# DETERMINANTS OF PORT PERFORMANCE – A CASE STUDY OF FIVE MAJOR CONTAINER PORTS IN MYANMAR

WAI PHYO PAING

A THESIS REPORT SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE IN LOGISTICS AND SUPPLY CHAIN
MANAGEMENT
INTERNATIONAL COLLEGE
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| **THESIS TITLE** | Determinants of Port Performance – Case study of Five Major Container Ports in Myanmar |
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## ABSTRACT

Container ports play a pivotal role in facilitating global logistics and supply chains. Therefore, their performance and overall competitiveness must be improved to retain shipping lines and shippers. This study aims to analyse the relationship between container throughput (Twenty-Foot Equivalent Unit (TEU) per year) and other important Key Performance Indicators (KPIs). This analysis can help the Myanma Port Authority (MPA) and container port operators in the country to identify which KPIs are essential for monitoring and improving their performance. The data used in this study were collected from five major Myanmar container ports under the authority of the MPA for the period 2010-2015. This study employed a quantitative analysis method by applying a regression modelling technique. As a result, it is concluded that container throughput is influenced only by some KPIs namely total berth length and the total numbers of ship calls per year.

# ACKNOWLEDGEMENT

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Wai Phyo Paing

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# LIST OF DEFINITIONS

| | |
|---|---|
| **TEU** | Twenty-foot Equivalent Unit |
| **KPI** | Key Performance Indicator |
| **GDP** | Gross Domestic Product |
| **GRT** | Gross Register Tonnage |
| **NRT** | Net Register Tonnage |
| **DEA** | Data Envelopment Analysis |
| **TSLS** | Two-Stage Least Squares |
| **OLS** | Ordinary Least Squares |
| **LPI** | Logistic Performance Index |

# CHAPTER 1

# INTRODUCTION

## 1.1 Research Background

Myanmar possesses many ports, not only river ports but also seaports. These ports are undergoing significant development with processing and manufacturing projects being implemented at many of them. There are, in total, five major container ports in Myanmar, Thilawa is a seaport located 25 kilometres from Yangon city, adjacent to the Thilawa Special Economic Zone while the others are river ports (namely Asia World Port Terminal, Myanmar Industrial Port, Myanmar Terminal Port, Alone International Port Terminal) situated in the Yangon City Area. They handle 90% of the export and import containers in Myanmar (Elly, 2015). There was an increase in container traffic between 2007 and 2016 (CEIC, 2017) and since the enactment of a new Foreign Direct Investment Law, many foreign companies have been investing in ports and related infrastructure.

Myanmar potentially has numerous transshipment opportunities because of its strategic position in close proximity to India and Bangladesh and also near to China, Laos and Thailand. 75% of Myanmar's ports, known as "landlord ports" (VDB, 2016), are being leased to the private sector by a new government trying to promote private sector investment in coastline ports and thereby increase their traffic capacity. As ports are certainly important for a country in terms of facilitation the movement of goods (Tarantola, 2015), performance indicators are needed in order to measure the performance and grasp the operation of ports in a country (Atika, 2017). There are many ways of measuring container port efficiency or productivity (Trujillo, 1999). With regards to single output criteria, the throughput of container terminals in TEU is a popular indicator display in maritime business rankings (Vera, 2012). Container throughput is a standard measure for the productivity of a seaport (U.S Department of Transportation, 2016). Therefore, to increase the productivity of the ports, MPA, an organization operating under the authority of the Ministry of Transport and Communications, has selected container throughput (TEU per year) as its main KPI for all the container ports of Myanmar. As we can see in Fig.1, total TEU/year from 2005 to 2015 shows an upward trend because during these years respective governments tried to change public service ports into landlord ports as they knew it would increase the performance of all ports. Furthermore, the improvement of the country's logistics performance allowed for a further increase to the container throughputs during these 10 years.

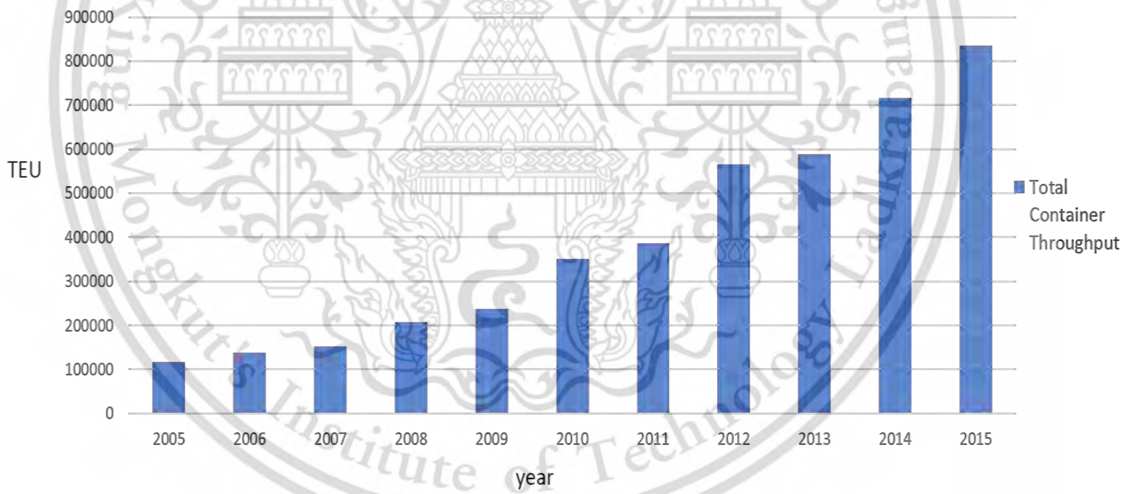


**Figure 1.1** Total Container Throughput from 2005 to 2015

## 1.2 Problem Statement

As both container traffic and GDP increased between 2009 and 2014, Myanmar's ports served the country by distributing goods domestically and internationally, which served as a gateway for trade and stimulated national development and growth. However, compared to other maritime nations in Southeast

Asia, Myanmar still has poorer than average port services and facilities. So, knowing which KPIs influence the container throughput at the five major container ports of Myanmar is important for the MPA and stakeholders of the port industry. Regression analysis is a very valuable which can be used to model such things as the relationship between a dependent variable and independent variable (Render, Stair & Hanna, 2010).

## 1.3 Objectives of the Study

The objective of the study undertaken from this thesis is to help the MPA and its stakeholders to investigate whether there is any relationship between total container throughput and other Key Performance Indicators (KPIs) to determine which predictors, among all our selected predictors can be used to focus total container throughput per year.

## 1.4 Scope of the Study

Data was collected data from each of the five major container ports in Myanmar which are Asia World Port Terminal (AWPT), Myanmar Industrial Port (MIP), Myanmar Terminal Port (TMT), Alone International Port Terminal (AIPT) and Myanmar International Terminals Thilawa (MITT) between 2011 and 2015, including KPIs such as:

- ✓ total container throughput (TEU per year)
- ✓ total number of berths
- ✓ total berth length (m)
- ✓ total terminal area ($m^2$)
- ✓ total number of quay cranes
- ✓ total number of transfer cranes
- ✓ total number of reach stackers

- ✓ total number of forklifts
- ✓ total number of ship calls per year

Regression analysis was used for this study which includes many techniques for modelling and analysing several variables in order to know the relationship between total container throughput and other selected KPIs. Moreover, it can help to understand how the value of total container throughput changes when any one of the independent variables is varied, while the other KPIs are help fixed.

R studio software which is a free and open-source integrated development environment for R, a programming language for statistical computing and graphics was used as a tool for investigation for the study.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Port

### 2.1.1 Definition of Port

There are many definitions about port in literature. A port (or seaport) is a place that provides for the vessel transfer of cargo and passengers to and from waterways and shores (Kevin, 2015). According to Atika (2017), Ports are the medium that connects shops with land for both passengers and logistics flows. Trantola (2005) also described a port as an area connected to sea, ocean or river and considered as entities. For the better understanding, Soner Esmer (2008) defined the port as a terminal and an area within which ships are loaded and/or unloaded with cargo and includes the usual places where ships wait for their turn or order or obliged to wait for their turn no matter the distance from that area.

### 2.1.2 Port Performance Indicators

Understanding performance is a concept fundamental to any business, whether it is the measuring of achievements against set goals and objectives or, against the competition. Ports are no exception and it is only by comparison that performance can be evaluated. The subject is further complicated by the various types of port ownership and organisational structures that exist throughout the world (Valentine, 2001). By using indicators, the port supervisor can assess how equipment is being used by the port authority and how good the management is in terms of operational performance and the cost need (Atika, 2007).

Many authors have investigated on defining port performance indicators. The weight of these indicators varies from port to port, its location, the nature of cargoes that this ports usually handles, port infrastructure, facilities and equipment and so on (Osman, Eli and Drakuli). Many indicators have been used in port-related research papers to measure the performance of the ports in the literature.

Traditionally, the performance of ports has been variously evaluated by calculating cargo-handling productivity at berth, by measuring single factor productivity or by comparing actual with optimum throughput over a specific period (Soner Esmer, 2008). Kek (1993) showed that port performance indicators can be divided into two groups: operational performance indicators and financial performance indicators.

### 2.1.3 Classification of Port Performance Indicators

Port Performance Indicators can be classified into two specific groups. They are financial and operational indicators (UNCTAD, 1976). Operational indicators are important for selecting the medium-term planning control for the port. They are arrival rate, waiting time, service time, turnaround time, tonnage per ship, a fraction of time berthed ships worked, numbers of gangs employed per ship per shift, tons per ship hour in port, tons per ship hour at berth, tons per gang-hour, the fraction of time gangs idle. Financial indicators are intended to measure the costs generated by its operation and the revenue resulting from these operations such as tonnage worked, berth occupancy revenue per ton of cargo, cargo-handling revenue per ton of cargo, labour expenditure per ton of cargo, capital equipment expenditure per ton of cargo, contribution per ton of cargo and total contribution. Many authors have used these indicators as reference points in their port-related research papers.

Port performance indicators can be classified into three groups according to the aspects that they aim to measure: physical indicators, factor productivity indicators and economic and financial indicators (Trujillo, 1990). Physical indicators are focused to measure time measures and total volume of traffic that the port receives which include ship turn-around times, waiting rate, berth occupancy rate, working time overtime at berth and cargo dwell-times. Factor productivity indicators are aiming to measure the productivity of ports' labour and capital such as tons per worker-hour or per gang-hour, tons per crane-hour, Tons per berthing location per linear meter, tons per ship-day. Financial indicators are focused to measure port finances and level of charges to users. They are operation surplus over GRT/NRT3 or operation surplus over a handled ton, total income (expenditure) over GRT/NRT or a ton and charge per TEU.

There are many classifications for measuring the performance of a container port. Kisi at all (1990) classified that there are four levels of classification for container ports as shown in the figure.

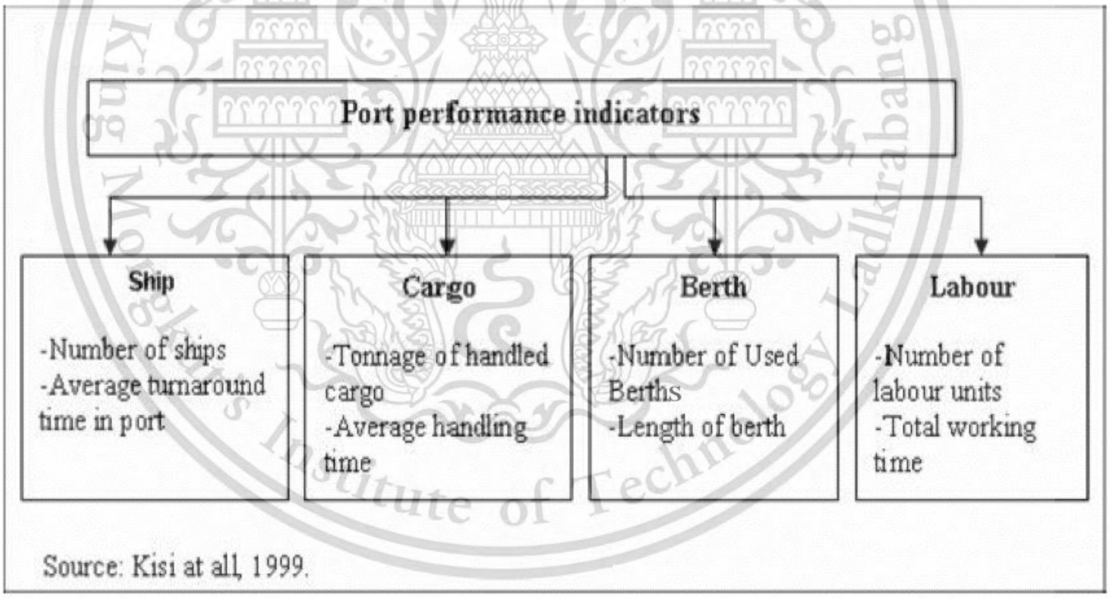


**Figure 2.1** Port Performance Indicators for Container Terminals

According to Soner (2008), the performance measures of the container port can be divided into four categories. They are production measures which indicate traffic measures and throughput measures, productivity measures which is aiming to calculate the ratio of output to input, utilization which allow management to determine how intensively the production resources are used, and service measures which indicate the satisfaction of the customers with the services offered to them in terms of reliability, regularity and rapidity.

**Table 2.1** Port Performance Measures Classification

| Production Measures | Productivity Measures | Utilization Measures | Services Measures |
|---|---|---|---|
| ship throughput | ship, crane, quay, terminal area productivity | Quay utilization | Ship turnaround time |
| quay transfer throughput | equipment productivity | Storage utilization | Road vehicle turnaround time |
| container yard throughput | labour productivity | Gate utilization | Rail service measures |
| Receipt/delivery throughput | cost-effectiveness | Equipment utilization | |

Source: Soner E 2008 Performance measure of container terminal operation.

## 2.2 Literature Review on Port KPI

### 2.2.1 Commonly Used Operational KPIs in Literature

At first, when the containers are started to use wildly in the port industry, an organization namely UNTCAD classified that port performance indicators can be classified into two groups which are operational KPIs and finical KIPs (UNCTAD, 1976). Many authors have used operational indicators as reference points in their port-related research papers. Operational indicators are easy to collect and get data from ports to compare to finical indicators as many ports do not want to share their finical information. Operational KPI can be measured generally in terms of the speed with a vessel is despatched, the rate at which cargo is handled and the duration that cargo stays in port prior to shipment or post-discharge (Kek, 1993).

Osman (2016) used total traffic handled, waiting time, ships dwell time, size of vessel calling the port and ratio of full and empty containers as main KPIs to the identification and the measurement of performance of port of Durres. Okeudo (2013) also used operational performance indicators (productivity) such as ship turn-round time and cargo dwell time to calculate the efficiency of the Onne and Rivers seaport by using data envelopment analysis. Operational KPIs namely numbers of the container (TEUs) in the year, frequency of ship calls, average crane hours per working hr, average vessel size were used to make a multiple linear regression model to identify the various factors influencing a port's performance and efficiency of several ports (Tongzon, 1994). Verena (2012) described total container throughput, one of the operational KPIs as most popular KPI in the maritime business ranking. And many studies used operational performance indicators as main KPIs for their research.

According to related literature, the most useful operational KPIs for ports are average turnaround time (6- times), average waiting time (6 times), container throughput (5 times), average tonnage per ship (4 times), berth occupancy rate (4 times), dwell time (4 times), ton per gantry crane per hour (2 times) and vessel size (2 times), truck turnaround times.

**Table 2.2** Commonly Used Operational KPIs in Literature

| | **paper number** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **KPIs** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| average turnaround time | | X | X | | X | | X | X | | X |
| average waiting time | X | X | | X | X | | X | | X | |
| container throughput | | X | X | X | | X | | | | X |
| average tonnage per ship | X | | | | X | | X | | X | |
| berth occupancy rate | | X | X | | X | | | | | X |
| dwell time | X | | | | X | | | | X | X |
| Truck turnaround time | | | | | | | | X | | |
| ton per gantry crane per hours | | | | | X | | X | | | X |
| vessel size | X | | | | | | | | X | |

Paper 1: Atika Aqmarina, Nuzul Achjar 2017 Determinants of port performance – case study of 4 main ports in Indonesia (2005-2015)

Paper 2: Osman M, Eli V, Olta N 2016 Performance measurement: the case of Durres port

Paper 3: Okeudo, G.N. 2015 Measurement of efficiency level in Nigerian seaport after reform policy implementation. case study of Onne and Rivers seaport, Nigeria

Paper 4: Nazery K, 2012 Measuring the performance of Malaysian container ports

Paper 5: Kek C 1993 Port performance indicators, transportation, water and urban development department

Paper 6: Jose L. Tongzon 1995 Determinants of port performance and efficiency

Paper 7: UNCTAD 1976 Port performance indicator

Paper 8: Soner E 2008 Performance measure of container terminal operation

Paper 9: UNTCAD 2015 Port performance

Paper 10: Min-Ho Ha et al., 2017 Revision port performance measurement: A hybrid multi-stakeholder framework for the Modelling of Port Performance indicators

### 2.2.2 KPIs' Calculation Method from Literature

Many authors described and determined how to calculate and define KPIs. Among them, most of the commonly used operational KPIs calculation or definitions were described by Kek (1993) who chose the main indicators used by ports, and many authors used them as a reference for their port-related research papers.

Selected KPIs for this project with calculations or definitions are:

*Average ship turnaround time*: total hours vessels stay in port divided by the total number of vessels (Kek, 1993)

*Average waiting time*: total hours vessels wait for berth divided by the total number of vessels berthed (Kek, 1993)

*Tons per gang hour*: total tonnage handled divided by total number of gangs x total number of hours worked (Kek, 1993)

*Dwell time*: total number of cargo tons x days in port divided by total tonnage of cargo handled (Kek, 1993)

*Berth occupancy rate*: total times of ships at berths x 100 divided by the total number of berths x 360 days (Kek, 1993)

*Truck turnaround time*: the time required to collect a container from the terminal or deliver one (Soner Esmer, 2008)

*Berth throughput*: total tonnage of cargo handled at berths divided by the number of berths (Kek, 1993)

## 2.3 Multiple Linear Regression Analysis

### 2.3.1 Definition and Terminology

Regression analysis is a statistical technique for estimating the relationship among variables which have reason and result relation (Gulden, 2013). There are generally two purposes for regression analysis. Firstly, it is used to understand the relationship between variables. Secondly, it is used to predict the value of one variable based on the value of the other. In any regression model, the variable to be predicted is called the dependent variable or response variable. The value of this is said to be dependent upon the value of an independent variable, which is sometimes called an explanatory variable or a predictor variable (Render, 2010). Regression analysis can be classified into three categories as shown in the figure.

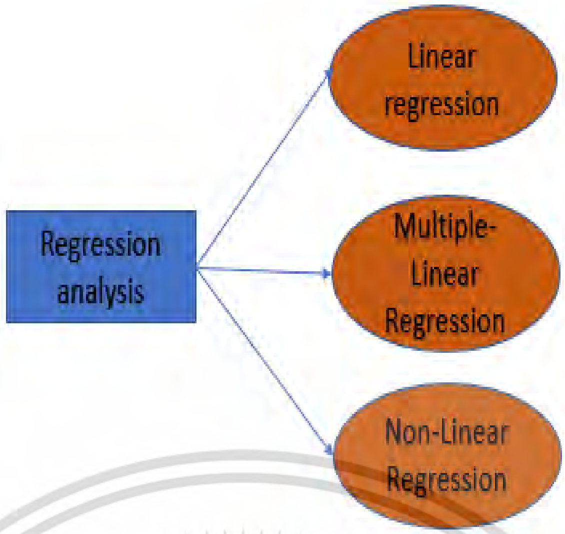


**Figure 2.2** Classification of Regression Analysis

The multiple regression model is a practical extension of the linear regression model. It is used to explain the relationship between one continuous dependent variable and two or more independent variables which can be continuous or categorical. It allows us to build a model with several independent variables (Render, 2010). The underlying multiple linear regression model is

$$Y=\beta_0 + \beta_1X_1 + \beta_2X_2 + \ldots\ldots + \beta_kX_k + \varepsilon \qquad (2.1)$$

Where Y = dependent variable (respond variable)

Xi = ith independent variable (predictor variable)

$\beta_0$ = intercept (value of when all Xi = 0)

$\beta_i$ = coefficient of the ith independent variable

k = number of independent variables

$\varepsilon$ = random error

### 2.3.2 Review of Related Literature

Uyanik (2013) studied the multilinear regression model by collecting data from Sakaya University Education Faculty students lesson scores and their 2012 KPSS score. He examined normality, linearity, no extreme values and missing values as model assumptions for the study. It was founded that whether the five independent variables in the standard model could predict the KPSS score according to ANOVA statistics.

Shyti (2017) also discussed regression analysis by using multiple linear regression model to analysis to know the trend of an economic trend of the transitory economy of Albania, a production company. Regression analysis, correlation analysis and ANOVA are being used for the study. As a result, it can be concluded that several employees and the price of the product have a big impact on the level of sales revenue of the company.

Tongnoz (1994) established a multiple linear regression model to identify to know the various factors influencing a port's performance and efficiency of several ports by using the two-stage least squares (TSLS), ordinary least squares (OLS) method.

## 2.4 Model Validation for the Study

To make a regression model it is certainly necessary to examine how well the model represents the data it is derived from and to what extent it is possible to use the model. For model validation, different statistical tools had to be used to get a predictive one for the study.

### 2.4.1 Coefficient of Determination and Coefficient of Correlation

The Sum of Squares due to Regression (SSR) is sometimes called the explained variability in Y while the sum of the squared error (SSE) is the unexplained variability in Y. The proportion of the variability in Y that is explained by the regression equation is called the coefficient of determination and is denoted by $r^2$.

$$r^2 = \frac{\mathrm{SSR}}{\mathrm{SST}} = 1 - \frac{SSE}{SST} \tag{2.2}$$

Where SSR = sum of squares due to regression

SSE = sum of the square error

SST = squares total

$r^2$ = coefficient of determination

If every point in the simple were on the regression line then 100% of the variability in Y could be explained by the regression equation, so $r^2 = 1$ and SSE = 0. The lowest value of $r^2$ is 0, indication that X explained 0 % of the variability in Y. Thus, $r^2$ can range from a low of 0 to a high of 1. In developing a regression equation, a good model will have an r value closed to 1 (Render, 2010).

The coefficient of correlation can show the linear relationship's strength which is can be expressed as r. The range of the r is between and including +1 and -1. Figure 2.3 illustrates possible scatter diagrams for different values of r. The value of r is the square root of $r^2$. It is negative if the slope is negative, and it is positive if the slope is positive.

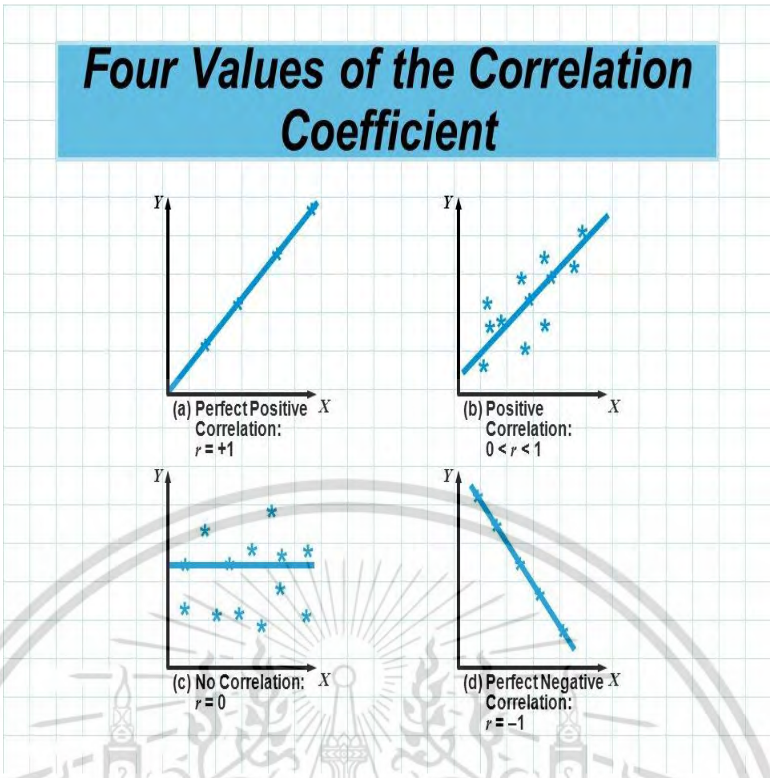


**Figure 2.3** Four Values of Correlation Coefficient

Source: Render (2010)

### 2.4.2 Hypothesis Test

Hypothesis testing is the use of statistics to determine the probability that a given hypothesis is true. The usual process of hypothesis testing consists of four steps.

1. Formulate the null hypothesis $H_0$ (commonly, that the observations are the result of pure chance) and the alternative hypothesis $H_a$ (commonly, that the observations show a real effect combined with a component of chance variation).

2. Identify a test statistic that can be used to assess the truth of the null hypothesis.

3. Compute the P-value, which is the probability that a test statistic at least as significant as the one observed would be obtained assuming that the null hypothesis was true. The smaller the P-value, the stronger the evidence against the null hypothesis.

4. Compare the p-value to an acceptable significance value alpha (sometimes called an alpha value). If $p <= \alpha$, that the observed effect is statistically significant, the null

hypothesis is ruled out, and the alternative hypothesis is valid (Math World, 2014). Common values are 0.01 and 0.05 (Render, 2010).

# CHAPTER 3

# RESEARCH METHODOLOGY

## 3.1 Study Area

Myanmar, officially the Republic of Union of Myanmar, one of the Southeast Asia counties, potentially has numerous transhipment opportunities because of its strategic position in close proximity to India and Bangladesh and also near to China, Laos and Thailand as shown in figure 3.1.

For about the container ports, Yangon is the main container port city of Myanmar. Five major container ports are handling about 90% of exports and import volume. Most of the container port in Myanmar is situated near the industrial zones of Myanmar which are in Yangon city area as shown in figure 3.2.


**Figure 3.1** Map of Myanmar


**Figure 3.2** Location of Industrial Zones and Container Ports in Yangon

### 3.1.1 Asia World Port Terminal (AWPT)

The Asia World Port Terminal (AWPT) is owned by Asia World Co., Ltd. This multi-purpose container terminal is situated in Alone township with 30.436 acres total land area. A wide variety of facilities to cater to virtually all cargo handling modes, including breakbulk, container, dry and liquid bulk operations can be provided by AWPT. Large Vessels with over 9.5meter draft cannot dock at AWPT due to the maximum draft limit of Yangon river. This river port has totally 8 berths and has the highest container throughput (TEU)/year and also got the highest numbers of ship calls among all the container ports.

### 3.1.2 Alone International Port Terminal (AIPT)

Alone International Port Terminal AIPT is owned by Myanmar Economic Corporation (MEC) which is a multi-purpose container terminal situated in Alone township with 53.709 acres total land area. It is modernized and dedicated facilities nominated to serve both container and general cargo with a new first-class wharf facility. Large vessels with over 9.5meter draft cannot dock at AIPT due to the maximum draft limit of Yangon river. Three berths have been built in this river port.

### 3.1.3 Myanmar Terminal Port (TMT)

TMT port is operated by Portia, an international port operator company. It is also a multi-purpose container terminal working in high-level operational positions within all aspects of the worldwide cargo handling industry – including containers, bulks (dry & liquid) and breakbulk. It is situated in the Yangon city area. Large vessels with over 9.5meter draft cannot dock at TMT due to the maximum draft limit of Yangon river. Totally 2 berths have been built in this river port which is the very first container terminal of Myanmar.

### 3.1.4 Myanmar Industrial Port (MIP)

MIP is 100% investment under B.O.T (Build, Operate & Transfer) for 25 years by Myanmar Annawa Swan:A:Shin Group(S) Co.,Ltd which is designed to serve as both inland container depot and advance container port with international standard to provide berthing facilities for two 12000 deadweight tonnage sea-going vessels. It is a river port since large vessels with over 9.5meter draft cannot dock at MIP due to the maximum draft limit of Yangon river. There are totally 4 berths this river Port. It has not only the highest growth rate of container throughput (TEU)/year among all container ports but also has the highest growth rate of total no. of ship calls with 65 acres total land area.

### 3.1.5 Myanmar International Terminal Thilawa (MITT)

Myanmar International Terminals Thilawa (MITT) is a multi-purpose container terminal located at Thilawa near the mouth of the Yangon River. It is located just 25 kilometres from Yangon. The terminal is adjacent to the Thilawa Special Economic Zone planned. This seaport has five berths capable of handling a wide variety of cargo, large seagoing vessels with deeper draft could dock at MITT compared to the city terminals or river ports. A rail line is being built at MITT to link Yangon city and the national rail network. MITT provides international standard service with berthing capacity for five ocean-going vessels of up to 2,000 TEU feeder ships and conventional cargo ships of 35,000 tons dead weight. It has both the highest growth rate of Through Put (TEU)/year and highest growth rate of the total number of ship calls per year, among all container ports.


**Figure 3.3** Location of AWPT


**Figure 3.4** Location of AIPT


**Figure 3.5** Location of TMT


**Figure 3.6** Location of MIP


**Figure 3.7** Location of MITT

## 3.2 Data Collection and Time Frame

The study this time, we used quantitative analysis with the aim of understanding and predicting the determinants of total throughput per year for the five major container ports in Myanmar between 2011- 2015 by applying a Multi Linear Regression Model.

**Table 3.1** Port Data of TMT

| The Myanmar Terminal Ports (TMT) | | | | | | |
|---|---|---|---|---|---|---|
| Year | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
| Number of berths (m) | 2 | 2 | 2 | 2 | 2 | 2 |
| Total berth length (m) | 320 | 320 | 320 | 320 | 320 | 320 |
| Total terminal area (m2) | 61,918 | 47,377 | 47,377 | 47,377 | 47,377 | 47,377 |
| Total throughput (TEU/year) | 55,188 | 31,852 | 18,085 | 11,922 | 29,390 | 20,094 |
| Total number of Quay (container) crane | 2 | 3 | 3 | 3 | 3 | 4 |
| Total number of Transfer crane (RTGC, RMGC, Straddle carrier) | 2 | 2 | 2 | 2 | 2 | 5 |
| Total number of Reach Stacker | 5 | 5 | 8 | 8 | 8 | 8 |
| Total number of Forklift | 5 | 5 | 5 | 5 | 5 | 5 |
| Total number of container ship to call a port/year | 81 | 55 | 35 | 21 | 52 | 44 |

**Table 3.2** Port Data of MIP

| Myanmar Industrial Port (MIP) | | | | | | |
|---|---|---|---|---|---|---|
| Year | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
| Number of berths (m) | 2 | 2 | 2 | 3 | 4 | 4 |
| Total berth length (m) | 310 | 310 | 310 | 510 | 750 | 750 |
| Total terminal area (acre) | 17 | 17 | 65 | 65 | 65 | 65 |
| Total throughput (TEU/year) | 72,774 | 96,104 | 145,528 | 195,638 | 236,665 | 37,3170 |
| Total number of Quay (container) crane | | | | | 5 | 5 |
| Total number of Transfer crane (RTGC, RMGC, Straddle carrier) | 2 | 2 | 7 | 7 | 12 | 22 |
| Total number of Reach Stacker | 10 | 12 | 13 | 18 | 20 | 20 |
| Total number of Forklift | 6 | 6 | 7 | 8 | 8 | 8 |
| Total number of container ship to call a port/year | 107 | 124 | 178 | 198 | 221 | 349 |

**Table 3.3** Port Data of MITT

| Myanmar International Terminal Thilawa (MITT) | | | | | | |
|---|---|---|---|---|---|---|
| Year | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
| Number of berths (m) | 2 | 2 | 2 | 2 | 2 | 2 |
| Total berth length (m) | 400 | 400 | 400 | 400 | 400 | 400 |
| Total terminal area (Ha) | 75 | 75 | 75 | 75 | 75 | 75 |
| Total throughput (TEU/year) | 14,005 | 2,540 | 18,249 | 10,166 | 14,139 | 35,295.80 |
| Total number of Quay (container) crane | 2 | 2 | 2 | 2 | 2 | 2 |
| Total number of Transfer crane | 3 | 3 | 3 | 3 | 3 | 3 |
| Total number of Reach Stacker | 2 | 2 | 2 | 2 | 2 | 2 |
| Total number of Forklift | 2 | 2 | 2 | 2 | 2 | 2 |
| Total number of container ship to call a port/year | 30 | 8 | 26 | 8 | 13 | 69 |

**Table 3.4** Port Data of AWPT

| Asia World Port Terminal (AWPT) | | | | | |
|---|---|---|---|---|---|
| Year | 2011 | 2012 | 2013 | 2014 | 2015 |
| Number of berths (m) | 3 | 3 | 3 | 3 | 3 |
| Total berth length (m) | 614 | 1044 | 1044 | 1044 | 1044 |
| Total terminal area (acre) | 30.436 | 53.709 | 53.709 | 53.709 | 53.709 |
| Total throughput (TEU/year) | 25,6419 | 38,3794 | 37,0387 | 43,6936 | 40,2276 |
| Total number of Quay (container) crane | 3 | 5 | 5 | 5 | 5 |
| Total number of Transfer crane (RTGC, RMGC, Straddle carrier) | | 4 | 4 | 4 | 4 |
| Total number of Reach Stacker | 16 | 20 | 20 | 24 | 24 |
| Total number of Forklift | 12 | 12 | 13 | 14 | 16 |
| Total number of container ship to call a port/year | 271 | 290 | 301 | 344 | 385 |

**Table 3.5** Port Data of AIPT

| **Alone International Port Terminal (AIPT)** | | |
|---|---|---|
| Year | 2014 | 2015 |
| Number of berths (m) | 3 | 3 |
| Total berth length (m) | 600 | 600 |
| Total terminal area (sqm) | 190,000 | 190,000 |
| Total throughput (TEU/year) | 223 | 4235 |
| Total number of Quay (container) crane | 2 | 2 |
| Total number of Transfer crane (RTGC, RMGC, Straddle carrier) | 2 | 4 |
| Total number of Reach Stacker | 2 | 4 |
| Total number of Forklift | 6 | 6 |
| Total number of container ship to call a port/year | 1 | 17 |

### 3.3 Multi Linear Regression Model for Study

Generally, there are generally two purposes for using regression analysis. The first is to understand the relationship between variables such as container throughput and the number of ship calls per year. The second purpose is to predict the value of one variable based on the value of the others.

Looking at the literature data, it was found that a total of 10 KPIs have been commonly used in past studies up to now. They are average turnaround time, average waiting time, container throughput, average tonnage per ship, berth occupancy rate, dwell time, vessel size and average tonnage per ship. For this study, in Myanmar, it was only possible to acquire data for one of these commonly used KPIs over a five-year period (container throughput) for our dependent variables. Consequently, we used the KPIs previously collected by the MPA as independent variables (numbers of berths, berth length, terminal area ($m^2$), the total number of quay container crane, the total number of transfer crane, number of reach stacker, number of frock lift, number of ship calls per year). Other paragraphs are indented.

Total throughput can be assigned as below:

$$Y = f(X1, X2, X3, X4, X5, X6, X7, X8) \quad (3.1)$$

According to above equation, it can be converted into MLR model to explain about the factors effecting on throughput as that:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \varepsilon \quad (3.2)$$

Where $Y$ = total container throughput (TEU per year)

$X_1$ = total number of berths

$X_2$ = total berth length (m)

$X_3$ = total terminal area ($m^2$)

$X_4$ = total number of quay container cranes

$X_5$ = total number of transfer cranes

$X_6$ = total number of reach stackers

$X_7$ = total number of forklifts

$X_8$ = total number of ship calls per year

$\varepsilon$ = random error

$\beta_0$ = intercept (value of Y when all X=0)

$\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7, \beta_8$ = regression coefficients

For the R programming, in order to get the best model through our regression equation, we have to run and reduce the primary model according to the following test as shown in the figure.

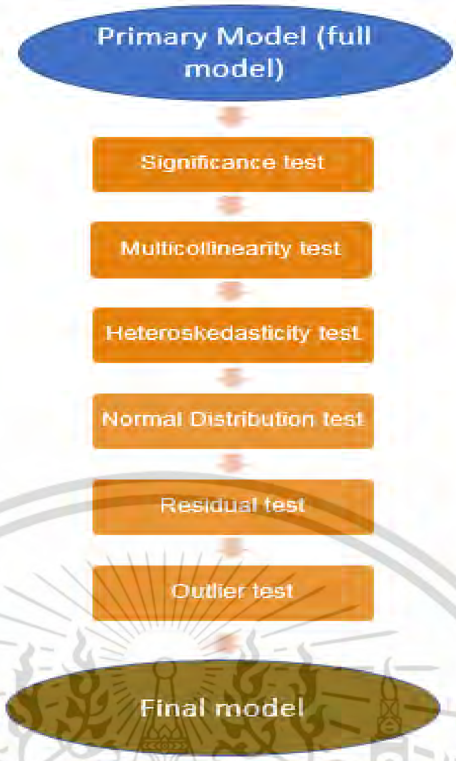


**Figure 3.3** Require Tests to Run in R programmed

## 3.4 Model Assumption

In order to run a regression model by using R studio, we have to make the following assumption:

- ✓ the current MLR model form is reasonable
- ✓ the residuals have constant variance
- ✓ the residuals are normally distributed
- ✓ the residuals are uncorrelated
- ✓ the predictors are not highly correlated with each other and no outlier.

## CHAPTER 4

## RESULTS AND DISCUSSIONS

In this chapter present the three multiple linear regression models namely preliminary model, reduced model and final model through different statistical tests such as significance test, multicollinearity test, heteroskedasticity test, normal distribution test, residual test and outliers test to get the best model in order to focus the total container throughput base on the value of the selected KPIs for the study and also to know the relationship between the total container throughput and selected KPIs.

### 4.1 Preliminary Model

For the preliminary model, total container throughput is used as dependent variables and all the selected KIPs is used as an independent. Model significance test and variable significance test have to be tested to know that which independent have relationship with total container throughput.

#### 4.1.1 Significance Test for Preliminary Model

$H_0$: $ß_1 = ß_2 = ß_3 = ß_4 = ß_5 = ß_6 = ß_7 = ß_8 = 0$ (no linear relationship)

$H_1$: At least one $ß_1$ is not equal to Zero (linear relationship exists)

given $\alpha = 0.05$,

It can be rejected $H_0$ if P-value $< \alpha$

**Table 4.1** Significance Test Result for Preliminary Model

| Coefficients: | Estimate | $Pr(>\|t\|)$ |
|---|---|---|
| (Intercept) | -1.109e+04 | 0.705521 |
| Total number of berths | -2.312e+04 | 0.080730 · |
| Total berth length | 2.522e+02 | 0.000371 *** |
| Total terminal area | -3.908e-02 | 0.257517 |
| Total number of quay cranes | -1.205e+03 | 0.726055 |
| Total number of transfer cranes | -8.842e+02 | 0.664097 |
| Total number of reach stackers | 3.748e+03 | 0.051641 · |
| Total number of forklifts | -1.227e+04 | 0.063655 · |
| Total number of ship calls per year | 9.702e+02 | 2.49e-05 *** |

Significant codes:0 '***'0.001 '**'0.01 '*'0.05 '.'0.1 ' '1
Residual standard error: 15380 on 13 degrees of freedom
Multiple R-squared: 0.9943, Adjusted R-squared: 0.9907
F-statistic: 282 on 8 and 13 DF, p-value: 2.66e-13

According to the above result, P-value=$2.66e^{-13} < \alpha = 0.05$. Therefore, the null hypothesis $H_0$ can be rejected. This means that a relationship exists between Xi and Y for at least one variable. In addition, $R^2$=0.9943 which means that an approximate 99.43% variation in total throughput can be explained by our model. The next test will be proceeded to find out which variables are the most effective in forecasting the total throughput.

### 4.1.2 Variable Significance Test for Preliminary Model

Variable Significance test for $X_1$,

$H_0$: $ß_1 = 0$ (No linear relationship exists between the total number of berths and total throughput)

$H_1$: $ß_1 \neq 0$ (A relationship exists between the total number of berths and total throughput)

Given that $\alpha = 0.05$,

Due to P-value=0.080730>$\alpha$ = 0.05. In other words, it is failed to reject $H_0$. Thus, the total number of berths cannot be used to predict total throughput.

Variable Significance test for $X_2$,

$H_0$: $ß_2 = 0$ (No linear relationship exists between total berth length and total throughput)

$H_1$: $ß_2 \neq 0$ (A linear relationship exists between total berth length and total throughput)

Given that $\alpha = 0.05$

Due to P-value=0.000371< $\alpha = 0.05$. In other words, it is failed rejected $H_0$. Thus, total berth length can be used to predict total throughput with a 99.9 % significance level (Signif. codes:'***' 0.001).

Variable Significance test for $X_3$,

$H_0$: $ß_3 = 0$ (No linear relationship exists between total terminal area and total throughput)

$H_1$: $ß_3 \neq 0$ (A linear relationship exists between total terminal area and total throughput)

Given that $\alpha = 0.05$,

Due to P-value=0.257517>$\alpha = 0.05$. In other words, it is failed to reject $H_0$. Thus, the total terminal area cannot be used to predict total throughput.

Variable Significance test for $X_4$,

$H_0$: $ß_4 = 0$ (No linear relationship exists between the total number of quay cranes and total throughput)

$H_1$: $ß_4 \neq 0$ (A linear relationship exists between the total number of quay cranes and total throughput)

Given that $\alpha = 0.05$,

Due to P-value=0.726055> $\alpha = 0.05$. In other words, it is failed to reject $H_0$. Thus, the total number of quay cranes cannot be used to predict total throughput.

Variable Significance test for $X_5$,

$H_0$: $ß_5 = 0$ (No linear relationship exists between the total number of transfer cranes and total throughput)

$H_1$: $ß_5 \neq 0$ (A linear relationship exists between the total number of transfer cranes and total throughput)

Given that $\alpha = 0.05$,

Due to P-value=0.664097> $\alpha = 0.05$. In other words, it is failed to reject $H_0$. Thus, the total number of transfer cranes cannot be used to predict total throughput.

Variable Significance test for $X_6$,

$H_0$: $ß_6 = 0$ (No linear relationship exists between the total number of reach stackers and total throughput)

$H_1$: $ß_6 \neq 0$ (A linear relationship exists between the total number of reach stackers and total throughput)

Given that $\alpha = 0.05$,

Due to P-value=0.051641> $\alpha = 0.05$. In other words, it is failed to reject $H_0$. Thus, the total number of reach stackers cannot be used to predict total throughput.

Variable Significance test for $X_7$,

$H_0$: $ß_7 = 0$ (No linear relationship exists between the total number of forklifts and total throughput)

$H_1$: $ß_7 \neq 0$ (A linear relationship exists between the total number of forklifts and total throughput)

Given that $\alpha = 0.05$,

Due to P-value=0.063655> $\alpha = 0.05$. In other words, it was failed to reject $H_0$. Thus, the total number of forklifts cannot be used to predict total throughput.

Variable Significance test for $X_8$,

$H_0$: $ß_8 = 0$ (No linear relationship exists between the total number of ship calls per year and total throughput)

$H_1$: $ß_8 \neq 0$ (A linear relationship exists between total berth length and total throughput)

Given that $\alpha = 0.05$

Due to P-value=2.49e-05< $\alpha = 0.05$. In other words, it is observed $H_0$. Thus, total berth length can be used to predict total throughput with 99.9 % significant level (Signif. codes:'***' 0.001)

According to the variable significance tests above, it is observed that total berth length and the total number of ship calls per year correlate with total throughput (P-value< $\alpha = 0.05$). On the other hand, the total number of berths, total terminal area, the total number of quay cranes, the total number of reach stackers, total number of forklifts and the total number of transfer cranes have no relation with total throughput (P-value> $\alpha = 0.05$).

Next, the scatter plots where be checked to select real significant independence variables as our dependence variable.

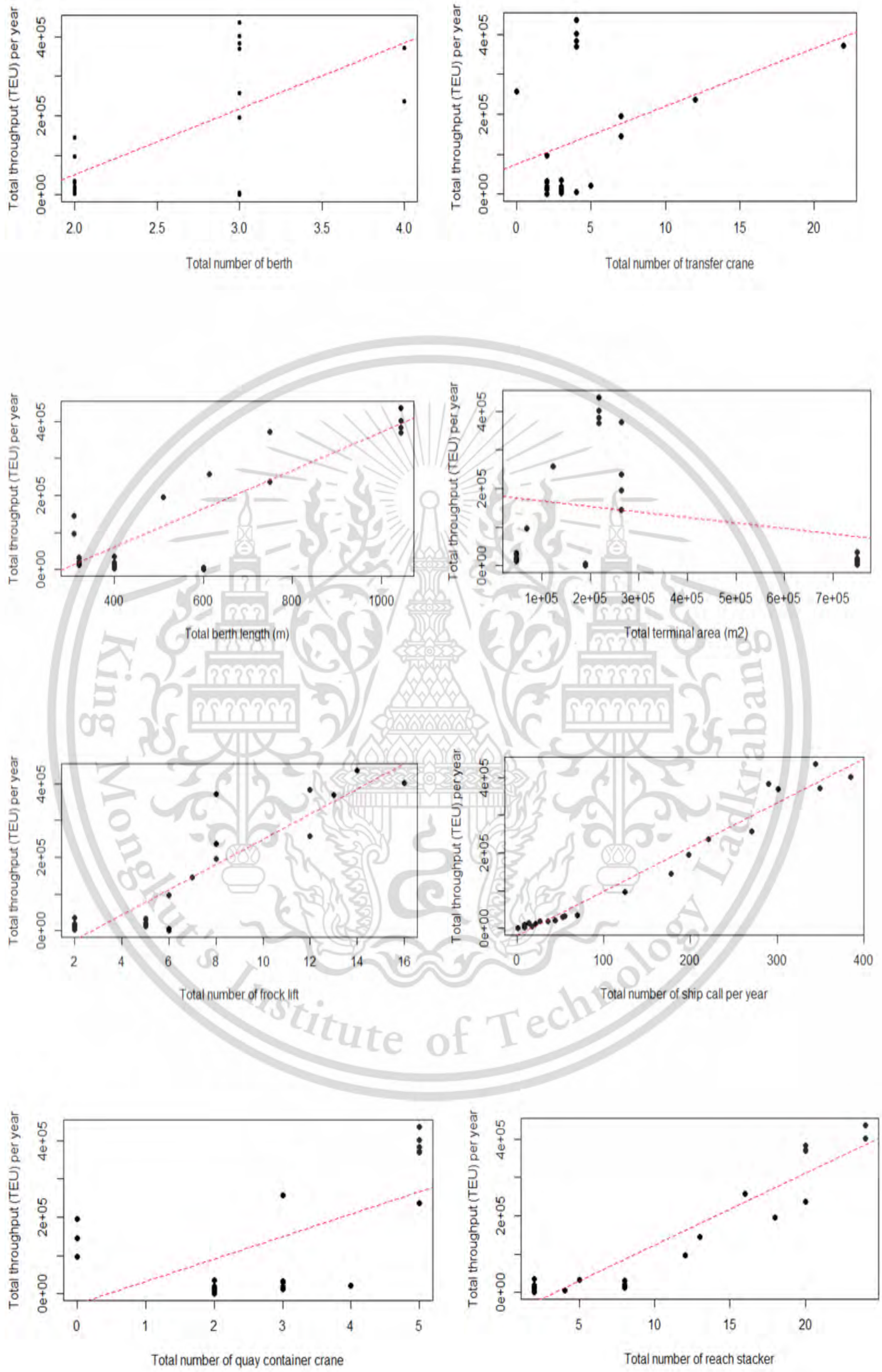


**Figure 4.1** Scatter Plots for Y and Each X in Preliminary Model

According to the plots above, these variables have various linear lines. Indeed, we already observed that total number of berths, total terminal area, total number of quay cranes, total number of reach stackers, total number of forklifts, total number of transfer cranes (P-value> $\alpha = 0.05$). As a result, it has been able to determine that all the other significant independence variables such as total berth length, and the total number of ship calls per year have a positive correlation with our dependence variable.

Therefore, it is concluded that the two variables could be used to predict our model. Although it will be reduced the other independent variables, the new model will be needed.

## 4.2 Reduced Model

For a reduced model, all independent variables that have no relationship with the dependent variable except total berth length and the total number of ship calls per year have been removed. Significance tests, multicollinearity test and heteroskedasticity have to be run again to know this model is a predictive model or not.

### 4.2.1 Significance Test for Reduced Model

$H_0$: $ß_1 = ß_8 = 0$ (no linear relationship)

$H_1$: At least one $\beta$ is not equal to Zero (linear relationship exists)

given $\alpha = 0.05$

It can be rejected $H_0$ if P-value < $\alpha$.

**Table 4.2** Significance Test Result for Reduced Model

| Coefficients: | Estimate | Pr(>\|t\|) |
|---|---|---|
| (Intercept) | -66387.99 | 2.48e-06*** |
| Total berth length | 139.57 | 2.41e-05*** |
| Total number of ship calls per year | 946.21 | 1.40e-13*** |
| Significant codes0 '***'0.001 '**'0.01 '*'0.05 '.'0.1''1 | | |
| Residual Standard Error: 18330 on 19 degrees of freedom | | |
| Multiple R-Squared: 0.9881, Adjusted R-Squared: 0.9869 | | |
| F-statistic: 789.4 on 2 and 19 DF, p-value: <2.2e-16 | | |

According to the above result, it is determined that our new P-value=2.2e-16<α = 0.05. Therefore, it can be rejected by the null hypothesis $H_0$. This means that a relationship exists between Xi and Y for at least one variable. It is proceeded to test which variables were most effective in forecasting total throughput.

### 4.2.2 Variable Significance test for Reduced Model

Variable Significance test for $X_1$,

$H_0$: $ß_1 = 0$ (No linear relationship exists between total berth length and total throughput)

$H_1$: $ß_1 \neq 0$ (A linear relationship exists between total berth length and total throughput)

Given that α = 0.05,

Due to P-value=2.41e-05< α = 0.05. In other words, it is rejected $H_0$. Thus, total berth length can be used to predict total throughput with a 99.9 % significance level (Signif. codes:'***' 0.001).

Variable Significance test for $X_8$,

$H_0$: $ß_8 = 0$ (No linear relationship exists between the total number of ship calls per year and total throughput)

$H_1$: $ß_8 \neq 0$ (A linear relationship exists between the total number of ship calls per year and total throughput)

Given that α = 0.05,

Due to P-value=1.40e-13< α = 0.05. In other words, it can be rejected $H_0$. Thus, the total number of ship calls per year can be used to predict total throughput with 99.9 % significant level (Signif. codes:'***' 0.001).

According to the variable significance tests, it is observed that total berth length and the total number of ship calls per year correlated with total throughput (P-value<α = 0.05). Therefore, it is concluded that our new model is an improvement on the old one. It is also concluded that two variables can be used to predict Y and there is no need to remove any further variables from the model.

Next, the scatter plots are checked to select real significant independent variables for our dependence variable.

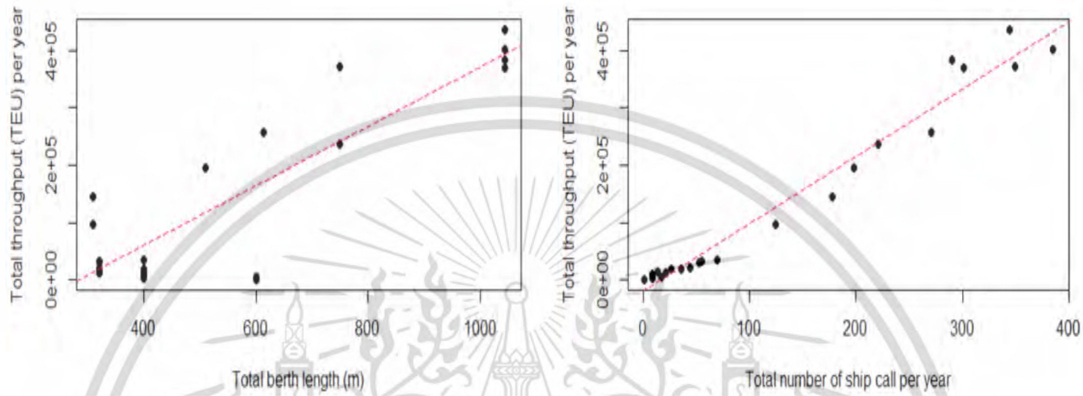


**Figure 4.2** Scatter plots for Y and each dependent variable in a reduced model

According to the plots above, these variables have various linear lines. From this data, it is able to determine that all the other significant independence variables such as total berth length, and the total number of ship calls per year have a positive correlation with our dependence variable. Therefore, it is concluded that two variables can be used to predict our model and do not need to reduce the model.

### 4.2.3 Multicollinearity Test for Reduced Model

VIF (variances inflation factor) > 4 suggests collinearity (R-blogger, 2016)

**Table 4.3** Multicollinearity Test Result for Reduced Model

| **vif(test2)** | |
|---|---|
| Total berth length | Total number of ship calls per year |
| 2.943587 | 2.943587 |

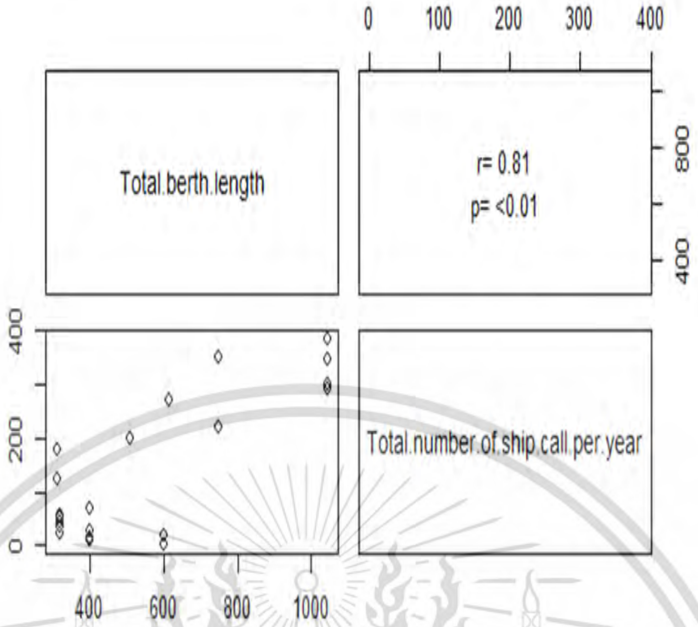


**Figure 4.3** Multicollinearity Plots for Reduced Model,

After plotting the graph and results, it can be seen that there is no collinearity between the 2 variables by VIF (Variance Inflation Factor) in R programming as the VIF values are smaller than 4. it also can be identified the value of r in the graph. Since the value of r is 0.81, which is near to +1, it is concluded that there is no collinearity in our model.

### 4.2.4 Heteroskedasticity Test for Reduced Model

$H_0$: The residuals are homoskedastic.

$H_1$: The residuals are heteroskedastic.

Given $\alpha = 0.05$,

It can be rejected $H_0$ if P-value $< \alpha$.

**Table 4.4** Heteroskedasticity Test Result for Reduced Model

| **residual plots**(test2, quadratic = FALSE) | | |
|---|---|---|
| | Test stat | Pr(>\|t\|) |
| Total berth length | 1.916 | 0.071 |
| Total number of ship calls per year | -0.602 | 0.555 |
| Tukey test | 0.247 | 0.805 |
| ncvTest(test2) | | |
| Non-constant Variance Score Test | | |
| Variance formula: ~ fitted values | | |
| Chisquare = 7.345889 Df = 1 p = 0.00672163 | | |

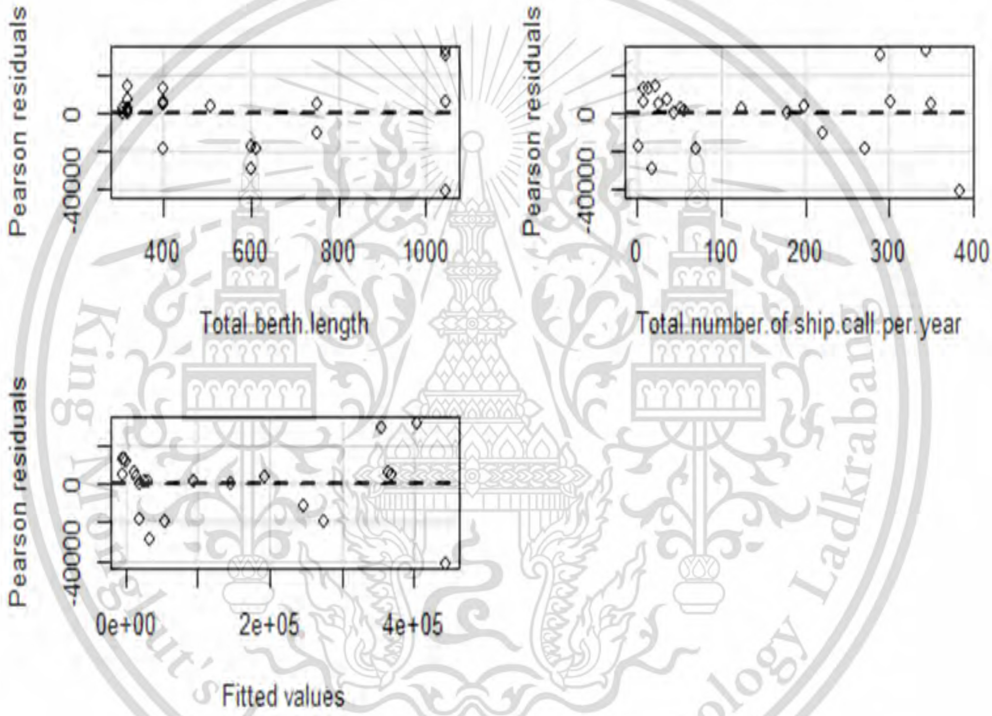


**Figure 4.4** Residual Plots for Reduced Model

According to the above results, it was observed that P-value=0.00672163 < α = 0.05. Therefore, it cannot be rejected null hypothesis $H_0$. This means that there is a heteroskedasticity problem. Thus, log transformations were used for our independent variables to help to solve the heteroskedasticity problem.

### 4.3 Final Model

The final model is established by taking log transformation for these two dependent variables and respective statistical tests such as significance test, multicollinearity test, heteroskedasticity test, normal distribution test, residual test and outlier test have to be run to get the best model to understand and focus the total container throughput.

#### 4.3.1 Significance Test for Final Model

$H_0$: $ß_1 = ß_8$ (no linear relationship)

$H_1$: At least one ß is not equal to Zero (a linear relationship exists)

given $\alpha = 0.05$,

It can be rejected $H_0$ if P-value < $\alpha$.

**Table 4.5** Significance Test Result for Final Model.

| Coefficients: | Estimate | Pr(>\|t\|) |
|---|---|---|
| (Intercept) | -1390554 | 1.41e-09*** |
| Log (Total berth length) | 210546 | 1.24e-08*** |
| Log (Total number of ships call per year) | 53911 | 6.78e-08*** |
| Significant codes0 ‘***’0.001 ‘**’0.01 ‘*’0.05 ‘.’0.1‘’1 | | |
| Residual Standard Error: 40720 on 19 degrees of freedom | | |
| Multiple R-Squared: 0.9413, Adjusted R-Squared: 0.9351 | | |
| F-statistic: 152.3 on 2 and 19 DF, p-value: <2.009e-12 | | |

According to the above result, it was observed that P-value=2.009e-12<$\alpha$ = 0.05. Therefore, it could be rejected by the null hypothesis $H_0$. This means that a relationship exists between Xi and Y for at least one variable. So, it was proceeded to test which variables were most effective in forecasting total throughput.

#### 4.3.2 Variable Significance Test for Final Model

Variable Significance test for $X_1$,

$H_0$: $ß_1 = 0$ (No linear relationship exists between total berth length and total throughput)

$H_1$: $ß_1 \neq 0$ (A linear relationship exists between total berth length and total throughput)

Given that $\alpha = 0.05$,

Due to P-value=0.141e-09< $\alpha = 0.05$, we can reject $H_0$. Thus, total berth length can be used to predict total throughput with 99.9 % significant level (Signif. codes:'***' 0.001).

Variable Significance test for $X_8$,

$H_0$: $ß_8 = 0$ (No linear relationship exists between the total number of ship calls per year and total throughput)

$H_1$: $ß_8 \neq 0$ (A linear relationship exists between the total number of ship calls per year and total throughput)

Given that $\alpha = 0.05$,

Due to P-value=6.78e-08< $\alpha = 0.05$. In other words, it can be rejected $H_0$. Thus, total berth length can be used to predict total throughput with 99.9 % significant level (Signif. codes:'***' 0.001).

According to the variable significance tests above, it is observed that total berth length and the total number of ship calls per year have a relationship with total throughput (P-value< $\alpha = 0.05$). Therefore, it is concluded that two variables can be used to predict Y and there is no need to remove any further variables from the model.

Next, the scatter plots are checked to select real significant independent variables for our dependent variable.

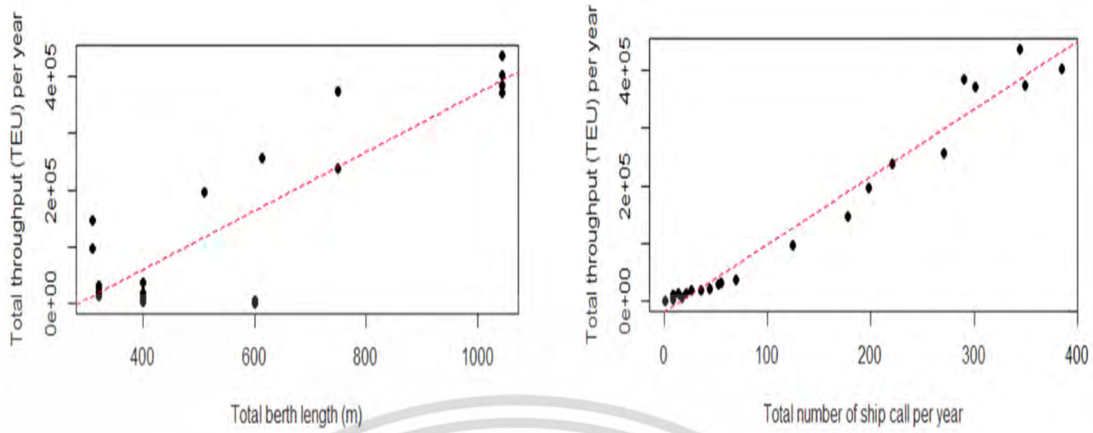


**Figure 4.5** Scatter Plots for Y and Each X in Final Model

According to the plots above, these variables have various linear lines. From this data, it can be able to determine that all the other significant independence variables such as total berth length, and the total number of ship calls per year have a positive correlation with our dependence variable.

### 4.3.3 Multicollinearity Test for Final Model

VIF (variances inflation factor) > 4 suggests collinearity

**Table 4.6** Multicollinearity Test Result for Final Model

| vif(test2) | |
|---|---|
| Log (Total berth length) | Log (Total number of ship calls per year) |
| 1.282395 | 1.282395 |

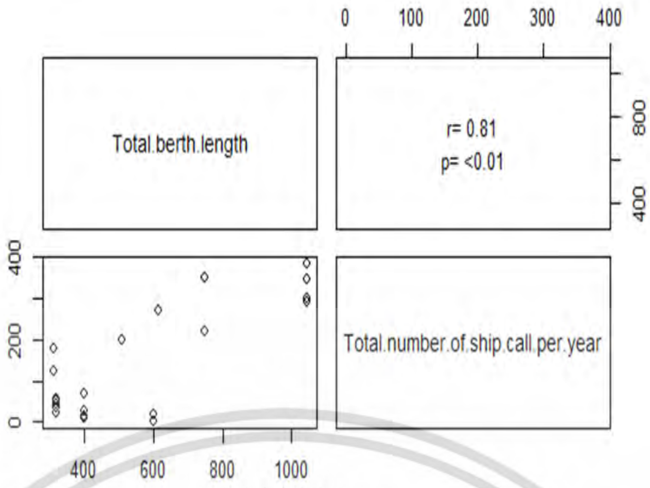


**Figure 4.6** Multicollinearity Plots for Final Model

After plotting the graph and results, it can be seen that there is no collinearity between the two variables by VIF (Variance Inflation Factor) in R programming as the VIF values are smaller than 4. it also can be identified the value of r in the graph. Since the value of r is 0.81, which is near to +1, it can be concluded that there is no collinearity in our model.

**4.3.4 Heteroskedasticity Test for Final Model**

$H_0$: The residuals are homoskedastic.

$H_1$: The residuals are heteroskedastic.

Given $\alpha = 0.05$,

It can be rejected $H_0$ if P-value < $\alpha$,

**Table 4.7** Heteroskedasticity Test Result for Final Model

| **Residual Plots (test 3, quadratic = FALSE)** | | |
|---|---|---|
| | Test stat | Pr(>\|t\|) |
| Log (Total berth length) | 1.676 | 0.111 |
| Log (Total number of ship calls per year) | 3.498 | 0.003 |
| Tukey test | 3.652 | 0.000 |
| nCVTest (test 3) | | |
| Non-constant variance score test | | |
| Variance formula: ∽ fitted values | | |
| Chisquare = 0.05416069 | Df = 1 | P = 0.8159753 |

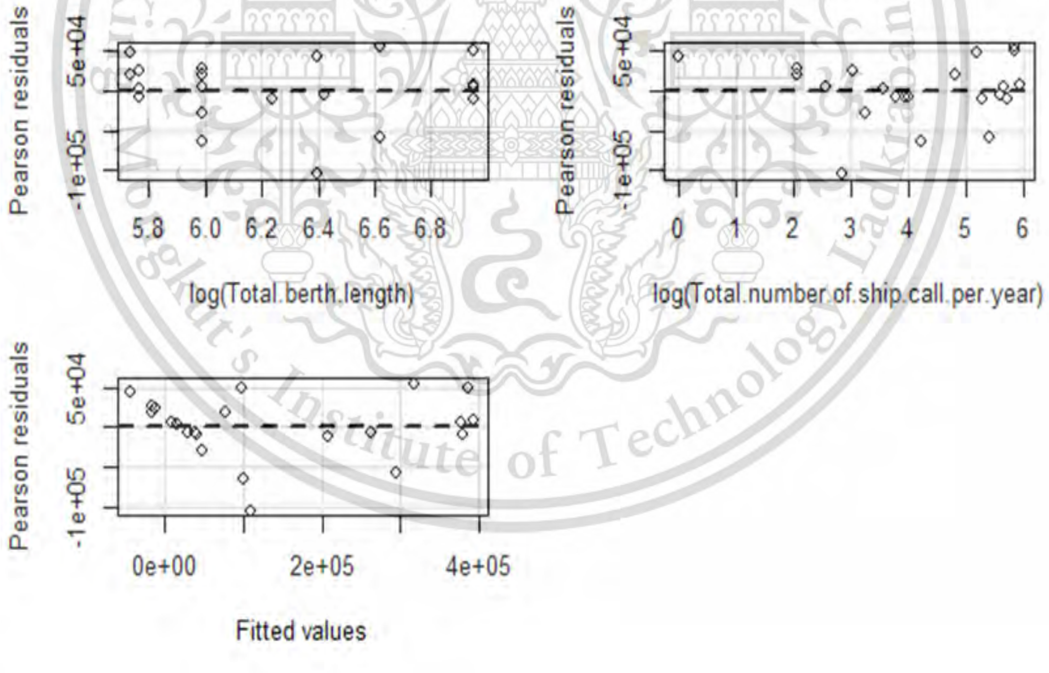


**Figure 4.7** Heteroskedasticity Plots for Final Model

According to the above results, it is observed that P-value=0.8159753>$\alpha$ = 0.05 and. Therefore, it is failed to reject the null hypothesis $H_0$. This means that no heteroskedasticity has occurred in our final model.

According to the graphs above, the plotted points do not correlate with the linear line, but all variables in each graph are spread out uniformly. Therefore, it is believed that the model remains effective in this case as the residuals are homoskedastic.

### 4.3.5 Normal Distribution Test for Final Model

$H_0$: The residuals are normally distributed

$H_1$: The residuals are not normally distributed

Given that $\alpha = 0.05$,

It can be rejected $H_0$ if P-value < $\alpha$ =0.05,

**Table 4.8** Normal Distribution Test Result for Final Model

| **Shapiro-Wilk normality test** | |
|---|---|
| data: test 3$residuals | |
| W=0.91945 | p-value=0.07405 |

Using the Shapiro-Wilk normality test, it is observed that P-value= 0.07405>$\alpha$=0.05. Therefore, it is failed to reject $H_0$. This means that the residuals are normally distributed, and it can be identified that W value from the table. Since our W value (0.91945) is close to 1, we can say that residuals are normally distributed.

### 4.3.6 Residual Test for Final Model

$H_0$: The residuals are not serially correlated

$H_1$: The residuals are serially correlated

Given that $\alpha = 0.05$,

It can be rejected $H_0$ if P-value < $\alpha$ =0.05

**Table 4.9** Residual Test Result for Final Model

| Durbin-Watson test (test3) | | | |
|---|---|---|---|
| Lag | Autocorrelation | D-W Statistic | p-value |
| 1 | -0.1008584 | 2.19831 | 0.56 |
| Alternative hypothesis: rho !=0 | | | |

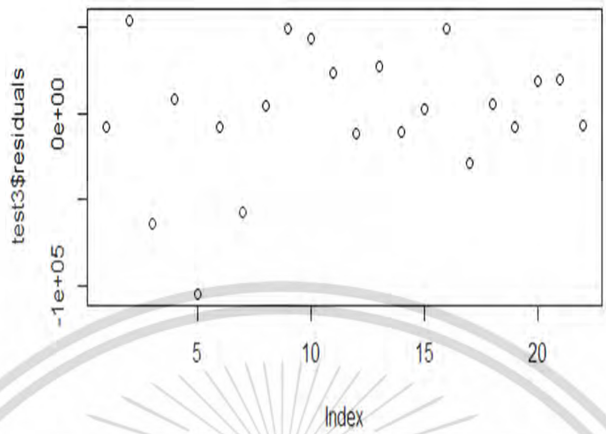


**Figure 4.8 Residual Plot for Final Model**

According to the Durbin Watson test, it is observed that p-value = 0.56>α=0.05. Therefore, it is failed to reject $H_0$. This means that the residuals are not serially correlated. The graph shows that all variables are plotted randomly.

### 4.3.7 Outlier Test for Final Model

$H_0$: The observation is an outlier.

$H_1$: The observation is not an outlier.

Given that $\alpha = 0.05$,

It can be rejected $H_0$ if P-value < α=0.0

**Table 4.10** Outliers Test Result for final model

| Rstudent | Unadjusted p-value | Bonferonni p |
|---|---|---|
| 103.641764 | 0.00089208 | 0.033007 |

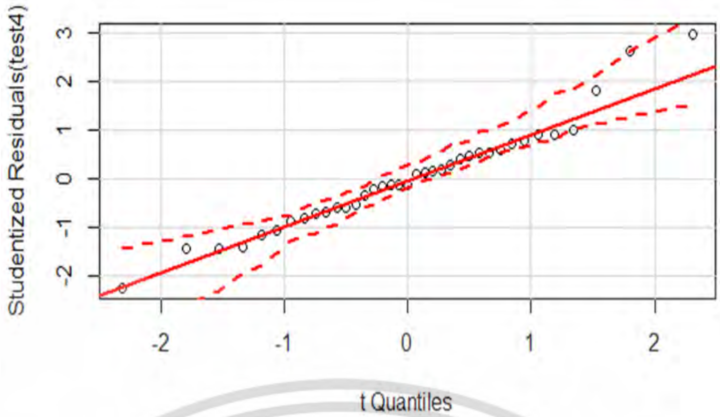


**Figure 4.9** QQ Plot for Final Model

According to the outlier test, it is observed that P-value=0.00089208 < $\alpha$ =0.05. Therefore, we could reject $H_0$. This means that the observation has no outlier problem. So, even though it is found some outlier points since the P-value is significant, any outliers that are did not affect our model.

### 4.3.8 Final Multi Linear Regression Model

$$Y = -1390554 + 210546 \log X_2 + 53922 \log X_8 \quad (4.1)$$

Where Y = Total container throughput (TEU per year)

$X_2$ = Total berth length

$X_8$ = Total number of ship calls per year

## 4.4 Discussion on Finding

This research established the three multiple linear regression models namely preliminary model, reduced model and final model, using statistical tests to create the finest model for not only to understand the relationship between the total container throughput and the selected KPI but also to predict the total container throughput base on the value of the selected KPIs collected by the MPA.

In analysing the data, the study explains that the dependent variables used in preliminary model (full model) are significantly influencing the total container through put only for total number berth length and total number of ship calls per year. It can also be seen that the slope for the total number of berths is negative. It means that total number of berths has negative correlation with total container throughput. The negative correlation means when total number of berths increasing, the total container throughput is likely to decrease. It is reasonable because the increasing number of berths do not mean the port can provide more services for the container vessels. Some container ports have many berths but not all the berths can work or provide service for container vessels due to the limited draft of river, small length of berth and aging berth to accept the new and large container vessel. For example, MIP has 4 berths, but they usually use 2 berths normally because of berth length and the limited draft of the Yangon river.

The analysis clearly shows that both the slope of total berth length and the total number of ship calls per year are positive. It means that both these independent variables show positive correlation. That is because of the total berth length is the important area. It is one of the busiest working areas of the container terminal operation for unloading/loading of containers form the container vessel with quay cranes. Container ports should have sufficient berth lengths for the container vessel to come alongside. The total number of ship calls is also certainly important and is a direct proportion with container throughput. If the more vessels berth the port, the number of containers will increase.

Normally, for typical container ports, slope of the machines which aims at helping ports to increase in productivity should be positive. But in the five major container ports of Myanmar, slope of total number of quay crane and forklifts are found to be negative. Almost all container ports (AIPT, TMT, AWPT and MIP), they started to use more reach stackers than the quay cranes and forklifts. In 2015, MITT which is the only seaport that has the highest total container throughput using only three transfer crane (RMGC) it is the only port that can provide such large and modern facilities to serve the increasing demands and activities cause by economy expansion of the country. This trend led to negative of the slope of the total number of transfer cranes.

It can also be suggested that among the container ports MITT provides the biggest impact in establishing the regression models since it has both highest growth rate of throughput per year and highest growth rate of the total number of ship calls per year.

# CHAPTER 5

# CONCLUSIONS AND RECOMMENDATIONS

## 5.1 Conclusions

This study aims to analyse the relationship between container throughput and other important KPIs. It can help the MPA and container port operators in the country to identify which KPIs are essential for monitoring and improving their performance.

Firstly, selecting total container throughput in TEU as single output criteria is not enough to measure the performance of container ports and grasp the operation of the port in Myanmar. Since a container port can offer many facilities and services, it's performance measure can be measured to focus in traffic of the ships, throughput of the port, utilization and machines that are used in the port. Moreover, there can be other KPIs that should be used to focus the total container throughput.

Secondly, to find out the relationship between variables and to focus the value of one based on the value of others, multiple linear regression is commonly used method in the literature. The others related literature written by different authors, commonly used KPIs can be selected from the port-related research papers.

Thirdly, to establish multilinear regression analysis with the limitation of the study and the model assumption which were used in the literature. To achieve the best model to predict the total container throughput, the study employed a quantitative analysis method by applying a regression modelling technique which consisted of 3 model namely preliminary model, reduced model and final model through statistic tests such as significance test, multicollinearity test, heteroskedasticity test, normal distribution test, residual test and outliers test. In short, it can be concluded that two independent variables affect total throughput namely total berth length and total ship calls per year. According to test results, no collinearity and no heteroskedasticity was found. The residuals were found to be normally distributed, not serially correlated and without outliers. This implies that these two variables can be used to determine the total container throughput of the five major container ports in Myanmar.

Finally, from the results, it can be known that reach stackers are becoming more popular than other cranes types namely quay cranes, transfer crane and forklifts in major containers port.

## 5.2 Recommendations

In this study, a major limitation is the amount of data that could be obtained. Therefore, an important suggestion for future work is to gather more data and include it in any analysis. This should increase the reliability of the analysis results.

For future studies, Data Envelopment Analysis (DEA) can be used as a methodology for calculating port efficiency. One of the popular measurements in port productivity for each container port can be calculated to help the MPA to know which ports are inefficient. Moreover, another regression model should be established to know how the performance of port is related to the Logistic Performance Index (LPI).

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# APPENDIX A

# PUBLISHED PAPER

# Determinants of Port Performance – Case Study of Five Major Container Ports in Myanmar

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**Abstract**. Container ports are playing a pivotal role in facilitating global logistics and supply chains. Therefore, their performance and overall competitiveness must be improved in order to retain shipping lines and shippers. This study aims to analyze the relationship between container throughput (Twenty-Foot Equivalent Unit (TEU) per year) and other important Key Performance Indicators (KPIs). This analysis can help the Myanma Port Authority (MPA) and container port operators in the country to identify which KPIs are essential for monitoring and improving their performance. The Data used in this study was collected from five major Myanmar container ports under the authority of the MPA for the period 2010-2015. This study employed a quantitative analysis method by applying a regression modelling technique. As a result, it is concluded that container throughput is influenced only by some KPIs namely total berth length and the total numbers of ship calls per year.

**Keywords:** Myanmar, container ports, container throughput, key performance indicators

## 1. Introduction

Myanmar possesses many ports, not only river ports but also seaports. These ports are undergoing significant development with processing and manufacturing projects being implemented at many of them. There are, in total, five major container ports in Myanmar, Thilawa is a sea port located 25 kilometers from Yangon city, adjacent to the Thilawa Special Economic Zone while the others are river ports (namely Asia World Port Terminal, Myanmar Industrial Port, Myanmar Terminal Port, Alone International Port Terminal) situated in the Yangon City Area. They handle 90% of the export and import containers in Myanmar [1]. There was an increase in container traffic between 2007 and 2016 [2] and since the enactment of a new Foreign Direct Investment Law, many foreign companies have been investing in ports and related infrastructure.

Myanmar potentially has numerous transshipment opportunities because of its strategic position in close proximity to India and Bangladesh and also near to China, Laos and Thailand. 75% of Myanmar's ports, known as "landlord ports" [3], are being leased to the private sector by a new government trying to promote private sector investment in coastline ports and thereby increase their traffic capacity. As ports are certainly important for a country in terms of facilitation the movement of goods [4], performance indicators are needed in order to measure the performance and grasp the operation of ports in a country [5]. There are many ways of measuring container port efficiency or productivity [6]. With regards to single output criteria, the throughput of container terminals in TEU is a popular indicator display in maritime business rankings [7]. Container throughput is a standard measure for the productivity of a seaport [8]. Therefore, in order to increase the productivity of the ports, MPA, an organization operation under the authority of the Ministry of Transport and Communications, has selected container throughput (TEU per year) as its main Key Performance Measure (KPI) for all the container ports of Myanmar. As we can see in Fig.1, total TEU/year from 2005 to 2015 shows an upward trend because during these years respective governments tried to change public service ports into landlord ports as they knew it would increase the performance of all ports. Furthermore, the improvement of the country's logistics performance allowed for further increase to the container throughputs during this 10-year period.

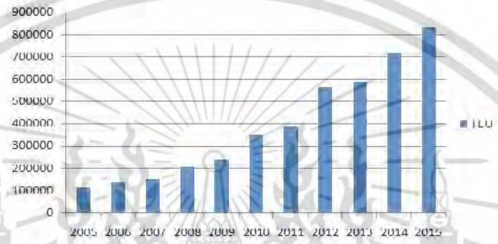


**Figure 1.** Total container throughput from 2005 to 2015.

As both container traffic and GDP increased between 2009 and 2014, Myanmar's ports served the country by distributing goods domestically and internationally, which served as a gateway for trade and stimulated national development and growth. However, compared to other maritime nations in Southeast Asia, Myanmar still has poorer than average port services and facilities. So, knowing which KPIs influence the container throughput at the five major container ports of Myanmar is important for the MPA and stakeholders of port industry. Regression analysis is a very valuable which can be used to model such things as the relationship between dependent variable and independent variable [9].

Therefore, the objective of the study undertaken from this paper is to help the MPA and its stakeholders to investigate whether there is any relationship between total container throughput (TEU per year) and other Key Performance Indicators (KPIs) so as to determine which predictors, among all our selected predictors can be used to determine total container throughput per year.

## 2. Research Methodology

The study this time, we used quantitative analysis with the aim of understanding and predicting the determinants of total throughput per year for the five major container ports in Myanmar between 2011- 2015 by applying a Multi Linear Regression Model.

There are generally two purposes for using regression analysis. The first is to understand the relationship between variables such as container throughput and number of ship call per year. The second purpose is to predict the value of one variable based on the value of the others.

Looking at the literature data, we found that a total of 10 KPIs have been commonly used in past studies up to now. They are average turnaround time, average waiting time, container throughput, average tonnage per ship, berth occupancy rate, dwell time, vessel size and average tonnage per ship [5, 10, 11, 12, 13, 14, 15, 16, 17, 18]. For this study, in Myanmar, it was only possible to acquire data for one of these commonly used KPIs over a five-year period (container throughput) for our dependent variables. Consequently, we used the KPIs previously collected by the MPA as independent variables (numbers of berths, berth length, terminal area, total number of quay container crane, total number of transfer crane, number of reach stacker, number of frock lift, number of ship calls per year). Other paragraphs are indented.

Total throughput can be assigned as below:

$\mathbf{Y = f (X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8)}$

According to above equation, we can convert into MLR model to explain about the factors effecting on throughput as that:

$Y = ß_0 + ß_1X_1 + ß_2X_2 + ß_3X_3 + ß_4X_4 + ß_5X_5 + ß_6X_6 + ß_7X_7 + ß_8X_8 + \in$

Where,

$\in$ = random error

$ß_0$ = intercept (value of Y when all X=0)

$ß_1, ß_2, ß_3, ß_4, ß_5, ß_6, ß_7, ß_8$ = regression coefficients

**Table 1.** Variables used for study.

| Symbol | Variables |
|---|---|
| $Y$ | Total container throughput (TEU per year) |
| $X_1$ | Total number of berths |
| $X_2$ | Total berth length (m) |
| $X_3$ | Total terminal area ($m^2$) |
| $X_4$ | Total number of quay container cranes |
| $X_5$ | Total number of transfer cranes |
| $X_6$ | Total number of reach stackers |
| $X_7$ | Total number of forklifts |
| $X_8$ | Total number of ship calls per year |

In order to run a regression model by using R studio, we have to make the following assumption: the current MLR model form is reasonable, the residuals have constant variance, the residuals are normally distributed, the residuals are uncorrelated, and the predictors are not highly correlated with each other and no outlier.

## 3. Results and Discussion

3.1. Model 1

*3.1.1. Significance test for model 1.*

**Table 2.** Significance test results for model 1.

| Coefficients: | Estimate | $Pr(>\|t\|)$ |
|---|---|---|
| (Intercept) | -1.109e+04 | 0.705521 |
| Total number of berths | -2.312e+04 | 0.080730 · |
| Total berth length | 2.522e+02 | 0.000371 *** |
| Total terminal area | -3.908e-02 | 0.257517 |
| Total number of quay cranes | -1.205e+03 | 0.726055 |
| Total number of transfer cranes | -8.842e+02 | 0.664097 |
| Total number of reach stackers | 3.748e+03 | 0.051641 · |
| Total number of forklifts | -1.227e+04 | 0.063655 · |
| Total number of ship calls per year | 9.702e+02 | 2.49e-05 *** |

Significant codes:0 '***'0.001 '**'0.01 '*'0.05 '.'0.1 ' '1

Residual standard error: 15380 on 13 degrees of freedom
Multiple R-squared: 0.9943, Adjusted R-squared: 0.9907
F-statistic: 282 on 8 and 13 DF, p-value: 2.66e-13

According to the above results, we observed that P-value=$2.66e^{-13} < \alpha = 0.05$. Therefore, we could reject the null hypothesis $H_0$. This means that a relationship exists between Xi and Y for at least one variable. In addition, we can see that $R^2$=0.9943. This means that an approximate 99.43% variation in total throughput can be explained by our model. We proceeded to test which variables were most effective in forecasting total throughput.

*3.1.2. Variable Significance test for each independent variable*. According to the variable significance tests, we observed that total berth length and total number of ship calls per year correlated with total throughput (P-value< $\alpha$ = 0.05). On the other hands, total no. of berths, total terminal area, total number of quay cranes, total no. of reach stackers, total no. of forklifts and total no. of transfer cranes have no relation with total throughput (P-value> $\alpha$ = 0.05). Therefore, we concluded that there are two variables that can be used to predict Y. We removed the insignificant independent variables and created a new model.

3.2. Model 2

*3.2.1. Significance test for model 2.*

**Table 3.** Significance test results for model 2.

| Coefficients: | Estimate | Pr(>\|t\|) |
|---|---|---|
| (Intercept) | -66387.99 | 2.48e-06*** |
| Total berth length | 139.57 | 2.41e-05*** |
| Total number of ship calls per year | 946.21 | 1.40e-13*** |

Significant codes0 '***'0.001 '**'0.01 '*'0.05 '.'0.1''1
Residual Standard Error: 18330 on 19 degrees of freedom
Multiple R-Squared: 0.9881, Adjusted R-Squared: 0.9869
F-statistic: 789.4 on 2 and 19 DF, p-value: <2.2e-16

According to the above results, we determined our new P-value=$2.2e^{-16} < \alpha = 0.05$. Therefore, we can reject the null hypothesis $H_0$. This means that a relationship exists between Xi and Y for at least one variable. We proceeded to test which variables were most effective in forecasting total throughput.

*3.2.2. Variable Significance test for each independent variable*. According to the Variable Significance tests, we observed that total berth length and total number of ship calls per year correlated with total throughput (P-value<$\alpha$ = 0.05). Therefore, we could conclude that our new model is an improvement on the old one. We also concluded that there are two variables that can be used to predict Y and there was no need to remove any further variables from the model.

*3.2.3. Multicollinearity test.*

**Table 4.** Multicollinearity test results for model 2.

| vif(test2) | |
|---|---|
| Total berth length | Total number of ship call per year |
| 2.943587 | 2.943587 |

According to the above results we observed that VIF value of 2 dependence variables remain smaller than 4 (VIF > 4 suggest collinearity). Thus, we could conclude that there's no collinearity in our model.

*3.2.4. Heteroskedasticity test.*

**Table 5.** Heteroskedasticity test results for model 2.

| residualPlots(test2, quadratic = FALSE) | | |
|---|---|---|
| | Test stat | Pr(>\|t\|) |
| Total berth length | 1.916 | 0.071 |
| Total number of ship calls per year | -0.602 | 0.555 |
| Tukey test | 0.247 | 0.805 |
| ncvTest(test2)<br>Non-constant Variance Score Test<br>Variance formula: ~ fitted values<br>Chisquare = 7.345889 Df = 1 p = 0.00672163 | | |

According to the above results, we observed that P-value=0.00672163 < $\alpha$ = 0.05. Therefore, we cannot reject null hypothesis $H_0$. This means that there is no heteroskedasticity problem. Thus, we used log transformations for our independent variables to help to solve the heteroskedasticity problem.

3.3. Model 3

*3.3.1. Significance test for model 3.*

**Table 6.** Significance test results for model 3.

| Coefficients: | Estimate | Pr(>\|t\|) |
|---|---|---|
| (Intercept) | -1390554 | 1.41e-09*** |
| Log (Total berth length) | 210546 | 1.24e-08*** |
| Log (Total number of ships call per year) | 53911 | 6.78e-08*** |
| Significant codes0 '***'0.001 '**'0.01 '*'0.05 '.'0.1''1<br>Residual Standard Error: 40720 on 19 degrees of freedom<br>Multiple R-Squared: 0.9413, Adjusted R-Squared: 0.9351<br>F-statistic: 152.3 on 2 and 19 DF, p-value: <2.009e-12 | | |

According to the above results, we observed that P-value=2.009e-12<$\alpha$ = 0.05. Therefore, we could reject the null hypothesis H0. This means that a relationship exists between Xi and Y for at least one variable. So, we proceeded to test which variables were most effective in forecasting total throughput.

*3.3.2. Variable significance test for each independent variable.* According to the Variable Significance tests above, we observed that total berth length and total number of ship calls per year have a relationship with total throughput (P-value< $\alpha$ = 0.05). Therefore, we concluded that there are two variables that can be used to predict Y and there was no need to remove any further variables from the model.

*3.3.3. Multicollinearity test result for model 3.*

**Table 7.** Multicollinearity test results for model 3.

| vif(test2) | |
|---|---|
| Log (Total berth length) | Log (Total number of ship calls per year) |
| 1.282395 | 1.282395 |

According to the above results, we observed that the VIF value of two dependent variables remains smaller than 4 (VIF > 4 suggests collinearity). Thus, we could conclude that there is no collinearity in our model.

*3.3.4. Heteroskedasticity test.*

**Table 8**. Heteroskedasticity test results for model 3.

| Residual Plots (test 3, quadratic = FALSE) | | |
|---|---|---|
| | Test stat | Pr(>\|t\|) |
| Log (Total berth length) | 1.676 | 0.111 |
| Log (Total number of ship calls per year) | 3.498 | 0.003 |
| Tukey test | 3.652 | 0.000 |
| nCVTest (test 3)<br>Non-constant variance score test<br>Variance formula: ~ fitted values | | |
| Chisquare = 0.05416069 | Df = 1 | P = 0.8159753 |

According to the above results, we observed that P-value=0.8159753>$\alpha$ = 0.05 and. Therefore, we fail to reject null hypothesis H0. It means that there's no heteroskedasticity occurred in our model 3.

*3.3.5. Normal distribution test.*

**Table 9**. Normal distribution test results for model 3.

| Shapiro-Wilk normality test | |
|---|---|
| data: test 3$residuals | |
| W=0.91945 | p-value=0.07405 |

Using the Shapiro-Wilk normality test, we observed that P-value= 0.07405>$\alpha$=0.05. Therefore, we failed to reject $H_0$. This means that the residuals were normally distributed.

*3.3.6. Residual test.*

**Table 10.** Residual test results for model 3.

| durbinwatsonTest (test3) | | | |
|---|---|---|---|
| Lag | Autocorrelation | D-W Statistic | p-value |
| 1 | -0.1008584 | 2.19831 | 0.56 |
| Alternative hypothesis: rho !=0 | | | |

According to the Durbin Watson test, we observed that the p-value = 0.56>$\alpha$=0.05. Therefore, we failed to reject H0. This means that the residuals were not serially correlated.

*3.3.7. Outlier test.*

**Table 10.** Outlier test results for model 3.

| Rstudent | Unadjusted p-value | Bonferonni p |
|---|---|---|
| 103.641764 | 0.00089208 | 0.033007 |

According to the outlier test, we observed that P-value=0.00089208<α =0.05. Therefore, we could reject H0. This means that the observation is no outlier problem. So, even if we found some outlier points, since the P-value is significant, any outliers that were found had no effect on our model.

**4. Conclusion**

In short, we can conclude that there are two independent variables that effect on total throughput such as total berth length and total ship call per year respectively. According to result tests, there are no collinearity and no heteroskedasticity found. The residuals are found to be normally distributed, not serially correlated and no outliers. This implies that these two variables can be used to determine total container throughput of the five major container ports in Myanmar.

In this study, a major limitation is the amount of data that can be obtained. Therefore, an important suggestion for future work is to gather more data and take them into the analysis. This could increase the reliability of the analysis results.

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# APPENDIX B

## COLLECTED KPIS FROM EACH CONTAINER PORTS

| The Myanmar Terminal Ports (TMT) | | | | | | |
|---|---|---|---|---|---|---|
| Year | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
| Number of berth (m) | 2 | 2 | 2 | 2 | 2 | 2 |
| Total berth length (m) | 320 | 320 | 320 | 320 | 320 | 320 |
| Total terminal area (m2) | 61,918 | 47,377 | 47,377 | 47,377 | 47,377 | 47,377 |
| Total storage area (m2) | 48,000 | 42,977 | 42,977 | 42,977 | 42,977 | 42,977 |
| Total throughput (TEU/year) | 55,188 | 31,852 | 18,085 | 11,922 | 29,390 | 20,094 |
| Total number of Quay (container) crane | 2 | 3 | 3 | 3 | 3 | 4 |
| Total number of Transfer crane (RTGC, RMGC, Straddle carrier) | 2 | 2 | 2 | 2 | 2 | 5 |
| Total number of Reach Stacker | 5 | 5 | 8 | 8 | 8 | 8 |
| Total number of Forklift | 5 | 5 | 5 | 5 | 5 | 5 |
| Total number of Yard tractor | 23 | 27 | 27 | 27 | 30 | 30 |
| Total number of container ship to call a port/year | 81 | 55 | 35 | 21 | 52 | 44 |

| Myanmar Industrial Port (MIP) | | | | | | |
|---|---|---|---|---|---|---|
| Year | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
| Number of berth (m) | 2 | 2 | 2 | 3 | 4 | 4 |
| Total berth length (m) | 310 | 310 | 310 | 510 | 750 | 750 |
| Total terminal area (acre) | 17 | 17 | 65 | 65 | 65 | 65 |
| Total storage area (acre) | 15 | 15 | 61 | 61 | 61 | 61 |
| Total throughput (TEU/year) | 72,774 | 9,6104 | 145,528 | 195,638 | 236,665 | 373,170 |
| Ratio of TEU/VAN | 1,819 | 2,002 | 1,820 | 2,445 | 2,366 | 3,732 |
| Total number of Quay (container) crane | | | | | 5 | 5 |
| Total number of Transfer crane (RTGC, RMGC, Straddle carrier) | 2 | 2 | 7 | 7 | 12 | 22 |
| Total number of Reach Stacker | 10 | 12 | 13 | 18 | 20 | 20 |
| Total number of Forklift | 6 | 6 | 7 | 8 | 8 | 8 |
| Total number of Yard tractor | 40 | 48 | 80 | 80 | 100 | 100 |
| Total berth time (service time) in port (hr) | 60 | 57 | 52 | 48 | 32 | 31 |
| Total berthing/deberthing time (hr) | 20 | 20 | 20 | 20 | 20 | 20 |
| Total berth time (hr) | 68 | 65 | 60 | 52 | 48 | 48 |
| Total number of container ship to call a port/year | 107 | 124 | 178 | 198 | 221 | 349 |
| Average operation day/year | 267 | 310 | 296 | 297 | 331 | 348 |
| Average dwell time | 30 | 28 | 29 | 28 | 28 | 27 |
| Average truck turnaround time | 15 | 15 | 10 | 10 | 9 | 9 |
| Total number of workers | 5,564 | 6,448 | 9,256 | 10,296 | 11,492 | 18,148 |

| Myanmar International Terminal Thilawa (MITT) | | | | | | |
|---|---|---|---|---|---|---|
| Year | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
| Number of berth (m) | 2 | 2 | 2 | 2 | 2 | 2 |
| Total berth length (m) | 400 | 400 | 400 | 400 | 400 | 400 |
| Total terminal area (Ha) | 75 | 75 | 75 | 75 | 75 | 75 |
| Total storage area (m2) | 15,540 | 15,540 | 15,540 | 15,540 | 15,540 | 15,540 |
| Total throughput (TEU/year) | 14,005 | 2,540 | 18,249 | 10,166 | 14,139 | 35,295.80 |
| Ratio of TEU/VAN | 1.0230 | 1.0300 | 1.1910 | 1.0040 | 1.0050 | 1.1030 |
| Total number of Quay (container) crane | 2 | 2 | 2 | 2 | 2 | 2 |
| Total number of Transfer crane (RTGC, RMGC, Straddle carrier) | 3 | 3 | 3 | 3 | 3 | 3 |
| Total number of Reach Stacker | 2 | 2 | 2 | 2 | 2 | 2 |
| Total number of Forklift | 2 | 2 | 2 | 2 | 2 | 2 |
| Total number of Yard tractor | 12 | 12 | 12 | 12 | 12 | 12 |
| Total berth time (service time) in port (hr) | 308.80 | 89.22 | 431.33 | 277.36 | 395.16 | 2078.57 |
| Total berth time (hr) | 1,514.83 | 638.26 | 1,081.92 | 311.09 | 609.16 | 1,889.89 |
| Total number of container ship to call a port/year | 30 | 8 | 26 | 8 | 13 | 69 |
| Average dwell time | 12 | 12 | 14 | 16 | 14 | 12 |
| Average truck turnaround time | 5 | 5 | 5 | 5 | 5 | 5 |

| Asia World Port Terminal (AWPT) | | | | | |
|---|---|---|---|---|---|
| Year | 2011 | 2012 | 2013 | 2014 | 2015 |
| Number of berth (m) | 3 | 3 | 3 | 3 | 3 |
| Total berth length (m) | 614 | 1044 | 1044 | 1044 | 1044 |
| Total terminal area (acre) | 30.436 | 53.709 | 53.709 | 53.709 | 53.709 |
| Total storage area (slot) | 2,278 | 4,455 | 4,455 | 4,455 | 4,455 |
| Total throughput (TEU/year) | 256,419 | 383,794 | 370,387 | 436,936 | 402,276 |
| Ratio of TEU/VAN | 3.1 | 3.1 | 2.1 | 2.1 | 2.1 |
| Total number of Quay (container) crane | 3 | 5 | 5 | 5 | 5 |
| Total number of Transfer crane (RTGC, RMGC, Straddle carrier) | | 4 | 4 | 4 | 4 |
| Total number of Reach Stacker | 16 | 20 | 20 | 24 | 24 |
| Total number of Forklift | 12 | 12 | 13 | 14 | 16 |
| Total berth time (service time) in port (hr) | 36 | 36 | 36 | 36 | 36 |
| Total berth time (hr) | 40 | 40 | 40 | 40 | 40 |
| Total number of container ship to call a port/year | 271 | 290 | 301 | 344 | 385 |
| Average operation day/year | 11.23 | 13.49 | 13.50 | 12.06 | 12.81 |
| Average dwell time | 3 | 3 | 3 | 3 | 3 |
| Total number of workers | 479 | 657 | 654 | 652 | 559 |

| Alone International Port Terminal (AIPT) | | |
|---|---|---|
| Year | 2014 | 2015 |
| Number of berth (m) | 3 | 3 |
| Total berth length (m) | 600 | 600 |
| Total terminal area (sqm) | 190,000 | 190,000 |
| Total storage area (sqm) (General cargo) | 2400 | 2,400 |
| Total storage area (sqm) (container) | 13,210 | 13,210 |
| Total throughput (TEU/year) | 223 | 4235 |
| Total number of Quay (container) crane | 2 | 2 |
| Total number of Transfer crane (RTGC, RMGC, Straddle carrier) | 2 | 4 |
| Total number of Reach Stacker | 2 | 4 |
| Total number of Forklift | 6 | 6 |
| Total number of Yard tractor | 8 | 8 |
| Total berth time (service time) in port (hr) | 2,365 | 3,074 |
| Total berth time (hr) | 2,640 | 3,402 |
| Total number of container ship to call a port/year | 1 | 17 |
| Total number of general cargo ship to call a port/year | 13 | 65 |
| Average operation day/year | 99.00 | 128.00 |
| Average dwell time (container) | 7 | 7 |
| Average dwell time (general cargo) | 7 | 7 |
| Average truck turnaround time | 4 | 4 |
| Total number of workers | 84 | 84 |

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