, the container terminal of Tanga port was recorded with small dock length of 381 meters as compared with others while Dar es Salaam terminals are the leading one for 725 meters. However, Dar es Salaam consists six dock crane higher number than the other three terminals, the terminal of Zanzibar owns only one crane, and their output seemed gradually increased.

Private contribution among container terminals seemed to be less relative significant among the container terminals in Tanzania. Because the data have shown as only one terminal (Dar es Salaam) among four included in the study are adapt to the private participation in the operation of the container terminal.

For the quality of cargo handling, the data showed that half of the terminals (Zanzibar and Dar es Salaam) rated in good quality of cargo handling. The quality of cargo handling depends on various attributed such as on-time submission (short for government procedures), a proper plan for handling, quality of handling equipment ports charges, and functional connectivity of the port/terminals. For regional level (East Africa), Tanzania ports are rated poorly as compared to other neighboring countries

4.3 Ship Call Information

The number of ship calls from all four terminals has been collected and presented in Table 4.3; for a span of nine years from 2010 – 2018. Ship calls have been used to see the effect of call to the output of the container terminals depending on the technological modification taken to the respects terminals during the periods of study. In this study, the ship calls treated as input factors since the study assumes only one output factor, which is berth throughput in TEUs.

We observe that there was a significant difference in frequencies calling of the vessel in the Dar es Salaam terminals compared to those three terminals. This difference evidenced that advance investment of cargo handling equipment was invested in Dar es Salaam terminal than other three terminals during the periods of study.

It might be the reason that cargo owner and shipping line choose to stack their cargo in the port of Dar es Salaam instead of loading Mtwara, Tanga, and Zanzibar. In general, the trend of vessel visited the terminals was gradually increased from 2011 to 2014, however slightly drop in 2015 and 2016 before starting to increase 2017

Table 4.3 Ship Calls of Container Terminals in Tanzania (2010-2018)

Terminals / Year	Dar es Salaam	Tanga	Mtwara	Zanzibar	Total
2010	810	226	42	177	1,255
2011	1,510	212	60	166	1,948
2012	1,427	102	111	156	1,796
2013	1,366	197	567	193	2,323
2014	1,487	102	544	194	2,327
2015	1,502	106	409	142	2,159
2016	1,518	86	99	120	1,823
2017	1,712	133	609	174	2,628
2018	1,847	141	645	121	2,754

Sources: (TPA, 2019) and (ZPC, 2019)

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CHAPTER 5
ANALYSIS AND DISCUSSION

5.1 Introduction

Before doing analyses, the data was prepared in an excel sheet software. Checking the data characteristics were done (correlation, descriptive, and data distribution), then continuous data converted into a natural logarithm and therefore transferred to the STATA do editor sheet for estimating the models through maximum likelihood procedure.

5.2 Output Variation in Container Terminals of Tanzania

During the period of 2010-2018, the majority of container handling occurred in Dar es Salaam terminals for about 86% of the total container trade followed by Zanzibar terminal, which handles only 11% of the total TEU per year. Tanga and Mtwara have shown relative lower operating container trade by performing only 1% and 2%, respectively

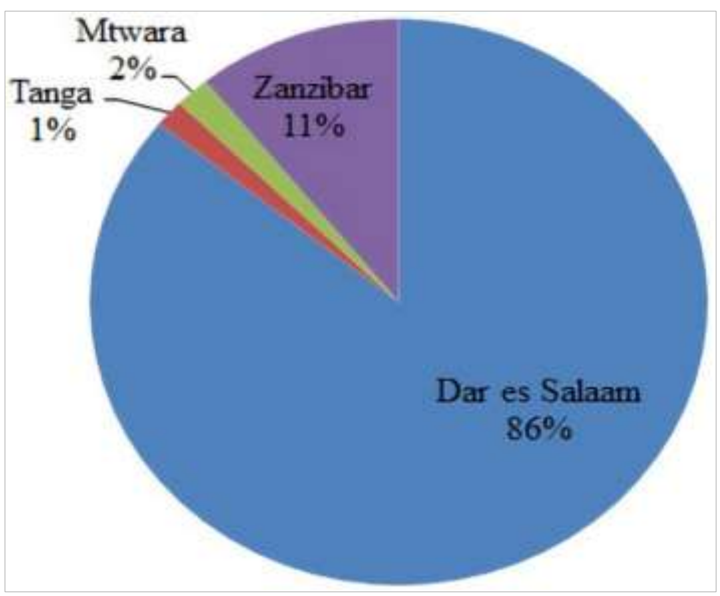

Figure 5.1 Distribution of Berth Throughput among Terminals

This insignificant distribution of the trade among the container terminals might be contributed by various factors (Production technique), further in chapter 5 discussed in detail those factors that accelerated or decelerated the production in the container terminals of Tanzania. To facilitate this, Table 4.2 displayed selected input factors of production available in each terminal that will reflect the production situation in the terminals that included in the study.

5.3 Descriptive Statistics

The data explore has been conducted, and the result shown in Table 5.1 with descriptive measures of maximum, minimum, skewness, kurtosis, standard deviation, average, and the number of observations in the sample. The descriptive statistics perform the variety in outcome since the container terminals in Tanzania are distinct in size, equipment, and throughput

Container terminals output of Tanzania ports for the periods 2010-2018 have been shown an uneven distribution of average 158,631.86TEUs with a maximum of 645,561 TEUs while the minimum was 6,057 TEUs and the deviation among the observation was about 230,934.52 TEUs. The available berth length among the terminals found, on average, 468.25 meters long, the most extended berth was observed about 725 meters while the lowest was 381 meters with a deviation of about 150.345 meters. The critical factor in container operating is quay crane for indeed smoothing operating in container terminals of Tanzania for the periods 2010-2018.

Table 5.1 Descriptive Statistics of Variables

Variables	Number of observation	Average	Standard deviation	Kurtosis	Skewness	Min	Max
Throughput	36	158631.86	230934.52	-0.144	1.288	6057	645561
Berth length	36	468.25	150.34	-0.583	1.205	381	725
Quay crane	36	3.00	1.90	-0.967	0.717	1	6
Terminal area	36	60857.50	74374.94	-0.601	1.184	12000	187500

On average three quay cranes were found, while the highest number in one particular terminal observed six cranes and smallest number of operating quay crane was 1 in the terminal, which form a standard deviation of about 1.9 among the terminals. The goodness of these terminals none of them operating without quay crane. If the quay crane used properly would push the efficiency to a satisfactory level among terminals. Area of terminals also included as input factors which appeared with an average area about 60,857.5 square meter, the terminals which consist large area was recorded about 187,500 square meter while the terminal that consist minimum area was 12,000 square meter which creates standard deviation about 74,374.94 square meter among the terminals

For all variables, measures of skewness have shown positive asymmetry of the data sets, which indicate that massive data value lies on the long right-hand tail of the distribution curve. Also, because all coefficient of skewness value is greater than zero, which makes no justification on normality assumption of the data sets. Therefore our study plan methods or assumption would be reasonably preferred in the data analysis as suggested

5.4 Correlation between Variables

Correlation measures describe the relationship between two variables, and usually it measures the strength and direction of linear relationships among variables. Correlation value between variable range from –1 to +1, the variables which have correlation value equal to +1, meaning that these variables have perfectly strong relationship and they can perfectly explain each other's while -1 correlation value the variables have perfectly otherwise.

All variables are accepted since there are no negative correlations between variables. The dependent and independent variables are reasonably correlated and provide a venue toward analysis. For the three inputs with output, Berth length has the highest correlation with throughput (output), whereas quay crane has the lowest correlation with throughput.

Table 5.2 Correlations among Variables

	Throughput	Quay crane	Terminal area	Berth length
Throughput	1.000	0.871	0.967	0.975
Quay crane	0.871	1.000	0.951	0.929
Terminal area	0.967	0.951	1.000	0.998
Berth length	0.975	0.929	0.998	1.000

This finding suggests relatively lower importance of quay crane to the efficient throughput of container traffic. Among the four inputs themselves, berth length, storage yard, and quay crane are positively correlated to each other.

5.5 Container Terminals Productivity (2010-2018)

Productivity is the most essential issue in container terminals which paid great attention. The success of the any terminals reflects how better is it in the production process and therefore facilitate the economic growth of the country. However to measure productivity of the container terminals may not reflects the reality if poor defining of physical and capital equipment experienced. Productivity allow to evaluate the capacity and efficiency of the terminals or ports in its operation
Physical, operational indicators such as the volume of containers handled in the ports per day and volume of containers handled by each crane per hour allow for measuring the productivity of each production factor and influence the development strategy of the port.

The volume of containers handled at the ports daily obtained from the volume of containers moved (TEUs) divided by 365 days, which is the total of operational days of the terminals at the international level. The indicator of the volume of containers handled by each crane per hour obtained by dividing the container volume of each terminal expressed in TEUs by the number of cranes and the total operational hours in the terminals at the international level (365×24).

Table 5.3 Movement of Container among Terminals

	Movement of Container (TEUs per Day)								
Year	2010	2011	2012	2013	2014	2015	2016	2017	2018
Dar es Salaam	984	1204	1452	1673	1684	1769	1630	1374	1622
Tanga	31	33	31	33	33	28	22	17	17
Mtwara	19	19	45	40	39	36	39	45	45
Zanzibar	106	141	178	193	217	206	210	201	226
	Movement of Container in TEUs per crane per hour								
Dar es Salaam	10	13	15	17	18	18	17	14	17
Tanga	1	1	1	1	1	1	0	0	0
Mtwara	0	0	1	1	1	0	1	1	1
Zanzibar	4	6	7	8	9	9	9	8	9
	TEUs per Ship Call								
Dar es Salaam	443	291	371	447	413	430	392	321	368
Tanga	50	56	110	61	118	96	94	46	44
Mtwara	168	118	150	26	26	32	145	63	65
Zanzibar	219	309	417	366	409	529	640	422	680

The highest value of the operational indicators of port productivity has been reached by the Dar es Salaam container terminal in 2015. It was observed with the ratio of 1,769 TEUs per day and 18 TEUs/crane/hour, while further reduced to 1,622 TEUs per day in 2018 and 17 TEUs/crane/hour. However, the lowest value of the operational indicators of port productivity has been reached by the Tanga container terminal in 2017 and 2018, with a ratio of 17 TEUs per day.

5.6 Maximum Likelihood Estimated Models

The coefficients of unknown parameters of the stochastic frontier and inefficacy model found by using maximum likelihood estimates through STATA software version 15. The six models proposed have been successeful estimated. However, only three models were adequately explained the dataset. The following are the definitions of the models performed as used in this study.

Model Definition

The model in this study defined or specified in three coded form such that

- The first code digit represent functional form (1= Cobb-Douglas function)
- The second digit represent model type ((1= Battese and Coelli, 1992), and (2 = Battese and Coelli, 1995))
- The third digit represent number of variable specification ((1 = three inputs variable with exogenous variables), and (2 = three inputs variable with trend and /or exogenous variables))

Therefore, based on the above description our models given the special coded name as follow

- Three models follow Cobb-Douglas function (1.2.1; 1.2.2; and 1.1.2)
- Three models fall under Translog function (2.2.1; 2.2.2; and 2.1.2)

The Cobb-Douglas function was preferred to generate models as the proposed Translog function could not fit our data set. It is concluded so, because the null hypotheses IV accepted, and therefore all coefficient of the second-order variables are equal to zero.

5.6.1 Cobb-Douglas Estimated Models

The different of the models mainly observed from the exogenous and trend variables applied in the calculation. Table 5.4 shows the summary of the maximum likelihood estimations results of the equations described in Chapter 3, section 3.2.3. From the model's calculation, we examined only three different model specifications as follow:

- The model (1.2.1), a full Cobb-Douglas model and an explanatory model for the technical inefficiency
- The model (1.2.2), a full Cobb-Douglas model with control variables (trend) and an explanatory model for technical inefficiency
- The model (1.1.2), a Cobb-Douglas model that calculates the frontier without modeling the determinants of technical inefficiency.

These models results are contain the following aspects displayed in the Table 5.4

i. The coefficients of variables in the frontier models
ii. The coefficients of inefficient determinant models
iii. The variance parameter of the models and the likelihood function

Three models (2.1.2; 2.2.1; and 2.2.2) among all were ultimately eliminated in the study as violated the required functional assumption

Production Elasticity of Frontier Model

As usual for all parametric frontier models, estimating the coefficients of different variables in order to obtain the structure of the production frontier (1.1.2; 1.2.1; and 1.2.2) is unavoidable as the primary objective of the study. These coefficients termed as the elasticity coefficients (Beta) of the production model.

The elasticity of production shows the responsiveness of the output when there is a change in one unit of input. It defined as a proportional change in the product, divided the proportional change in the quantity of input.

Regarding to our selected model 1.2.2 in this study, we found that the terminal area has a positive influence and statistically significant at a 5% level. The result meaning that increasing berth throughput (TEUs) by 1% push significantly the handling area of the container terminal of about 4.319% meter squares among terminals, ceteris paribus; this means that more land investment demanded among the terminals under the study of the output maximized. However, quay crane observed with a negative effect on the output production, which is highly significant, these results imply that berth throughput (TEUs) increased by 1% effect in the number of quay crane by -4.641% among container terminals in Tanzania

The same situation acknowledged the berth length, which experienced a negative sign of its elasticity coefficient when the berth throughput (TEUs) increased by 1% would impact significantly in length of a berth by -2.292% in any container terminals.

Table 5.4 Production Frontier Models

Variables	Estimated Parameters	1.1.2	1.2.1	1.2.2
Constant	β_0	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_0		-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	$\sigma^2 = \sigma_u{}^2 + \sigma^2{}_v$	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	$2.75\text{x}10^7$	$2.99\text{x}10^8$

The maximum likelihood estimated parameters values obtained using STATA software application, at 5% level of significant, the p-value showed in bracket. The maximum iteration set 100. The panel data models with total observations 36 in four seaport terminals.

In general, all elasticity coefficients (beta) are empirically found significant at $p<5\%$ showing that all three inputs (quay crane, terminal area, and berth length) have a significant effect on berth throughput (production) among container terminals. This result is consistent with those observed by (Zheng et al., 2016; Hlali, 2018; and Yang et al., 2011). However, the quayside cranes and the berth length are not relevant since their coefficients have negative signs, 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 the difference of quay crane and the length of the berth are too large among terminals. Therefore some terminals enjoy higher traffic volume in their daily operation and handling containers.

In the evaluation of container terminals, economies of scale became potential aspect in running the business at the container terminals. Avoiding unnecessary operating costs in the production would be appreciated.

We are backing to the production elasticity on our selected model herein, the results displayed compared with the previous study.

The sum of elasticity coefficients of studied inputs appears to be less than 1. The results indicate that container terminals of Tanzania shift the situation of constant returns to scale towards decreasing returns to scale. This result supported by a study of five major container ports 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 also contrast from the study of (Notteboom et al., 2000; Hlali, 2017; Suárez-Alemán et al., 2015; and Liu, 2010). The revealed behaviour of decreasing return to scale, meaning that among the terminals, the tendencies of uses few resources of input factors against the level of output produced in the production process have been experienced. Therefore the government of Tanzania should be responsive to the ports infrastructures investment policies to smoothing cargo handling and maintain the attractive for their customers

In contrast with the study herein, the container ports among 26 main ports appear to be constant return to scale for both model distributions (Hlali, 2017 and Hlali, 2018). These results suggest that 26 major ports reached extremely usage of input factors in the production process against level of output. The same result observed from the study conducted in the container port of developing countries using Cobb-Douglas and Translog function tends to increase scale among the container ports (Suárez-Alemán et al., 2015). However, the constant return to scale 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 to the characters of the input among terminals are not sufficient to handle the container cargo. Traditional input characters (physical infrastructures) would surpass the output of the production and will remain attractiveness to the users and customers. Therefore for the container terminals' authority to review their quality services level offered to the customers and maintain their loyalty is unavoidable.

Trend Variable

Backing to the production frontier estimated the trend (time) included in the study. The trend variable regular associated with annual percentage change of output due to technological modifications over time. It is included in the study as a control variable to improve the strength of explanatory power of the model. The results are evidenced by the model which include trend have more significant value of likelihood function than those without trend as shown in Table 5.4. However, the positive sign of trend variable indicating improvement among container terminals. In model 1.2.2 the trend variable has positive sign meaning that terminals have been growing higher output under constant technological modification during the study period. This result was also consistent with those found in the study of (Lopez-Bermudez et al., 2018). However, those two models used followed translog function form. The positive trend was also revealed in all models (1-4) except for the model (5) under the Cobb-Douglas function form (Sarriera et al., 2013).

The surprising observed to the model 1.1.2, where the trend sign was found negative. Similar results were found for model (1) specification in the study of (Suárez-Alemán et al., 2015) and model (2) in column (6) in the study of (Liu, 1995). It was inefficient models that used the translog function form and experienced a relatively higher likelihood function. Besides the production technique trend appears to be negative in both models (Liu, 2010). It noted that the model used was translog function tend to examine efficiency of container port. Negative sign for the trend variable indicating that the annual percentage change in output is slower than the technological change adopted among the terminals. This result conflicts with the present study in the model 1.2.2. Therefore technology investment among terminals has proven its necessity. The reason why it is a negative sign might be several reasons including overcapacity, the relationship between investment and traffic growth, transshipment, inadequate government procedures, higher port charges, and ownership

In the literature, there is no consistent conclusion on the application of the trend variable. Some study uses to examine sources of inefficiency (Sarriera et al., 2013) and other uses as control variable (Liu, 1995; and Lopez-Bermudez, et al., 2018). Also, other existing literature never applies trend variables at all, such as (Hlali, 2017; and Yang et al., 2011). And therefore the explanatory power is not justified by trend variable instead only variance parameter estimates

Inefficient Model

The inefficient model was designed to identify the determinant factors of the technical inefficiency among container terminals in Tanzania.

Based on Table 5.4 the maximum likelihood estimates of the parameters in the Cobb-Douglas frontier production function given with specification for the inefficient effects as defined by two specified models (1.2.1 and 1.2.2). For this study, the following factors considered as the determinant of inefficient, which affect the efficiency of container terminals directly but not affect productivity.

i. The private participation
ii. Quality of cargo handling

For inefficient models (1.2.1 and 1.2.2), 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 they are not statistically significance. The results suggest that both variables are not relevant in improving operation efficiency among container terminals in Tanzania.

For private sector participation, it is concluded that the terminals can operate efficiently without private participation. The results in contrast with many previous results reported by (Yang et al., 2011; Liu, 2010; and Demirel et al., 2012). These studies evaluate the efficiency estimation to container port/terminals and found a high level of technical efficiency associated more significant with private sector participation. In the present study, Figures 5.3 shows that on average the highest efficient terminals is public operating terminals than its counterpart. The results provide criticism of the 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 level of cargo handling present in the terminals would make it possible to improve technical efficiency because the high quality of cargo handling is not associated with inefficiency. However, the terminal of Dar es Salaam and Zanzibar observed with a high quality of cargo handling, which reflects to their average efficiency scores. There is possibility on improving technical efficiency among terminals if the terminals' authorities would be focused on improving the cargo handling services. Insignificant of these inefficient determinants might be insufficient variation in the variable to constitute a valid test of their influence, even though all variables have a strong correlation. Insignificant confirm that there is no linear relationship between these factors and efficiency, and hence it would not improve technical efficiency.

Model Relevant

The significance of parameter estimates assessed by variance parameters and then applying the likelihood ratio statistic. Before proceeding on the likelihood ratio test, the variance parameters (error component) were assessed to give justification to build a model of the study. The following are the procedures of obtain those parameters after estimating likelihood coefficients factors

- The squared variance due to random statistical error (σ_v) and inefficient disturbance (σ_u) calculated
- The sum of the squared variance of random error and squared inefficiency variance.
- The total ratio variation (γ) was also calculated by taking the squared inefficient disturbance divide by the sum of the squared variance of random error and squared inefficient variance.

The total ratio variation depicts the relationships of deviation between two composed errors (inefficiency error and random error). It is used to determine the dominant error in the model and make justification for proceeding the analysis in that particular methods under the specified assumption

In two models (inefficiency model, 1.2.1 and 1.2.2), the total shared variance is precisely equal to 1, as shown by Table 5.4, which indicates that 100% inefficiency dominates the overall error. This result suggests that stochastic frontier adequate to describe the production technique. Also, for model 1.1.2 the total shared variation is different from zero (0.374) but is not sufficient to rational justifying in explaining production technique compared to the two models mentioned above. The only 37.4 % inefficiency dominates the overall (composed) error; therefore the more significant portion is due to white noise

The estimated parameter associated with the period also observed. It usually shows a time-varying technical efficiency of the sample. In the model (1.1.2) under the study (η) is positive means that individual technical efficiency increased over time among container terminals.

Similarly, the likelihood ratio test was conducted to validate the explanatory power of the model function. In the calculation of the likelihood ratio, test procedures have shown in (ii) below. In order to decide if the model would provide more accurate data representation in the container terminals, several tests of the hypotheses concerning the nature of the production function and inefficient effects. Because we maximize the log-likelihood, the relative higher considerable value of the log-likelihood is satisfactory, indicating that the model is good fit for the dataset. The parameter is most likely to be correct which gives the maximum value of the likelihood function. When the log-likelihood is higher enough, surpass the critical value obtained from mix Chi-square distribution.

The result shows that in all models, the likelihood ratio is higher than the critical value at 5% significant level, as shown by Table 5.5. However, in this study, we are considering and propose the model 1.2.2 as the best model among all since it provides the most reasonable log-likelihood function compared with two remaining model

5.6.2 Hypothesis

Before proceeding to examine the parameter estimates of the production frontier and the factors that affect the inefficiency of the container terminals in Tanzania, we need to investigate the validity of the model used for the analysis. The validity of the model was done using variance parameter and the log-likelihood ratio, in truncated normal model distribution under Cobb–Douglas. In this study, the following procedures were taken to complete the proved hypothesis of the production model.

i. Estimating the model using STATA software and obtain the results from the dataset of the sample
ii. Calculate the likelihood ratio test (test statistics (λ)); calculation procedures described as follows.

   Test statistics (λ) = -2[(log-likelihood restricted)-(log-likelihood unrestricted)]

   Note: for the restricted log-likelihood obtained directly from the estimated generalized linear model while for unrestricted log-likelihood obtained from an estimated frontier model

iii. Obtained the estimate critical value exhibit mixed Chi-square distribution from table 1 of Kodde and Palm (1986) with the number of degree of freedom restricted to the model

iv. Compare the test statistics and critical value to prove the hypothesis.

v. Make a decision, if the value of test statistic is higher than the critical area than the decision is to reject the null hypothesis otherwise accept the null hypothesis

The results of the hypothesis based on the production function frontier were found and presented in Table 5.5. The basic test carried out under this study consist of the following postulate

i. Inefficient effects in the production function are not presented in the estimated model **(** $H_o : \gamma = 0$ **)**.

ii. The test for inefficiency determinants if would able to explain the technical inefficiency in container terminals of Tanzania also was conducted **(** $H_o : \delta_1 = \delta_2 = 0$ **)**.

iii. The second order of the coefficients in translog function is equal to zero, and then the Cobb-Douglas function should in favor **(** $H_o : \beta_{ij} = 0$ **).**

iv. The technical efficiency of the container terminal is varied overtime period **(** $H_o : \eta = 0$ **)**.

v. The technical coefficient parameters of input factors are not significant to the production of container terminals (P-value<5%).

The postulates (i - iv) usually follow direct the above-listed procedures while the postulate (v) has unique procedures. After estimating the model, the postulate (v) assessed by comparing directly the P-value of corresponding parameters obtained from the estimated model with desired significant value. The significant value desired depends on the nature of the research objectives and the interest of the researcher.

In order to decide if a model would provide a more accurate representation of data in the container terminals, several tests of the null hypothesis concerning the nature of

Table 5.5 Hypothesis of Production Model

Null hypothesis	Model	Log-Likelihood function	Test Statistic (λ)	Critical value (5%)	Decision
$H_o : \gamma = 0$	1.2.2	17.985	36.380	2.706	Rejected H_0
	1.2.1	15.866	36.176	2.706	Rejected H_0
	1.1.2	16.870	34.150	2.706	Rejected H_0
$H_o : \delta_1 = \delta_2 = 0$	1.2.2	17.985	36.380	5.138	Rejected H_0
	1.2.1	15.866	36.176	5.138	Rejected H_0
$H_o : \beta_{ij} = 0$	2.2.2	18.001	36.412	Undefined	Not rejected H_0
	2.2.1	15.883	36.176	Undefined	Not rejected H_0
	2.1.2	16.870	34.150	Undefined	Not rejected H_0
$H_o : \eta = 0$	1.1.2	16.870	34.150	2.706	Rejected H_0

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 obtained directly from the estimated maximum likelihood model (see the Table 5.4), the test statistics value found from the application of the equation number (ii) of hypothesis procedures.

the product function, and inefficiency effects were carried out. The relative more significant value of likelihood function is satisfactory, indicating that the model is a good fit for the dataset. In this study the most acceptable model was 1.2.2 which exhibits higher log-likelihood function. The decision is due to the log-likelihood is higher enough to surpass critical value at certain level of significant. The following are the description of the null hypothesis and their meaning on the decision was taken from each postulate

Hypothesis I ($H_o : \gamma = 0$)

"There is no technical inefficiency in the estimated models of container terminals."

If the inefficient effects in the production model are not present, this is implying that among container terminals are full of technical efficiency. By referring on our three model result presented in the table above, the Gamma parameter in all models has proven the rejected of the null hypothesis and are significantly different from zero. This is because the likelihood ratio statistics (model 1.1.2 = 34.150; model 1.2.1 = 36.176; and model 1.2.2 = 36.380) revealed greater than the critical value ($\chi^2(1,0.05) =$ 2.706). Then the null hypothesis is full rejected and concluded that in all estimated models element of inefficiency exist and given rational justification to proceed with maximum likelihood estimate

Hypothesis II ($H_o : \delta_1 = \delta_2 = 0$)

"Technical inefficiency is not affected by the independent variable included in the model"

Since the coefficients of all explanatory variables in the inefficiency model are simultaneously equal to zero, they are not useful in describing the inefficiencies of container terminals. By considering the inefficiency models (model 1.2.1 and model 1.2.2) of container terminals in the study, the likelihood ratio (λ) of that model are (36.380; and 36.176) respectively which are greater than Critical value (5.138) for both model (noted that all models have the same number of restriction than the same critical value appreciated). The results in Table 5.5 suggest that the determinants of technical inefficiency model affect the model.

Therefore the null hypothesis is full rejected for all two models and concludes that determinant of inefficient (Private participation and quality of cargo handling) strongly affect the technical inefficient among container terminals in Tanzania

Hypothesis III ($H_o : \beta_{ij} = 0$)

"The Cobb – Doglous function is appropriate than the Translog function to estimate parameter and technical efficiency."

If the two different production functions used in the study, the decision to test the nature of the function demanded if the second-order of coefficients associated with Translog production is equal to zero, then the Cobb-Douglas function should be applied to estimate parameters and efficiency.

In this study, all three models (2.1.2; 2.2.1; and 2.2.2) that have estimated in the truncated normal distribution, the squared factors, and interaction between the factors omitted. This result leads to a complicated description of the factors, and therefore, the null hypothesis should be rejected, and we concluded that the Cobb-Douglas function is in favor as compared to Translog.

Hypothesis IV ($H_o : \eta = 0$ **)**

"The fluctuation of technical efficiency of container terminals is not due to the period of time"

If the value of the estimated parameter (Eta = (η)) approaches to zero indicating that the technical efficiency among container terminals changes over time within individual terminals. This hypothesis validated under consideration of the model 1.1.2 which is a time-varying model

In this study, the value of the parameter (Eta) found to approaches Zero (0.240), meaning that in every individual terminal, the value of efficiency does not change across the period of study. Therefore, we strongly not rejected the null hypothesis and concluded that the fluctuation of efficiency of container terminals is constant across the periods for each container terminals understudy

Hypothesis V (P-value<0.05**)**

"The technical coefficient parameters of the input factors are not significant to the production efficiency of container terminals

The evaluation of technical coefficients parameters of the production model depend on the level of significance such that; if the value of the technical coefficient proves lower than the p-value (decision criteria) then we can conclude that the corresponding individual input is significant otherwise insignificant.

In the Table 5.4 we found that consistent results to all models, and hence we achieve the same conclusion on those parameter coefficients of the input factors that are significant because the null hypothesis rejected. Therefore, the results suggest that all factors (quay crane, terminal area, and berth length) employed in the production process among the container terminals and are well explaining the dependent variable (berth throughput) employed in the study. However, the quay crane and berth length both have negative influence in production process under the period of study, while terminal area has positive effects on the pushing output among container terminals.

5.7 Technical Efficiency Indices

Empirically our measurements rely on nine years panel containing (36) observations of four (4) container terminals in Tanzania. Mathematical models for calculating individual technical efficiency indices have shown in Chapter 3

Table 5.6 Technical Efficiency Indices over Time

Model 1.2.2	2010	2011	2012	2013	2014	2015	2016	2017	2018
Dar es Salaam	0.589	0.712	0.849	0.966	0.960	0.997	0.907	0.756	0.881
Tanga	0.952	0.995	0.929	0.971	0.967	0.811	0.637	0.470	0.479
Mtwara	0.435	0.430	0.997	0.867	0.825	0.752	0.820	0.934	0.993
Zanzibar	0.513	0.670	0.839	0.899	0.997	0.934	0.943	0.890	0.981
Model 1.2.1									
Dar es Salaam	0.556	0.680	0.821	0.945	0.951	0.999	0.921	0.777	0.916
Tanga	0.937	0.992	0.937	0.992	0.999	0.849	0.675	0.504	0.520
Mtwara	0.397	0.397	0.932	0.820	0.791	0.729	0.805	0.928	0.999
Zanzibar	0.471	0.623	0.790	0.857	0.962	0.913	0.932	0.891	0.999
*Model 1.1.2									
Dar es Salaam	0.764	0.764	0.764	0.764	0.764	0.764	0.764	0.764	0.764
Tanga	0.904	0.904	0.904	0.904	0.904	0.904	0.904	0.904	0.904
Mtwara	0.715	0.715	0.715	0.715	0.715	0.715	0.715	0.715	0.715
Zanzibar	0.736	0.736	0.736	0.736	0.736	0.736	0.736	0.736	0.736

*For model 1.1.2; is a time-varying model, the technical efficiency is constant over periods. Usual indices estimated after estimate maximum likelihood parameters

The efficiency value always estimated between 0 and 1, with 1 value being the most efficient otherwise the lower the efficiency. If the terminal is fully efficient, the necessity of adding input factors not appreciated to maximize output as the focus of the producers.

In this study efficiency indices for all three models are generated across container terminals after estimating parameter coefficients. In Table 5.6 represent individual efficiencies of container terminals from all relevant models 1.2.2; 1.2.1; and 1.1.2. Regarding to the model 1.2.2, we observe that there is a constant improvement in technical efficiency in all container terminals over periods under study.

Dar es Salaam terminals experienced a gradual increase from the year 2010 and approached close to the frontier for four consecutive periods from 2013 to 2016 and after that slightly drop. The closeness to the frontier suggests that the terminal induces more significant effort on technology to improve efficiency.

For Tanga terminal, the result has shown that there is fluctuation of efficiency and gradual increases inefficient from year 2015 to 2018, for the negative growth of efficiency implies that less effort exerted by terminal authority to improving efficiency in the terminals. The increasing inefficient in this terminal could justified by insufficient output displayed in Table 4.1, while no evidence of adjustment of input factors.

Coming to the Mtwara terminal, where the peak value reached closest to the production frontier observed in 2012, then gradual decrease efficient until 2016 and onward improve operating efficiency on handling container cargo. The recent improvement probable contributed by adding berth throughput due to increase productivity in the zonal port area where the introduction of cement, and increases productivity of nuts cashew commodity

Zanzibar terminals observed the tendency of gradual improvement of the operating efficiency from 2010 up to the year 2014, where the terminal reached closest to the production frontier after that, slightly efficiency improvement fluctuated with a little deviation between periods. This improvement might be a more significant

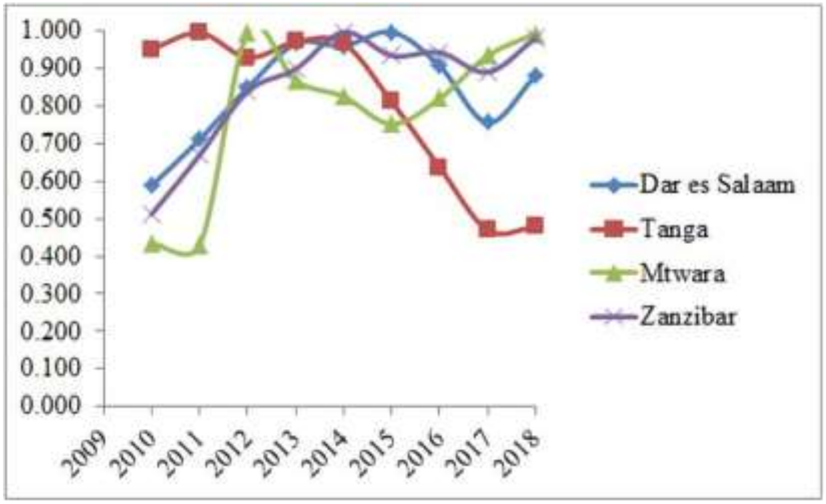

Figure 5.2 Efficiency Estimated from Model 1.2.2

effort exerted by authority on technological modification such as channel dredged and reserved allocation area outside of the port for empty container storage, which significantly reduces the congestion and improves efficiency. For this reason quality of handling container can be experienced even though empirical evidence is lacking.

In general operating efficiency among container terminals in Tanzania has shown a reasonable effort of improving handling of container cargo over periods. Figure 5.2 shows the pattern of terminals efficiency improvement across period of time under the study

Overall Container Terminals Efficiency

After estimating the individual efficiency indices, the heading stage was to calculate the average efficiency across container terminals. The average efficiency obtained by the summation of individual indices across periods divides by number of span periods studied. If an average efficiency close to 1, implying that the improvement in technical efficiency for container terminals was able to push output in the terminals close to the potential output level. For average technical efficiency across the container terminals, according to the model 1.2.2 represented in Table 5.7

with ranks signed accordingly. The higher the efficiency value, the higher the rank among the terminals.

The discussion involving efficiency analysis of this study referred to the model 1.2.2. The most technical efficiency terminal ranked at Zanzibar terminal, which overtakes terminal of Dar es Salaam for small difference of 0.006, while the least ranked terminal was found to be Mtwara with worth value 0.784 of average operating efficiency during the nine periods. However all terminals have deviated far from the production frontier. These results show 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.

Table 5.7 Average Technical Efficiencies Ranked among Terminals

Terminals	Technical Efficiency	Rank
Dar es Salaam	0.846	2
Tanga	0.801	3
Mtwara	0.784	4
Zanzibar	0.852	1

To compare the results with similar application in the literature, it found that the container port of Shanghai, Singapore, Shenzhen, Ningbo, and Dalian are the extreme efficient container ports among 26 major world ports which characterize the higher number of Containers (Hlali, 2017, and Hlali, 2018). These results have shown contrast with all container terminals in Tanzania which are almost efficiency with small number of container handling. The best efficiency port was upholding the average efficiency of 0.876, while in the present study the best terminals were sustained to the average efficiency of 0.852. The results illustrate that five ports among 26 have better management practices than container terminals of Tanzania.

The estimation of the efficient frontier reveals that no single port in the sample of developing economies has reached a full efficient input combination. The highest-ranked port reached a technical efficiency score of 85% over 2000–2010

(Suárez-Alemán et al., 2015). This result supporting the results found in the present study since the highest-ranked was reached efficiency scores 85.2%. The exciting results found in the Dar es Salaam port the efficiency was relative intermediate by score 0.660, while Tunjung Perak port was found lower than of about 0.550 scores of efficiency (Suárez-Alemán et al., 2015). It noted that the most efficient port in this study was (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 – Tunisia) from Africa.

In the cross-sectional study of Sub-Saharan African ports, the study results show that Mombasa port was full efficiency while the mean scores of technical efficiency of Dar es Salaam port were relative efficiency with scores of 0.813 (Carine, 2015). These results entirely support the present study for which Dar es Salaam own efficiency index with mean score of 0.846 higher than the scores of (Carine, 2015). This result has shown for the Dar es Salaam terminals witnessed improvement of infrastructures from 2015 to 2018 which lead efficiency. However still there are ongoing improvements in container handling infrastructures, which might bring improvement on efficiency of cargo handling.

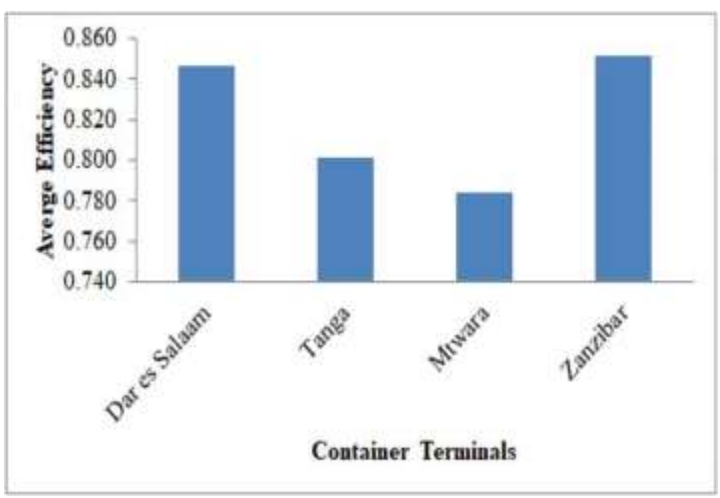

Figure 5.3 Efficiency Indices Ranked from Model 1.2.2

Table 5.8 shows the summary of technical efficiency indices among models of container terminals presented. The measure of descriptive includes mean, standard deviation, minimum and maximum value of technical efficiency presented

Regarding to the best model suggested in this study (model 1.2.2). On average a typical container terminal in the sample during the periods has efficiency level about 0.821 meaning that the terminal operating at 82.1% below the maximum potential output on the frontiers. Similarly, by holding the input factor constant there was possibility of terminals would increase efficiency by 17.9%.

The minimum efficiency level among container terminal was 0.430; indicating that the typical terminal operating at 43% below the maximum potential output, there was the possibility of increasing efficiency by 57% if the technical factors remain constant The maximum technical efficiency recorded about 0.997, which implies that the typical 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%

Table 5.8 Descriptive of Technical Efficiency Models

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

Models correlation

Among all models (1.2.1; 1.2.2; and 1.1.2), their correlation of estimated technical efficiency has drama interpretation. Only model 1.2.1 has highly correlated with model 1.2.2, while the correlation between model 1.2.1 and 1.1.2 is negative and very weak. The results indicate that the model 1.2.2 and 1.2.1 have great venue for its respect efficiency to be more meaningful for intervene in policy decision making

Table 5.9 Correlations among Technical Efficiency Models

	Model 1.2.1	Model 1.2.2	Model 1.1.2
Model 1.2.1	1		
Model 1.2.2	0.801	1	
Model 1.1.2	-0.208	0.403	1

Relationship between Throughput and Technical efficiency

The study reveals that there is no constant relation shown among the terminals in the scale productivity against the efficiency. The higher productive terminals improved its efficiency technically over periods of time same as the fewer productive terminals. Therefore the study criticizes linear relationship of the production theory that the higher output produced the more operational efficiency. It is not always exist depending the infrastructures and facility of the operating terminals.

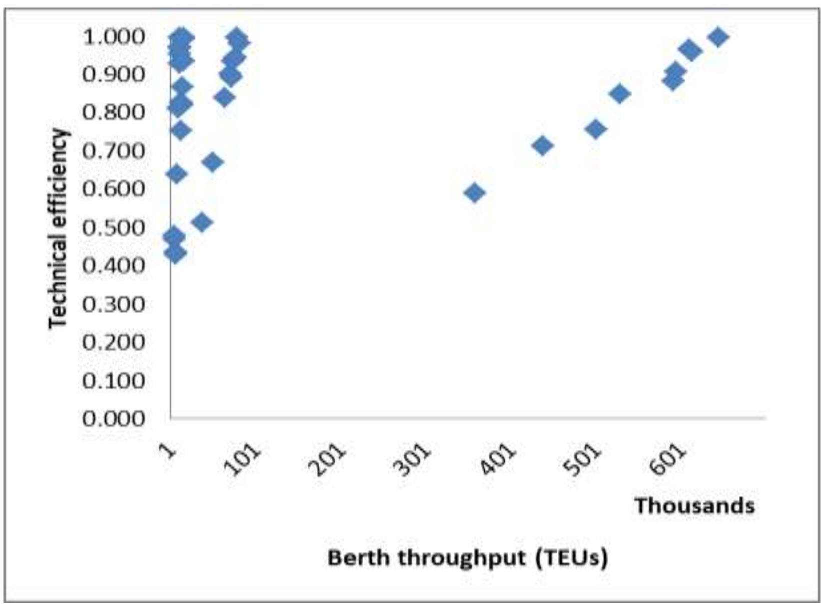

Figure 5.4 Efficiency against Throughput (TEUs)

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CHAPTER 6
CONCLUSION AND RECOMMENDATION

In the country which has a less sophisticated ports system, the development of port infrastructure and facilities should be paid special attention for the port to accommodate business activities. Seaport infrastructures influence the business activities and hence, economic growth of the region. This study builds an empirical model under the stochastic frontier analysis framework (1.2.2) to study the efficiencies of container terminals in Tanzania ports. The model built upon the recent panel data covering nine years (2010-2018). The empirical model evaluates technical efficiency of four container terminals. The following are conclusion of the study results and some recommendation.

Conclusions

The main findings of the study are summarized as follow

- The terminal area was found to be only relevant factor of production among container terminals in Tanzania, while berth length and quay crane are otherwise. According to our model revealed that the efficient terminal area is Zanzibar as compared to other terminals.
- Few operating resources are still used among terminals (decreasing return to scale), which indicate that shortage of container handling infrastructures faces among terminals
- Private contribution and quality of cargo handling are insignificant factors to technical inefficient. It found that technical efficiency among terminals in Tanzania does not have a linear relationship with private participation and quality of cargo handling. The most efficiency terminals (Zanzibar) operate without private contributions.
- Cobb-Douglas function appears to be highly accurate explaining our datasets

- As our best-selected model 1.2.2, the lowest efficiency index was 0.473, and the highest was 0.997 among terminals across the period of study
- On average, the most highly efficient terminal in container cargo handling observed is Zanzibar, and the least is Mtwara terminal.

For the terminals of Zanzibar and Dar es Salaam have emerged extremely efficient technical, even though it recognized that they faced with the problem of port congestion. However, port congestion in container terminals is unavoidable; every service made to services their customer base to the maximum of their capacity.

Recommendations

The following are some recommendation provided due to finding observed

- Several factors were excluded in this study due to the difficult of data availability and time constraint. These factors have a contribution to the influence efficiency of container terminals. Those factors include operational time, berth occupancy, ship call, and handling speeds of cranes. It would be appropriate to consider more exogenous factors that may influence the efficiency of container terminal such as hinterland connectivity, GDP, trade volume, corruption and so on
- Since the inefficiency factors were indeed explaining the inefficiency of container terminals, the following suggestion provided to the authorities and practicing personnel that
    - (i) The collaboration between private and public sectors became substantially in the port of Tanzania, since the modern port shift towards the private sector investment both infrastructures development and operation
    - (ii) Terminals or ports authority of Tanzania should promote higher degree of mechanization to reduce inefficiency levels
- Since the model obtained in the present study is applicable only for Tanzania Container Terminals, the container terminals' authority of Tanzania ports should redesign their terminals' commercial policy in order to act proactively and reduce idle capacity by attracting more cargo

- More categories are needed for the quality of cargo handling and private sector participation variable to capture deep information. Since the few categories may not reflect the results in the study analysis

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References

African Development Bank (2010), *African Development Report. Ports, logistics, and trade in Africa, Oxford University Press Inc., New York*

Ago, T. E., Hualong, Y. and Fousseni, G. M. (2016), "Container Ports Throughput Analysis: A comparative evaluation of China and five West African Countries Seaports efficiencies," *International Journal of Engineering Research in Africa,* Vol. 22, P. 162-173.

Aigner, D., Lovell, C. A. K. and Schmidt, P. (1977), "Formulation and Estimation of Stochastic Frontier Production Function Models," *Journal of Econometrics*, Vol. 6, P. 21–37.

Almawsheki, E. S. and Shah, M. Z. (2015), "Technical Efficiency Analysis of Container Terminals in the Middle Eastern Region," *Asian Journal of Shipping and Logistics*. Vol. 31, No. 4, P. 477–486.

Banker, R. D., Charnes, A., and Cooper. w. w. (1984), "Some Model for Estimating Technical Efficiency and Scale Inefficiency in Data Envelopment Analysis," *Management Science,* Vol. 30, No. 9, PP. 1078-1092

Battese, G.E., and Coelli, T.J., (1992), "Frontier production functions, technical efficiency and panel data: with application to paddy farmers in India." *J. Prod. Anal*. Vol. 3 No. 1–2, P. 153–169.

Battese, G.E., and Coelli, T.J., (1995), "A model for technical inefficiency effects in a stochastic frontier production function for panel data." *Empirical. Economics*. Vol. 20 No. 2, P. 325–332.

Boussofiane, A., Dyson, R. G. and Thanassoulis, E. (1991), "Applied Data Envelopment Analysis," *European Journal of Operational Research,* Vol. 52, No. 1, P. 1-15

Carine, A. C. F. (2015), "Analyzing the Operational Efficiency of Container Ports in Sub-Saharan Africa," *Open Journal of Social Sciences*, Vol. 3, P. 10-17

CMA CGM (2018), "Emergency Port Congestion Surcharge in Zanzibar," Available at https://www.cma-cgm.com/. Retrieved 15/06/2019.

D. A. Kodde and F. C. Palm (1986), "Wald Criteria for Jointly Testing Equality and Inequality Restrictions," Econometrica, Vol. 54, No. 5, 1986, pp. 1243-1248

Demirel, B. Cullinane, K. and Haralambides, H. (2012), "Container Terminal Efficiency and Private Sector Participation," *The Blackwell Companion to Maritime Economics*, Blackwell Publishing Ltd

DLCA. (2019), "Logistic Capacity Assessment," Available at https://dlca.logcluster.org/display/public/DLCA/2.1.3+Tanzania+Port+of+Tanga, retrieved at 15/06/2019 LCA

Elferjani, I. S. A. (2015), *Examination of Port Performance in a Developing Economy : A case study of Libyan ports*, Thesis Ph. D., College of Business, RMIT University

Farrell, M. J. (1957), "Measurement Productivity Efficiency" *Journal of the Royal Statistical Society.* Series A (General), Vol. 120, No. 3, P. 253–290.

Hlali, A. (2017), "Efficiency of the 26 major container ports in 2015: comparative analysis with different models", *International Journal of Economics & Strategies Management of Business,"* Vol. 10, P. 15-20

Hlali, A. (2018), "Efficiency Analysis with Different Models: The Case of Container Ports," *Journal of Marine Science: Research & Development*, Vol. 8, No. 2, P. 2155-9910

Hooper, P. G. (1985), *"Measuring Productivity in Transport : Some Lessons from Studies in the U. S. A,"* Royal Melbourne Institute of Technology', P. 287–305.

Kahyarara, G. and Simon, D. (2018), "Opportunity and Growth Diagnostic of Maritime Transportation in the Eastern and Southern Africa," *University of Dar-es-Salaam, United Republic of Tanzania*, Ad hoc expertise meeting under IAME conference

Kodde D. A. and Palm F. C., 1986. "Wald Criteria for Jointly Testing Equality and Inequality Restrictions*," Econometrica*, Vol. 54, No. 5, P. 1243-1248

Liu, Q. (2010), *"Efficiency Analysis of Container Ports and Terminals,"* Thesis Ph.D. University College London

Liu, Z. (1995), "The comparative performance of public and private enterprises: the case of British ports." *Journal of Transport Economics and Policy*, 29 (3), 263–274

Lopez-Bermudez, B., Freire-Seoane, M. J. and Gonzalez-Laxe, F. (2018), "Efficiency and Productivity of Container Terminals in Brazilian ports (2008–2017)", *Journal of Utilities Policy,* Vol. 56, P. 82–91.

Meeusen, W., van den Broeck, J., (1977), "Efficiency estimation from Cobb–Douglas production functions with composed error." *International Economic Review* 18 (2), 435–444.

Nathan Associate Inc (2014), "Multipurpose Port Development in Zanzibar," *Preliminary Assessment of PPP Options*

Notteboom, T., Coeck C., and Van Den Broeck, J. (2000), "Measuring and Explaining the Relative Efficiency of Container Terminals by means of Bayesian Stochastic Frontier Models" *IJME*, Vol. 2, No. 2, P. 83-106

OPM. (2015), "OPM Terminal management system and container handling facilities," Available at http://www.opm18.com/terminal.html, Retrieved on 20/06/2019.

PricehousewaterCoopers (2018), "An Analysis of Port Development in Sub-Saharan Africa" www.pwc.co.za/African-ports

Reker, R. A., Connell, D., and Ross, D. I. (1990) "*The Development of a Production Function for a Container Terminal in the Port of Melbourne,"* Australian Transport Research Forum, PP. 209–218.

Suárez-Alemán, A., Sarriera, J. M., Serebrisky, T. and Trujillo, L. (2015), "When it comes to container port efficiency, are all developing regions equal?", *Inter-American Development Bank,* working paper series no. IDB-WP-568

Talley, W. K. (2015), *"Container Port Efficiency and Output Measures,"* The Old Dominion University, Norfolk, Virginia, 23529 U.S.A.

Tanzania Ports Authority (2016), "*Annually report and audited account,"* Bandari road Kurasini, Dar es Salaam-Tanzania

Tanzania Ports Authority (2019), *"Tanzania Ports handbook 2019-2020"*, Bandari road Kurasini, Dar es Salaam-Tanzania

United Nations Conference on Trade and Development (2017), *Review of Maritime Transport.* Palais des Nations, 1211 Geneva 10, Switzerland

United Nations Conference on Trade and Development (2018), *Review of Maritime Transport.* Palais des Nations, 1211 Geneva 10, Switzerland

Wang, T. (2004), "Analysis of the Container Port Industry Using Efficiency Measurement: A Comparison of China with its International Counterparts," Thesis Ph.D. The Hong Kong Polytechnic University

Wang, T., Cullinane, K. and Song, D. (2003), "Container Port Production Efficiency: a Comparative Study of DEA and FDH Approaches," *Journal of the Eastern Asia Society for Transportation Studies*, Vol. 5, No. 1, P. 698–701.

WPS. (2019), "Port of Mtwara," Available at http://www.worldportsource.com/ports/maps/TZA_Port_of_Mtwara_1467.php, retrieved at 15/06/2019

Yang, H., Kennedy, O. R., Lin, K. and Ruth, B. (2011), "Sea-Port Operational Efficiency: An Evaluation of Five Asian Ports Using Stochastic Frontier Production Function Model," *Journal of Service Science and Management,* Vol. 4, No. 3, P. 391–399.

Zheng, X. B., and Park, N. K. (2016), "A Study on the Efficiency of Container Terminals in Korea and China," *Asian Journal of Shipping and Logistics*, Vol. 32, No. 4, P. 213–220.

BIOGRAPHY

The authors' name is Adam Ali, born in March 03, 1980 Tumbatu Island Zanzibar-Tanzania. His religion is Islam. His way of higher education start by graduates diploma in education in 2006 at Nkrumah Teacher Training Collage, Zanzibar followed by Diploma in Statistics in 2008 and thereafter graduates Bachelor of Official Statistics in 2015 at Eastern African Statistical Training Centre (EASTC), Dar es Salaam-Tanzania as a professional institution established at 1965.

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APPENDICES

The appendices section consist the potential description which are not included in the main text of this report. These appendices include Appendix 1, which shows the template of dataset supposed to be prepared in the STATA template. Appendix 2, has shown the results or output of STATA after writing the model code in the software. Therefore all six model result both Cobb-Douglas and Translog were presented in this section. Appendix 3, consist the approved latter for data collection in Zanzibar Port Corporation and Tanzania Port Authority. Finally, the Appendix 4, involve the table result of development and categorization of quality of Cargo handling as a variable used in inefficient model.

Appendix 1 STATA Template of Dataset

Terminal Name	Year	id	Y	QC	SY	BL	PP	QCH	lnY	lnQC	lnSY	lnBL	lnQC^2	lnSY^2	lnBL^2	lnQC*lnSY	lnQC*lnBI	lnSY*lnBI
Dar es Salaam	2010	1	359010	6	187500	725	1	1	12.79	1.792	12.142	6.586	1.792	12.14	6.586	1189.061	11.801	79.966
Dar es Salaam	2011	1	439464	6	187500	725	1	1	12.99	1.792	12.142	6.586	1.792	12.14	6.586	1189.061	11.801	79.966
Dar es Salaam	2012	1	530089	6	187500	725	1	1	13.18	1.792	12.142	6.586	1.792	12.14	6.586	1189.061	11.801	79.966
Dar es Salaam	2013	1	610503	6	187500	725	1	1	13.32	1.792	12.142	6.586	1.792	12.14	6.586	1189.061	11.801	79.966
Dar es Salaam	2014	1	614555	6	187500	725	1	1	13.33	1.792	12.142	6.586	1.792	12.14	6.586	1189.061	11.801	79.966
Dar es Salaam	2015	1	645561	6	187500	725	1	1	13.38	1.792	12.142	6.586	1.792	12.14	6.586	1189.061	11.801	79.966
Dar es Salaam	2016	1	595109	6	187500	725	1	1	13.3	1.792	12.142	6.586	1.792	12.14	6.586	1189.061	11.801	79.966
Dar es Salaam	2017	1	501690	6	187500	725	1	1	13.13	1.792	12.142	6.586	1.792	12.14	6.586	1189.061	11.801	79.966
Dar es Salaam	2018	1	592000	6	187500	725	1	1	13.29	1.792	12.142	6.586	1.792	12.14	6.586	1189.061	11.801	79.966
Tanga	2010	2	11262	2	16430	381	0	0	9.329	0.693	9.707	5.943	0.693	9.707	5.943	0.029	4.119	57.686
Tanga	2011	2	11922	2	16430	381	0	0	9.386	0.693	9.707	5.943	0.693	9.707	5.943	0.029	4.119	57.686
Tanga	2012	2	11262	2	16430	381	0	0	9.329	0.693	9.707	5.943	0.693	9.707	5.943	0.029	4.119	57.686
Tanga	2013	2	11922	2	16430	381	0	0	9.386	0.693	9.707	5.943	0.693	9.707	5.943	0.029	4.119	57.686
Tanga	2014	2	12013	2	16430	381	0	0	9.394	0.693	9.707	5.943	0.693	9.707	5.943	0.029	4.119	57.686
Tanga	2015	2	10207	2	16430	381	0	0	9.231	0.693	9.707	5.943	0.693	9.707	5.943	0.029	4.119	57.686
Tanga	2016	2	8118	2	16430	381	0	0	9.002	0.693	9.707	5.943	0.693	9.707	5.943	0.029	4.119	57.686
Tanga	2017	2	6057	2	16430	381	0	0	8.709	0.693	9.707	5.943	0.693	9.707	5.943	0.029	4.119	57.686
Tanga	2018	2	6257	2	16430	381	0	0	8.741	0.693	9.707	5.943	0.693	9.707	5.943	0.029	4.119	57.686
Mtwara	2010	3	7074	3	27500	385	0	0	8.864	1.099	10.222	5.953	1.099	10.22	5.953	2.615	6.540	60.854
Mtwara	2011	3	7076	3	27500	385	0	0	8.864	1.099	10.222	5.953	1.099	10.22	5.953	2.615	6.540	60.854
Mtwara	2012	3	16601	3	27500	385	0	0	9.717	1.099	10.222	5.953	1.099	10.22	5.953	2.615	6.540	60.854
Mtwara	2013	3	14609	3	27500	385	0	0	9.589	1.099	10.222	5.953	1.099	10.22	5.953	2.615	6.540	60.854
Mtwara	2014	3	14081	3	27500	385	0	0	9.553	1.099	10.222	5.953	1.099	10.22	5.953	2.615	6.540	60.854
Mtwara	2015	3	12982	3	27500	385	0	0	9.471	1.099	10.222	5.953	1.099	10.22	5.953	2.615	6.540	60.854
Mtwara	2016	3	14337	3	27500	385	0	0	9.571	1.099	10.222	5.953	1.099	10.22	5.953	2.615	6.540	60.854
Mtwara	2017	3	16528	3	27500	385	0	0	9.713	1.099	10.222	5.953	1.099	10.22	5.953	2.615	6.540	60.854
Mtwara	2018	3	17796	3	27500	385	0	0	9.787	1.099	10.222	5.953	1.099	10.22	5.953	2.615	6.540	60.854
Zanzibar	2010	4	38806	1	12000	382	0	1	10.57	0.000	9.393	5.945	0.000	9.393	5.945	0.000	0.000	55.843
Zanzibar	2011	4	51344	1	12000	382	0	1	10.85	0.000	9.393	5.945	0.000	9.393	5.945	0.000	0.000	55.843
Zanzibar	2012	4	65053	1	12000	382	0	1	11.08	0.000	9.393	5.945	0.000	9.393	5.945	0.000	0.000	55.843
Zanzibar	2013	4	70592	1	12000	382	0	1	11.16	0.000	9.393	5.945	0.000	9.393	5.945	0.000	0.000	55.843
Zanzibar	2014	4	79256	1	12000	382	0	1	11.28	0.000	9.393	5.945	0.000	9.393	5.945	0.000	0.000	55.843
Zanzibar	2015	4	75161	1	12000	382	0	1	11.23	0.000	9.393	5.945	0.000	9.393	5.945	0.000	0.000	55.843
Zanzibar	2016	4	76787	1	12000	382	0	1	11.25	0.000	9.393	5.945	0.000	9.393	5.945	0.000	0.000	55.843
Zanzibar	2017	4	73351	1	12000	382	0	1	11.2	0.000	9.393	5.945	0.000	9.393	5.945	0.000	0.000	55.843
Zanzibar	2018	4	82312	1	12000	382	0	1	11.32	0.000	9.393	5.945	0.000	9.393	5.945	0.000	0.000	55.843

Appendix 2 Cobb-Douglas and Translog Output

- Cobb-Douglas models estimated (1.2.1; 1.2.2; and 1.1.2)

The model 1.2.1 estimated as shown below and would presented as

$$\ln Y = -13.793 - 4.916X_1 + 4.701X_2 - 3.204X_3 + V_i - U_i$$

$$U_i = -5.411 - 1.093Z_1 - 1.885Z_2 + W_i$$

```
. *(19 variables, 36 observations pasted into data editor)

. xtset id year, yearly
       panel variable:  id (strongly balanced)
        time variable:  year, 2010 to 2018
                delta:  1 year

. sfpanel lny lnqc lnsy lnbl, model(bc95) dist(tn) emean( pp qch) ort(o)


initial:       Log likelihood = -75.534044
Iteration 0:   Log likelihood = -75.534044
Iteration 1:   Log likelihood = -61.985463  (backed up)
Iteration 2:   Log likelihood = -55.105326
Iteration 3:   Log likelihood = -29.811881
Iteration 4:   Log likelihood = -28.789499  (backed up)
.                    .                    .
.                    .                    .
.                    .                    .
Iteration 97:  Log likelihood =  15.864924  (backed up)
Iteration 98:  Log likelihood =  15.865653  (backed up)
Iteration 99:  Log likelihood =  15.866405  (backed up)
Iteration 100: Log likelihood =  15.866428  (backed up)

Inefficiency effects model (truncated-normal)      Number of obs =        36
Group variable: id                                 Number of groups =      4
Time variable: year                                Obs per group: min =    9
                                                                  avg =  9.0
                                                                  max =    9

                                                   Prob > chi2    =   0.0000
Log likelihood =    15.8664                        Wald chi2(3)   = 2.75e+07
```

lny	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Frontier						
lnqc	-4.916337	.0046482	-1057.69	0.000	-4.925447	-4.907227
lnsy	4.701042	.0064643	727.23	0.000	4.688372	4.713712
lnbl	-3.203544	.0150181	-213.31	0.000	-3.232979	-3.174109
_cons	-13.79343	.0298915	-461.45	0.000	-13.85202	-13.73484
Mu						
pp	-1.092574	4.251205	-0.26	0.797	-9.424783	7.239635
qch	-1.88541	3.955456	-0.48	0.634	-9.63796	5.867141
_cons	-5.410775	8.675848	-0.62	0.533	-22.41512	11.59358
Usigma						
_cons	.5090248	1.454533	0.35	0.726	-2.341808	3.359858
Vsigma						
_cons	-20.13061	10.69863	-1.88	0.060	-41.09953	.838322
sigma_u	1.289833	.9380523	1.38	0.169	.3100864	5.365175
sigma_v	.0000425	.0002275	0.19	0.852	1.19e-09	1.520685
lambda	30327.66	.9380541	3.2e+04	0.000	30325.82	30329.5

General Linear Model Related to Model 1.2.1

```
. glm lny lnqc lnsy lnbl

Iteration 0:   log likelihood = -2.2215724

Generalized linear models                          No. of obs      =         36
Optimization     : ML                              Residual df     =         32
                                                   Scale parameter =   .0745211
Deviance         =  2.384674314                    (1/df) Deviance =   .0745211
Pearson          =  2.384674314                    (1/df) Pearson  =   .0745211

Variance function: V(u) = 1                        [Gaussian]
Link function    : g(u) = u                        [Identity]

                                                   AIC             =   .3456429
Log likelihood   = -2.221572367                    BIC             =  -112.2879
```

lny	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnqc	-4.785602	.4299654	-11.13	0.000	-5.628319	-3.942885
lnsy	4.380176	.5872359	7.46	0.000	3.229214	5.531137
lnbl	-2.152651	1.431097	-1.50	0.133	-4.95755	.6522479
_cons	-17.24124	3.275579	-5.26	0.000	-23.66126	-10.82122

The model 1.1.2 estimated as shown below and would represented as

$$\ln Y = 290.223 - 7.385X_1 + 8.018X_2 - 10.669X_3 - 0.144T + V_i - U_i$$

```
. sfpanel lny lnqc lnsy lnbl year, model(bc92) dist(tn) ort(o)


initial:        Log likelihood = -97.089059
Iteration 0:    Log likelihood = -97.089059  (not concave)
Iteration 1:    Log likelihood = -34.081997  (not concave)
Iteration 2:    Log likelihood = -17.785916  (not concave)
Iteration 3:    Log likelihood = -17.275988  (not concave)
Iteration 4:    Log likelihood = -16.530847  (not concave)
Iteration 5:    Log likelihood = -2.0974244  (not concave)
Iteration 6:    Log likelihood =  1.5252691  (not concave)
Iteration 7:    Log likelihood =  1.9796682  (not concave)
.                     .                    .
.                     .                    .
.                     .                    .
Iteration 30:   Log likelihood =  16.869761
Iteration 31:   Log likelihood =  16.869796
Iteration 32:   Log likelihood =  16.869796

Time-varying decay model (truncated-normal)         Number of obs =        36
Group variable: id                                Number of groups =         4
Time variable: year                              Obs per group: min =         9
                                                               avg =       9.0
                                                               max =         9

                                                    Prob > chi2   =    0.0000
Log likelihood =    16.8698                         Wald chi2(4)  =   1667.28
```

lny	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Frontier						
lnqc	-7.38457	1.020587	-7.24	0.000	-9.384885	-5.384256
lnsy	8.017658	1.422583	5.64	0.000	5.229447	10.80587
lnbl	-10.66783	3.344964	-3.19	0.001	-17.22384	-4.111819
year	-.1440192	.0686475	-2.10	0.036	-.2785659	-.0094725
_cons	290.2279	144.2516	2.01	0.044	7.499877	572.9559
/lnsigma2	-3.779758	.6563273	-5.76	0.000	-5.066136	-2.49338
/ilgtgamma	-.5165532	1.896785	-0.27	0.785	-4.234184	3.201077
/mu	.2513216	.29941	0.84	0.401	-.3355112	.8381543
/eta	.2398344	.0885564	2.71	0.007	.066267	.4134017
sigma2	.0228282	.0149828			.0063067	.0826302
gamma	.3736586	.4439195			.0142846	.9608748
sigma_u2	.00853	.0154779			-.0218062	.0388661
sigma_v2	.0142983	.0037244			.0069986	.0215979

The model 1.2.2 estimated as shown below and would presented as

$$\ln Y = -40.315 - 4.641X_1 + 4.319X_2 - 2.292X_3 + 0.012T + V_i - U_i$$

$$U_i = -2.467 + 0.098Z_1 - 1.659Z_2 + W_i$$

```
. sfpanel lny lnqc lnsy lnbl year, model(bc95) dist(tn) emean( pp qch) ort(o)

initial:       Log likelihood = -75.789567
Iteration 0:   Log likelihood = -75.789567
Iteration 1:   Log likelihood = -61.818749  (backed up)
Iteration 2:   Log likelihood = -52.718276
.                     .                   .
.                     .                   .
.                     .                   .
Iteration 75:  Log likelihood =  17.744785  (backed up)
Iteration 76:  Log likelihood =  17.747203  (backed up)
Iteration 77:  Log likelihood =  17.766164  (backed up)
Iteration 78:  Log likelihood =  17.768366
Iteration 79:  Log likelihood =  17.774578

Inefficiency effects model (truncated-normal)       Number of obs =        36
Group variable: id                                Number of groups =         4
Time variable: year                              Obs per group: min =         9
                                                               avg =       9.0
                                                               max =         9

                                                     Prob > chi2    =    0.0000
Log likelihood =    17.9849                          Wald chi2(4)   =  2.99e+08
```

lny	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Frontier						
lnqc	-4.640892	.0423256	-109.65	0.000	-4.723849	-4.557936
lnsy	4.318619	.0575615	75.03	0.000	4.205801	4.431438
lnbl	-2.292306	.1311048	-17.48	0.000	-2.549267	-2.035345
year	.0122448	.0001214	100.83	0.000	.0120067	.0124828
_cons	-40.31549	.	.	.	.	.
Mu						
pp	-.0979616	2.224231	-0.04	0.965	-4.457375	4.261452
qch	-1.658935	2.140434	-0.78	0.438	-5.854108	2.536239
_cons	-2.467273	2.706265	-0.91	0.362	-7.771454	2.836908
Usigma						
_cons	-.1896383	.8979285	-0.21	0.833	-1.949546	1.570269
Vsigma						
_cons	-13.08369	3.298539	-3.97	0.000	-19.54871	-6.618674
sigma_u	.9095374	.4083497	2.23	0.026	.377278	2.192702
sigma_v	.0014418	.002378	0.61	0.544	.0000569	.0365404
lambda	630.8238	.4083932	1544.65	0.000	630.0234	631.6243

General linear model based on model 1.2.2 and 1.1.2

```
. glm lny lnqc lnsy lnbl year

Iteration 0:   log likelihood = -.20466064

Generalized linear models                          No. of obs      =        36
Optimization     : ML                              Residual df     =        31
                                                   Scale parameter =   .0687709
Deviance         =  2.131896391                    (1/df) Deviance =   .0687709
Pearson          =  2.131896391                    (1/df) Pearson  =   .0687709

Variance function: V(u) = 1                        [Gaussian]
Link function    : g(u) = u                        [Identity]

                                                   AIC             =   .2891478
Log likelihood   = -.2046606444                    BIC             =  -108.9572
```

lny	Coef.	OIM Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnqc	-4.785602	.4130438	-11.59	0.000	-5.595153	-3.976051
lnsy	4.380176	.5641249	7.76	0.000	3.274511	5.48584
lnbl	-2.152651	1.374775	-1.57	0.117	-4.847161	.5418595
year	.0324537	.0169276	1.92	0.055	-.0007239	.0656313
_cons	-82.60295	34.23719	-2.41	0.016	-149.7066	-15.49929

- **Translog Model estimated (2.2.2; 2.2.1; and 2.1.2)**

Technical Efficiency Model 2.2.2 estimated

```
. sfpanel lny lnqc lnsy lnbl lnqc2 lnsy2 lnbl2 lnqclnsy lnqclnbl lnsylnbl, model(bc95) dist(tn) emean( pp qch) ort(
> o)

note: lnqc2 omitted because of collinearity
note: lnsy2 omitted because of collinearity
note: lnbl2 omitted because of collinearity
note: lnqclnsy omitted because of collinearity
note: lnqclnbl omitted because of collinearity
note: lnsylnbl omitted because of collinearity

initial:       Log likelihood = -75.534044
Iteration 0:   Log likelihood = -75.534044
Iteration 1:   Log likelihood = -61.985463  (backed up)
Iteration 2:   Log likelihood = -55.105326
Iteration 3:   Log likelihood = -29.811881
Iteration 4:   Log likelihood = -28.789499  (backed up)
.              .                     .
.              .                     .
.              .                     .
Iteration 99:  Log likelihood =  15.883219
Iteration 100: Log likelihood =  15.883369  (backed up)

Inefficiency effects model (truncated-normal)       Number of obs =        36
Group variable: id                                Number of groups =         4
Time variable: year                              Obs per group: min =         9
                                                               avg =       9.0
                                                               max =         9

                                                    Prob > chi2   =    0.0000
Log likelihood =    15.8834                         Wald chi2(3)  =  4.44e+06
```

lny	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Frontier						
lnqc	-4.916245	.0237032	-207.41	0.000	-4.962702	-4.869787
lnsy	4.700882	.0321192	146.36	0.000	4.63793	4.763835
lnbl	-3.203044	.0737103	-43.45	0.000	-3.347513	-3.058574
lnqc2	8.98e-14	.	.	.	.	.
lnsy2	-7.19e-15	.	.	.	.	.
lnbl2	1.95e-14	.	.	.	.	.
lnqclnsy	9.47e-15	.	.	.	.	.
lnqclnbl	-3.91e-14	.	.	.	.	.
lnsylnbl	-1.34e-13	.	.	.	.	.
_cons	-13.79488	.1580574	-87.28	0.000	-14.10467	-13.48509
Mu						
pp	-1.244022	5.169393	-0.24	0.810	-11.37585	8.887802
qch	-2.135465	5.332605	-0.40	0.689	-12.58718	8.316249
_cons	-6.314846	13.79144	-0.46	0.647	-33.34557	20.71587
Usigma						
_cons	.6441672	2.007922	0.32	0.748	-3.291287	4.579621
Vsigma						
_cons	-20.20108	18.95553	-1.07	0.287	-57.35323	16.95107
sigma_u	1.38	1.385466	1.00	0.319	.1928884	9.873068
sigma_v	.0000411	.0003891	0.11	0.916	3.51e-13	4795.978
lambda	33611.52	1.385471	2.4e+04	0.000	33608.81	33614.24

Technical Efficiency Model 2.2.1 estimated

```
. sfpanel lny lnqc lnsy lnbl lnqc2 lnsy2 lnbl2 lnqclnsy lnqclnbl lnsylnbl, model(bc95) dist(tn) emean( pp qch) ort(
> o)

note: lnqc2 omitted because of collinearity
note: lnsy2 omitted because of collinearity
note: lnbl2 omitted because of collinearity
note: lnqclnsy omitted because of collinearity
note: lnqclnbl omitted because of collinearity
note: lnsylnbl omitted because of collinearity

initial:       Log likelihood = -75.534044
Iteration 0:   Log likelihood = -75.534044
Iteration 1:   Log likelihood = -61.985463  (backed up)
Iteration 2:   Log likelihood = -55.105326
.                  .                  .
.                  .                  .
.                  .                  .
Iteration 99:  Log likelihood =  15.883219
Iteration 100: Log likelihood =  15.883369  (backed up)

Inefficiency effects model (truncated-normal)     Number of obs    =        36
Group variable: id                                Number of groups =         4
Time variable: year                               Obs per group: min =       9
                                                               avg =       9.0
                                                               max =         9

                                                  Prob > chi2     =    0.0000
Log likelihood =    15.8834                       Wald chi2(3)    =  4.44e+06

------------------------------------------------------------------------------
         lny |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
Frontier     |
        lnqc |  -4.916245   .0237032  -207.41   0.000    -4.962702   -4.869787
        lnsy |   4.700882   .0321192   146.36   0.000      4.63793    4.763835
        lnbl |  -3.203044   .0737103   -43.45   0.000    -3.347513   -3.058574
       lnqc2 |   8.98e-14          .        .       .            .           .
       lnsy2 |  -7.19e-15          .        .       .            .           .
       lnbl2 |   1.95e-14          .        .       .            .           .
    lnqclnsy |   9.47e-15          .        .       .            .           .
    lnqclnbl |  -3.91e-14          .        .       .            .           .
    lnsylnbl |  -1.34e-13          .        .       .            .           .
       _cons |  -13.79488   .1580574   -87.28   0.000    -14.10467   -13.48509
-------------+----------------------------------------------------------------
Mu           |
          pp |  -1.244022   5.169393    -0.24   0.810    -11.37585    8.887802
         qch |  -2.135465   5.332605    -0.40   0.689    -12.58718    8.316249
       _cons |  -6.314846   13.79144    -0.46   0.647    -33.34557    20.71587
-------------+----------------------------------------------------------------
Usigma       |
       _cons |   .6441672   2.007922     0.32   0.748    -3.291287    4.579621
-------------+----------------------------------------------------------------
Vsigma       |
       _cons |  -20.20108   18.95553    -1.07   0.287    -57.35323    16.95107
-------------+----------------------------------------------------------------
     sigma_u |       1.38   1.385466     1.00   0.319     .1928884    9.873068
     sigma_v |   .0000411   .0003891     0.11   0.916     3.51e-13    4795.978
      lambda |   33611.52   1.385471  2.4e+04   0.000     33608.81    33614.24
------------------------------------------------------------------------------
```

Technical Efficiency Model 2.1.2 estimated as shown below

```
. sfpanel lny lnqc lnsy lnbl lnqc2 lnsy2 lnbl2 lnqclnsy lnqclnbl lnsylnbl year, model(bc92) dist(tn) ort(o)

note: lnqc2 omitted because of collinearity
note: lnsy2 omitted because of collinearity
note: lnbl2 omitted because of collinearity
note: lnqclnsy omitted because of collinearity
note: lnqclnbl omitted because of collinearity
note: lnsylnbl omitted because of collinearity

initial:       Log likelihood = -97.089059
Iteration 0:   Log likelihood = -97.089059  (not concave)
Iteration 1:   Log likelihood = -34.081997  (not concave)
Iteration 2:   Log likelihood = -17.785916  (not concave)
Iteration 3:   Log likelihood = -17.275988  (not concave)
.              .                            .
.              .                            .
.              .                            .
Iteration 28:  Log likelihood =  16.861095
Iteration 29:  Log likelihood =  16.867013
Iteration 30:  Log likelihood =  16.869761
Iteration 31:  Log likelihood =  16.869796
Iteration 32:  Log likelihood =  16.869796

Time-varying decay model (truncated-normal)        Number of obs    =        36
Group variable: id                                 Number of groups =         4
Time variable: year                                Obs per group: min =       9
                                                                  avg =     9.0
                                                                  max =       9

                                                   Prob > chi2    =    0.0000
Log likelihood =    16.8698                        Wald chi2(4)   =   1667.28
```

lny	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
Frontier						
lnqc	-7.38457	1.020587	-7.24	0.000	-9.384885	-5.384256
lnsy	8.017658	1.422583	5.64	0.000	5.229447	10.80587
lnbl	-10.66783	3.344964	-3.19	0.001	-17.22384	-4.111819
lnqc2	0	(omitted)				
lnsy2	0	(omitted)				
lnbl2	0	(omitted)				
lnqclnsy	0	(omitted)				
lnqclnbl	0	(omitted)				
lnsylnbl	0	(omitted)				
year	-.1440192	.0686475	-2.10	0.036	-.2785659	-.0094725
_cons	290.2279	144.2516	2.01	0.044	7.499877	572.9559
/lnsigma2	-3.779758	.6563273	-5.76	0.000	-5.066136	-2.49338
/ilgtgamma	-.5165532	1.896785	-0.27	0.785	-4.234184	3.201077
/mu	.2513216	.29941	0.84	0.401	-.3355112	.8381543
/eta	.2398344	.0885564	2.71	0.007	.066267	.4134017
sigma2	.0228282	.0149828			.0063067	.0826302
gamma	.3736586	.4439195			.0142846	.9608748
sigma_u2	.00853	.0154779			-.0218062	.0388661
sigma_v2	.0142983	.0037244			.0069986	.0215979

Appendix 3 Approved Latter for Data Collection

KEMENTERIAN RISET, TEKNOLOGI, DAN PENDIDIKAN TINGGI
INSTITUT TEKNOLOGI SEPULUH NOPEMBER
FAKULTAS TEKNOLOGI KELAUTAN
DEPARTEMEN TEKNIK PERKAPALAN
Kampus ITS Sukolilo - Surabaya 60111
Telp: 031-594 7254, 599 4251-4, Fax: 031-596 4182, PABX: 1173-1176
E-mail: kapal@its.ac.id
http://www.na.its.ac.id

Number : 68292 /IT2.V1.6.1/PP.05.02/2019
Enclosure : ----
Subject : Data Request for Thesis

Director of Tanzania Ports Authority
P.O. Box 9180 Dar es Salaam, Tanzania

Dear Sirs,

For the purpose of the completion of his master thesis, which is one of the requirements to graduate from the Graduate Program of the Department of Naval Architecture, Faculty of Marine Technology, Institut Teknologi Sepuluh Nopember, Indonesia, we would like to ask your permission for our student below to collect data in your company:

Name : Adam Haji Ali
Thesis Tittle : A Study of Port Efficiency of Container Terminal in Tanzania
Required Data : Port and container data from 2012 - 2018 → TEUs, Ship Call
Supervisors : Dr.Eng. IGN Sumanta Buana,S.T., M.Eng.
Dr. Ir. I Ketut Suastika, M.Sc.

In the hope of a positive response, we thank you for your kind attention and cooperation.

Surabaya, 22 August 2019
Head of Department,

Ir. Wasis Dwi Aryawan, M.Sc., Ph.D.
NIP. 19640210 198903 1 001

KEMENTERIAN RISET, TEKNOLOGI, DAN PENDIDIKAN TINGGI

INSTITUT TEKNOLOGI SEPULUH NOPEMBER

FAKULTAS TEKNOLOGI KELAUTAN

DEPARTEMEN TEKNIK PERKAPALAN

Kampus ITS Sukolilo - Surabaya 60111
Telp: 031-594 7254, 599 4251-4, Fax: 031-596 4182, PABX: 1173-1176
E-mail: kapal@its.ac.id
http://www.na.its.ac.id

Number : 68289/IT2.V1.6.1/PP.05.02/2019
Enclosure : ----
Subject : Data Request for Thesis

Director of Zanzibar Ports Corporation
Tanzania
Head office, Malindi Zanzibar

Dear Sirs,

For the purpose of the completion of his master thesis, which is one of the requirements to graduate from the Graduate Program of the Department of Naval Architecture, Faculty of Marine Technology, Institut Teknologi Sepuluh Nopember, Indonesia, we would like to ask your permission for our student below to collect data in your company:

Name : Adam Haji Ali
Thesis Tittle : A Study of Port Efficiency of Container Terminal in Tanzania
Required Data : Port and container data from 2012 - 2018
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Dr. Ir. I Ketut Suastika, M.Sc.

In the hope of a positive response, we thank you for your kind attention and cooperation.

Surabaya, 22 August 2019
Head of Department,

Dr. Ir. Wasis Dwi Aryawan, M.Sc., Ph.D.
NIP. 19640210 198903 1 001

Appendix 4 Categorization of Quality Cargo Handling Table

The development and categorization of the quality of cargo handling variable through port user's perspectives analysis was carried as presented hereunder.

Respondent Frequencies in Good Category

Port users	Dar es Salaam	Tanga	Mtwara	Zanzibar
Cargo owners	3	2	2	3
Clearing agent	6	1	1	5
Transport providers	2	2	1	1
Manager	0	0	0	1
Total	11	5	4	10

	Categories Signed in Dar es Salaam		
	Number of respondent	Average	Category signed
Good	11	0.55	1
Average	8	0.40	0
Poor	1	0.05	0

	Categories Signed in Tanga		
	Number of respondent	Average	Category signed
Good	5	0.25	0
Average	9	0.45	0
Poor	6	0.30	0

	Categories Signed in Mtwara		
	Number of respondent	Average	Category signed
Good	4	0.20	0
Average	9	0.45	0
Poor	7	0.35	0

	Categories Signed in Zanzibar		
	Number of respondent	Average	Category signed
Good	10	0.50	1
Average	6	0.30	0
Poor	4	0.20	0