REGRESSION MODEL ANALYSIS FOR VESSEL SERVICE TIME

KASYPI MOKHTAR

UNIVERSITI TEKNOLOGI MALAYSIA

To my beloved parents, Umi and arwah Abah

To Suhaili Mohd Nor, Muhamad Daud Basri and Muhamad Tarmizi

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ABSTRACT

Turnaround time in port industry portrays the capability and ability of a container terminal port in providing shipping services. This study is motivated by the rapid development in container terminal ports to provide efficient and effective services and high port productivity. The aim of this research is to develop mathematical relationships between port throughputs and port facilities. Presently, the factors that influence the performance of a port in terms of turnaround time are still debatable. This research proposes a regression model that relates the turnaround time and the port facilities. Two ports in Port Klang, i.e. the Westport and the Northport, were selected as the studied subjects from which the actual vessel call data were collected. A one - month data were used in the analysis. The overall results showed that the vessel turnaround time is highly correlated with crane allocation, number of containers loaded and discharged. The model relating these variables is in the form of multiple regression. The benefits of such a model include that of giving port operators the opportunity to determine optimum crane allocation in order to achieve the desired turnaround time given the quantity of containers to be processed.

ABSTRAK

Masa celusan di dalam industri pelabuhan memperlihatkan kepada keupayaan dan kebolehan terminal pelabuhan kontena dalam menyediakan perkhidmatan perkapalan. Penyelidikan ini dimotivasikan oleh pembangunan yang pesat di pelabuhan terminal kontena untuk menyediakan perkhidmatan yang cekap dan berkesan berserta dengan produktiviti pelabuhan yang tinggi. Tujuan penyelidikan ini adalah untuk membangun pertalian matematik di antara daya pemprosesan pelabuhan dan kemudahan pelabuhan. Pada masa ini, faktor-faktor yang mempengaruhi prestasi pelabuhan dari segi masa celusan masih boleh dibahaskan. Penyelidikan ini mencadangkan satu model regresi yang mengaitkan masa celusan dan kemudahan pelabuhan. Dua pelabuhan di Pelabuhan Kelang, iaitu Westport dan Northport, telah digunakan sebagai subjek kajian, yang mana data daripada panggilan sebenar kapal telah dikumpulkan. Data untuk tempoh sebulan telah digunakan di dalam analisis. Keputusan keseluruhan menunjukkan bahawa masa celusan kapal adalah amat berhubungkait dengan peruntukan kren, jumlah kontena-kontena yang dimuatkan dan diturunkan dari kapal. Model yang mengaitkan pembolehubah-pembolehubah ini adalah dalam bentuk regresi berganda. Kebaikan model regresi ini termasuklah memberi operator pelabuhan peluang dalam menentukan peruntukan kren yang optimum untuk mencapai masa celusan yang diingini bilamana diketahui jumlah kuantiti kontena untuk diproses.

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LIST OF SYMBOLS

α	-	Statistical significance level
β	-	Coefficient also known as beta
ε	-	Regression Error
r	-	Pearson's Coefficient of correlation
N, n	-	Number of observations
$\sum$	-	Total
μ	-	Mean of distribution
σ	-	Standard deviation
X	-	Number of container discharge and loading
R^2	-	Pearson's Correlation of determination
P	-	Significance value
H_0	-	Null hypothesis
H_1	-	Alternative hypothesis
Y	-	Dependent variable
$X_1, X_2 ... X_i$	-	Independent variables
$\leq$	-	Less than or equal
$\geq$	-	More than or equal

LIST OF ABBREVIATIONS

A	Analysis
AGV	Automated Guided Vehicles
ASC	Automated Stacking Cranes
C	Conclusion
CATOS	Container Automated Terminal Operating System
CNS	Community Network Services
COLS	Corrected Ordinary Least Square
COSMOS	Container Operation Management System
Cr	Critical Region
CrnAll	Crane Allocation
D	Decision
Df	Degree of Freedom
Disch	Discharge
IMO	International Maritime Organisation
ISO	International Organisation for Standardisation
KPA	Klang Port Authority
KPCT	Klang Port Container Terminal
Load	Loading
MAE	Mean Absolute Error

MSE	Mean Square Error
NCT1	Northport Container Terminal 1
NCT2	Northport Container Terminal 2
OLS	Ordinary Least Square
RMSE	Root Mean Square Error
SPSS	Statistical Package for Social Science
TEU	Twenty Foot Equivalent Units
UNCTAD	United Nations Conference on Trade and Development
WPCT	Westport Container Terminal

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The globalisation of trade and the subsequent breakdown of trade barriers have spurred tremendous growth in marine transportation. As a result, more international cargo moved in containers through major container ports. For this reason, the competition among port container terminals is very stiff, taking into consideration the revenue of port container terminal operation. Containerisation is a management intensive operation. The essence of effective transport was early identified as control of the movement of the container through the system (Graham and Hughes, 1985).

In the new era of port development, shippers look for ports with high productivity and efficiency. In other words, shippers are looking for ports, which are able to provide optimum services such as efficient custom clearance, less container damage, no untraced container, direct berthing and less turnaround time for vessel. United Nations Conference on Trade and Development (UNCTAD, 1976 p.8) has defined turnaround time as the total time between arrival and departure for all vessels divided by number of vessels. The port turnaround time is significant to a shipper as vessel turnaround time indicates port productivity and performance.

1.2 The Port Container Terminal System

There are several parties involved in port management, such as federal government, state government and private sector. Therefore, port systems are very complex and difficult to be analysed as a whole, as port management involves various parties (government agencies, forwarding agents, shipping agents, and shipping lines). This scenario sometimes compels sharing of facilities (i.e. tug, and pilot) by stakeholders. It also causes bureaucratic red tapism. However, some guidelines are necessary to mitigate this situation.

Port terminals cater for different types of cargo and are made up of varying systems: liquid, conventional and container terminals. Bulk terminal normally handles uniform non-packaged cargo in large quantities. So, it uses highly efficient mechanised handling equipment such as pipe-lines and conveyor belts, so that operations are able to run without break. The other type is neo-bulk cargo, which is shipped in large quantities but cannot be handled continuously, such as cars or steel. These two types of terminal are mostly character specific and can only handle one type of cargo.

Break-bulk cargo can be categorised as high value goods for maritime transportation. It can be divided into two categories, namely containerised and general cargo. Containerised cargo is where goods have been placed in standardised, International Organisation for Standardisation (ISO) weatherproof metal boxes called as containers. While, general cargo which consists of packaged goods shipped in separate units of various shapes and sizes (Esteban, 1996).

1.3 The Storage System

The basic functions of the storage system of a port are to keep cargo for certain formalities such as customs clearance and to accommodate cargo for varying periods of time. Hence it provides a flexible period for shippers to adjust to the delivery requirements. The system can therefore be said to function in various aspects as a buffer between the maritime and overland inflow-outflow of cargo.

There are several factors within the port system which can impede smooth operations and thus retard the level of throughput. For instance, the efficiency of handling equipment at berths, the number of forklift trucks available for cargo carriage service, the degree of sophistication in the overall information system, locations, restacking and consolidation, and relation with labour organisations.

However, one of the main determinants of berth throughput under normal circumstances is the capacity of the storage system. The fact that the amount of storage space available in port is usually quite limited and that any expansion scheme (including land reclamation) would involve a substantial reshaping of the port layout and thus, require considerable capital investment. It is not difficult to imagine the critical importance of this particular subsystem, especially in view of the danger of it becoming the bottleneck of the system.

The capacity of storage system cannot be defined for general purposes in any way other than in terms of space (cubic feet or metres) per cargo unit (ton or container or individual items). The following basic terms must also be defined:

i. **Holding capacity**: This is the static amount of space in the storage system, measured by specified units and clearly fixed at any one point in time.

ii. **Intrinsic capacity**: The intrinsic capacity is defined as the way to reduce the transit time the cargo spends in the storage system. This is a measurement of the effective capacity in terms of operations, which takes into account the dynamics of the movements of cargo through the storage system. Therefore, the storage system is defined as (Imakita, 1978 p. 101).

$$\textit{Intrinsic capacity} = \textit{Holding capacity} \times \textit{Number of times the cargo turns over}$$

The reason for shortages in capacity may be simply because the existing facilities are not large enough to absorb future as well as current traffic. The other reason is the efficiency or inadequacy of the operational aspects of the storage system, which may be improved in numerous ways such as a systematic layout with clearly defined as bays and gangways, efficient arrangements for stacking in store with good handling and good stacking equipment operated by adequate labour force, and fast custom clearance (Imakita, 1978 p. 102).

1.4 Problem Statement

The current scenario of world trade has huge impact on maritime industry as a whole. Despite the currency crisis in Asian countries in 1997 and following that the economic turmoil, the world trade has not declined in volume but undergone a slow-down in growth with regional trends varying significantly.

The challenges in maritime industries are not only related to quantity but also quality of the service. Here, continuous progress in globalisation of shipping and trade business results in increasing pressures on port container terminal to reduce terminal cost and improve operational efficiency. By achieving this standard, therefore port

operators are able to compete globally and offer efficient services with competitive charges.

The most important objective for a port container terminal is to increase its throughput or in particular, to decrease the turnaround times of vessels (Ng, 2003). The turnaround time of a vessel is high depending on the effectiveness of allocating and scheduling key resources, such as berths, yards, quay cranes, yard cranes and trucks. Otherwise, terminal will face huge problem to cater demands from port users. Therefore, a careful planning is necessary for obtaining satisfactory results (Nagorski, 1972).

A very critical part for port container terminal is vessel turnaround time where it portrays port capability to provide high level of services with high productivity and tremendous performance to port users (UNCTAD, 1976).

Higher turnaround time for a vessel in port means less berthing cost for shippers and thus, voyage can be increased. This will reduce queuing for vessel, which is cost incurred and time consuming. That is why queuing theory and congested cost has been studied (Nor Ghani, 1996).

Significant profit will increase when turnaround time and queuing for vessel is lower, where high productivity and performance for terminal are achieved, whereby still using the same inputs. Besides that, shippers prefer port container terminal that can provide higher turnaround and no queuing for their vessel.

As far as port container terminal is concerned, only ports which are able to provide high level of service, with tremendous productivity and lesser vessel turnaround time can attract liners to berth. According to Cullinane *et al*., (2002) Asian ports are ranked amongst the top 20 container ports in the world. And the top four positions are held by ports in Asia, where Hong Kong, Singapore and Shanghai still maintain as the

top three in ranking and most famous ports in terms of productivity and efficiency (Klang Port Authority, 2005).

Generally, there are a lot of ways that can enhance port performance as they have been studied by previous researchers. In order to obtain an efficient terminal, there are three aspects, which can be distinguished between planning and control level. These three aspects are the strategic level, tactical level, and operational level (Vis and Koster, 2003). These strategies are essential to minimise vessel turnaround time. For the client, a shorter turnaround time of the vessel reduces vessel chartering cost, while faster turnaround time improves berth utilisation and increases government revenue. As for shipping companies, faster vessel turnaround time means more trips and revenues (Business Breaky News, June 2004).

This research seeks to identify the problems related to vessel turnaround time. So far, there have been researches in this area where the objective was to minimise the time vessels spend at berth (Preston *et al.*, 2001). However these approaches focussed on the relationship between storage areas (yard) and vessels by using container location model. Huynh (2005) studied how to reduce truck turnaround time in marine container terminal by using regression model and simulation as the best fit model. This research aims to understand how turnaround time is measured and to identify the variables determining the vessel turnaround time using regression model.

Therefore, the research problem is stated as follows

"There is currently no significant regression model in Malaysia that relates port throughput, measured in TEUs, with port facilities (e.g. quay cranes, prime movers). Therefore, it is difficult to determine the significant factor(s) that influence port container terminal performance, in terms of turnaround time."

1.5 Research Questions

The research questions are:

i. What are the significant factors determining vessels turnaround time?

ii. How these significant factors relate to turnaround time?

1.6 Research Aim and Objectives

This study was carried out to identify how vessel turnaround time relates to port facilities. This will help port container terminals in planning and operational purposes as well establish the level of service to shipping lines patronising port container terminal.

The objective of this research is aimed at:

i. To measure turnaround time.

ii. To list port facilities that significantly determines turnaround time.

iii. To develop a regression model that relates turnaround time to port facility.

1.7 Scope and Limitation of Research

The main purpose of this research is to identify vessel turnaround time problem, which is very crucial to port container terminal. However, there is a time constraint. Therefore limitation of scope for this research will be:

1.7.1 Research will focus only on Port Klang which includes the following terminals for data collection:

i. Westport

ii. Northport

1.7.2 Focus on quantitative variables e.g. number of quay cranes, number of trailer/prime movers, number of yard cranes, and so on. However, qualitative variables e.g. staff skill; customer satisfaction and so on will not be selected as variable for this research.

1.8 The Significance of Research

This research can help to verify the problems in identified area and recommend appropriate suggestions, so as to provide services and improve operations and planning within the port. Consequently, a high level in productivity and efficiency can be achieved. No doubt this research can contribute to body of knowledge as prior researchers do not identify variables to determine vessel turnaround time. Hence it will benefit port container terminal and liner as turnaround time for vessel is very crucial for forecasting vessel schedule. Therefore, all parties involved in this industry will have a mechanism to be relied upon.

Huynh (2005) mentions that regression model is a simple and practical tool that port container terminal operators could use in deciding how many variables could be assigned in order to reduce turnaround time.

1.9 Methodology of Research

The general acceptance and reliability of any research depends on the research procedure used in the collecting data that is relevant to the population of study. Another element that portrays the strength of any research study is the originality of thought supported by empirical test or verification and researches already done on the related field. Also the acceptance of empirical verifications depends on methods of sampling and sample size, method of data analysis and good interpretation of results, and the matching of the research findings to the finding from the literature (Gays and Diehl, 1996).

Regression model entails the use of the method of least squares for estimating, among other statistical relationships between variable.

Turnaround Time (TT) is dependent upon the following port facilities:

i. Quay Crane
ii. Rubber Tyred Gantry Crane
iii. Straddle Carrier
iv. Reach Stacker
v. High Stacker
vi. Empty Stacker
vii. Trailer/Prime Mover
viii. Mobile Harbour Crane

ix. Front-end Loader

Therefore; TT = *f* {Port Facility}

1.10 Expected Contribution

The expected contribution of this research is to provide port container operator in guiding port container terminal in terms of operation, planning, and allocate necessary variables for vessel. Apart from that, this research is also able to determine which variables are significant to vessel in determining minimum turnaround time for vessel at berth. Lesser turnaround time for vessel at berth leads to gain in higher freight income and, is translated into the profit margin for port container terminal operator, shipping line, vessel's owner (principal), and hinterland's operator.

1.11 Organisation of the Thesis

Chapter 1 of this research provides an introduction to overall structure of research study. This chapter also includes the statement of the problem, the research questions, the aims and objectives of the research, the scope and limitation, outline methodology, the significance of the research, expected contribution and organisation of the thesis.

Chapter 2 provides the overall reviews of port performance and turnaround time method. The literature review covers the port performance indicator, performance and productivity measurement in port container terminal. Apart from this, it also includes turnaround time measurement in port container terminal, reason for delay in port

operation, operational procedure and process in port container terminal and the impact of technological advent in port container terminal.

Chapter 3 discusses the overall aspect of regression model for vessel turnaround time. It also justifies the use of multiple regression analysis for this research. Apart from that, the general regression model is developed accordingly. This chapter also justifies that selected quay crane being the main determinant instead of other determinants. For the next chapter, this research only focuses on service hour as dependent variable instead of turnaround time.

The following chapter, Chapter 4 discusses the methodology employed in performing this research. It also justifies the selection of variables to be studied and as well as methods to collect data and also develops the regression model used in the study.

Chapter 5 presents analysis and the results obtained from the regression model developed, and analysed using Statistical Packages for Social Science (SPSS). It also provides the regression model for vessel service hour, after been tested correlation among independent variables via bivariate correlation coefficient. This chapter also provides results from regression model validation from a new set of data (Westport).

The last chapter, Chapter 6, combines all findings to answer the research questions. It also provides significant variables for this research based on regression model and also produces the actual regression model. Finally, the chapter outlines the limitation to this research and ends with some suggestions on areas for future research.