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 Myanmar 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.](image)

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, truck turnaround time, ton per crane (hook) per hours and ton per gantry crane per hours [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 forklift, number of ship calls per year). Other paragraphs are indented.

Total throughput can be assigned as below:

\[ Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8) \]

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

\[ Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \epsilon \]

Where,

\[ \epsilon = \text{random error} \]

\[ \beta_0 = \text{intercept (value of } Y \text{ when all } X=0) \]

\[ \beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7, \beta_8 = \text{regression coefficients} \]

| 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 (m²) |
| 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.

| 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
According to the above results, we observed that $P\text{-value}=2.66e^{-13} < \alpha = 0.05$. Therefore, we could reject the null hypothesis $H_0$. This means that a relationship exists between $X_i$ 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 ($P\text{-value}< \alpha = 0.05$). On the other hand, 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 ($P\text{-value}> \alpha = 0.05$). 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.

| 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 codes: 0 ‘***’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 $P\text{-value}=2.2e^{-16} < \alpha = 0.05$. Therefore, we can reject the null hypothesis $H_0$. This means that a relationship exists between $X_i$ 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 ($P\text{-value}< \alpha = 0.05$). 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

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

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 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)

Non-constant Variance Score Test

Variance formula: ~ fitted values

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: (Intercept) | Estimate | Pr(>|t|) |
|---------------------------|----------|---------|
| Log (Total berth length)  | 210546   | 1.24e-08*** |
| Log (Total number of ships call per year) | 53911 | 6.78e-08*** |

Significant codes 0 ‘***’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 results, we observed that P-value=2.009e-12< $\alpha = 0.05$. Therefore, we could reject the null hypothesis $H_0$. This means that a relationship exists between $X_i$ 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) | 1.282395 |
| Log (Total number of ship calls per year) | 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)                          |           |         |
| Non-constant variance score test          |           |         |
| Variance formula: ~ fitted values         |           |         |
| Chisquare = 0.05416069                     | 0.05416069| 0.8159753|
|                                              | Df = 1    |         |
|                                              | P = 0.8159753|     |

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

3.3.5. **Normal distribution test.**

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

Shapiro-Wilk normality test

data: test 3$resid  
W=0.91945, p-value=0.07405

Using the Shapiro-Wilk normality test, we observed that P-value= 0.07405>α=0.05. Therefore, we failed to reject H₀. 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    |

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

| Table 11. Outlier test results for model 3. |
|--------------------------------------------|
| RstUDENT | Unadjusted p-value | Bonferonni p-value |
| 103.641764 | 0.00089208 | 0.033007 |

According to the outlier test, we observed that P-value=0.00089208<\alpha =0.05. Therefore, we could reject H_0. 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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**Acknowledgement**

We would like to show our gratitude to the Dr. Myo Nyein Aye, Deputy General Manager, Myanmar Port Authority, for not only sharing data but also for providing his valuable guidance for our study.