8-31-2012

Study on optimal dwell time at Jakarta International Container Terminal

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STUDY ON OPTIMAL DWELL TIME AT JAKARTA INTERNATIONAL CONTAINER TERMINAL

By

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A research paper submitted to the World Maritime University in partial
Fulfillments of the requirements for the award the degree of

MASTER OF SCIENCE

INTERNATIONAL TRANSPORT AND LOGISTICS

2012

DECLARATION

I certify that all the material in this research paper that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

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ACKNOWLEDGEMENT

I am thankful to the World Maritime University, Shanghai Maritime University, and Indonesia Port Corporation II for giving me this opportunity to study.

I am profoundly grateful to Associate Prof. Gu Weihong for all the times and guidance that she has given to me, from the beginning of this study, during the work, until the completion of this thesis.

I would like to thank Joint Educational Program Department staff and all my classmates for their continue help and support during the year I studied.

I am deeply thankful to Jakarta International Container Terminal for providing me the access to the data and information that is valuable for this study.

Last but not least, I am very grateful to my parents for their continue support and prayer. I am very grateful to all my sisters and brothers for their support and also my beloved best friends for always supporting me despite the distance apart.

ABSTRACT

Title of Dissertation : **Study on Optimal Dwell Time at Jakarta International Container Terminal**

Degree : **Master of Science in International Transport and Logistics**

Along with the rapid growth of containerization, ports are required to have an adequate terminal yard capacity in order to anticipate continued growth and compete in the business. Expansion of container terminal capacity is often costly to acquire and takes a long time. Effective policies will be a simple and inexpensive solution that may be used to improve terminal yard capacity by port operators. Since container dwell time is a principal factor that determines yard capacity, port operators must be able to describe the factors that may affect container dwell time and when they can influence the elements under their control. Good understanding of these factors might help port operators estimate optimal container dwell time; then it can help them manage yard capacity better and establish appropriate policies.

The research paper will study the optimal dwelling time in the terminal by considering the factors influencing container dwell time. Using SPSS software, a dummy regression model will be utilized to predict the container dwell time in practical scenarios based on factors influencing it. Furthermore, the yard capacity and the terminal's revenue earned from the demurrage fee will be calculated using the predicted container dwell time. The result from the calculation may assist terminal operators to better manage yard capacity and apply policies which are appropriate for existing needs.

KEYWORDS: container terminal yard, container dwell time, influencing factors, optimal model, dummy regression.

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LIST OF ABBREVIATIONS

ADT	Average Dwell Time
AVG	Average
CDT	Container Dwell Time
DM	Data Mining
ECDT	Export Container Dwell Time
HA	Hectare
ICDT	Import Container Dwell Time
JICT	Jakarta International Container Terminal
SPSS	Statistical Packages for the Social Sciences
TEUs	Twenty Equivalent Units
TGS	TEU Ground Slot

Chapter 1 INTRODUCTION

1.1 Background

Indonesia is an archipelago country which consists of many islands. Maritime transport has an important role in transporting goods for domestic as well as international trade. As a logistic base of ASEAN countries, Indonesia currently has a logistics cost reaching 17 percent, compared to South Korea's 12.5 percent, the Philippines' 7 percent, Singapore's 6 percent, Malaysia's 8 percent, Japan's 5.9 percent, and the United States' 9.4 percent. This high cost of logistics has weakened the competitiveness of national logistics companies in the global market.

		Indonesia	ASEAN+6	G-20	Lower middle income
Export	Best lead time (days)	1.44	1.67	2.05	3.99
	Median lead time (days)	2.12	2.09	3.00	4.70
Import	Best lead time (days)	4.02	2.29	3.60	3.79
	Median lead time (days)	5.35	3.35	5.39	6.12

**Lead time is the transport time for export and imports from the point of origin to the port of loading or equivalent or to the buyer's warehouse.*

Figure 1.1 Best and median lead times* for import/export transactions.

Source : The World's Bank LPI (2010)

Moreover, based on The World's Bank Logistics Performance Index (LPI) 2010, Indonesia ranked 75th in 2010 as measured by the International LPI. Indonesia's overall performance is in line with its per capita income level, while regarding time and cost for Domestic LPI exports, Indonesia's performance is slightly better than the ASEAN+6 countries' average and noticeably better than the G-20 and lower middle income group averages. While import costs and lead times are significantly higher than the ASEAN+6 averages, the best import lead time is still worse than the G-20 and lower middle income averages.

Port of Tanjung Priok is a major gateway port that has great potential. It not only plays a fundamental role in the Indonesia logistics chain but also in facilitating Indonesia's integration to international trade, where 75 percent of the in and out flow of goods in Indonesia is through this port. In fact, Indonesia's main international sea-freight gateway is inefficient because Tanjung Priok is close to full capacity.

Tanjung Priok Port has several dedicated container terminals, such as Koja and Jakarta International Container Terminal (JICT), which are operated by joint venture. JICT is one of the largest container terminals in Indonesia, is strategically located at the industrial heartland of Western Java, and serves as the nation's gateway with major deep-sea and short-sea shipping lanes. With this important role, JICT is required to perform an effective and efficient operation by minimizing the waiting time of cargo and ship. In order to minimize the ship and cargo waiting time, an adequate capacity of facilities and equipment in the terminal is an essential factor to achieve it.

There are several factors that affect the capacity of a container terminal. One of these factors is the dwelling time of containers on the stacking yard. Therefore, reduction of container dwelling time becomes an important priority for a container terminal to increase their capacity. Moreover, dwelling time has an important impact on growth, competitiveness and urban traffic. It can affect productivity (especially on exports and re-exports); affect terminal capacity, performance and cost; and also cause congestion, which is disruptive for the trade and port city environment, especially due to Tanjung Priok Port's location in a dense urban area, now operating close to full capacity.

The shorter the dwell time, the higher the storage yard capacity. Therefore, a thorough analysis should be performed to determine the optimal dwell time, by considering the factors influencing container dwell time, to help terminal operators manage yard capacity better and apply appropriate policies.

1.2 The Research Problem

There are two common ways to improve terminal capacity, namely terminal expansion and reduction on container dwell time. In this scenario, applying a terminal expansion seems impossible because of JICT's location in a dense urban area with limited expandable space within the existing port area. Therefore, reduction of dwell time could be the best way to increase the capacity of this particular container terminal.

The aim of this study is to determine the optimal dwelling time in the container terminal by considering the factors influencing container dwell time. We use the container dwell time modeling that will be utilized in practical scenarios to estimate the yard capacity and terminal revenue earned from the demurrage fee.

1.3 Methodology

The purpose of the study is to assess the optimal dwelling time by analyzing factors that influence container dwell time. First, we make a sensitivity analysis of container dwell time on storage yard capacity. Second, we analyze the terminal's existing capacity. Third is to list out and analyze the factors influencing container dwell time based on available data. Last, we estimate the capacity of the yard and the terminal revenue earned from the demurrage fee using estimated CDT, which is obtained by utilizing the container dwell time model in the practical scenario.

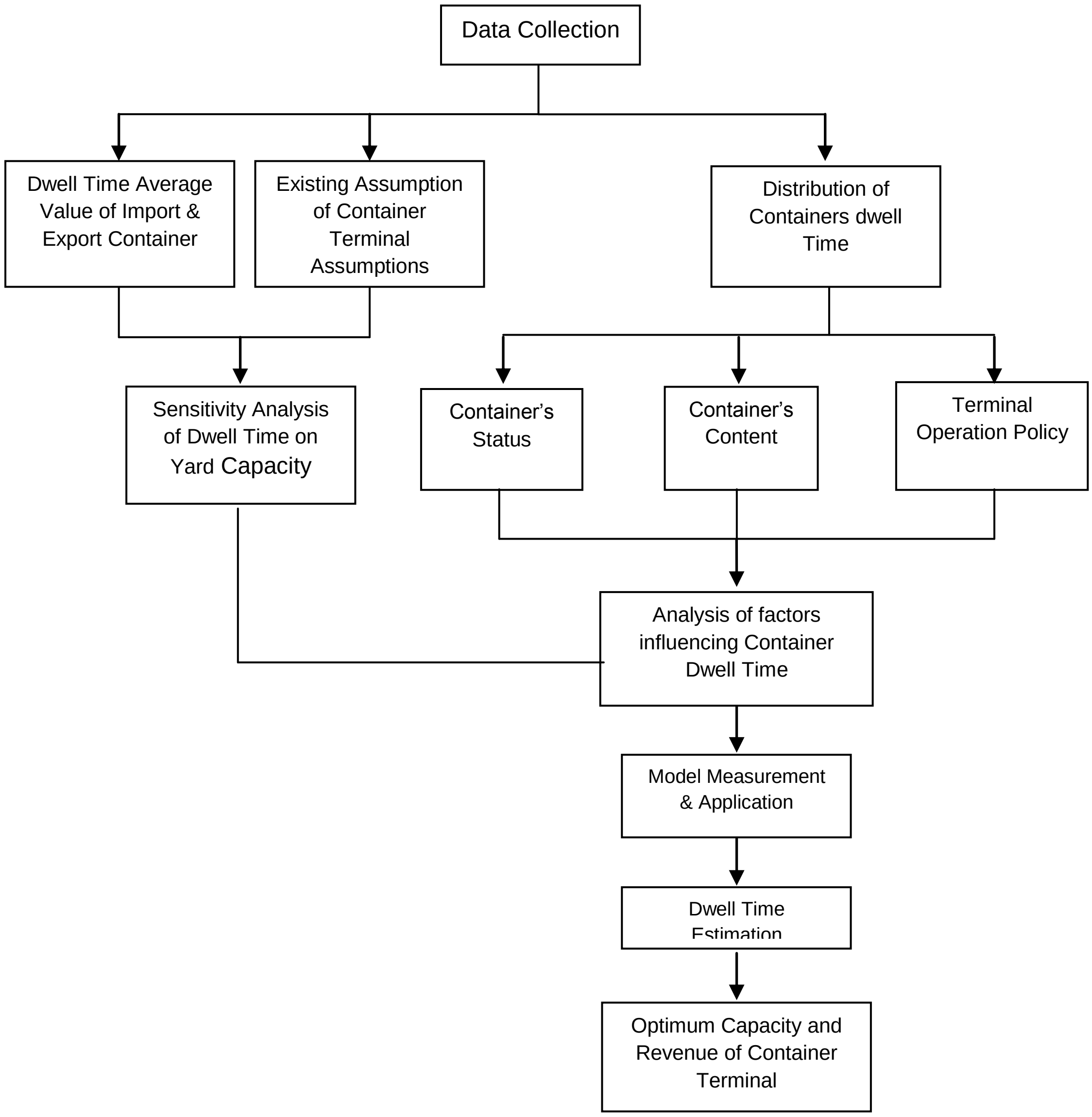

Figure 1.2 Research Methodology

1.4 Problem Limitation

To sharpen the scope of the study, some limitation is required in this research problem, as follows:

a. Object of the study is Terminal I Jakarta International Container Terminal (JICT), which is assumed to only handle import and export containers, due to the small proportion of the transshipment container.
b. Terminal facility to be analyzed is the container yard.
c. The analysis is based on primary data in the year of 2011, which was collected by a related institution.
d. Analysis of factors influencing dwell time is based on available data in JICT and only covered factors that resided in and were limited to terminal boundaries.

1.5 The Expected Contribution

The purpose of the study is to determine the optimal dwelling time at Jakarta International Container Terminal by analyzing factors that influence container dwell time. It is important because this information might assist terminal operators to achieve an expected balance between container dwell time and adequate yard capacity. Therefore, a better managed yard capacity and appropriate policies could be applied to anticipate the growth of containerization and to be able to compete in the business.

1.6 Structure of Thesis

Aiming to explain the study in a systematic order, the thesis will be presented in the five chapters as follows:

In Chapter 1, the background of the study, research problem, methodology, problem limitation of the study, and the expected contribution will be explained.

Chapter 2 will discuss relevant literature, such as research papers and findings related to container dwell time as a research topic, such as container terminal operation, container terminal capacity, the concept of dwell time divided into capacity constraints on dwell time, factors influencing dwell time, and also data mining techniques.

Chapter 3 presents the existing conditions and data collection about JICT, such as terminal facilities and equipment, terminal traffic flow and operation time, container dwell time and container yard capacity.

Chapter 4 will analyze the data and do a case study related to the existing problems at JICT, especially regarding container dwell time. This study will present a sensitivity analysis of container dwell time on yard capacity and an analysis of factors influencing container dwell time.

The measurement and application of the model will be presented in Chapter 5. Since the dummy regression model is the most suitable model, this chapter will utilize this model to estimate container dwell time based on the various scenarios, which is then used to calculate container yard capacity and terminal revenue.

The last is Chapter 6, which will present the conclusions that can be drawn from this research and suggest some recommended studies for the future.

Chapter 2 LITERATURE REVIEW

To support this research, some literature and theoretical framework related to container terminal operation and dwelling time will be presented in this section.

2.1. Container Terminal

2.1.1 Container Terminal Operation

An overview of container terminal operation can be found in four main literatures, namely Vis and de Koster (2003), Steenken et al. (2004), Murty et al. (2005), and Kim (2005), as well as Günther and Kim (2005). Vis and de Koster (2003) explain the main logistics processes in container terminals, while Steenken et al. (2004) presents an overview of optimization methods in container terminal operations. According to Dirk Steenken, Stefan Voß, and Robert Stahlbock (2004), seaport container terminals differ in size, function, and geometrical layout but consist of the same sub-system (see figure 2.1). The container terminal is divided into four main areas. They are the ship operation or berthing area; quayside operation area, which is equipped with quay cranes for the loading and unloading of vessels; yard operation area, which consist of yards for stacking import and export containers, divided into a number of blocks; and also special areas for special needs containers, such as reefer container or hazardous goods. Separate areas are also reserved for empty containers. In some terminals, there are sheds for stuffing and stripping containers or additional logistic services. The truck and train operation area links the terminal to outside transportation systems.

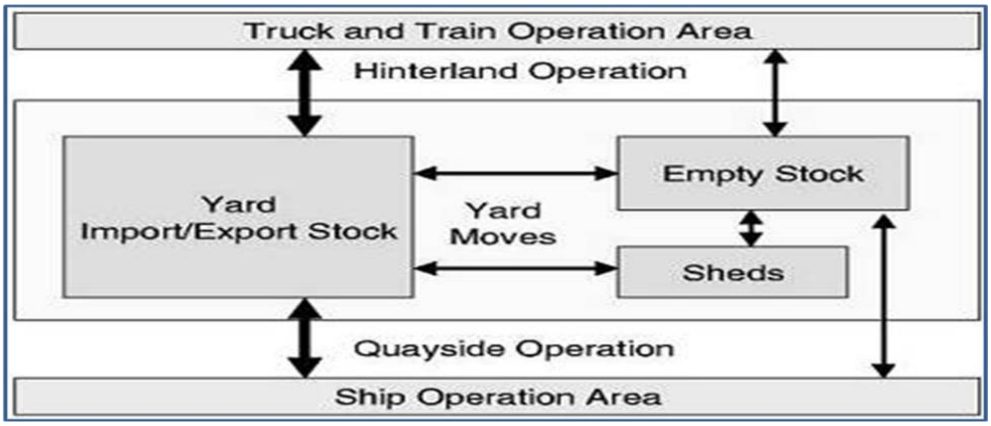

Figure 2.1 Operation areas of a seaport container terminal and flow of transports

Source: Steenken et al. (2004), p. 6

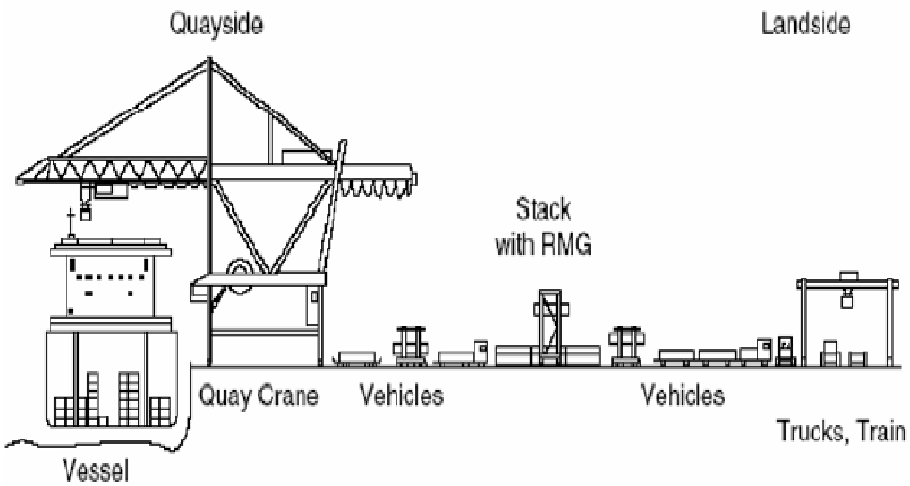

Figure 2.2 Transportation and handling chain of a container

Source: Steenken et al. (2004), p. 13

Steenken et al. (2004) explain that operations in a container terminal can be divided into two sides, quayside and landside. The quayside manages the loading and unloading of ships, and the landside is where containers are loaded and unloaded on/off trucks and trains. Containers are stored in stacks, thus facilitating the decoupling of quayside and landside operation.

On the quayside, there is ship-to-shore operation, which is associated with a process of discharging or loading containers from a ship to the quay or in the reverse order by using Quay Cranes (QCs). After arrival at the port, a container vessel is assigned to a berth equipped with cranes to load and unload containers. Unloaded import containers are transported to yard positions near to the place where they will be transshipped next. Containers arriving at the terminal by road or railway are handled within the truck and train operation areas. They are picked up by internal equipment and distributed to the respective stocks in the yard. Additional moves are performed if sheds and/or empty depots exist within a terminal; these moves encompass the transports between empty stock, packing center, and import and export container stocks. On the landside, there are three subsystems, namely transfer operation, storage and receiving/delivery. For import or inbound containers, after being discharged from the ship, the containers are then transferred from the apron to the stacking yard by internal transportation equipment. Trucks or trains that arrive at the terminal and have been identified and registered with container major data—such as content, destination, inbound vessel, shipping line, etc—pick up the containers. The operations to handle an export container are performed in the reverse order.

2.1.2 Container Terminal Capacity

NPC Bulletin (1980), Manalytics (1979), De Monie (1981 and 1985), and Lester et al. (1986) present the general framework of how to calculate terminal capacity. Ding (2010) defines container terminal capacity as the maximum theoretical throughput, which is limited by the capacities of the berths, equipment, stacks and transportation. Meanwhile, Huang et al. (2008) define container terminal capacity as the throughput level beyond which the terminal cannot sustain operations because either the overflow of containers at the yard exceeds certain acceptable levels or the Berth-On-Arrival (BOA) rate drops below the target percentage.

Ding (2010) calculates container terminal throughput capacity by using a formula focusing on berth capacity,

$$CC = \alpha_1 . \alpha_2 . \alpha_3 . N . Vq . Eq . t \tag{2.1}$$

Where,

CC = Throughput capacity of a container terminal in a year (TEUs/year);

α_1 = Conversion coefficient of TEU per move;

α_2 = Quay cranes rates in good condition;

α_3 = Ratio of terminal operation time per day (hours/day);

N = Total number of the quay cranes at a container terminal;

Vq = Quay cranes utilization rates;

Eq = Average operation efficiency of quay cranes (moves/hour);

t = Total terminal operation hours in a year.

Dally (1983) proposes a formula related to yard capacity. He calculates the throughput capacity of a container yard as follows,

$$CC = \frac{Tgs * H * U * K}{DT * PF} \qquad (2.2)$$

Where,

CC = Yard throughput in a year;

Tgs = Total ground slot;

H = Average stacking height;

U = Land utilization ratio;

K = Service days of the yard (usually 265 days);

DT = Dwell time of containers;

PF = Peaking factor.

2.1.3 Container Terminal Performance

Related to the container terminal performance, Theofanis et al. (2008) and Le-Griffin et al. (2006) define the key factors in measuring marine terminal performance as productivity, utilization, and service rate.

Table 2.1 Common productivity measures in container terminal

	Productivity	Utilization	Service Rate
Crane	Moves per crane-hour	TEUs/year per crane	

Berth		Vessels/year per berth	Vessel service time (hours)
Yard	TEUs/Storage-Acre	TEUs/year per gross acre	
Gate		Gate throughput (containers/hour/lane)	Truck turn time

Source: Le-Griffin et al., 2006

The quay crane and berth productivity are major factors of seaside operation. Vessel turn time is the time between arrival and departure of a vessel, which includes waiting time, the vessel movement time from anchorage to a berth, service time, the vessel movement time from anchorage to a berth, service time, the time between vessel berthing and leaving the berth, sailing delay, and the delay between a vessel leaving the berth and leaving the port. Therefore, this time becomes one of the factors to measure berth productivity.

Related to the yard side, container dwell time is a major factor impacting yard performance because yard performance or utilization is defined as the average number of containers per area unit per time unit. From the operational side, gantry crane utilization is also necessary.

The key factors on the landside are gate and truck interchange area performance, which is measured by truck turn time. Truck turn time is the time between a truck's arrival and departure at the gates, which includes the truck's arrival at the gate, a driver's service at the reception counter, the truck's arrival at the interchange area, the truck's leaving the interchange area, the truck's arrival at the exit gate, and the truck's leaving the gate.

2.2 Dwell Time Concept

In general terms, container dwell time is the average time a container remains stacked on the terminal waiting for some activity to occur (Manalytics, 1979:31). Merckx (2005) defines the same concept of dwell time as the average time a container remains stacked on the terminal. The capacity of a container terminal depends on several factors, but dwell time becomes one of the major factors because it has a direct impact on terminal productivity and overall terminal operations, whereby the reduction of dwell time could improve yard efficiency. According to Vickerman (2000), reducing the mean dwell time by one half doubles the storage yard capacity of a container terminal.

Chu et al. (2005) explains that there are two approaches that can be drawn on in the container yard calculations using container dwell time, namely demand and supply approach. Hoffman (1985) concluded that the land area needed for a container yard can be measured for a specific demand. He developed an equation to estimate the required storage yard area as a function of container dwell time, number of containers handled per year, height of the containers stacked, and the peak-hour. UNCTAD (1985) developed approaches from the demand side. He developed some container terminal planning charts accompanied with an algorithm designed to estimate the container park area needed for port planners.

Meanwhile, Dally (1983) developed another equation to estimate annual yard capacity using container dwell time, number of container ground slots, mean stacking height, and working slots in the container yard from supply approach sides. The estimation of terminal yard capacity based on container dwell time variations is present in this study by utilizing this developed formula. Dharmalingam (1987) modified Dally's equation by introducing a slot utilization factor. He calculated the annual yard capacity using the total number of available slots, slot utilization factor, and the result of the division of a number of days per year by the mean of container dwell time.

2.2.1 The Capacity Constraints of Container Terminal to Optimize Dwell Time

Watanabe (2001) analyzed capacity constraints, productivity, selectivity and flexibility of different container handling systems in function of the type and size of the terminal. Merckx (2005) discussed the impact of dwell times on container terminal capacity and provides a theoretical framework of capacity constraints that a terminal operator has to take into consideration to determine the optimal dwell time, namely the quay capacity and the gate capacity or level of gate utilization. He describes that the unremitting pressures to reduce dwell time will result in capacity problems in other segments of the container terminal system. He also explains the impact of dwell time charges and the different schemes of dwell time charges, and he summarizes a number of pricing mechanisms available in order to optimize terminal capacity. In conclusion, he defined that implementation of a terminal charge will affect the dwell time by optimizing the available quay and gate capacities.

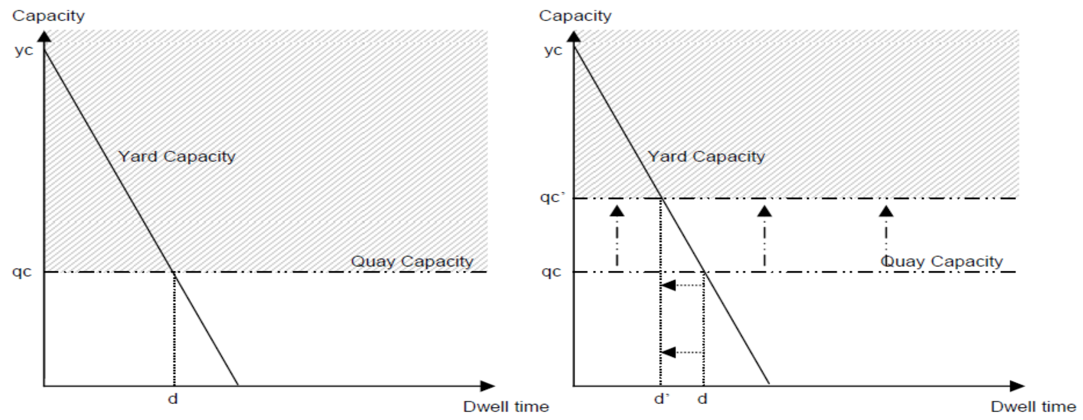

Figure 2.3 Optimal Dwell Time Given a Constraint in Quay Capacity

Source: Merckx (2005), p. 12.

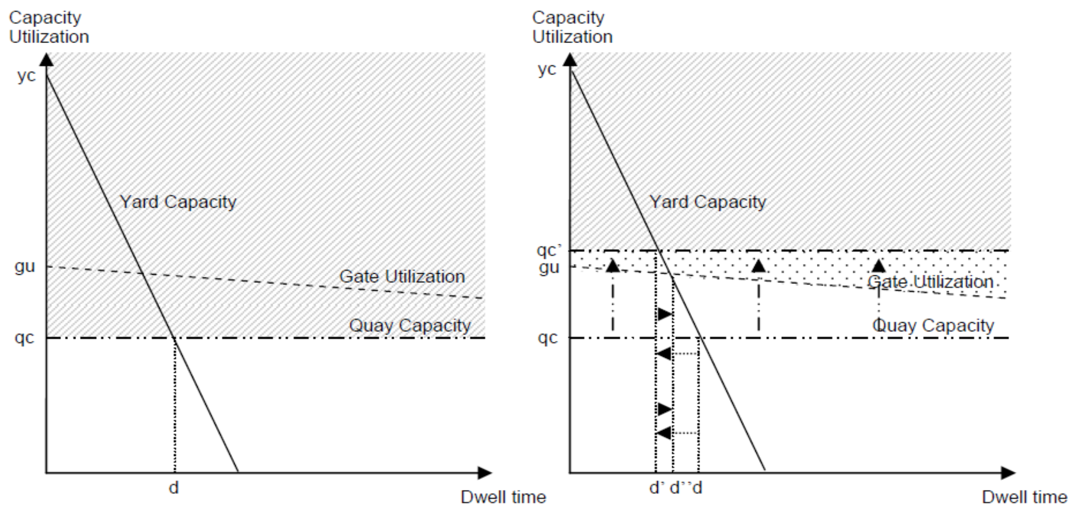

Figure 2.4 Optimal Dwell Time given an Additional Constraint in Gate Capacity

Source: Merckx (2005), p. 13.

Moreover, Merckx (2006) introduced parameters in his other literature that influence storage yard capacity, namely yard area, container dwell time, stacking height, and the handling system. He observed the effect of dwell time changes on storage yard capacity and resultantly performed a sensitivity analysis to determine the impact of the reduction of container dwell time on yard capacity.

2.2.2 Factors Influencing Container Dwell Time

Container dwell time can be influenced by many factors, some of which are unrelated to service quality (Merckx, 2005). He gives examples, such as commercial customers potentially creating an intentional delay because they often use the storage yard as an overflow node in their supply chain. Another aspect is time required to process the paperwork for the release or intake of a container.

From another side, Rodrigue (2008) discussed factors that influence container dwell time from the interaction of logistic players with different interests in sea port terminals. He argued, for example, that freight forwarders are using terminals as an extended component of their distribution centers, so they make the best use of the free time available in seaport. On the other hand, terminal operators find that dwell time becomes a problem that has a direct impact on terminal capacity, especially yard capacity. Therefore, he reacts by imposing restrictions in terms of dwell time and conditions for terminal access. Finally, he concludes that the extension of gate hours can help reduce container dwell times at seaport terminals.

Moini (2010) examined the impact of container dwell time determinant factors and investigates the relation between these factors by delineating the frequency of each factor’s appearance in different classes of container dwell time. He describes that factors influencing container dwell time are divided into two parts. First are factors which resided within and are limited to terminal boundaries, such as port policy and management, container status and cargo flow pattern, and the content of a container. Meanwhile, factors residing outside of a terminal’s boundaries are an ocean carrier, truck carrier, modal split, container’s security level, business connection, shipper, consignee, freight forwarder or broker, and also a third party logistic company. This study examines the dependency analyses between containers' dwell time determinant factors limited to within a terminal's boundaries, helping us predict container dwell time at Jakarta International Container Terminal.

Huynh (2008) considered that there are two import storage strategies. First is non-mixed: no stacking of new import containers on top of old ones, where the increase in container dwell time lowered throughput while it increased re-handling productivity. The second strategy is mixed: stacking where the increase in container dwell time raised throughput but decreased re-handling productivity. He uses a different approach to introduce a method to evaluate the effect of the CDT and storage policies on import container throughput, storage density, and re-handling productivity.

2.3 Data Mining Techniques

Data mining techniques are techniques utilized to establish a relationship between container dwell time and its determinants, which is employed in a mining database.

Moini (2010) describes that data mining refers to the process of analyzing data in order to determine patterns and their relationships, where technically, data mining requires either exploring an immense amount of material or intelligently probing it to find where the value resides. In his literature, he examines how the objectives will be addressed by Data Mining algorithm capabilities and how the algorithm manipulates categorical, discrete and non-numeric data, as the most determinant data on container dwell time has these characteristics.

Three common approaches can be traced in mining data: first is market basket analysis, second is unsupervised learning, and third is supervised learning.

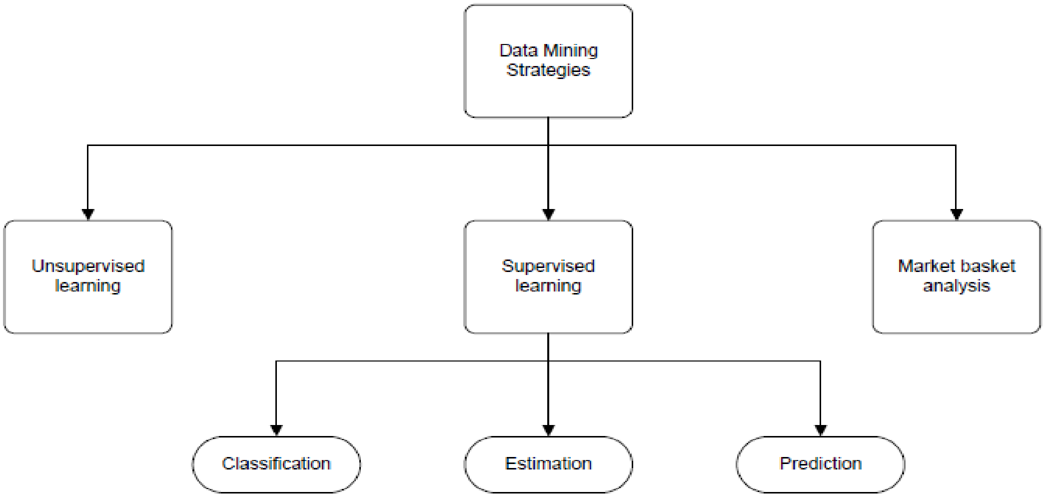

Figure 2.5 Hierarchy of data mining strategies

Source: Roiger, et al., 2003

Data mining problem types are related to appropriate modeling techniques, followed by a description of the most common modeling techniques (Rudjer Boskovic Institute, 2001).

Table 2.2 DM problems with corresponding proposed DM algorithms

Segmentation or clustering	K-Mean Clustering, Neural networks, Visualization methods
Dependency analysis	Correlation analysis, Naïve Bayesian, Association rules, Bayesian networks
Classification	Decision trees, Neural networks, K-nearest neighbors
Prediction	Regression analysis, Logistic regression, Neural networks, K-nearest neighbors

Source: Rudjer Boskovic Institute (2001)

Chapter 3 CONTAINER DWELL TIME AT JAKARTA INTERNATIONAL CONTAINER TERMINAL (JICT)

This chapter will present an overview and evaluation of the existing condition of JICT based on the terminal facilities and equipment, container traffic, and container dwell time, which is expected to give an existing picture of JICT related to the dwell time problem. The evaluation will be limited to cover only Terminal 1 of JICT.

3.1 Terminal Facilities and Equipment

Jakarta International Container Terminal (JICT) is strategically located at the industrial heartland of West Java. JICT is a joint venture between Hutchison Port Holdings and PT Pelabuhan Indonesia II and was formed to operate Container Terminal 1 and 2 at Tanjung Priok Seaport. JICT covers a total of 100 hectares, which is the largest container terminal in Indonesia and serves as a national hub port and as the gateway to Jakarta and the industrial heartland of West Java.

As container volume grew, JICT committed to providing excellent, efficient and reliable service for 24 hours a day, all year round to more than 30 shipping lines with direct services to 25 countries.

JICT has accredited to ISO 9001:2008, which aims to promote excellence in container handling services through the dedication of the workforce and the application of proven and reliable technology to its operation.

With 85 hectares of area currently in use, JICT consist of two terminals, namely T1 and T2, as shown in a figure 3.1. They have a total quay length of 2.150 meters with alongside depth of 8.5 - 14 meters, equipped with 19 quay cranes, four of which are Super Post Panamax size. The yard operation is serviced by 74 Rubber Tyred Gantry Cranes (RTGCs) and backed by more than 150 trucks and chassis, as listed on table 3.1.

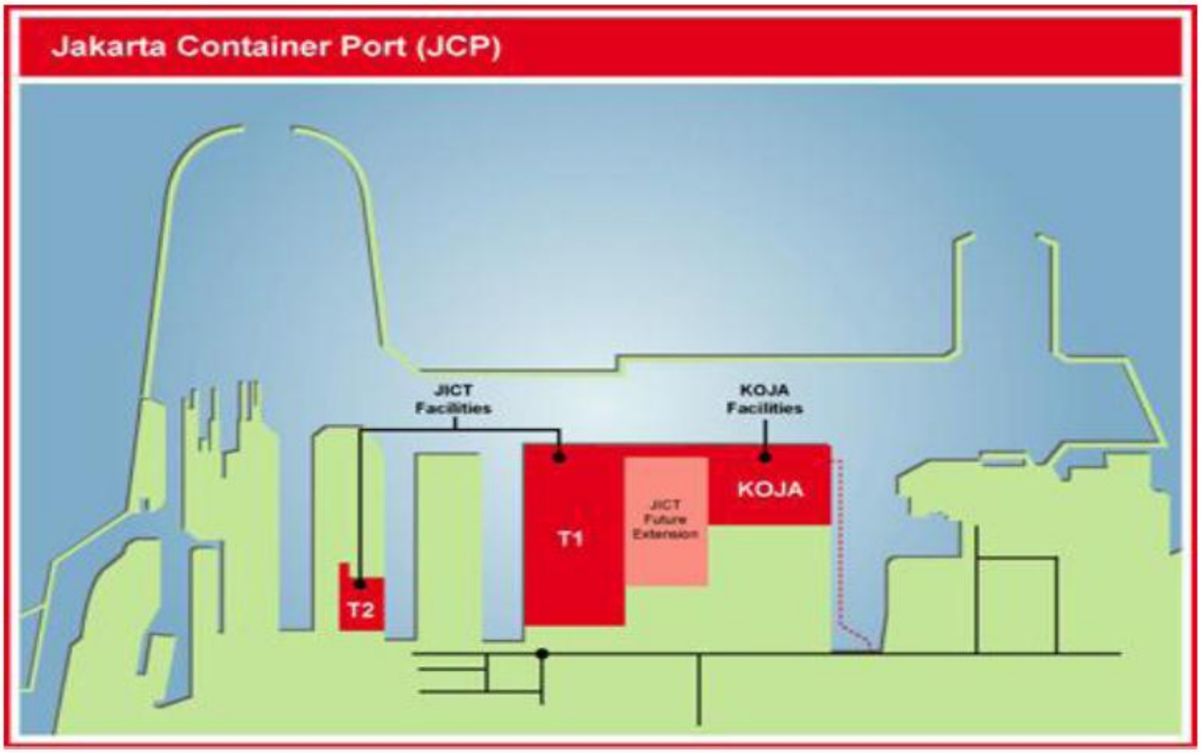

Figure 3.1 Terminal Layout of JICT

Source: http://www.jict.co.id/en/content/terminal-layout

Table 3.1 Equipment & Facility of JICT in 2011

Description	Terminal I	Terminal II	Total
I. Berth			
• Length • Width • Draught	1640 M 26.5 – 34.9 M 11 – 14 M	510 M 16 M 8.6 M	2150
II. Container Yard			
• Area • Capacity • Ground Slot 1. Import 2. Export 3. Reefer - 220 V - 380 V	40.00 Ha 4,614 Teus 4,317 Teus - 260 Plug	9.24 Ha 960 Teus 984 Teus - 68 Plug	49.24 Ha 5,574 Teus 5,301 Teus - 328 Plug
III. Equipment			

• Quay Crane Container	16 Unit	3 Unit	19 Unit
• Rubber Tyred Gantry Crane	63 Unit	11 Unit	74 Unit
• Head Truck	129 Unit	13 Unit	142 Unit
• Chassis/Trailer	112 Unit	21 Unit	133 Unit
• Forklift Diesel	8 Unit	6 Unit	14 Unit
• Reach Stacker	4 Unit	1 Unit	5 Unit
• Side Loader	6 Unit	-	6 Unit

Source: http://www.jict.co.id/en/content/terminal-facilities

3.2 Container Traffic Flow and Operation Time

Operational data comprises container traffic flow and ship call, container dwell time, terminal operational time, and other supporting data.

3.2.1 Container Traffic Flow

As presented in table 3.2 and figure 3.2, container traffic flow at JICT from 2006 until 2011 has continuously increased. Even though the throughput volume was decreased from 1,995 million TEUs to 1,675 million TEUs in 2009 because of the economic crisis, 2010 saw a slight increase to 2,095 million TEUs. Import containers' volume occupied the biggest proportion of JICT traffic flow. The average proportion of import volume was 52%, while export containers' volume is 43%, and transshipment is around 5%.

Table 3.2 Container Throughput at JICT

YEAR	SHIP CALLS	IMPORT TEUS	EXPORT TEUS	TRANSHIPMENT TEUS	TOTAL TEUS
2006	1,900	839,313	688,649	91,533	1,619,495
2007	2,030	950,065	778,585	92,642	1,821,292
2008	1,852	1,010,628	908,386	76,767	1,995,781
2009	1,680	884,330	727,969	63,096	1,675,395
2010	1,879	1,049,882	946,658	98,468	2,095,008
2011	1,984	1,180,387	1,011,181	103,697	2,295,264

Source: JICT

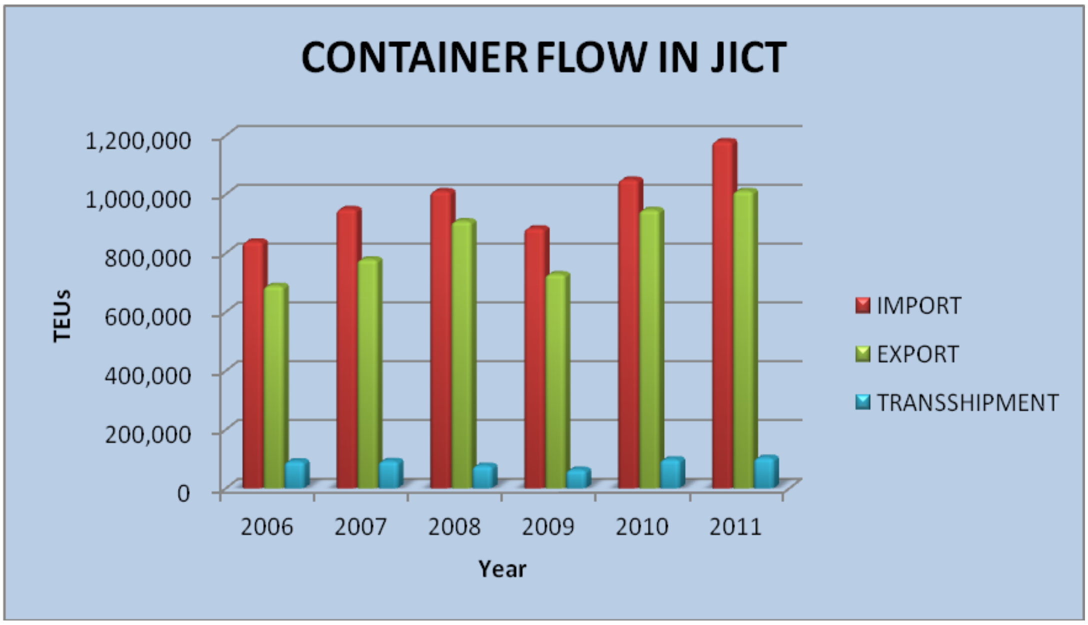

Figure 3.2 Container Traffic in JICT from 2006 to 2011

Source: JICT

Based on figure 3.2, there was not much fluctuation in ship calls. Year 2007 was recorded as the year with the biggest number of ship calls in JICT. The growth was smaller than container traffic growth, where the average growth is 2% per year for ship calls and 6% for container traffic growth. In line with the decrease in container volume in 2009 as presented in figure 9, the number of ship calls also dropped significantly from 1,852 ship calls in 2008 to 1,680 ship calls in 2009, but then it slightly increased in 2010 into 1,879 ship calls and 1,984 ship calls in 2011.

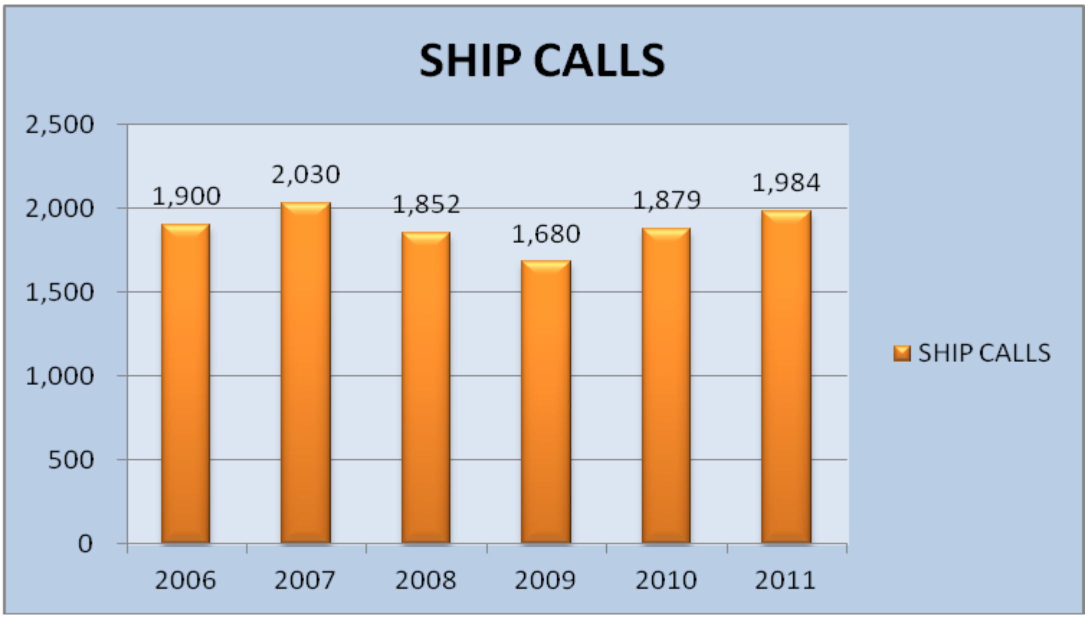

Figure 3.3 Ship Calls in JICT from 2006 to 2011

Source: JICT

3.2.2 Terminal Operational Time

This section provides information about the work hours of Terminal 1 JICT, operational time of the gate, and the policy on storage services, including free time for container stacking on yard.

Based on table 3.3, the operational time and gate in Terminal 1 JICT is 24/7, meaning the terminal and gate are operated 24 hours, 7 days per week. The policy in the stacking yard is divided into three periods, and import and export containers are treated differently regarding the free time policy.

Table 3.3 Operational Time and Storage Policy in Terminal 1 JICT

Description	Data
Terminal Work Hours	· Shift 1: 07.00 – 15.30 · Shift 2: 15.30 – 23.00 · Shift 3: 23.00 – 07.00
Gate Operation Hours	· Shift 1: 07.00 – 15.30 · Shift 2: 15.30 – 23.00 · Shift 3: 23.00 – 07.00
Free time for stacking on yard	· Empty and full imported container will be counted as follow: - 1st day to 3rd day is free time; - 4th day to 10th day will be counted 200% per day from basic tariff per day; - 11th day up to the next is counted 300% per day from basic tariff. · Empty and full export container will be counted as follow: - 1st day to 5th day is counted as 1 day basic tariff; - 6th day to 10th day will be counted 200% per day from basic tariff per day; - 11th day up to next is counted 300% per day from basic tariff.

Source: JICT

3.3 Container Dwell Time and Container Yard Capacity at JICT

3.3.1 Container Dwell Time at JICT

The average container dwell time for an import container in 2009 was 5.3 days, which then decreased in 2010 to 5.2 days, but then increased to 5.6 days in 2011. The international definition of import container dwell time includes the total container time from vessel to gate, out of the port area, while the container dwell time mentioned on the table below is the time from unloading the container until the container leaves the port through the main gate. In this case, the gate is located at the exit point of the JICT Container Yard (JICT, 2011). Therefore, the average dwell time in JICT might increase due to time added at *overbrengen* and inspection yards to around 9 days for 2011.

For export containers, the average dwell time in 2009 was 2.3 days and remained the same in 2010, but then it increased in 2011 to become 4.3 days, as presented in table 5. This shows that dwell time for import containers is longer than export containers. This is because import container operations deal with uncertainty, dependent on many factors, such as the trucks' arrival time at the terminal to pick up the container.

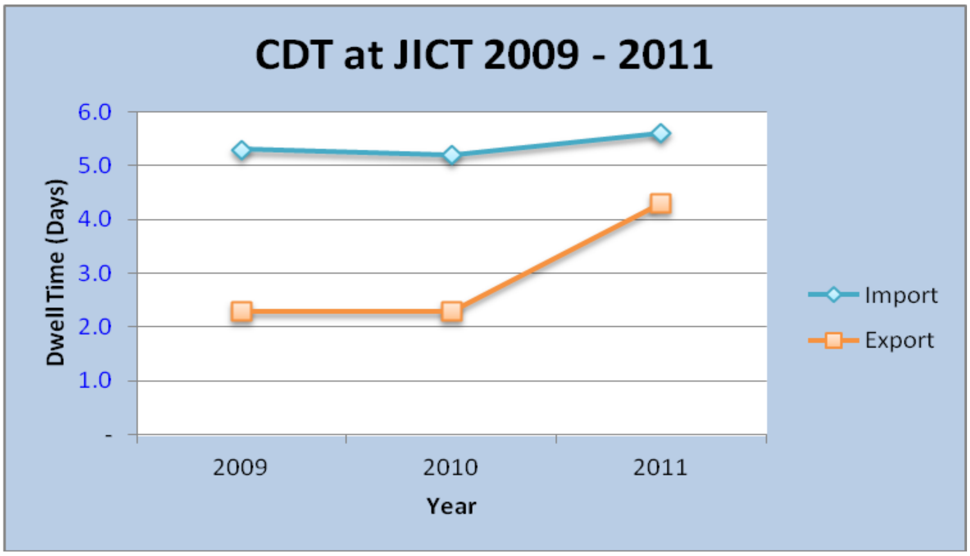

Figure 3.4 CDT at JICT from 2009 to 2011

Source: Author

Table 3.4 Container Dwell Time at JICT from 2009 to 2011

CDT	2009	2010	2011
Import	5.3	5.2	5.6
Export	2.3	2.3	4.3

Source: JICT

Table 3.5 and 3.6 presents container dwell time at JICT in detail. Based on table 3.5 and figure 3.5 in import containers, full container dwell time occupies the longest time of any container. Average stay at port for a full import container was 5.4 days in 2009 and remains the same in 2010, then increases the next year to 5.7 days. For an imported empty container, the dwell time is almost half compared to full container, where the empty container occupied the yard for 2.1 days in 2009, increased the next year to 2.7 days in 2010, and became 3.1 days in 2011.

Table 3.5 Import Container Dwell Time

ICDT		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
2009	Full										5.5	5.0	5.7	5.4
	Empty										1.9	1.7	2.7	2.1
	Overall										5.3	4.9	5.6	**5.3**
2010	Full	6.0	4.9	5.3	5.3	5.3	5.3	5.5	5.3	5.6	5.3	5.3	5.4	5.4
	Empty	2.6	2.3	2.4	2.6	3.0	2.7	2.3	2.7	3.0	2.6	3.1	2.9	2.7
	Overall	5.8	4.8	5.1	5.2	5.3	5.3	5.4	5.2	5.4	5.0	5.1	5.3	**5.2**
2011	Full	5.3	5.5	4.8	5.0	5.5	6.1	5.9	5.4	6.8	6.2	5.8	5.9	5.7
	Empty	2.4	2.8	2.6	3.1	2.6	3.0	3.1	4.1	2.7	3.6	3.6	3.7	3.1
	Overall	5.2	5.4	4.7	5.0	5.4	6.0	5.8	5.4	6.7	6.1	5.8	5.8	**5.6**

Source: JICT

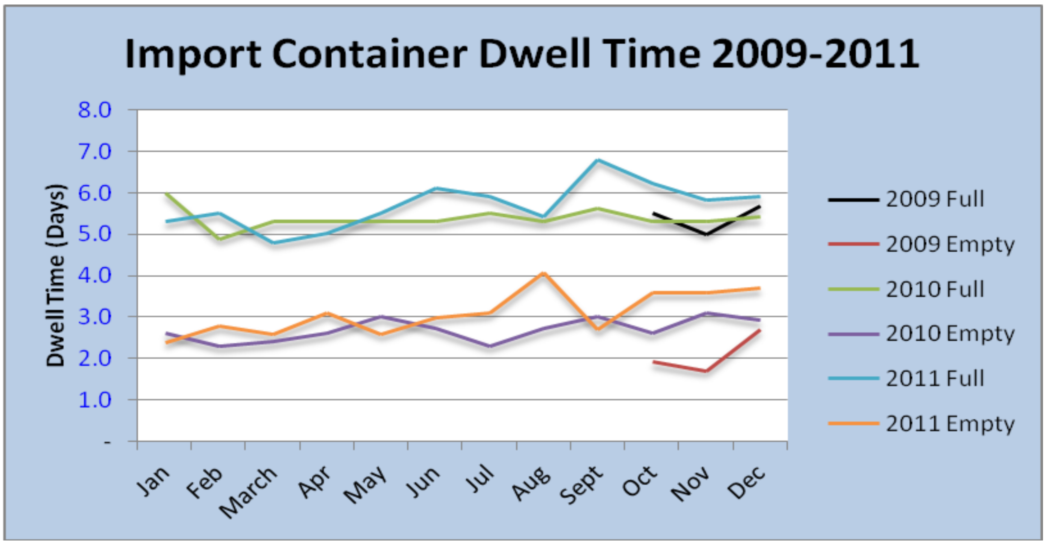

Figure 3.5 Import Container Dwell Time 2009 – 2011

Source: Author

The dwell time of export containers experience the opposite of import containers, where empty containers have a longer dwell time than full containers. As described on table 7, the average dwell time of a full export container in 2009 was 2.3 days, while an empty container was 2.4 days. When the dwell time of a full export container remains the same in 2010, the dwell time of an empty container is increased slightly to 2.5 days, and then it increases more in 2011 to become 2.7 days, while the dwell time of a full container averages 2.5 days (table 3.6 and figure 3.6).

Table 3.6 Export Container Dwell Time

ECDT		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
2009	Full										2.3	2.3	2.3	2.3
	Empty										2.5	2.1	2.5	2.4
	Overall										2.3	2.2	2.3	2.3
2010	Full	2.2	2.4	2.2	2.3	2.3	2.3	2.3	2.4	2.3	2.1	2.2	2.3	2.3
	Empty	2.3	3.3	2.2	2.1	2.4	2.4	2.5	2.9	3.1	2.2	2.4	2.2	2.5
	Overall	2.2	2.6	2.2	2.2	2.3	2.4	2.4	2.5	2.5	2.1	2.2	2.2	2.3
2011	Full	2.6	2.3	2.5	2.4	2.6	2.5	2.4	2.6	2.3	2.6	2.3	2.3	2.5
	Empty	2.4	2.3	2.6	2.9	2.9	2.9	3.0	2.8	2.9	2.9	2.3	2.8	2.7
	Overall	2.5	2.3	2.6	2.6	2.7	2.6	2.6	2.6	2.5	2.6	2.3	2.5	2.5

Source: JICT

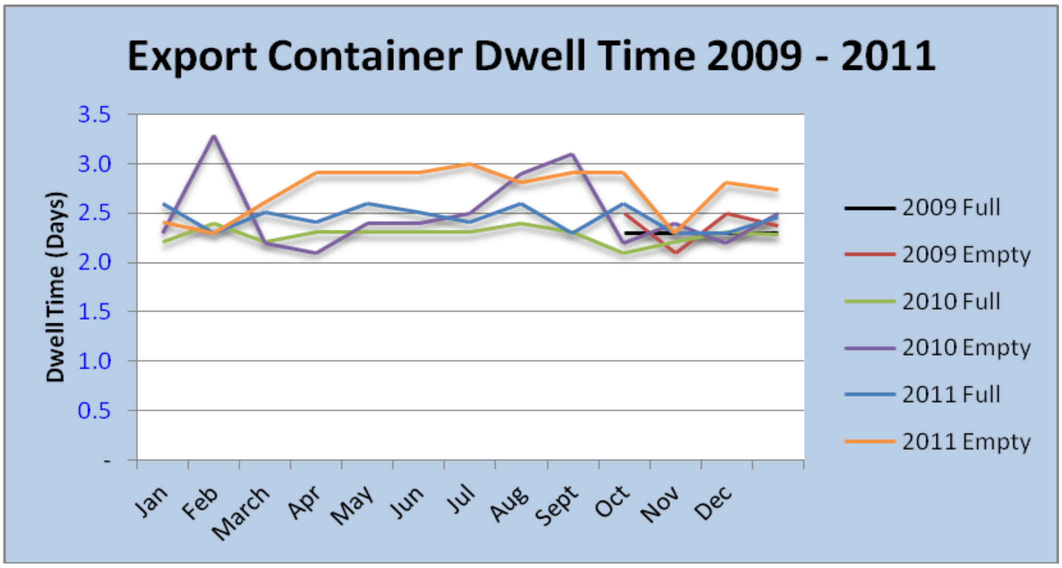

Figure 3.6 Export Container Dwell Time 2009 – 2011

Source: Author

3.3.2 Container Yard Capacity at JICT

The analysis situation of the container terminal on JICT is based on the previous data and information about the condition of JICT. This section presents an analysis of container yard capacity based on throughput.

Based on what has been mentioned previously in table 3, JICT Terminal 1 area is 40 Ha or 400,000 m2. To analyze whether container yard capacity in Terminal 1 JICT is sufficient for the existing throughput, calculating the area required for stacking is an important step. To calculate the area required for the stacking yard, there are several assumptions and steps, as explained in table 3.8:

Table 3.7 Data Assumption

No.	Assumption	Data
1	Capability of stacking and spanning using RTG as equipment at the stacking yard	One over four with spanning 7 rows
2	Distance between containers in a block	0.25 meter
3	Dimension of a TEU container	6.1 m x 2.4 m
4	Number and width of roadways for trailer in a block	3 roadways with 3.75 meter for the width of each
5	Number and width of side roadways for RTG in a block	2 sides with a width of 1.5 m each
6	Width of roadway between blocks	25 meter
7	Number of slots and rows (in each slot) in a block	66 slots with 7 rows in each slot
8	The proportion of export and import containers	54% for import and 46% for export
9	Average Dwelling Time (DT) for import and export	4.3 days (import is 5.6 days and export 2.5 days)
10	Peaking factor (PF)	1.30
11	Average Stacking height (H) for export and import	3.2 containers high (3.5 for export and 3 for import)
12	Land utilization (U) ratio	80%
13	Number of working days in a year (K)	365 days

Source: JICT

Table 3.8 Calculation of Container Yard Area Required

Year	Throughput	TGS	No of Slot Required	Block required	Total area of overall slot	Area for distance between container	Effective Area	Total Area for trailer roadways	RTG	Roadway between block	Total Area Required	
											m2	Ha
2011	2,295,264	13,731	1,962	30	205,969	8,114	214,083	140,049	49,795	23,013	426,941	43

Source: Author's Calculation

According to table 3.8, the area required to fulfill the needed space of the container yard based on throughput in 2011 is exceeding the available area. This means there is a shortage of container yard space at JICT, where the need of space for the import and export container yard is around 43 Hectare, but the available area is around 40 Hectare.

Expansion of a new container terminal is the best solution to capitalize on opportunities anticipated from the rapid growth of containerization. In this case, the expansion of a new container terminal is a long-term development program of Tanjung Priok Port, where the first phase is to be operational in 2015.

To cope with container yard space shortages that have occurred since 2011, JICT must find solutions to solve the problem while waiting for the expansion of the new container terminal. There are several factors that can influence the container yard capacity in the terminal. Since the longer time of a container stay in the JICT terminal yard is one of the major problems in JICT, this study will focus on finding the optimal dwell time from the factors influencing it to find a solution for the area shortage problem in JICT.

Chapter 4 ANALYSIS OF CONTAINER DWELL TIME

This chapter will further analyze data that was presented in the previous chapter. The analysis that will be presented in this chapter consists of the following subjects:

a. Sensitivity analysis of dwell time on container yard capacity is the first methodology that will be used in this study. Recall the fact that JICT's storage yard forms the bottleneck in throughput capacity, causing the necessity to limit container dwell times. By using this analysis, the impact of mean container dwell time on storage yard capacity will indicate the importance of dwell time on container terminal capacity.

b. We analyze factors influencing container dwell time. Since the reduction of container dwell time will improve yard capacity at a container terminal, measurement of the factors influencing container dwell time is important in order to develop a proper strategy of container dwell time reduction.

4.1 Sensitivity Analysis of Container Dwell Time on Yard Capacity

The first step in this study is to analyze the average container dwell time based on the cargo flow of import and export containers. The analysis will give a hint how sensitive the effects of dwell time changes are on container yard capacity at Terminal 1 JICT. Therefore, this analysis will present the effect of varying average container dwell times on the TGS required and on the area required for stacking containers with the existing throughput in 2011. The analysis will be conducted using Dally's (1983) formula with several assumptions based on the situation in Terminal 1 JICT.

Dally (1983) proposed a formula related to yard capacity. He calculated the throughput capacity of a container yard as follows,

$$CC = \frac{Tgs * H * U * K}{DT * PF}$$

(4.1)

Where,

CC = Yard throughput in a year;

Tgs = Total ground slot;

H = Average stacking height;

U = Land utilization ratio;

K = Service days of the yard (usually 265 days);

DT = Dwell time of containers;

PF = Peaking factor.

Recalling the previous analysis about the existing situation of JICT, with the storage yard forming the bottleneck to increasing the throughput capacity, therefore limiting the container dwell times becomes important.

Table 4.1 Various Scenarios of Average Dwell Time

Container Status	Dwell Time	Existing Average Dwell Time	ADT *3	ADT *2	ADT/2	ADT/3
Export	2.5	4.3	6.4	5.3	3.7	3.6
Import	5.6		10.7	7.5	2.7	2.1

Source: Author's Calculation

Table 4.1 presents different scenarios of container dwell time by multiplying and dividing the existing container dwell time in JICT. These figures will be used in the calculation on table 4.2 to measure how sensitive the increases and decreases of container dwell time affect the capacity of the container yard, which table 4.2 defines as TGS and area required.

Table 4.2 Calculation of TGS and Area Required

	Existing	EADT*3	IADT*3	EADT*2	IADT*2	EADT/2	IADT/2	EADT/3	IADT/3
TGS Required ('00)	137	205	340	171	238	119	85	113	68
Area Required	43	64	106	53	74	37	26	35	21

Source: Author's Calculation

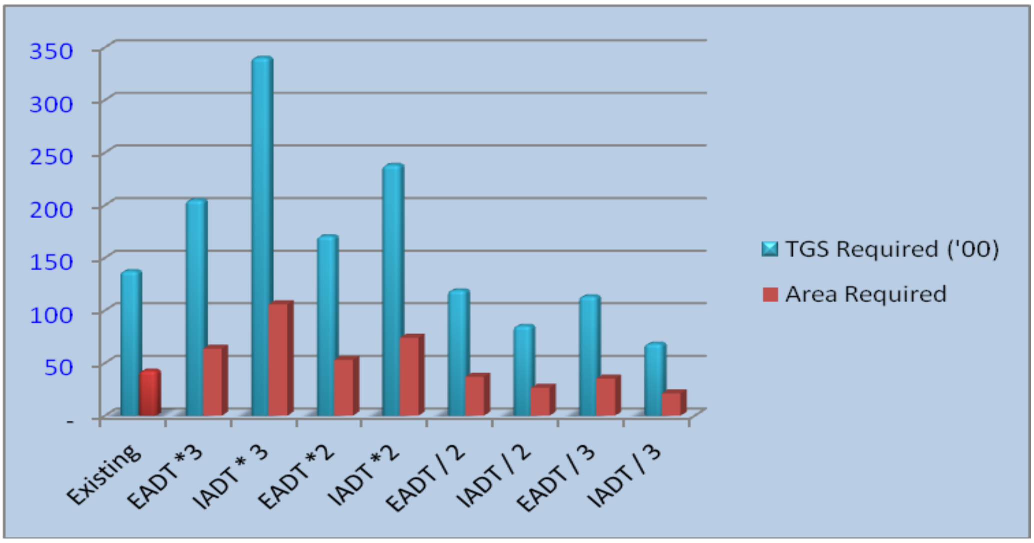

Figure 4.1 TGS and Area Required Based on Difference Dwell Time

Source: Author's

Table 4.2 shows the effect of varying average container dwell times on the TGS required and area required for stacking containers with the existing throughput. Table 4.2 and figure 4.1 describe that when import container dwell time is doubled, the TGS required is increased by almost one half, which means a reduction in storage yard capacity. And when the import container dwell time is reduced by one half, it reduces the TGS required by one half and doubles the storage yard capacity. Meanwhile, the effect for export containers is not as dramatic as import containers. This is because in JICT, the proportion of import container volume is much higher, and import containers have a longer dwell time than export containers.

From the analysis above, it can be concluded that the longer the dwell time, the less space there is available for additional throughput. So, a reduction in dwell times would increase the capacity of the container yard. Therefore, it is essential that containers be moved through the terminal as quickly as possible.

Moreover, analyzing the obtained information on average container dwell times for the different container statuses, import containers have the highest dwell times. Import container operations deal with uncertainty, depending on many factors, such as a truck's arrival time at the terminal to pick up a container, current habits of the consignee using the container terminal as cheap storage of their goods, etc.

4.2 Analysis of Factors Influencing Container Dwell Time

Sensitivity analysis on the previous section shows that container dwell time has a direct impact on terminal productivity, and the yard efficiency can be improved by reducing the time. Container dwell time, which refers to the length of container stay in the terminal, is influenced by several factors.

This section provides a dependency examination of factors influencing container dwell time. It therefore investigates the correlation between factors that influence container dwell time and container dwell time as the next step in this study. The investigation will be limited to the factors influencing the dwell time of containers that resided within and were limited to terminal boundaries. The analysis in this study is also only cover export and import containers, due to the small proportion of transshipment containers. This way, the analysis examines whether a container's status, content of the unit container, and operation day policy for export and import containers have an impact on container dwell time in JICT.

The first step of this investigation is to make an observation on the proposed factors that can influence container dwell time based on the available data by providing the significant percentage values of the factors in each class of container dwell time on the specific period. In this observation, the data were provided by JICT about containers that were handled by Terminal 1 during May, June and July, which is considered the three-month peak period, and September, October and December as a low period. This analysis will classify the dwell time into classes of one to nine days of dwell time, since the average import container dwell time in JICT in 2011 was around 8 days.

4.2.1 The Factor of Container's Status

Container status in this analysis refers to a full or empty container. As described on the previous chapter, the average proportion of transshipment container volume is only around 5% of the whole container's volume, so this analysis was confined to import and export containers.

Table 4.3 Distribution of Import & Export Container in Different Class of Dwell Time

Peak Period		Dwell Time		
		1,2,3	**4,5,6**	**7,8,9**
Export	**Empty**	59%	38%	3%
	Full	66%	30%	4%
Import	**Empty**	73%	24%	3%
	Full	40%	36%	24%
Low Period		**Dwell Time**		
		1,2,3	**4,5,6**	**7,8,9**
Export	**Empty**	78%	21%	1%
	Full	69%	28%	4%
Import	**Empty**	63%	28%	9%
	Full	45%	35%	19%

Source: Author's Calculation

Table 4.3 describes a different pattern of container dwell time distribution between import and export containers during the peak period and low period. As shown in the table, export containers for both empty and full containers are more often distributed in the class of shorter dwell time (three or less class) for about 59% in the peak period and 78% in the low period for empty containers and 66% in the peak period and 69% in the low period for full containers. For import containers, containers with a status of empty have distributed more in the class of three days or less dwell time, for about 73% on peak period and 63% on low period.

In the longer class of dwell time (four or more days), full import containers are distributed highest, with the peak period around 60% while empty imports are about 27%, full export is around 34%, and 41% for empty export containers. The same pattern occurred in the low period, where full import containers have the greatest value of about 55% on the dwell time class of four while empty import is about 37%, full export is around 32%, and 22% for empty export containers.

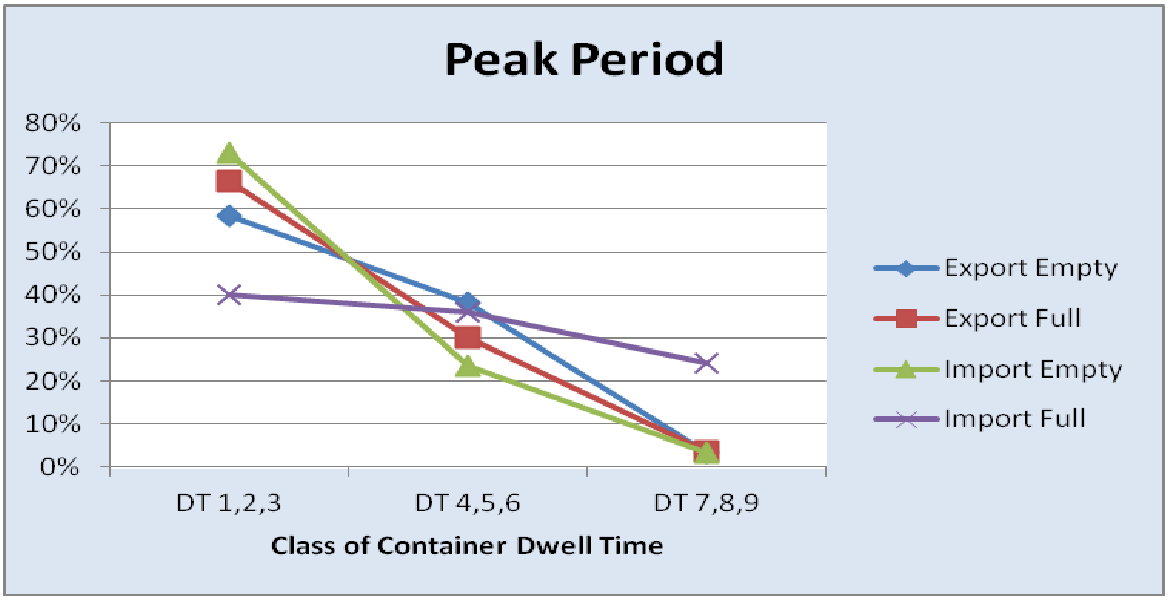

Figure 4.2 Distribution of Export Containers in Each Class of Dwell Time

Source: Author's

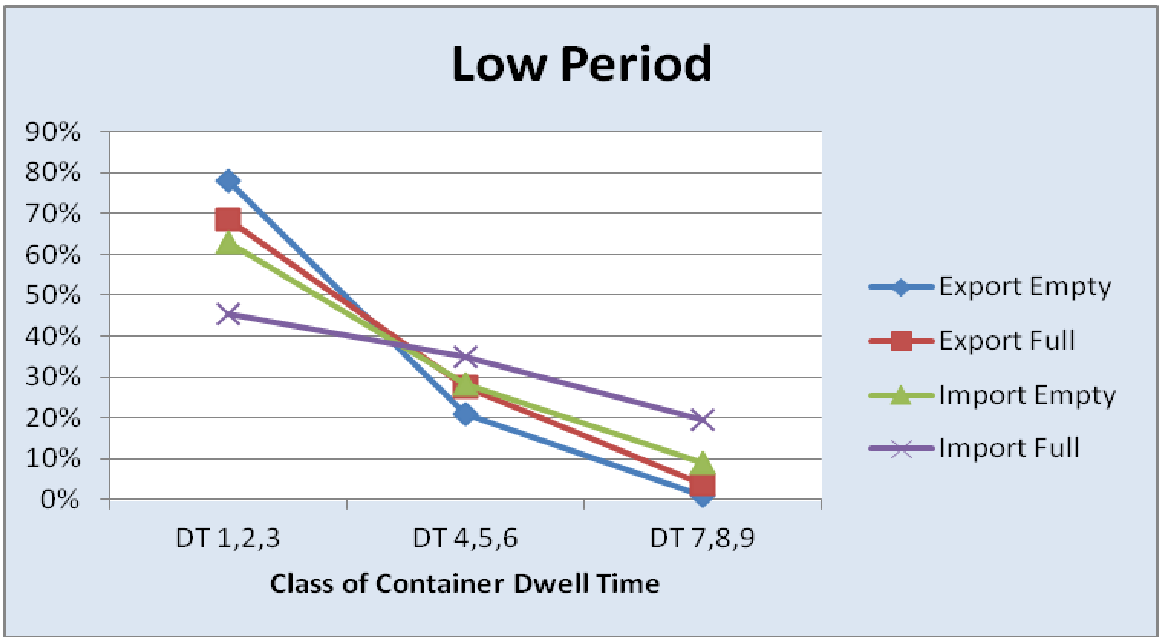

Figure 4.3 Distribution of Import Containers in Each Class of Dwell Time

Source: Author's

Figure 4.2 and 4.3 illustrate that export full, export empty and empty import containers are expected to leave the container yard in three days or less.

Conversely, full import containers can be expected to stay in the container yard longer, for about four or more days.

The volume proportion between full and empty containers, policy of storage service tariff, and the existence of an inland container depot at or near the terminal could be interpreted as the cause of different patterns of dwell time between import and export containers. The proportion between full and empty container flow in JICT is as follows for export containers: full container is about 73% while empty is 27%. For import containers, full containers are around 97%, and empty is 3%. From the policy side, for import containers in this terminal, the first to third days count as free time or free of charge for storage services, and demurrage fees are calculated after that. But for export containers, the basic tariff is already counted from the first day. Hence, export full containers left the terminal yard in three days or less while import full containers stayed longer, for four or more days after demurrages fees are calculated.

The existence of an empty container depot and the lack of an inland container depot for importers to stack their goods near the terminal could be interpreted as a cause of lower value for empty container dwell time and higher value for full import containers on the longer class of container dwell time. Therefore, from the observation above, we can conclude that a container's status plays a role in the length of time the container remains in the terminal yard.

4.2.2 The Factor of Container's Type and Size

In this section, container's type and size are observed to determine whether they have an influence on container dwell time by comparing data of dry and reefer containers in each class of container dwell time.

Figure 4.4 shows that the distribution of each class of container dwell time in export containers for dry and reefer in the container size of 20 feet and 40 feet have similar patterns, where each type and size of export container has distributed more in the dwell time class of shorter dwell time (three or less days), then the value decreases for the longer dwell time. The graph also shows that reefer containers have the greatest value on the container dwell time class of three or less days in both the peak and low period for more than 89% for full reefer and 57% for empty reefer. This means most of export reefer containers leave the terminal yard during the first three days.

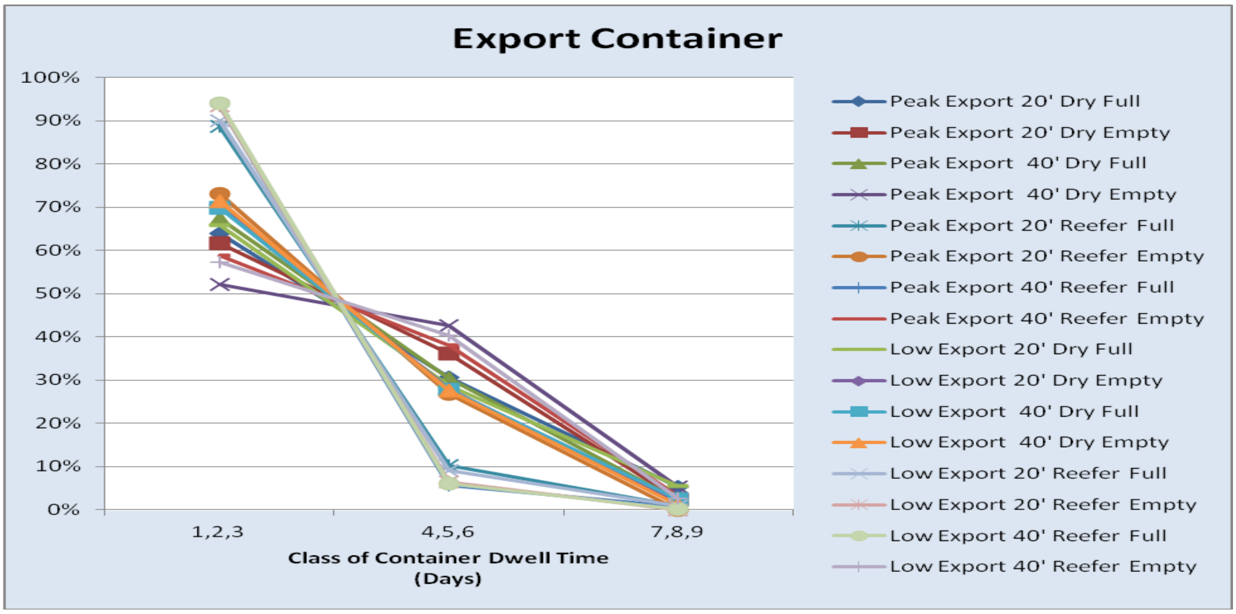

Figure 4.4 Distribution of Type & Size Export Containers in Different Class of Dwell Time

Source: Author's

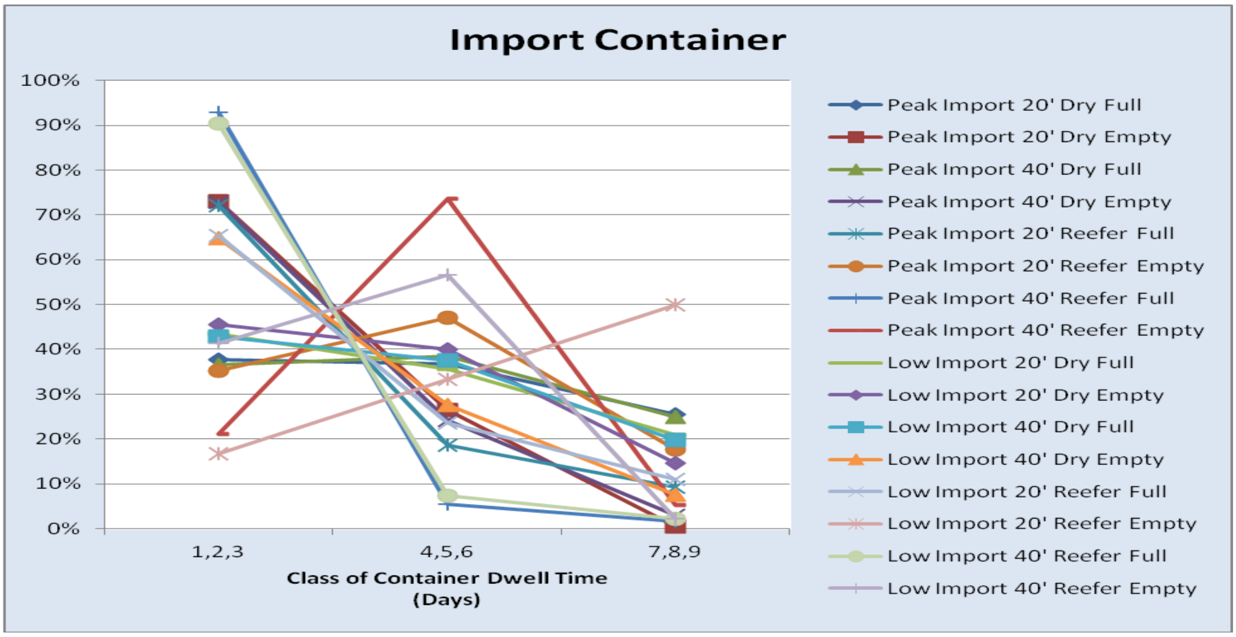

Figure 4.5 Distribution of Type & Size Import Containers in Different Class of Dwell Time

Source: Author's

While figure 4.5 shows that for import containers, container dwell time for the different types and sizes of containers have different patterns. Based on the graph, full reefer containers have a greater value on the shorter class of container dwell time, while 40-foot full reefer containers have accounted for more than 90% on both periods, which is the greatest value on the container dwell time of three or less days. This is followed by the 20-foot full reefer containers with about 65% on the low period and 72% on the peak period.

Table 4.4 Distribution of Container Dwell Time based on Container's Type and Size

Export	Container Type & Size	Status		CDT (days)					
		Full	Empty	Full			Empty		
				1,2,3	4,5,6	7,8,9	1,2,3	4,5,6	7,8,9
Peak	20' Dry	69%	31%	64%	31%	5%	62%	36%	2%
	40' Dry	82%	18%	67%	30%	2%	52%	43%	5%
	20' Reefer	46%	54%	89%	10%	1%	73%	27%	0%
	40' Reefer	25%	75%	94%	5%	1%	59%	38%	3%
Low	20' Dry	71%	29%	66%	29%	5%	71%	28%	1%
	40' Dry	79%	21%	70%	28%	2%	71%	28%	1%

	20' Reefer	49%	51%	90%	9%	1%	94%	6%	0%
	40' Reefer	33%	67%	94%	6%	0%	57%	40%	3%
Import	**Container Type & Size**	**Status**		**CDT (days)**					
				Full			**Empty**		
		Full	**Empty**	**1,2,3**	**4,5,6**	**7,8,9**	**1,2,3**	**4,5,6**	**7,8,9**
Peak	20' Dry	99%	1%	38%	37%	25%	73%	26%	0%
	40' Dry	98%	2%	37%	38%	25%	73%	24%	3%
	20' Reefer	97%	3%	72%	19%	9%	35%	47%	18%
	40' Reefer	99%	1%	93%	5%	2%	21%	74%	5%
Low	20' Dry	98%	2%	43%	36%	21%	46%	40%	15%
	40' Dry	99%	1%	43%	37%	20%	65%	28%	8%
	20' Reefer	97%	3%	65%	24%	11%	17%	33%	50%
	40' Reefer	99%	1%	90%	7%	2%	41%	57%	2%

Source: Author's Calculation

Table 4.4 performs more investigation to examine whether container types and sizes influence container dwell time in JICT. As illustrated in this table, there are different proportions between import and export containers. For export containers, full containers have a greater value than dry containers and reefer containers, of which more than 69% of dry containers are full and more than 18% are empty. For empty containers, reefer containers occupied more value than dry containers for around 51% and above for empty reefer and 25% for full reefer. That means most reefer export containers were empty, while most dry export containers were full. From the distribution of container dwell time, the percentage of containers shipped within the first day is more than 52%, which means both of full and empty dry and full and empty reefer export containers were shipped within the first three days. In contrast, for import containers, 97% and above of the reefer and dry containers are full.

For these containers, dry and reefer containers have a different pattern on the distribution of container dwell time. Table 4.4 also shows that in both periods, most of the full 20-foot and 40-foot reefer containers stayed at the terminal yard for three or less days, while for empty 20-foot and 40-foot reefer containers stayed longer at the yard, for four or more days. On the other hand, empty 20-foot and 40-foot dry import containers mostly moved in three or less days, and full 20-foot and 40-foot dry import containers are more common in the class of four or more days. That means both sizes of empty dry import containers stayed in the terminal yard for three or less days, while the consignee of full dry import containers will stack their containers for four or more days in the terminal yard.

From the observation above, it can be concluded that different types and sizes of containers perform differently on container dwell time.

4.2.3 The Factor of Port Policy on Daily Terminal Operation Time

This analysis will examine whether daily operation time has an impact on container dwell time. The operation time in this analysis is divided into 2 categories: first is Weekday time, which contains the operation days of Monday, Tuesday, Wednesday, and Thursday; and second is Weekend time, which covers the operation days of Friday, Saturday, and Sunday.

Figures 4.6 and 4.7 provide the distribution of daily terminal operation in each container dwell time class in JICT. Based on these figures, export containers have the greater percentage value in the shorter dwell time class during weekend terminal operation for about 65% on Friday, 72% on Saturday, and 80% on Sunday. On weekdays, the percentage of export containers in the three or less day class is not more than 49%.

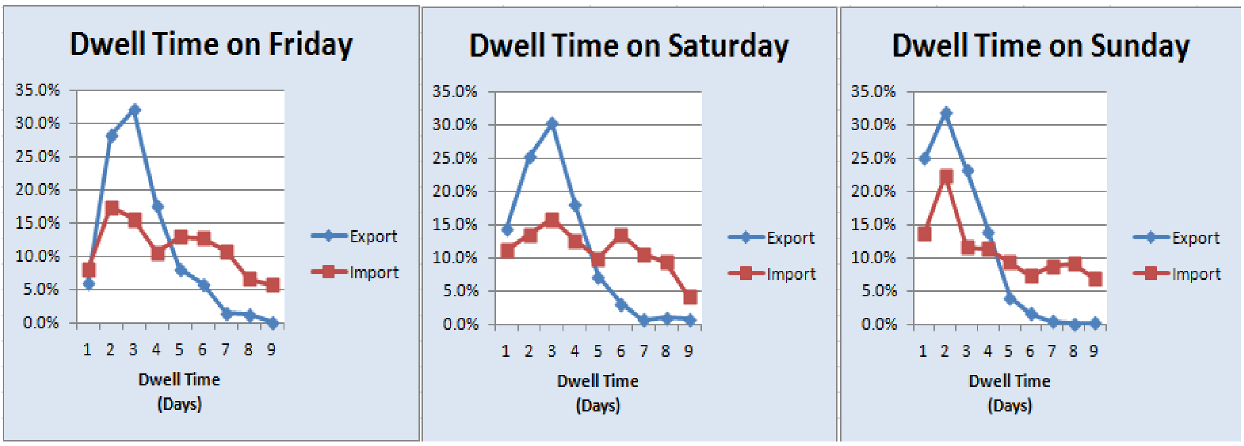

Figure 4.6 Distribution of Weekend Terminal Operation in each Class of Dwell Time

Source: Author's

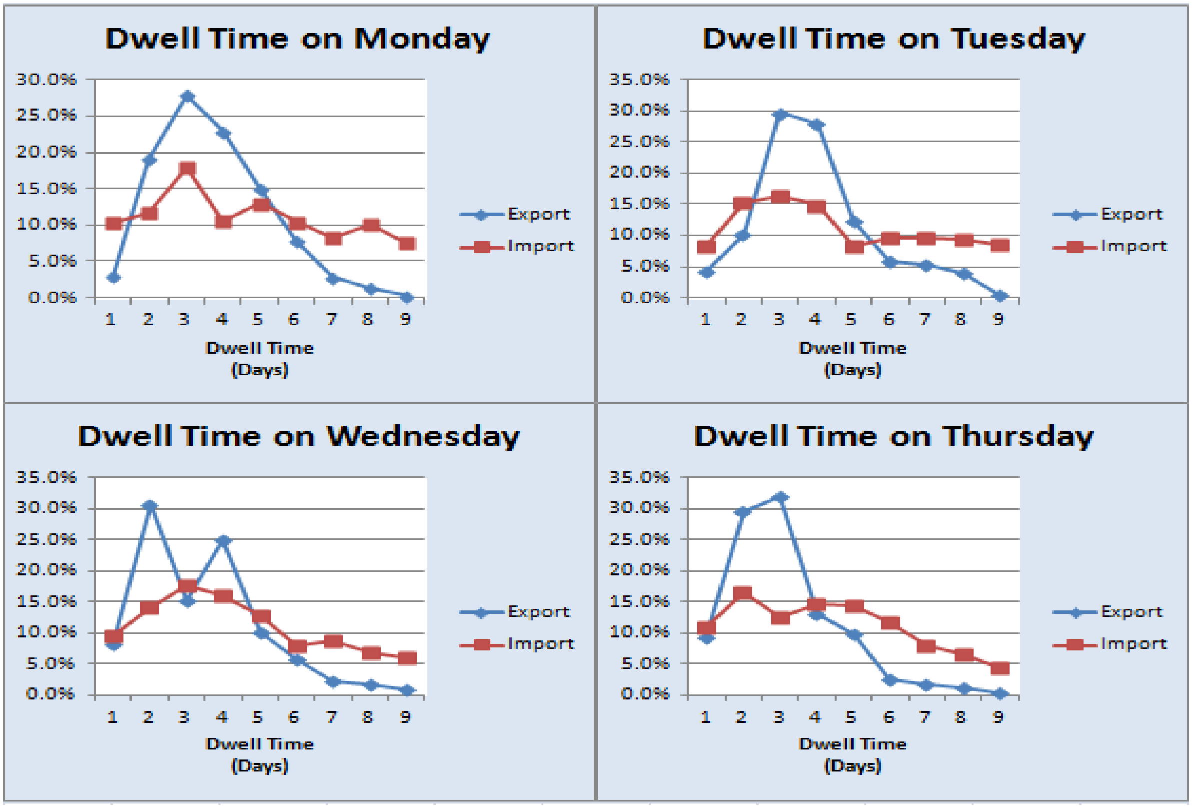

Figure 4.7 Distribution of Weekday Terminal Operation in each Class of Dwell Time

Source: Author's

Table 4.5 presents the percentage proportion of each type and status of containers in 2011, while table 4.6 describes the distribution of container dwell time daily operation time.

Table 4.7 presents more observation about the distribution of container dwell time classes in daily container terminal activities by considering the container status. The table illustrates that in export containers, the three or less days class of container dwell time contributed to a greater percentage value for full and empty containers in dry and reefer containers. This happened in both a peak period and a low period, which means export containers had a shorter dwell time. The percentage of containers that arrived at the terminal on a weekday was higher than on weekend terminal operation. That means there are more containers arriving on weekdays.

For import containers, dry full import containers accounted for around 44% of the whole container volume and had a greater percentage of longer container dwell time (four or more days) for about 62% during the peak period and 56% in the low period. These containers were transported into the terminal mostly on weekdays. In line with dry full containers, empty reefer containers also had a higher value of the four or more day class of container dwell time for about 61% in the peak period and 100% in the low period, but it was mostly transported on weekends.

Meanwhile, dry empty containers and full reefer containers have a greater value of the three or less day container dwell time. The percentage of dry empty containers on the shorter class of dwell time is 62% and above, while it is more than 86% for full reefer containers. These containers are transported into the terminal mostly on weekends.

Table 4.5 Percentage of Containers Population

Period	Export				Import			
	Dry		Reefer		Dry		Reefer	
	Full	Empty	Full	Empty	Full	Empty	Full	Empty
Peak	37.43%	12.14%	0.62%	1.62%	44.31%	1.38%	2.47%	0.02%
Low	37.90%	12.59%	0.88%	1.64%	43.13%	1.46%	2.37%	0.03%

Source: Author's Calculation

Table 4.6 Distribution of Container Flow in Daily Operation Time

Export		Friday	Saturday	Sunday	Monday	Tuesday	Wednesday	Thursday
Dry	**Empty**	16%	15%	13%	18%	15%	9%	13%
	Full	9%	13%	28%	14%	10%	13%	14%
Reefer	**Empty**	7%	13%	15%	16%	15%	19%	15%
	Full	8%	7%	41%	8%	6%	15%	15%
Import		**Friday**	**Saturday**	**Sunday**	**Monday**	**Tuesday**	**Wednesday**	**Thursday**
Dry	**Empty**	18%	13%	28%	7%	8%	7%	18%
	Full	16%	15%	6%	11%	18%	17%	17%
Reefer	**Empty**	19%	29%	1%	23%	25%	3%	0%
	Full	12%	19%	11%	15%	13%	14%	16%

Source: Author's Calculation

Table 4.7 Distribution of Daily Terminal Operation in Each Class of Dwell Time

Export	Dwell Time	Weekday				Weekend			
		Dry		Reefer		Dry		Reefer	
		Full	Empty	Full	Empty	Full	Empty	Full	Empty
Peak	1,2,3	55%	55%	92%	53%	77%	62%	82%	73%
	4,5,6	39%	39%	8%	42%	21%	37%	13%	27%
	7,8,9	6%	5%	1%	4%	2%	1%	5%	0%
Low	1,2,3	60%	72%	89%	59%	77%	68%	98%	65%
	4,5,6	35%	26%	11%	40%	20%	31%	2%	32%
	7,8,9	5%	2%	0%	2%	3%	1%	0%	4%
Import	**Dwell Time**	**Weekday**				**Weekend**			
		Dry		**Reefer**		**Dry**		**Reefer**	
		Full	**Empty**	**Full**	**Empty**	**Full**	**Empty**	**Full**	**Empty**
Peak	1,2,3	37%	72%	89%	15%	37%	75%	93%	39%
	4,5,6	38%	27%	8%	68%	37%	20%	5%	59%
	7,8,9	25%	1%	3%	17%	26%	5%	2%	2%
Low	1,2,3	44%	52%	85%	31%	42%	75%	89%	0%
	4,5,6	36%	39%	11%	41%	38%	17%	7%	63%
	7,8,9	20%	9%	3%	28%	20%	8%	4%	38%

Source: Author's Calculation

Based on the results from figures 4.6 and 4.7, as well as table 4.6, the hint that could be drawn is export full dry containers and export full reefer containers arrive at the terminal most often on Sunday, at the same time as most of the import empty dry containers also arrived, and all of those containers will be shipped out and transported in the next two days. Therefore, it is possible that there will be a high number of containers flowing into the terminal on the same day. So, a new policy in the terminal would be necessary to handle the surges of container flow more efficiently.

CHAPTER 5 MODELLING AND APPLICATION

Two prediction techniques, namely logistic regression and dummy regression, are assessed in this chapter by using SPSS software to find the most suitable model for CDT prediction. Then the model will be utilized to estimate container dwell time based on the influencing factors to calculate the terminal yard capacity and revenue.

5.1 Assessment of the Fitness of a Model

To evaluate the performance of the models for predicting the container dwell time, the value of R^2 is used as a determination coefficient, whether or not a model is fit to the data sample. Where the larger value of R^2 is the better, means model with larger value of R^2 is much fit with the data than model with lower value. The determination coefficient has a maximum value of 1.0, which means the model exactly matches the data.

Table 5.1 Goodness-of-Fit of Models

Model	R Square
Logistic Regression	0.173
Dummy Regression	0.338
Linear regression	0.094

Source: SPSS Software Calculation

The result from an SPSS Software calculation on table 5.1 shows that every model performs different values of R^2, where logistic regression is about 0.173, dummy regression is 0.338, and linear regression is about 0.094. Since the dummy regression model has a higher R^2 value than the other models, it means the dummy regression model is the most suitable model to predict container dwell time based on the available data.

5.2 Dummy Regression

Dummy regression was utilized in the regression equation, where the independence variable is a qualitative variable, such as nominal data or ordinal. This model is an extension of the range of regression analysis application. The aim of using dummy regression is to predict the value of dependent variable or dependent on the basis of one or more independent variable where one or more independent variables used are dummies. A dummy variable is a variable that is used to create a category of data that are qualitative (qualitative data does not have a unit of measurement). Therefore, the qualitative data that will be used in the regression analysis must be transformed first into a quantitative form by using binary code.

In this study, the variables of operational day, type of container and container's size each have two categories, such as operational day being either a weekday or weekend, which is qualitative data. Therefore, it will be transformed into the form of Weekday is 0; Weekend is 1. The type of container categories are dry and reefer, so the transformation is 0 for Reefer and 1 for Dry. For container size, it will be transformed into 0 for 20 feet and 1 for 40 feet.

There are four categories for container status, such as import empty, import full, export empty, and export full. Thus, the transformation follows: for the import empty category, it will be transformed into the form of import empty is 1, import full is 0, and export empty is 0. When the category is import full, the form is 0 for import empty, 1 for import full, and 0 for export empty. And when the category is export empty, the form is 0 for import empty, 0 for import full, and 1 for export empty. Moreover, when the category is export full, the form of import empty is 0, import full is 0, and export empty is 0.

To analyze this, multiple regression or hierarchical regression can be utilized in dummy regression. Multiple regression finds a direct prediction of all the independent variables, but to see the prediction of each independent variable in sequence, a hierarchical regression is utilized. This study will be using multiple regression.

In multiple regression analysis with dummy variables, not all categories of dummy variables were included in the regression analysis. If the category is more than 2, then the number of categories that are involved is k-1 (k = number of categories). The category that was not included in the analysis will be the basis for future interpretations of the variable. For example, in this study the category of status of container is 4, then the number of categories that we are involved is 4-1 = 3 category. Therefore, the variables that will be analyzed are container dwell time (Y); operational day (X_1); three categories in the status of container, namely import empty (X_2), import full (X_3), and export empty (X_4); type of container (X_5); and size of container (X_6). The export full category will be the basis for future interpretation of the variable status of a container.

The equation of dummy regression is formulated as follows:

$$\boldsymbol{Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6} \qquad (5.1)$$

Where,

Y	= Container Dwell Time
X_1	= Operational Days (Weekday or weekday)
X_2	= Status 1 (Import Empty)
X_3	= Status 2 (Import Full)
X_4	= Status 3 (Export Empty)
X_5	= Type of Container (Reefer or Dry)
X_6	= Size of Container (Feet: 20' or 40')
a	= Constanta
$b_1, b_{2,\ldots}b_6$	= Regression Coefficient

The equation is the same as the linear regression equation, but the resulting interpretation changed it because one of the variables in dummy regression is a qualitative variable.

To calculate the yard capacity and revenue of the terminal in the various scenarios, the container dwell time is estimated from different scenarios, based on the factors that influence it (variable X_1, X_2, X_3, X_4, $X_{5,}$ X_6), which are define as qualitative variables. Therefore, the dummy regression model incorporates qualitative explanatory variables into a linear model.

The result of the processing software SPSS 13 for multiple regression analysis are presented in table 5.2.

Table 5.2 Result of Multiple Regression Analysis

Variables	Regression Coefficient	Std. Error	t	Sig.
(Constant)	4.360	0.038	116.255	0.000
X1	-0.073	0.031	-2.337	0.019
X2	-1.463	0.039	-37.184	0.000
X3	0.836	0.033	-25.168	0.000
X4	-0.380	0.052	-7.314	0.000
X5	-0.122	0.085	-1.435	0.151
X6	-0.039	0.030	-1.308	0.191

Source: Author's Calculation

Based on the calculation in table 5.2, the dummy regression equation is:

$$Y = 4.360 — 0.073\ X_1 – 1.463\ X_2 + 0.836\ X_3 – 0.380\ X_4 – 0.122\ X_5 – 0.039\ X_6 \quad (5.2)$$

Regression coefficient values of the independent variables show that if the independent variable is estimated to rise by one unit and other independent variables are estimated as constant or equal to zero, then the value of the dependent variable can be expected to go up or down according to the sign of the regression coefficients of independent variables.

From equation 5.2, constant values were obtained at 4.360. This means if the CDT variable (Y) is not affected by the six independent variables, namely operational days (X_1), status 1 as import empty (X_2), status 2 as import full (X_3), status 3 as export empty (X_4), reefer or dry type of container (X_5), and 20-foot or 40-foot size of container (X_6), then the average value of the CDT will be worth 4.360 or 4.36 days.

The sign of regression coefficients of independent variables indicate the direction of the relationship of the variables concerned with CDT. The regression coefficient for the independent variable X is negative, indicating the existence of trade-offs between the factors influencing CDT with CDT, means each increment of one unit of variable X would lead to a decrease of CDT (Y). Meanwhile, if the regression coefficient of the independent variable X is positive, it indicates a direct relationship between factors influencing CDT with CDT, which means each increment of one unit of variable X would lead to an increased of CDT (Y).

5.2.1 Hypothesis Testing

In this section, an F Test and T Test of variables are utilized to find out whether the independent variables have a significant influence or not on the dependent variable.

F Test is overall hypothesis testing to find out the significance of the independent variables' collective influence on the dependent variable.

The first step to do an F test is formulating a statistical hypothesis, where:

- Ho or Null Hypothesis means there is no significant effect from the independent variables, namely Operational Days (X_1), Status 1 (X_2), Status 2 (X_3), Status 3 (X_4), Container Type (X_5), and Container Size (X_6) against CDT (Y) as the dependent variable.
- Ha means there is a significant effect from Operational Days (X_1), Status 1 (X_2), Status 2 (X_3), Status 3 (X_4), Container Type (X_5), and Container Size (X_6) against CDT (Y).

Statistic Test formula: $$F = \frac{R^2(n-k-1)}{k(1-R^2)} \quad (5.3)$$

F Table formula = $F_{\alpha ; (df1, df2)}$; df1 = k , df2 = n-k-1
Where,
n = number of sample
k = number of regression coefficient

α = 5% (significance level)

df = degree of freedom

Testing Criteria:

1. If the value of ‘F Count’ < ‘F Table’, then null hypothesis is accepted.
2. If the value of ‘F Count’ ≥ ‘F Table’, then null hypothesis is rejected.

Table 5.3 Result of F Testing

F Count	Degree of freedom (df)	F Table	Sig
372.022	df1 = 8	2.099	0.000
	df2 = 23100		

Source: Author’s Calculations

Table 5.3 presents results of F Testing by SPSS 13 software. Based on the table, the value of F Calculate is 372.022, which is higher than F Table’s value (2.099). This means the result meets the second criteria which the null hypothesis is rejected. Thus, it can be concluded that there is simultaneously a significant effect of Operational Time (X_1), Status 1 (X_2), Status 2 (X_3), Status 3 (X_4), Container Type (X_5), and Container Size (X_6) against CDT (Y).

Partial Hypothesis Testing is a test to find out the significance of the independent variables’ effect on the dependent variable. In this hypothesis testing, each of the independent variables will be tested to find out whether they have a significant effect or not on the CDT as the dependent variable. Therefore, the statistical hypothesis in this testing will be divided, based on the independent variables as follows:

- $H_{01} : \beta_1 = 0$ meansOperational Days(X_1) has no significant effect on CDT (Y).
  $H_{a1} : \beta_1 \neq 0$ meansOperational Days(X_1) has significant effect on CDT (Y).
- $H_{02} : \beta_2 = 0$ means Status 1 (X_2) has no significant effect on CDT (Y).
  $H_{a2} : \beta_2 \neq 0$ means Status 1 (X_2) has significant effect on CDT (Y).
- $H_{03} : \beta_3 = 0$ means Status (X_3) has no significant effect on CDT (Y).
  $H_{a3} : \beta_3 \neq 0$ means Status (X_3) has significant effect on CDT (Y).
- $H_{04} : \beta_4 = 0$ means Status (X_4) has no significant effect on CDT (Y).
  $H_{a4} : \beta_4 \neq 0$ means Status (X_4) has significant effect on CDT (Y).

- H_{05} : β_5 = 0 means Container Type (X_5) has no significant effect on CDT (Y).
  H_{a5} : β_5 ≠ 0 means Container Type (X_5) has significant effect on CDT (Y).
- H_{06} : β_6 = 0 means Container Size (X_6) has no significant effect on CDT (Y).
  H_{a6} : β_6 ≠ 0 means Container Size (X_6) has significant effect on CDT (Y).

With Testing Criteria:

1. If the value of '-T Table' ≤ 'T Count' ≤ 'T Table', then null hypothesis is accepted.
2. If the value of 'T Count' < '-T Table' or 'T Count' > 'T Table', then null hypothesis is rejected.

By utilizing the Statistic Test formula :

$$T_{test} = \frac{b}{Se(b)} \quad , df = n-k-1 \qquad (5.4)$$

Where,

n = number of sample

k = number of regression coefficient

α = 5% (significance level)

df = degree of freedom

The results of T test based on SPSS processing is present on the table 5.4:

Table 5.4 Partial Hypothesis Testing Results

Variables	T Count	df	T Table	Sig
X1	-2.337	23100	±1.960	0.019
X2	-37.184			0.000
X3	-25.168			0.000
X4	-7.314			0.000
X5	-1.435			0.151
X6	-1.308			0.191

Source: Author's Calculations

Based on table 5.3, variables such as Operational Days (X_1), Status 1(X_2) or import empty container, Status 2 (X_3) or import full container, and Status 3 (X_4) or export empty all have a T count value lower than –T table value, which means Null Hypothesis is rejected. Therefore, it can be concluded that operational days has a partially significant effect on CDT (Y).

The Container Type (X_5) and Container Size (X_6) variables obtained a T count equal to -1.435 and -1.308. Since T count (-1.435 and -1.308) is bigger than T table (-1.960), the Ho is accepted, which means the Status 1 variable does not have a significant effect on CDT (Y).

Based on the results on table 5.3, the scenario that will be drawn in the next section is a scenario on container status and operational days in JICT.

5.3 Container Dwell Time Estimation

Moini (2010) states that container dwell time modeling based on the factors influencing it may assist in achieving an expected balance between optimal or suitable container dwell time and an adequate yard capacity. There are two different scenarios that will be presented in this section. The first scenario is to assess whether a change in the characteristics of a terminal has an impact on container dwell time, while the second scenario is the scenario to assess the impact of changing terminal policy on container dwell time.

The container dwell time to be predicted in the two different scenarios will be estimated using dummy regression technique.

Base scenario for export and import containers

Based on the calculations of table 3.9 in chapter 3, the average container dwell time is about 4.3 days, with composition 2.53 days for export containers and 5.61 days for import containers. The area required to fulfill the needed container yard space based on throughput in 2011 is 43 Ha, which exceeds the available area of only about 40 Ha. To make the available area sufficient with the existing throughput, the average container dwell time must be reduced to 4 days with composition 2.51 days for export and 5.12 days for import, which will be used as the base scenario for this study.

Table 5.5 Area Required on Different Average CDT

Average CDT	Throughput in 2011	Total Area Required	
		m2	Ha
4.3	2,295,264	426,941	43
4.2		416,993	42
4.1		407,046	41
4.0		397,098	**40**

Source: Author's Calculation

Scenario 1: Changing on the container's status

Table 5.5 shows that by changing the container's status, the dummy regression model results present that the average container dwell time is changed. When empty export containers become full export containers, the value of average dwell time decreases to 2.52 days, but when the container's status of full changes to export empty, the average container dwell time increases slightly to 2.90 days. When the status of import containers changes from empty into import full containers, the average container dwell time is increased to 5.20 days, and the average container dwell time decreases to 2.78 days when the status of container is changed from full containers to import empty containers.

Table 5.6 Estimated CDT based on Container's Status

Container's Status		CDT
Export	Empty into Full	2.52
	Full into Empty	2.90
Import	Empty into Full	5.20
	Full into Empty	2.78

Source: Author's Calculations

From the dummy regression outcomes above, for import containers, the changing of the status from empty to full containers obtained a higher value of average container dwell time than other container status changes, but the value change is not very much from the base case CDT scenario. But when the status changes from full into empty containers, the CDT value changes dramatically, reduced by almost half from the base case scenario (from 5.12 days to 2.78 days). It indicates that nearly 99% of import containers were full containers, and almost 60% of the full containers stay in the yard for four or more days, while 63% and up of empty containers are stacking for three days or less.

Scenario 2: Changing on the Operational Day

The operational time and gate in Terminal 1 JICT is 24/7, which means the terminal and the gate are operated 24 hours a day, 7 days a week for all containers.

According to table 4.6, which shows the distribution of container flow in daily operation time at JICT in chapter 4, export containers have low volume on Tuesday, which is defined as a weekday operational day in this study. Meanwhile, import containers have low volume on Sunday, which is defined as a weekend operational day. Based on that result, this study will draw the scenario on the operational day by dedicating import or export containers on the one of truck gates operational day.

Table 5.7 Estimated CDT Based on Operational Day

Operational Days		CDT
Export	Dedicated on Weekend	2.90
	Dedicated on Weekday	2.82
Import	Dedicated on Weekend	5.12
	Dedicated on Weekday	5.20

Source: Author's Calculations

The results in table 5.7 show that when the gates' operational day is dedicated for export or import containers, the average value of CDT increases. In export containers, dedication of the gates' operational day on weekends will obtain a higher CDT average value for about 2.90 days than when dedicated on a weekday, which results in around 2.82 days. On the other hand, when on the weekend the gates are dedicated to handle import containers, the average CDT value obtained is lower than when it is dedicated on a weekday.

5.4 Yard Capacity and Terminal Revenue Optimization

Optimal container dwell time is defined as a suitable number of days a container remains in the terminal yard, in balance with an adequate yard capacity. Moini (2010) described that increasing container dwell time would reduce the yard capacity, but it may serve as a revenue stream for terminal operators who charge demurrage fees.

In this section, the study will evaluate the impact of the new container dwell time predicted by dummy regression on the terminal yard capacity and terminal earnings based on the demurrage fees policy. Therefore, the tradeoff between storage yard capacity and earnings from demurrage fees will be assessed.

The results from the analysis could assist terminal operators in managing the terminal better by determining the optimal dwell time, so the desired balance between container dwell time and yard capacity can be achieved.

In the previous section, some practical scenarios were drawn to calculate the yard capacity and the revenue earned from the demurrage fee in this section. Revenue from demurrage fees on table 5.8 below is calculated based on the estimated CDT by dummy regression technique in each scenario and according to the basic tariff structure presented on table 5.7 and the storage policy at JICT in table 3.4. In JICT terminal, there are different policies between import and export containers, where import containers have three days free time for empty and full container, then after these three days, a demurrage fee is charge for about 200% per day of the basic tariff per day. For export containers, there is no free time, but the first day until the fifth day are counted as 1 day basic tariff, then after five days the demurrage fee will be counted 200% per day from basic tariff. In this calculation the demand is assumed fixed (using demand in 2011), and all containers are 20 feet in size.

Table 5.8 Basic Tariff of Container Storage Services in JICT

Container Storage Tariff	Tariff (USD)	Remarks
Empty	62.25	Per Box/ day
Full	83	Per Box/ day

Source: JICT

The formula to be used to calculate the annual capacity yard is developed by Dally (1983) as equation 5.5.

$$C = \frac{(Cs*H*W*K')}{(T*F)} \quad (5.5)$$

Where,

Cs = Number of container ground slots (TEU),

H = Mean profile height,

W = Working slots (TEUs) in the container storage expressed as a proportion (0.8),

K' = Number of days per year (365),

T = Mean CDT in the CY, and

F = Peaking factor (about 1.3 based on the existing assumption in JICT). It's ensuring the storage space sufficiency.

The static capacity in JICT for export is about 4,317 TEU, and import is 4,614 TEU as mentioned in the previous chapter on the table 4.1.

Table 5.9 presents the results of the annual container yard capacity and annual demurrage fee earning calculation. The table shows that by changing the container's status and operational days of export and import containers, the dummy regression outcomes show that the average CDT is changing, resulting in a change of the annual yard capacity and also the annual earnings from demurrage fees.

Table 5.9 Summary of Base Case & Different Scenario

Scenarios	Average CDT (Day)	Annual Yard Capacity (TEU per annum)	Change in capacity (TEU per annum)	Demurrage fee ($ per annum in '000)	Change in Revenue ($ per annum)
Base Scenario					
Export	2.51	3,386.92	0	158,755.76	-
Import	5.12	1,774.62	0	336,562.21	-
Scenario 1					
Export					
Empty into Full	2.52	3,377.50	(9.42)	158,755.76	-
Full into Empty	2.90	2,934.47	(452.45)	119,066.82	(39,688.94)
Import					
Empty into Full	5.20	1,748.93	(25.69)	348,500.64	11,938.43
Full into Empty	2.78	3,273.66	1,499.04	119,066.82	(217,495.39)
Scenario 2					
Export					
Dedicated on Weekend	2.90	2,934.47	(452.45)	158,755.76	-
Dedicated on Weekday	2.82	3,010.33	(376.59)	158,755.76	-
Import					
Dedicated on Weekend	5.12	1,773.92	(0.69)	336,879.72	317.51
Dedicated on Weekday	5.20	1,748.93	(25.69)	348,500.64	11,938.43

Source: Author's Calculation

Scenario 1 : The changing of the status of export containers from empty to full and from full to empty resulted in an increase of average CDT, but the increase from the full to empty scenario is much higher than the empty to full scenario. As the effect of CDT increases, the annual yard capacity is reduced by about 9.42 TEU per annum due to changing from empty to full and about 452.45 TEU per annum for changing from full to empty. This indicates that the volume of full export containers is much higher than empty containers, but the time an empty container stays in the terminal yard is longer than a full container. On the demurrage fee earning, there is no changing in earning from the empty to full scenario, though the full to empty scenario reduces the demurrage fee earnings by about $39,688.94. This is because the basic tariff for an empty container is much cheaper than a full container.

In import containers, the changing of the empty into full containers result in an increase in average CDT from 5.12 days (base case CDT) to 5.20 days and reduces the annual yard capacity for about 25.69 TEU, but the demurrage fees earned increases slightly for about $11,938.43. Also, by changing import containers' status from full to empty, the average CDT is reduced by almost half, from 5.12 days (import CDT on base scenario) to 2.78 days. Reducing average CDT by half doubled the annual yard capacity from 1,774.62 TEU to 3,273.66 TEU. On the other hand, earnings from demurrage fees are reduced to about $217,495.39.

The results above may help JICT terminal operators to establish a new policy in the container terminal, where they could prefer to earn more from the demurrage fees when yard capacity is not a significant constraint or when the volume of containers is not high or low season. Increasing the demurrage fees or shortening the policy on free storage time could be an alternative choice to gain more storage capacity during the peak season.

Scenario 2: The specialization of the truck gates scenario for export containers results in the increasing of the average CDT in weekday scenarios for about 2.90 days and 2.82 days for weekend scenarios. It reduces the annual yard capacity, but the demurrage fee earnings remain the same.

For import containers, the increasing of average CDT only occurs when weekday gates are dedicated to handle these containers, where 5.12 days becomes 5.20 days. But when the gates' dedication changes to the weekend, the average CDT is the ideal time or same with average CDT on base scenario (5.12 days). From the annual yard capacity perspective, the gates' dedication both on weekdays and weekends reduces the capacity, but the reduction of the weekend scenario is only about 0.69 TEU, which is far less than the capacity reduction in the weekday scenario. Since the average CDT increases, the earnings from demurrage fees also increases. In the weekend scenario, the demurrage fees revenue is about $317.51 and $11,938.43 in a weekday scenario.

The results from the changing of the policy of the gates' operational day scenario could give a little hint for the terminal operator that dedicating the truck gates for import containers on weekends may result in the optimal dwell time, where the reduction in yard capacity is not much, but the terminal operator still gets the revenue from the demurrage fee.

Generally, as the average CDT and revenue from the demurrage fees increases, it will reduce the capacity. But it does not apply to both scenarios above, especially for export containers, because even the average CDT is increasing, and yard capacity is reducing, but the revenue from the demurrage fee is not increasing. This is because of the policy on storage charge structure at JICT stipulating that for export containers, the first day until fifth day will be counted as 1 day basic tariff. In export containers, the base average CDT is about 2.52 days, and estimated average CDT is around 2.52 to 2.90 days. This is why there is no changing of the demurrage fee earnings for empty to full and operational day scenarios in export containers.

Chapter 6 CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Expansion of a new terminal container is the best solution to improve container terminal capacity in order to capitalize on opportunities, anticipating the rapid growth of containerization, but it is costly to acquire and takes a long time. Another simple and inexpensive solution may be used to improve terminal capacity by establishing an effective policy to the factors that determine yard capacity. Container dwell time is a principal factor that has direct impact on the container yard capacity in a terminal. Therefore, JICT as port operator as well as decision maker should be able to understand the factors that can affect container dwell time, which is under their control. Better understanding of these factors might assist port operators to optimize container dwell time, manage the yard capacity efficiently, and establish policies appropriately.

This study analyzes the factors that influence container dwell time, varying from physical location and operational policy of JICT terminal to the characteristics of the containers in JICT, namely status of containers, type and size of containers, and operational day of containers. Henceforth, these factors are estimated by utilizing dummy regression techniques. The estimation CDT is used to measure how changes in the factors that influence CDT effects container dwell time, yard capacity, and terminal revenue.

Generally, it can be concluded that any changes in the factors that influence CDT in Terminal 1 JICT could affect the CDT, yard capacity, and revenue earning from demurrage fees. The analysis shows that based on the sample dataset, type of container and container size does not have a significant effect on CDT in JICT. Meanwhile, container status and container operational day have significant effect on CDT in JICT. From the container status scenario results, JICT terminal operators may help establish a new seasonal policy in the container terminal, where they could prefer to earn more from the demurrage fees when yard capacity is not a significant constraint or when the volume of the containers is not in high or low season. Increasing the demurrage fees or changing the policy on free time storage by shortening it could be an alternative choice during the peak season in order to gain more storage capacity.

The analysis from the operational day policy scenario could assist JICT to establish a new policy on operational day by dedicating truck gates on the weekend for import containers and weekday for export containers, since the gates being dedicated for import containers on weekends seem result in a balance between CDT and an adequate yard capacity.

6.2 Recommendation

Based on this study, we recommend to JICT as a terminal operator to not only establish new policies based on the analysis of influencing factors, such as container dwell time and operational status of the day, but also to review the policies that are likely to affect the length of the container in container yard, such as free time, storage charges, and structure policies. Therefore, for future study, the free time, storage charge, and structure evaluation should be considered to measure the most suitable free time period and storage charge and structure in order to achieve optimal dwell time. Moreover, in calculating revenue earned from the demurrage fees using CDT, a more elaborate economic analysis should be provided to perform further evaluation on the effectiveness of this policy.

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APPENDICES

Appendix I- Sensitivity Changes of Yard Capacity on Different Level of CDT

Scenario	Throughput 2011	Average Dwell Time	TGS	No of Slot Required	Block required	Total area of overall slot	area for distance between container	Effective Area	Total Area for trailer roadways	RTG	Roadway between block	Total Area Required	
												m2	Ha
Existing	2,295,264	4.3	13,731	1,962	30	205,969	8,114	214,083	140,049	49,795	23,013	426,941	**43**
EADT *3		8.6	27,619	3,946	60	414,286	16,320	430,606	281,694	100,158	47,099	859,557	**86**
IADT * 3		6.7	21,341	3,049	46	320,115	12,611	332,725	217,663	77,391	36,211	663,990	**66**
EADT *2		6.2	19,930	2,847	43	298,943	11,777	310,720	203,267	72,273	33,763	620,022	**62**
IADT *2		5.3	16,791	2,399	36	251,858	9,922	261,779	171,251	60,889	28,319	522,238	**52**
EADT / 2		2.6	8,395	1,199	18	125,929	4,961	130,890	85,625	30,445	13,759	260,718	**26**
IADT / 2		3.1	9,965	1,424	22	149,472	5,888	155,360	101,633	36,136	16,481	309,610	**31**
EADT / 3		2.2	7,114	1,016	15	106,705	4,204	110,908	72,554	25,797	11,536	220,796	**22**
IADT / 3		2.9	9,206	1,315	20	138,095	5,440	143,535	93,898	33,386	15,165	285,985	**29**

Appendix II- CDT Distribution based on Container's Status

Peak Period

CDT		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Export	Empty	8.5%	22.2%	27.9%	20.6%	11.4%	6.1%	1.6%	1.4%	0.3%
	Full	13.0%	27.1%	26.3%	18.4%	8.0%	3.6%	1.9%	1.3%	0.5%
Import	Empty	9.5%	41.4%	22.2%	12.5%	7.9%	3.2%	2.1%	1.0%	0.2%
	Full	10.0%	14.7%	15.4%	13.3%	11.7%	10.9%	9.5%	8.3%	6.3%

Low Period

CDT		1	2	3	4	5	6	7	8	9
Export	Empty	33.8%	21.7%	22.5%	15.7%	3.9%	1.3%	0.7%	0.2%	0.1%
	Full	14.1%	27.0%	27.6%	17.7%	6.7%	3.1%	2.0%	1.1%	0.6%
Import	Empty	9.9%	35.0%	18.1%	14.1%	7.7%	6.4%	5.3%	2.7%	0.9%
	Full	10.5%	17.4%	17.6%	14.1%	11.6%	9.3%	7.3%	6.1%	6.2%

Appendix III- CDT Distribution based on Type and Size of Container

Peak Period

Export	CDT	Size	1	2	3	4	5	6	7	8	9
Empty	Dry	20'	8.6%	25.4%	27.6%	19.0%	11.6%	5.5%	1.1%	0.9%	0.4%
		40'	7.7%	16.7%	27.8%	22.9%	12.4%	7.3%	2.7%	2.4%	0.2%
	Reefer	20'	26.0%	19.8%	27.3%	23.3%	2.1%	1.5%	0.0%	0.0%	0.0%
		40'	9.2%	20.2%	29.4%	22.9%	8.8%	6.2%	1.4%	1.7%	0.1%
Full	Dry	20'	11.9%	26.3%	25.8%	18.6%	7.9%	4.2%	2.6%	2.0%	0.8%
		40'	12.4%	27.5%	27.4%	18.8%	8.5%	3.2%	1.4%	0.6%	0.2%
	Reefer	20'	29.2%	41.5%	17.9%	6.1%	3.4%	0.7%	0.5%	0.5%	0.0%
		40'	49.8%	33.6%	10.2%	3.6%	1.2%	0.9%	0.6%	0.1%	0.0%

Low Period

Export	CDT	Size	1	2	3	4	5	6	7	8	9
Empty	Dry	20'	10.3%	30.9%	29.5%	20.9%	5.5%	1.5%	1.2%	0.2%	0.1%
		40'	6.7%	30.8%	33.8%	21.8%	4.4%	1.3%	0.5%	0.2%	0.3%
	Reefer	20'	5.9%	43.6%	44.0%	5.9%	0.6%	0.0%	0.0%	0.0%	0.0%
		40'	6.1%	21.9%	29.2%	26.5%	8.8%	4.9%	1.1%	1.1%	0.3%
Full	Dry	20'	13.0%	25.6%	27.2%	17.3%	7.2%	4.2%	2.8%	1.6%	1.1%
		40'	13.1%	27.9%	28.9%	18.9%	6.6%	2.3%	1.4%	0.7%	0.3%
	Reefer	20'	31.4%	41.2%	17.5%	6.2%	1.5%	1.3%	0.2%	0.7%	0.0%
		40'	54.9%	30.4%	8.6%	3.8%	2.0%	0.2%	0.0%	0.0%	0.0%

Peak Period

Import	CDT	Size	1	2	3	4	5	6	7	8	9
Empty	Dry	20'	15.0%	32.8%	25.2%	12.7%	9.1%	4.6%	0.5%	0.0%	0.0%
		40'	11.1%	33.5%	28.3%	15.7%	7.1%	1.3%	1.2%	1.5%	0.3%
	Reefer	20'	8.8%	0.0%	26.5%	11.8%	26.5%	8.8%	8.8%	0.0%	8.8%
		40'	15.8%	1.8%	3.5%	36.8%	17.5%	19.3%	5.3%	0.0%	0.0%
Full	Dry	20'	7.2%	15.2%	15.4%	13.6%	11.9%	11.2%	10.0%	8.7%	6.7%
		40'	6.0%	14.3%	16.2%	14.1%	12.7%	11.6%	9.9%	8.7%	6.4%
	Reefer	20'	22.7%	26.9%	22.5%	8.3%	5.7%	4.7%	4.5%	2.1%	2.6%
		40'	75.6%	11.8%	5.6%	2.7%	1.5%	1.3%	0.7%	0.2%	0.7%

Low Period

Import	CDT	Size	1	2	3	4	5	6	7	8	9
Empty	Dry	20'	14.1%	18.1%	13.3%	19.6%	11.2%	9.1%	7.5%	5.0%	2.0%
		40'	10.8%	31.9%	22.1%	14.2%	7.2%	6.2%	5.1%	2.3%	0.2%
	Reefer	20'	8.3%	0.0%	8.3%	0.0%	0.0%	33.3%	36.1%	8.3%	5.6%
		40'	30.4%	8.7%	2.2%	21.7%	8.7%	26.1%	2.2%	0.0%	0.0%
Full	Dry	20'	8.1%	17.7%	17.6%	14.7%	11.8%	9.0%	7.4%	6.5%	7.0%
		40'	7.3%	17.0%	18.5%	14.5%	12.4%	10.5%	7.7%	6.1%	5.9%
	Reefer	20'	20.5%	24.8%	20.1%	10.1%	8.9%	4.7%	5.1%	3.2%	2.7%
		40'	67.6%	15.1%	7.7%	3.9%	2.2%	1.2%	1.1%	0.6%	0.5%

Appendix IV-CDT Distribution based on Operational Day

Peak Period

Friday	CDT	1	2	3	4	5	6	7	8	9
Export										
Dry	Empty	7%	28%	29%	11%	15%	10%	0%	1%	0%
	Full	5%	28%	34%	22%	4%	3%	2%	2%	0%
Reefer	Empty	9%	26%	29%	3%	14%	17%	1%	0%	0%
	Full	17%	64%	16%	3%	1%	0%	0%	0%	0%
Import										
Dry	Empty	7%	39%	32%	4%	8%	7%	4%	0%	0%
	Full	6%	17%	15%	11%	13%	13%	11%	7%	6%
Reefer	Empty	18%	0%	0%	47%	29%	0%	0%	0%	6%
	Full	59%	17%	11%	2%	3%	4%	1%	0%	2%

Monday	CDT	1	2	3	4	5	6	7	8	9
Export										
Dry	Empty	7%	19%	21%	17%	18%	13%	4%	3%	0%
	Full	1%	19%	31%	26%	14%	5%	2%	1%	0%
Reefer	Empty	8%	15%	24%	17%	13%	16%	5%	2%	0%
	Full	6%	58%	31%	5%	1%	0%	0%	0%	0%
Import										
Dry	Empty	1%	52%	43%	2%	2%	0%	0%	0%	0%
	Full	6%	11%	18%	12%	14%	11%	9%	11%	8%
Reefer	Empty	33%	0%	0%	0%	43%	14%	10%	0%	0%
	Full	66%	15%	11%	2%	2%	2%	1%	0%	1%

Saturday	CDT	1	2	3	4	5	6	7	8	9
Export										
Dry	Empty	9%	20%	31%	26%	9%	5%	0%	1%	0%
	Full	16%	27%	30%	15%	7%	2%	1%	1%	1%
Reefer	Empty	16%	21%	36%	17%	3%	7%	0%	0%	0%
	Full	41%	41%	14%	3%	1%	0%	0%	0%	0%
Import										
Dry	Empty	2%	21%	32%	28%	2%	5%	6%	2%	0%
	Full	7%	14%	16%	13%	11%	15%	11%	10%	4%
Reefer	Empty	8%	4%	42%	46%	0%	0%	0%	0%	0%
	Full	79%	9%	6%	3%	1%	1%	1%	0%	0%

Sunday	CDT	1	2	3	4	5	6	7	8	9
Export										
Dry	Empty	18%	27%	19%	19%	12%	5%	0%	0%	0%
	Full	25%	33%	24%	13%	3%	1%	0%	0%	0%
Reefer	Empty	13%	36%	27%	23%	2%	0%	0%	0%	0%
	Full	62%	25%	6%	3%	1%	2%	1%	0%	0%
Import										
Dry	Empty	8%	70%	5%	8%	6%	0%	1%	2%	0%
	Full	8%	17%	13%	13%	10%	9%	11%	11%	8%
Reefer	Empty	0%	0%	0%	0%	0%	100%	0%	0%	0%
	Full	85%	11%	1%	2%	1%	0%	0%	0%	0%

Thursday	CDT	1	2	3	4	5	6	7	8	9
Export										
Dry	Empty	9%	26%	28%	20%	14%	1%	0%	1%	1%
	Full	9%	31%	34%	10%	8%	3%	2%	1%	0%
Reefer	Empty	7%	23%	25%	30%	15%	0%	0%	0%	0%
	Full	47%	38%	9%	2%	2%	0%	1%	0%	0%
Import										
Dry	Empty	24%	41%	9%	9%	12%	4%	0%	0%	0%
	Full	8%	16%	13%	15%	15%	12%	8%	7%	5%
Reefer	Empty	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Full	67%	17%	4%	4%	3%	2%	1%	0%	1%

Tuesday	CDT	1	2	3	4	5	6	7	8	9
Export										
Dry	Empty	1%	15%	41%	25%	9%	3%	4%	3%	0%
	Full	6%	7%	24%	31%	14%	7%	6%	4%	1%
Reefer	Empty	1%	15%	39%	16%	13%	6%	3%	8%	0%
	Full	32%	23%	24%	14%	5%	0%	0%	1%	0%
Import										
Dry	Empty	1%	5%	52%	28%	7%	3%	2%	0%	0%
	Full	6%	15%	16%	15%	8%	10%	10%	10%	9%
Reefer	Empty	0%	0%	0%	22%	22%	39%	9%	0%	9%
	Full	58%	18%	13%	5%	1%	2%	2%	0%	1%

Wednesday	CDT	1	2	3	4	5	6	7	8	9
Export										
Dry	Empty	9%	26%	25%	30%	2%	3%	2%	1%	2%
	Full	7%	33%	12%	23%	12%	7%	2%	2%	1%
Reefer	Empty	19%	11%	27%	39%	3%	1%	0%	0%	0%
	Full	47%	34%	11%	5%	2%	1%	0%	0%	0%
Import										
Dry	Empty	16%	13%	27%	23%	20%	0%	1%	1%	0%
	Full	7%	14%	18%	16%	13%	8%	9%	7%	6%
Reefer	Empty	0%	0%	0%	0%	0%	33%	67%	0%	0%
	Full	69%	10%	7%	6%	3%	2%	2%	1%	1%

Low Period

Monday	CDT	1	2	3	4	5	6	7	8	9
Export										
Dry	Empty	8%	42%	29%	18%	2%	1%	0%	0%	0%
	Full	1%	21%	38%	26%	8%	2%	1%	1%	1%
Reefer	Empty	6%	34%	40%	13%	6%	0%	0%	0%	0%
	Full	17%	49%	28%	6%	0%	0%	0%	1%	0%
Import										
Dry	Empty	2%	28%	35%	17%	14%	3%	0%	1%	0%
	Full	6%	11%	19%	11%	15%	10%	9%	10%	9%
Reefer	Empty	100%	0%	0%	0%	0%	0%	0%	0%	0%
	Full	50%	24%	15%	4%	1%	3%	1%	1%	1%

Tuesday	CDT	1	2	3	4	5	6	7	8	9
Export										
Dry	Empty	8%	36%	39%	13%	3%	0%	0%	0%	0%
	Full	6%	12%	30%	26%	13%	7%	4%	2%	1%
Reefer	Empty	4%	24%	22%	32%	9%	3%	5%	0%	1%
	Full	40%	31%	11%	6%	11%	1%	0%	0%	0%
Import										
Dry	Empty	8%	12%	35%	30%	5%	5%	4%	0%	0%
	Full	8%	18%	19%	15%	9%	9%	8%	7%	8%
Reefer	Empty	0%	8%	12%	0%	0%	60%	20%	0%	0%
	Full	56%	17%	13%	6%	3%	2%	1%	1%	1%

Wednesday	CDT	1	2	3	4	5	6	7	8	9
Export										
Dry	Empty	5%	22%	35%	27%	5%	1%	3%	1%	0%
	Full	12%	30%	13%	20%	13%	5%	4%	1%	1%
Reefer	Empty	3%	10%	42%	39%	6%	0%	1%	0%	0%
	Full	56%	31%	6%	6%	1%	0%	0%	0%	0%
Import										
Dry	Empty	13%	14%	17%	15%	21%	9%	11%	0%	1%
	Full	9%	19%	20%	17%	11%	6%	7%	6%	6%
Reefer	Empty	13%	9%	4%	0%	0%	17%	22%	4%	30%
	Full	61%	15%	9%	7%	4%	1%	2%	1%	0%

Thursday	CDT	1	2	3	4	5	6	7	8	9
Export										
Dry	Empty	11%	28%	26%	24%	7%	3%	2%	0%	0%
	Full	14%	33%	28%	7%	7%	6%	4%	1%	1%
Reefer	Empty	2%	30%	22%	32%	11%	2%	1%	0%	0%
	Full	52%	28%	6%	9%	4%	1%	0%	0%	0%
Import										
Dry	Empty	13%	33%	4%	7%	13%	17%	8%	6%	0%
	Full	9%	18%	15%	16%	15%	9%	5%	5%	7%
Reefer	Empty	0%	0%	0%	53%	21%	0%	21%	5%	0%
	Full	56%	18%	10%	5%	6%	2%	1%	1%	2%

Friday	CDT	1	2	3	4	5	6	7	8	9
Export										
Dry	Empty	6%	29%	28%	28%	6%	1%	1%	0%	1%
	Full	5%	28%	32%	20%	4%	4%	3%	2%	2%
Reefer	Empty	3%	21%	34%	11%	11%	18%	0%	0%	1%
	Full	46%	36%	16%	3%	0%	0%	0%	0%	0%
Import										
Dry	Empty	11%	47%	21%	6%	1%	4%	8%	1%	0%
	Full	6%	19%	18%	13%	14%	12%	8%	4%	6%
Reefer	Empty	0%	0%	0%	0%	0%	67%	0%	33%	0%
	Full	51%	20%	13%	4%	3%	3%	4%	1%	1%

Saturday	CDT	1	2	3	4	5	6	7	8	9
Export										
Dry	Empty	5%	26%	34%	23%	10%	1%	0%	0%	0%
	Full	21%	29%	29%	13%	5%	1%	1%	1%	0%
Reefer	Empty	14%	18%	51%	18%	0%	0%	0%	0%	0%
	Full	47%	37%	11%	4%	1%	0%	0%	0%	0%
Import										
Dry	Empty	10%	16%	44%	14%	4%	1%	3%	8%	0%
	Full	7%	16%	18%	14%	10%	13%	10%	7%	5%
Reefer	Empty	0%	0%	0%	0%	0%	60%	0%	0%	40%
	Full	80%	7%	3%	3%	3%	0%	2%	1%	0%

Sunday	CDT	1	2	3	4	5	6	7	8	9
Export										
Dry	Empty	22%	27%	29%	17%	3%	2%	0%	0%	0%
	Full	24%	32%	25%	15%	2%	1%	0%	0%	0%
Reefer	Empty	30%	18%	18%	20%	0%	0%	0%	12%	0%
	Full	67%	26%	5%	1%	0%	0%	0%	0%	0%
Import										
Dry	Empty	8%	64%	2%	15%	2%	2%	0%	4%	3%
	Full	8%	19%	15%	14%	11%	9%	8%	8%	6%
Reefer	Empty	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Full	74%	18%	3%	2%	1%	2%	0%	1%	0%

Appendix V- Logistic Regression Case Processing Summary

Case Processing Summary

		N	Marginal Percentage
DWELL	1.00	2998	13.0%
	2.00	3714	16.1%
	3.00	3737	16.2%
	4.00	3301	14.3%
	5.00	2666	11.5%
	6.00	2084	9.0%
	7.00	1752	7.6%
	8.00	1519	6.6%
	9.00	1338	5.8%
DAYS	WEEKDAYS	15238	65.9%
	WEEKEND	7871	34.1%
STATUS	IMPORT EMPTY	776	3.4%
	IMPORT FULL	12735	55.1%
	EXPORT EMPTY	2521	10.9%
	EXPORT FULL	7077	30.6%
REF_DRY	DRY	18913	81.8%
	REF	4196	18.2%
FEET	20	10905	47.2%
	40	12204	52.8%
LOWPEAK	PEAK	12512	54.1%
	LOW	10597	45.9%
Valid		23109	100.0%
Missing		1	
Total		23110	
Subpopulation		3979[a]	

a. The dependent variable has only one value observed in 1909 (48.0%) subpopulations.

Model Fitting Information

Model	Model Fitting Criteria			Likelihood Ratio Tests		
	AIC	BIC	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	40951.7	41016.1	40935.710			
Final	36744.0	37323.4	36599.977	4335.732	64	.000

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	33558.987	31760	.000
Deviance	22376.286	31760	1.000

Pseudo R-Square

Cox and Snell	.171
Nagelkerke	.173
McFadden	.044

Appendix VI- Dummy Regression Case Processing Summary

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	LOWPEAK, STATUS2, FEET, BOX, DAYS, STATUS1, REF_DRY, STATUS3[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: DWELL

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.581[a]	.338	.338	2.22544

a. Predictors: (Constant), LOWPEAK, STATUS2, FEET, BOX, DAYS, STATUS1, REF_DRY, STATUS3

Appendix VII- Linear Regression Case Processing Summary

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	LOWPEAK, STATUS2, FEET, BOX, DAYS, STATUS1, REF_DRY, STATUS3[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: DWELL

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.338[a]	.114	.114	2.22544

a. Predictors: (Constant), LOWPEAK, STATUS2, FEET, BOX, DAYS, STATUS1, REF_DRY, STATUS3

Appendix VIII- Partial Hypothesis Testing Results

Model	Un standardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	4.360	.038			
DAYS	-.073	.031	-0.15	-2.337	.019
STATUS1	-1.463	.039	-.239	-37.184	.000
STATUS2	-.836	0.33	-0.176	-25.168	.000
STATUS3	-.380	.052	-.050	-7.314	.000
REF_DRY	-.122	.085	-.009	-1.435	.151
FEET	-.039	.030	-.008	-1.308	.191

a. Dependent Variable: DWELL