UNIVERSITY OF MORATUWA

Faculty of Engineering

Department of Transport and Logistics Management

MBA in Supply Chain Management

The Study of Determining the Factors Affecting the Truck Turnaround Time in a Container Terminal

(*With special reference to Jaya Container Terminal –Port of Colombo*)

Thesis

By

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Submitted in partial fulfillment of requirements of the subject
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University of Moratuwa

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DECLARATION

I certify that all the material in this research study that is not my work has been adequately cited and referenced the sources. I also declare that no material is included for which a degree has previously been conferred on me.

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

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ABSTRACT

Maritime transportation has become the most popular cargo transportation mode over a long period of time. It has evolved, today, up to container transportation where it has geared up the platform to container terminal operation. Port of Colombo is one of the major transshipment hub ports in the world, which consists of three major container terminals including the Jaya Container Terminal which is the largest government owned container terminal. The East Container Terminal was added to the above terminals at the end of the year 2020 which is also operates under the Sri Lanka Port Authority. Around 80 per cent of the containers handled inside the Port of Colombo are transshipment. To maintain the highest connectivity rates the shipping lines have to move the transshipment containers among the vessels calling across these container terminals. Therefore, the truck movements are on the increase inside the port area as well as in the respective terminals. Hence, this research is focused on one of the critical parameters for the terminals; Truck Turnaround Time.

This research is carried out as a case study analysis, to find out the most important factors that affect the truck turnaround time inside a container terminal and thereby improve the terminal's efficiency and productivity levels in minimizing the effects of the factors identified. The factors were identified using a pilot survey and literatures on the related studies. A questionnaire is adopted to collect the data using Likert scale values and the data analysis is performed using statistical techniques such as Hypothesis Testing, Karl Pearson's Correlation Coefficient, Regression Analysis and the question by question analysis.

As per the research findings, the relationships against all the four independent variables; Vessel Operations, Yard Utilization, Handling Equipment and the Human factor, were found with the Truck Turnaround Time (TTT). Pearson correlation coefficients for the above factors were found as 0.636, 0.816, -0.091 and 0.656 respectively. Therefore, we may summarize the relationships as follows.

- TTT vs Factors relating to Vessel Operations - Strong Positive Relationship
- TTT vs Factors relating to Yard Utilization - Strong Positive Relationship
- TTT vs Factors relating to Handling Equipment - Negative Relationship
- TTT vs Human factors - Strong Positive Relationship

However, the analysis data has an R-squared value of 0.721. Therefore, it further hints that there can be many other factors that could affect the dependent variable. Apart from the data gathered through interviews and the questionnaire, the relationships found are tested with the real data to get a better understanding of the numerical values. The measurable figures give an idea of the threshold values of each of the major factors on the acceptable Truck Turnaround Time values. However, it is to be noted that the container terminal operation is highly dynamic in nature. So that the threshold values identified in the study require continuous assessments with time. From the outcome of the analysis, suitable recommendations are made for the Jaya Container Terminal to reduce the truck turnaround time within the terminal and finally to improve its overall productivity

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KEY WORDS

CICT – Colombo International Container Terminal

EQF – Handling Equipment related Factors

ITT – Inter Terminal Transfer

JCT – Jaya Container Terminal

KPI – Key Performance Indicator

MNF – Manning related Factors

PDS – Position Detection System

POC – Port of Colombo

QC – Quay Crane

RF ID – Radio Frequency Identification

RMG – Rail Mounted Gantry cranes

RTG – Rubber Tyred Gantry cranes

SAGT – South Asia Gateway Terminal

SLPA – Sri Lanka Ports Authority

TEU – Twenty-foot container Equivalent Unit

TMS – Terminal Management System

TTT – Truck Turnaround Time

VOPF – Vessel Operation related Factors

YUF – Yard Utilization related Factors

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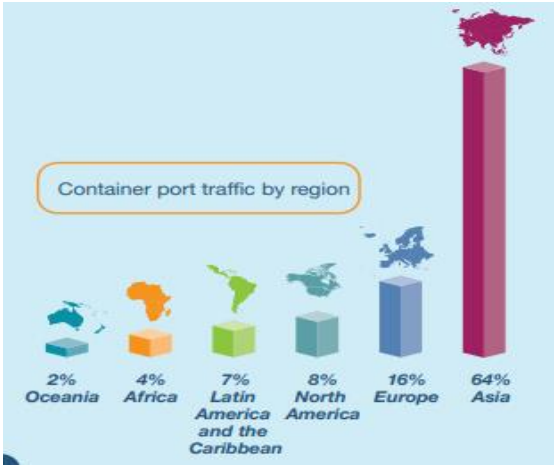
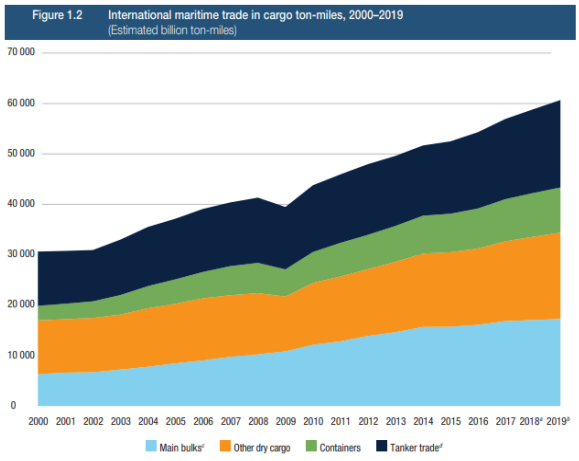
CHAPTER ONE - INTRODUCTION

Today maritime transportation plays an important role in global trade by facilitating transportation over 90% of the goods via countries and which made, maritime Transport "the backbone of the global trade and the global economy" (UN, 2016). In line with the regional development recorded recent past, Asia is identified as the fastest growing region in the next few decades which brace a number of opportunities for the associated countries at large.





Source: UNCTAD (2019)

By being located in the most strategic location in East-West Shipping route; today, Port of Colombo, Sri Lanka is also able to grab the opportunities and could stay ahead in the shipping business by holding the 24th world ranking position. Even at present, Port of Colombo is well facilitated with exclusive terminals, modern technologies, equipment and so on; there are many more aspects to be developed and enhanced to get a forecasted growth in the future.

On these grounds, enhancing the truck turnaround time has been identified as a key determinant in deciding the terminal productivity which is the major drawback experienced in all terminals of Port of Colombo (POC). According to Karunanayaka, et, al. (2019) Seaports' performances highly depend upon the "performance and efficiency of the connecting land's transport systems and infrastructure". But currently, an in-efficient truck movement within terminals is becoming a severe problem for all operators in POC which generally creates huge queues / congestion by adding extra cost while hindering the productively at large.

1.1 Background of the study

The research was carried out at the Jaya Container Terminal (JCT) in Port of Colombo. JCT is a container terminal operated by the Sri Lanka Ports Authority. Its primary operational activity is providing handling services for container vessels. In order to carry out the container handling with container vessels in and out, the terminal needs to store containers in its yard, receive and deliver containers. The container movements are done by container carrying trucks. The trucks come inside the container terminal in several ways;

- To bring in containers to the yard as exports from outside port premises and bring containers as transshipments from other container terminals located in the Port of Colombo
- To deliver out imports to the consignees
- To transfer out import containers to be de-stuffed inside the warehouses operated by the Sri Lanka Ports Authority.

1.2 Importance of the Study for the Terminal Operation

During a particular 24-hour operational period, in addition to internal truck movements which are directly related to vessel operations, JCT deals with around 1000 to 1300 truck movements inside the terminal area. Therefore, if the terminal does not handle these external truck movements, it would affect the terminal's primary operation severely. Since, the number of truck movements cannot be reduced the only remedy is to minimize the time a truck stays inside the terminal. Therefore, the research study would identify the factors affecting the Truck Turnaround Time. Then, it would find possible actions to improve the efficiency of the truck visits of the terminal by reducing the truck turnaround time of the trucks.

From the real data relating to the identified factors and the TTT, threshold values are calculated to maintain a balance between an acceptable TTT and dependent variables. These numerical figures will essentially guide the terminal operations team towards a much understandable factual situation. The severity of the effects of the major factors such as Yard Utilization, Vessel Productivity can be addressed with precise solutions. And the study suggests the terminal management, of different approaches to reduce TTT including improving gate transactions efficiency, handling efficiency and improved workmen attitude.

1.3. Significance of the study

The Fig.1 shows the average truck movements during the days of the week for ITT Truck movements and Import delivery as per the terminal records. The ITT movements gradually increase towards the weekend whereas the Import delivery is high on just after the weekend. Therefore, there is a regular pattern for the truck movements inside the terminal based on the day of the week.

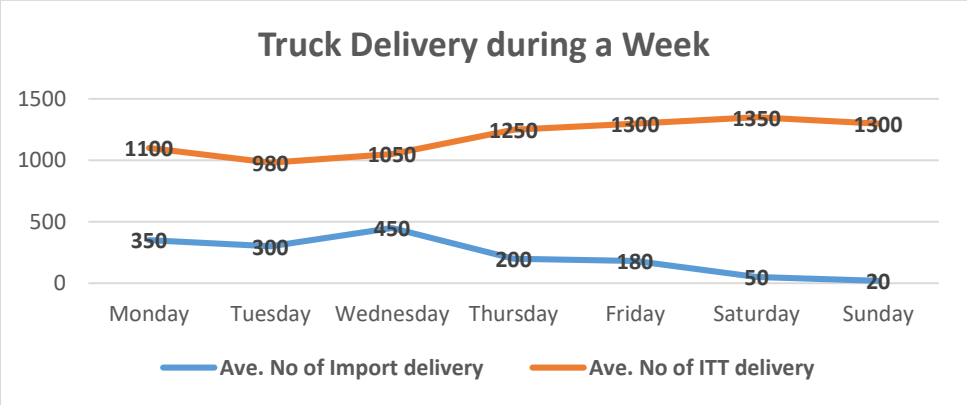


Fig. 1: Average truck movement for a week; Source: SLPA Database (2020)

From randomly selected driver feedback and SLPA Terminal Management System records a pilot study was done to get an idea of the Average Truck Turnaround Time (TTT) at its highest and lowest levels. Table 1, shows the findings during the three months from January 2020.

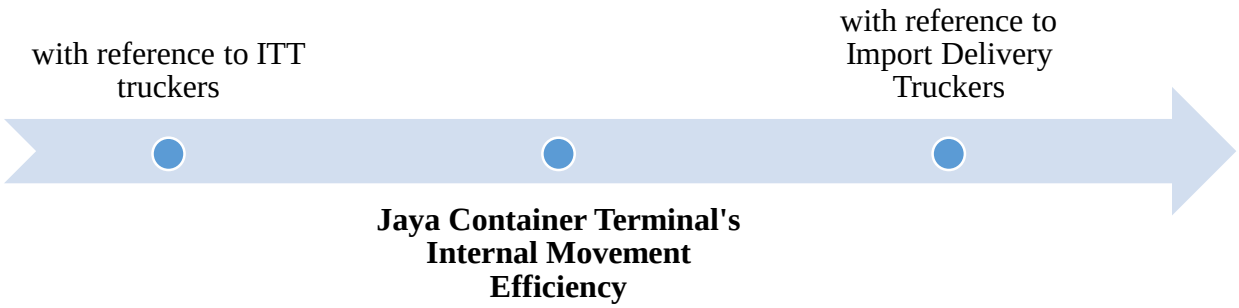
	Average TTT at Peak	**Average TTT at Off-peak**
For Import Container Delivery	67.34 min	23.12 min
For Inter Terminal Transfer trucks	51.88 min	16.64 min

Table 1: Average TTT at Peak and Off-peak; Source: Driver feedback and SLPA data (2020)

Note: Since, ITT movements take place regularly on a day, the Peak hours are considered based on the Import delivery truck movements. In consideration of the system data, the Peak hours are considered as from 06.00pm to 01.00am (the following day).

1.4 Scope

Generally, it can be seen a large number of trucks within a port and particularly in a terminal serving different operations. To define the scope of the study, the study is focused on identifying the factors affecting the truck turnaround time to improve the terminal internal movement efficiency.



1.4.1 Primary Research Question

What are the main factors affecting Truck Turnaround Time in a Container Terminal?

1.4.2 Secondary Research Questions

- What are the main truck movements existing in a Container Terminal?
- What are the key factors affecting Truck turnaround Time?
- What is the relationship between truck turnaround and the Terminal productivity?
- What are the major challenges in reducing the Truck Turnaround Time of a Terminal?
- What are the strategic approaches suggesting in reducing Truck Turnaround Time?

1.5 Main Aim

The study was mainly aimed at identifying the acceptable average Truck Turnaround Time to maintain the terminal operations at an optimal level by referring to the case of Jaya Container Terminal.

1.6 Objectives

1.6.1 Primary Objective

To define the major factors affecting the truck turnaround of a container terminal to enhance the productivity of the terminal.

1.6.2 Secondary Objectives

To generate the causal relationship between reduced truck turnaround with terminal productivity and provide recommendations to gain the highest productivity through reducing extra cost at large.

CHAPTER TWO - LITERATURE REVIEW

2.1 Container Terminal Operation

The Jaya Container Terminal (JCT) at Port of Colombo is a container terminal developed in 1985. It has gone through several changes to equipment and yard expansions over the years. However, the master plan for the Quay cranes, the yard utilization and gate functions, which were developed by the Japanese experts, is continued to be followed with few modifications. (SLPA, 2020)

In general, the operation functions in a terminal consist of 03 main functionalities; Quayside Operations, Yard Operations and Gate Functions. This has no different from the basic functionality at the Jaya Container Terminal. The Fig.2 summarizes the 03 main general operational functions at a Container Terminal.

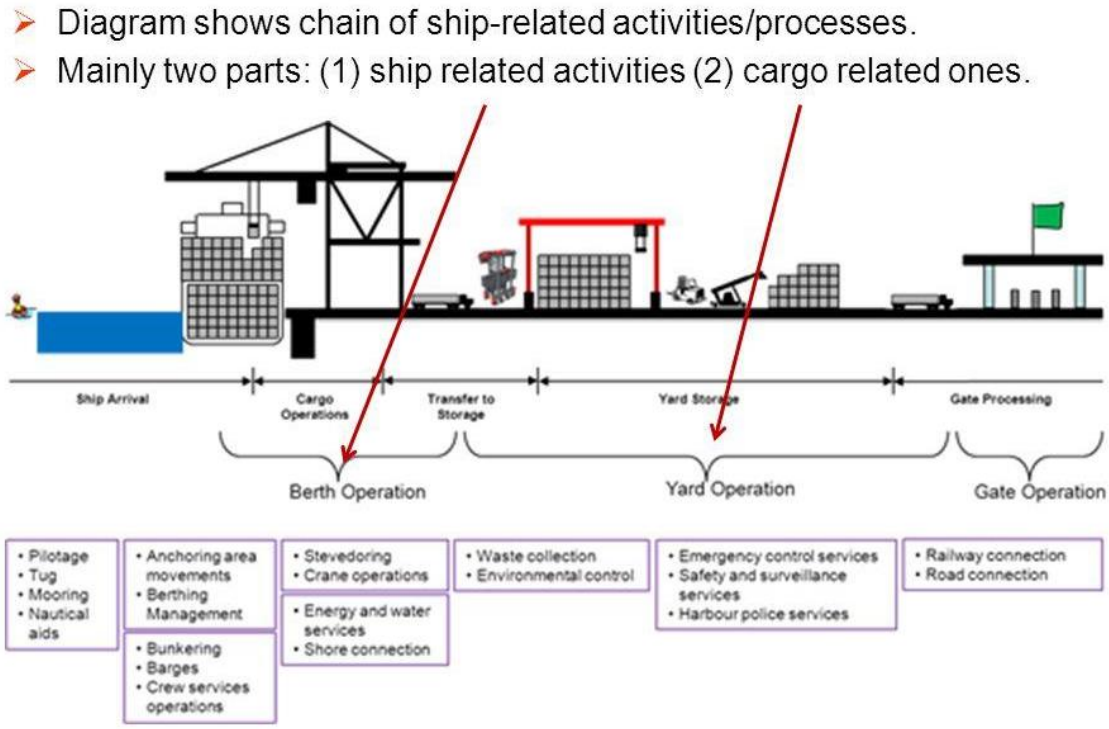


Fig. 2: Container Terminal Operation Overview – IMO (2020)

Stojakovic and Twrdy (2021) carried out a study on finding the right number of yard trucks in a container terminal to gain better productivity levels in berth, yard as well as gates. Thus, they have derived the event based simulation model by sequencing the terminal activities as shown in Fig. 3.

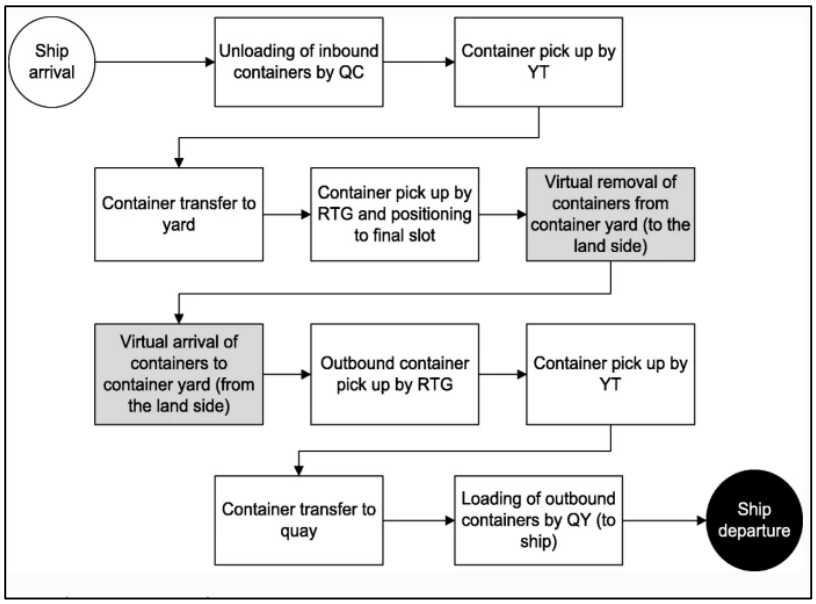


Fig. 3: Operations Sequence at a Container Terminal, Source: (Stojaković and Twrdy, 2021)

Note: QC – Quay Crane, YT – Yard Truck, RTG – Rubber Tyred Gantry crane

Container Logistics chain inside a terminal

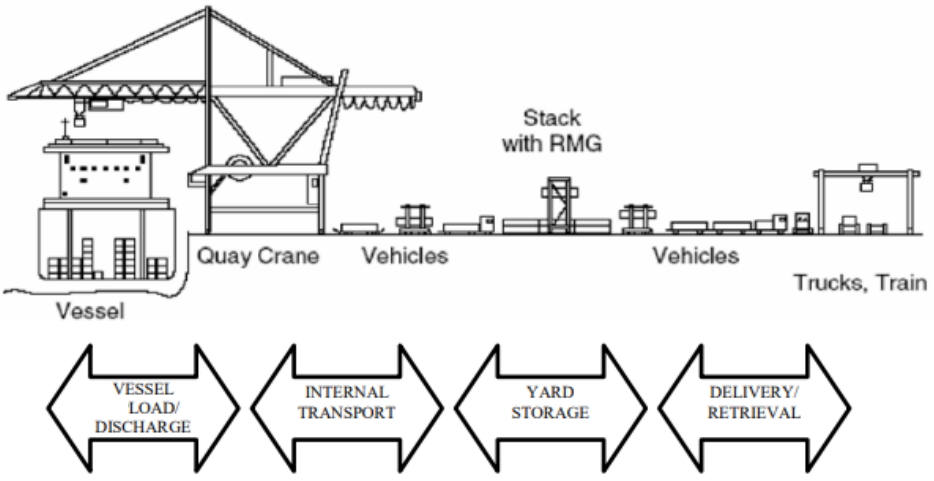


Fig. 4: Container Transport within a terminal, Source: Cobo (2016)

Note: RMG: Rail Mounted Gantry crane

As stated in the study of Cobo (2016); trucks are considered to be the important mode that helps to interchange the containers between the sea and land platforms. Thus, the terminal has to be equipped with a proper terminal layout as to have minimized truck turnaround times at the terminal which will be beneficial to the terminal in terms of the shorter queues at gates, desired productivity levels, uninterrupted transshipment cargo flow as well as ITT movements.

2.2 Global Developments in Containerized Cargo Movement

Year by year, the carrying capacity of the container vessels has increased to match the increasing demand in sea trade. As listed among the largest container vessels at present by Marine Insight (2020), all the biggest vessels built recently have the capacity of over 23,000 TEUs (Twenty-foot container Equivalent Unit). To cater to the largest vessels moving on the sea, the seaports have to have a suitable infrastructure. In proportionate to the carrying capacity expansion, the width and the height of the container vessels are also have increased. Marine Insight (2020) confirms that the largest of the vessels can carry 24 containers side by side at its broadest parts of the vessel. Therefore, the Quay cranes at the seaports should have the required length in their beam (Outreach) to cater to the largest vessels on the sea. To be competitive with other competing ports all the leading container terminals upgrade or maintain an equipment renewal process.

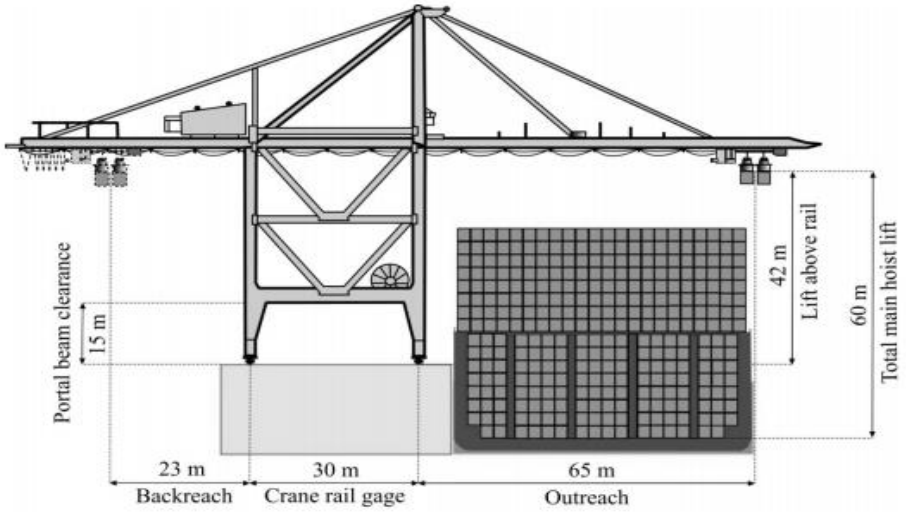


Fig. 5: Cross Sectional View of a container quay crane – (Bartošek & Marek, 2013)

As shown in the **Fig. 5**, the Outreach length, which is the longest distance that a Quay Crane could handle containers from a vessel berthed at a quay, should be long enough at least 2 or 3 more containers widths than the largest vessels that could carry at the moment. Bartošek & Marek (2013) emphasize the importance of having a futuristic view in selecting the Quay cranes on the fact that they have an average life span of 25 years.

2.3 Container Movements between Quay-Yard-Gate

Steenken et al (2004) divide the main container movement activities into two as quayside and landside. Usually, these container movements happened to overlap at the yard storage or stacking area. The quayside movements affect the overall productivity of Quay cranes and subsequently to the vessel operations. The shipping lines always want to have a shorter vessel turnaround time for their ships at the terminal. Further, terminals also try to minimize vessel turnaround time. Since, the core operation is at the quayside for a vessel, the terminals tend to have more focus on quayside movements to attract more vessels.

Though, booking systems and receiving window allocation could be applied for the containers receiving to a terminal, Steenken et al (2004) highlight that the trucks coming into terminals comes with a high complexity depending on their destinations and outbound vessels. Since, Port of Colombo is located in the middle of the world sea route **(**Fig. 6**)**, the cargo complexity is very high at the JCT. When the cargo complexity is high, their stacking locations are segregated all over the terminal yard and finally result in heavy truck movements inside the terminal.

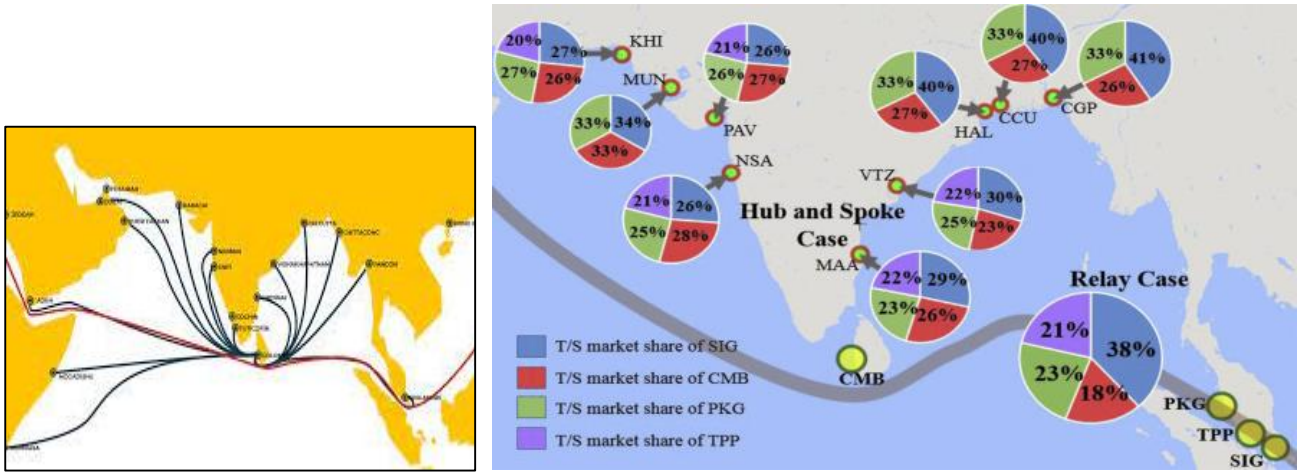


Fig. 6: Geo positioning of Port of Colombo in sea routes. (SLPA,2020)

When it comes to the storage of containers in the yard area Carlo et al (2014) highlight that there are 02 commonly used yard layouts viz; Asian Layout Fig. 7 (a) where frequently followed in large Asian ports and European Layout Fig. 7 (b) where frequently followed in large European ports.

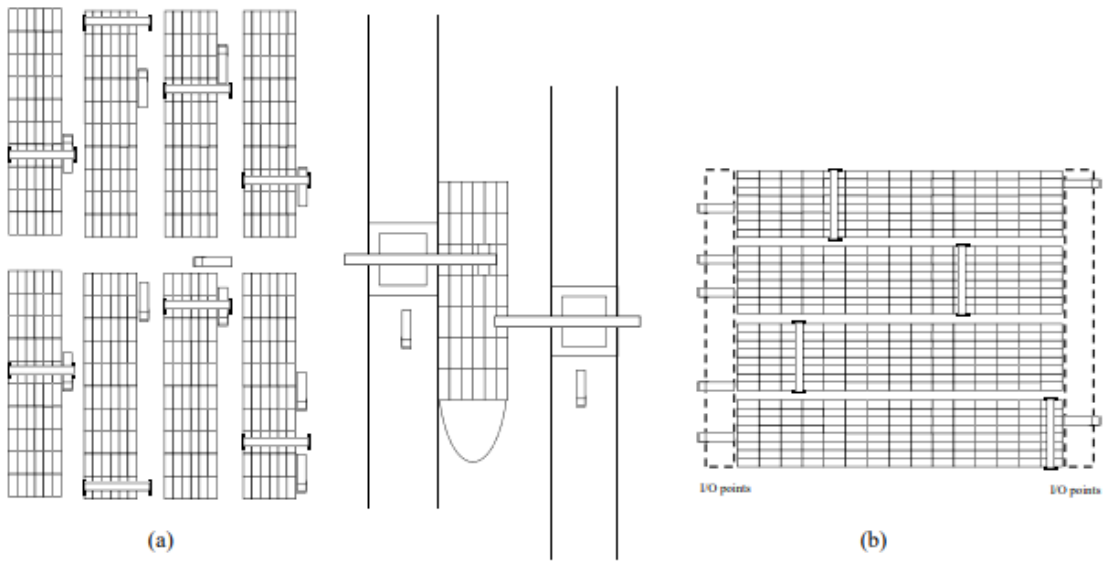


Fig. 7: (a) Asian Layout; has stack + truck lanes, parallel to the quay. (b) European Layout; In/Out points at each end of a lane, perpendicular to the quay.

The layout known as Asian Layout has a truck lane in addition to the container stacks for each lane. Since, the lanes are parallel to the Quay, the lanes are built to the length of the Quay. Therefore, the lanes are lengthier and RTGs are deployed as yard cranes. Since, the RTGs can change the lanes easily, operations can be managed using a minimal number of RTGs. Therefore, the capital cost is lower than the perpendicular layout. In contrast, the European layout uses RMGs and dedicated RMGs have to be permanently placed for each lane. This allows the use of automated systems and less labour is required.

JCT has a yard layout similar to the Fig. 7 (a). Carlo et al (2014) further point out that longer lanes make the truck cycles longer. And trucks should move on the truck lanes along with the yard stacks. If the truck lanes are occupied with loading or discharging points, other moving trucks should also wait till the truck queue moves ahead. Therefore, it tends to create more congestion in the yard and affects the truck flow in a terminal.

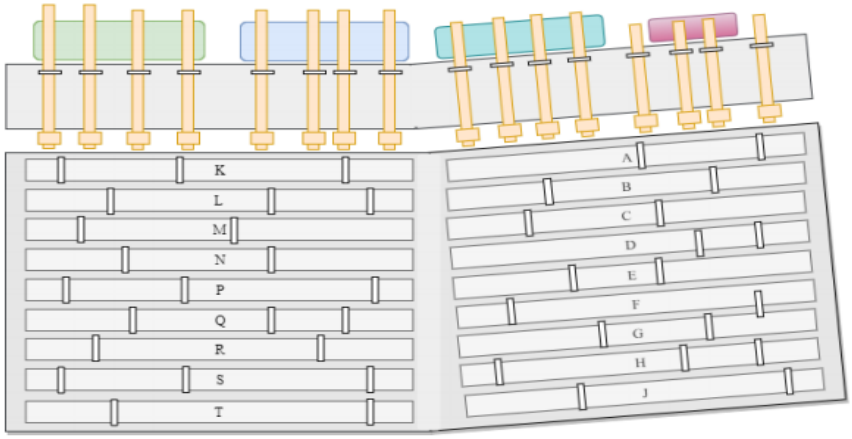


Fig. 8: Layout of JCT, Source: Premathilake (2018)

2.4 Importance of an efficient Truck Turnaround Time and related factors

The yard is the main operational area for a Container Terminal as described by Hussein (2012). And therefore Hussein (2012) points out that managing the truck movement in the yard is very important. Chakraborty et al (2016) have considered that the truck turnaround time is a key performance indicator for any commercial institution related to the logistics industry. And thereby it needs to find out factors that hinder the truck movement in a container terminal.

According to Premathilake (2018); several factors are affecting the vessel turnaround time that is experienced in the Terminals of the Port of Colombo where some of these factors have been defined under the control of the terminal operators and some are not. Further, he has revealed from his study that the Vessel operation factors including the Berthing and sailing delays, Yard allocation & its traffic flow and human factors are the key factors that determine the performance levels of JCT.

Azab and Eltawil (2016) emphasize that the terminal's main focus should be to utilize the equipment efficiently to satisfy the customers. On the other hand, Azab and Eltawil (2016) point out that the minimal truck turnaround time in the terminal benefits both the terminal and the customer. However, if the terminal fails maintain a lesser turnaround time will result in trucks staying much time at a yard, thus, creating more queues and congestion.

According to Jovanovic (2018), managing trucks at container ports could minimize the length of the entry gate queue and have effective use of container yard equipment. Further Jovanovic (2018) highlights that managing the truck transactions would result in improved yard operation efficiency and subsequently the quayside operations. Therefore, it shows that these are interrelated within a container terminal. Further, Lange et al (2017) reiterate the fact that handling of a larger container volume results in an increase in truck movement and finally leading to heavy queues at the yard and the gates.

Inadequate berths, cranes, storage, handling, and labor all result in delays and lead to more congestions. Therefore, these factors affect truck in and outflows in a terminal (Guan, 2009). Especially, Guan (2009) mentions that one main of the objectives of the yard operation should be to minimize the truck turnaround time.

Furthermore, Asperen et.al, (2011) studied container stacking efficiency which is key for ensuring the truck turnaround time of the JCT as well. According to them, a terminal should have a plan for container stacking. And the following should be considered in the plan.

- effective usage of yard space
- Optimize/minimum travel time
- Avoid container re-shuffles

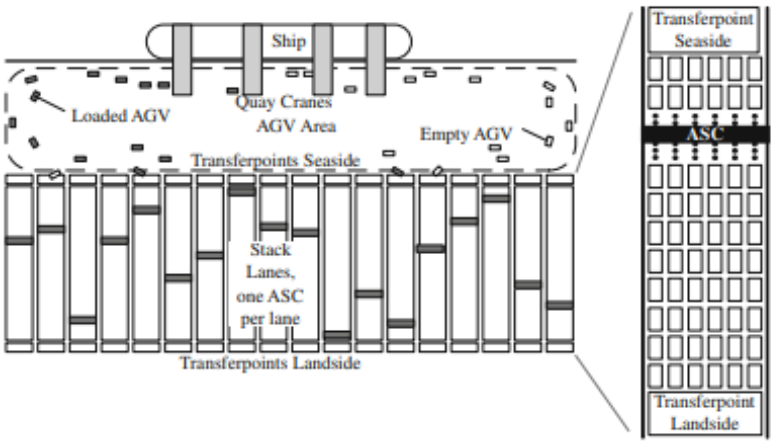


Fig. 8: Proposed Terminal Layout, Source: Asperen et.al, (2011)

Furthermore, the Inter Terminal Transferring (ITT) of containers within the terminals of Port of Colombo plays a major role in the truck movement inside the JCT. Bandara & Edirisooriya (2017) highlight that maintaining an optimal fleet for the ITT would effectively lessen the unnecessary traffic movement in a terminal. And that it will positively reflect on the truck turnaround time for all the movements in the terminal.

Based on the studies made on the truck movements in a facility and especially concerning Container Terminals the factors are identified and the research study will explore the effective approaches to reduce the Truck Turnaround Time (TTT) in the terminal. Thereby, it would contribute to the Vessel Operation productivity, the Yard Operation efficiency and towards high customer satisfaction levels.

2.5 Truckers Role in a logistical platform

Trucks moving in a terminal play a vital role in inter-modalism in the maritime business where the unit considers as the first and last linkage of container transportation by linking with a vessel to the doorstep of the customer and vice versa. In line with that; Guan (2009) has extensively studied container gates functions as a way forward of optimizing the truck turnaround of the container terminal by increasing the efficiency of gates subsystems.

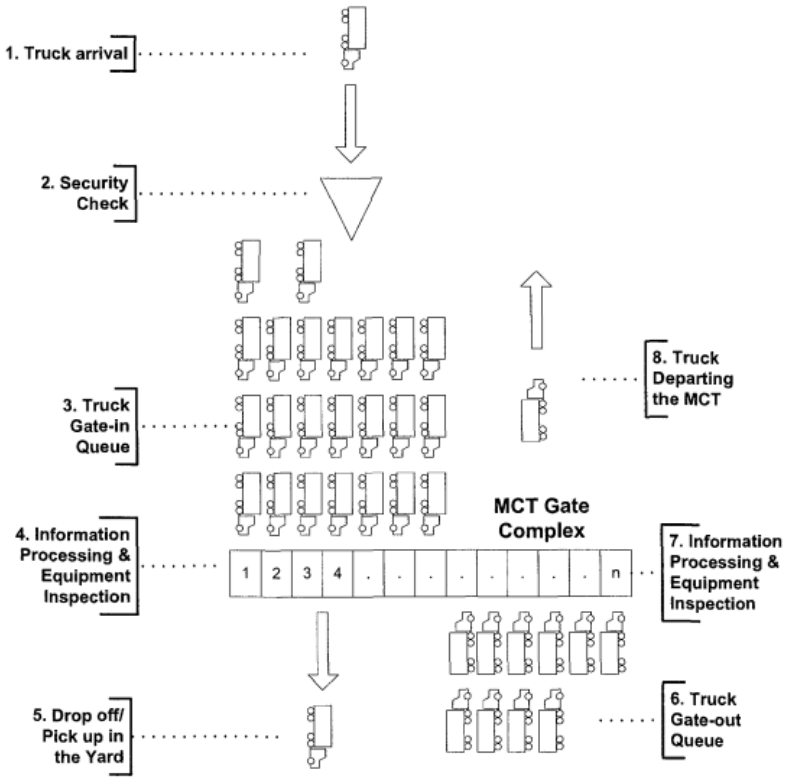


Fig. 9: Trucking movements at Gate of a Terminal, Source: Guan (2009)

As illustrates above even though the trucker has to go through several processes at the gate in receiving or delivering from and to the terminal; the terminal has to facilitate vital management options to ensure fast movement while minimizing the cost of serving the gates.

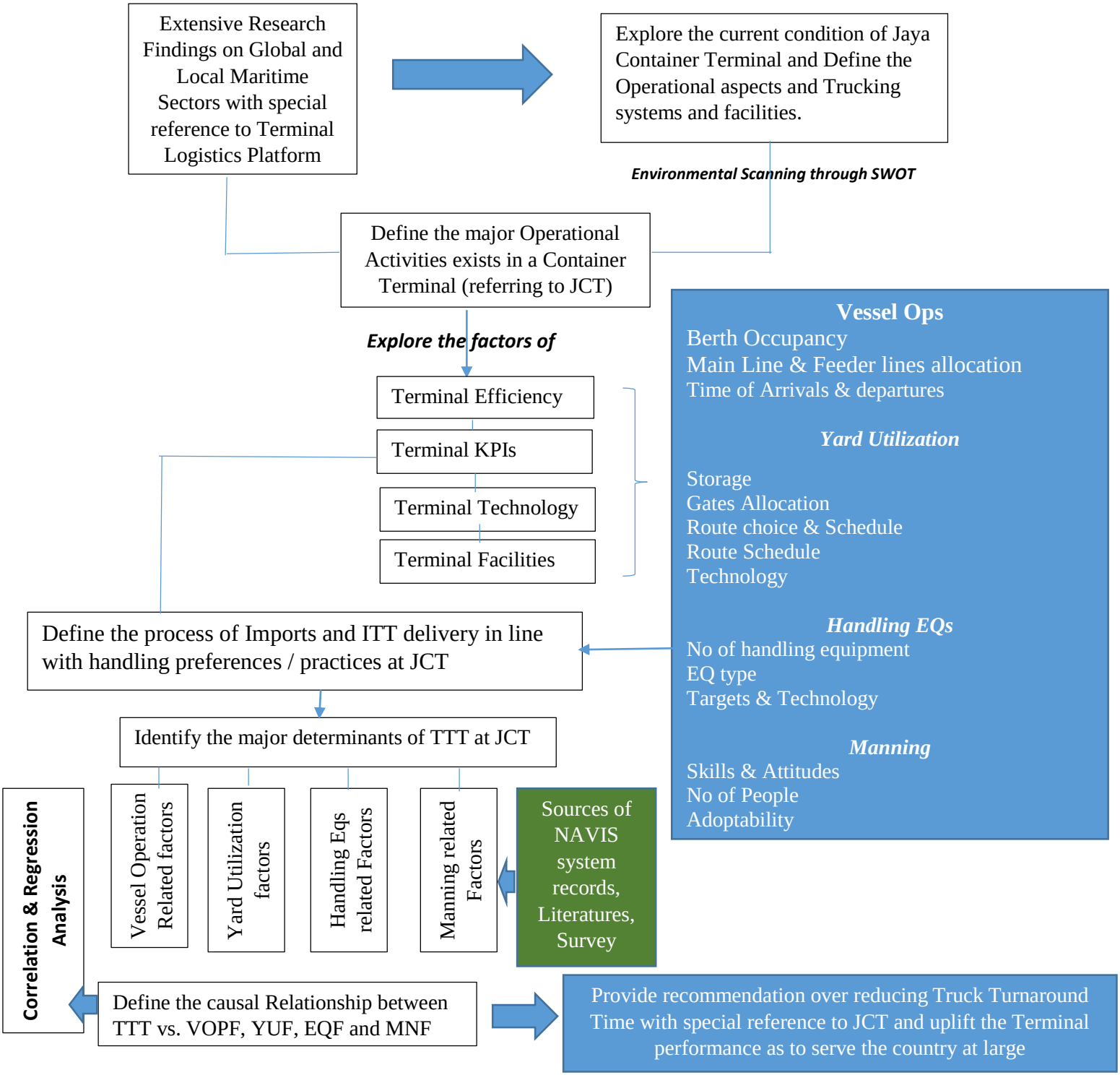
Fathi (2018) has designed a new method of making an appointment for a truck visit by referring to the terminals of Ports of Los Angeles and Seattle that is to increase the satisfaction of a driver. As it's common to a majority of the drivers; they make multiple trips to a container terminal on a particular day which need special measures such as reserving time slots, get through the gates in less time, managing delivery priority etc., at the terminal to enhance TTT while better off the truckers as well.

As suggested by Maguire (2009); two alternatives can have an effect on truck turn time reduction in a terminal which is adding more yard cranes and utilization of truck appointment systems. The study done by Maguire (2009) revealed that; the truck appointment is one of the best ways of reducing truck turnaround time. It can bring many benefits to the terminal in terms of achieving the highest productivity levels.

CHAPTER THREE - METHODOLOGY

3.1 Research Methodology

According to LibGuides (2020), Research Methodology is defined as a "specific procedure or a technique which helps to identify, select, process and analyze information about a topic by enabling to decide on validity and reliability of the study. The core concept of this research is mainly targeted at measuring one of the main operational aspects of Terminal operation which is Truck Turnaround Time. The Research methodology is defined in a way, to achieve the defined objectives of the study.

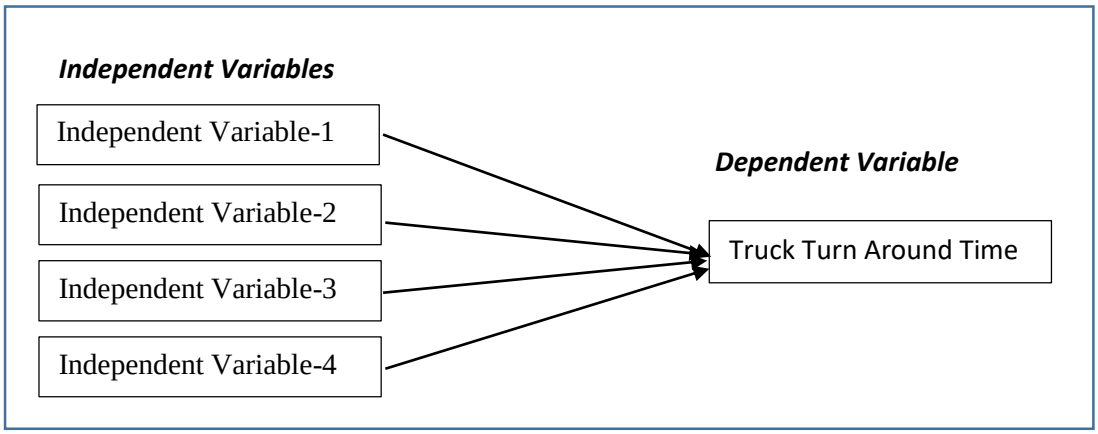


3.2 Pilot Survey for the study

When this comes to the study, measuring the impact of Truck Turnaround time solely depends upon operational activities of the Terminal side as well as the customer side. Each party's direct / indirect engagement / involvement should be identified for the study. Hence, a pilot survey was carried out with identified customers in the form of private truckers as well as the terminal operational team. In the pilot study, a questionnaire survey was done with identified 50 people comprising of 30 truck operators and 20 terminal operation team members to uncover the main factors affecting the truck turnaround time.

3.3 Conceptual Framework

Even though the increased Truck turnaround Time is a critical issue which faces by many terminal operators globally, there are limited works of literatures available which addressed this particular issue in respect of container terminals. The factors uncovered, from the pilot survey and several other sources, helped to develop the factors contributing to the truck turnaround time at JCT.

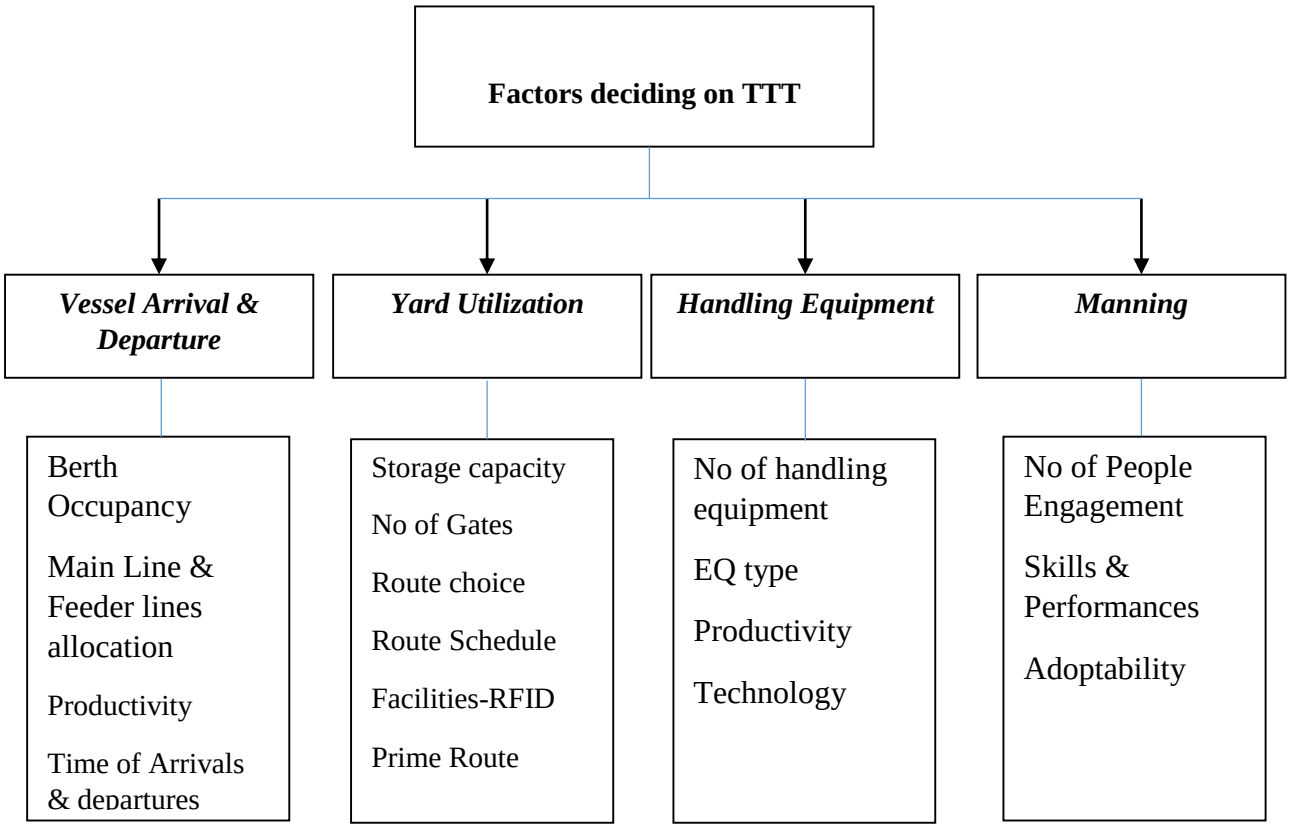


According to Extensive Research carried out by Yoon (2007), Terminal Structure, Handling Equipment, International Agreements & Initiatives, Container security Initiatives are some of the major determinants of Trucks turnaround time of a Terminal. Furthermore, Ravichandra (2005) defined that truck turnaround time in terms of Time from the arrival, loading of materials, inspecting a truck and completion of commercial formalities. And most importantly, Wang et al,. (2014) highlighted that routing choice and routine attributes are also the major determinants of Truck turnaround time.

3.4 Research Strategy

Even though the measuring of Truck turnaround time is mainly providing an impression of a quantitative aspect of the Operation, it is very much important to assess the background details of the terminal operation as to build up the relationship. Hence, an environmental analysis is also to be carried out through SWOT to validate the outcomes of the study.

3.4.1. Conceptual Model



Author (2020)

3.4.2 Methods of gathering data

By being very specific to the study, it is decided to use following methods to gather data to explore the true causes of the identified problem of increased truck turnaround time at JCT.

- Available secondary data (Journal, magazines, Books & etc)
- Pilot Survey with internal employees and external customers
- JCT Profile
- Data from Terminal Management System
- Questionnaire Survey given to SLPA employees and truck drivers

3.4.2.1 JCT Profile

The facilities available at the JCT will give a brief understanding of the terminal's capabilities in terms of the infrastructure, equipment. The details are summarized as per below.

- 1,292m of Quay wall length (JCT stage I/II - 632m and JCT stage III/IV - 660m)
- 12.0m - 15.0m Dredged Depth
- 19 Nos. of Quayside Gantry Cranes (Panamax & Super Post Panamax)
- 59 Nos. of Rubber Tyred Gantry Cranes (RTG)
- 4 Nos. of Rail mounted Gantry Cranes (RMG) to stack empty containers at 8 high
- 90-95 Nos. of Terminal Tractors / Trucks (Average daily availability)
- 06 Nos. of Top Lifters and heavy fork lifters
- 53,990 TEU Dry Container Stacking Capacity
- 1,548 TEU Reefer Container Stacking Capacity

Source: SLPA (2020) and JCT records (2020)

3.4.3 Data Types & Collection

3.4.3.1 Sampling Plan

When referring to the general scenario at POC; there are different types of truck drivers are involved in the container delivery. Therefore, the sample needed to be comprised of each type of truck driver and should include SLPA employees as well to generalize the research findings.

3.4.3.2 Sample composition

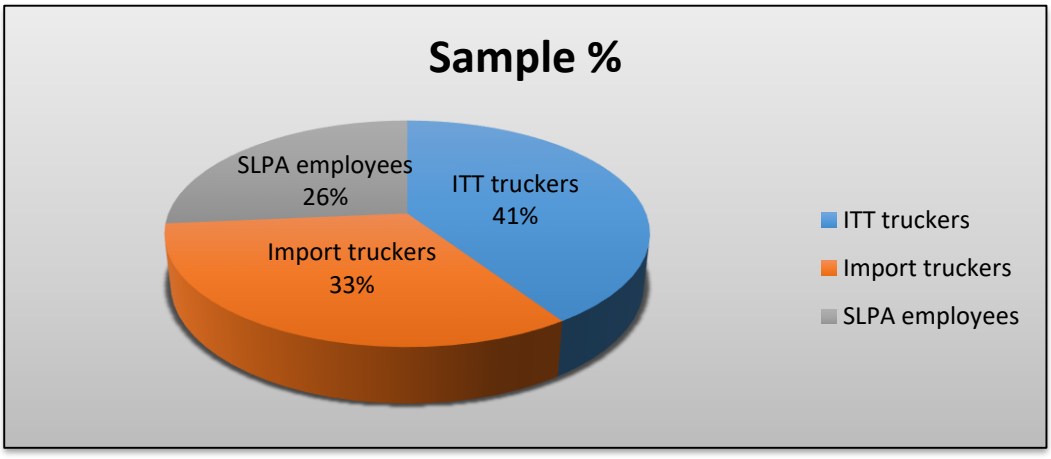


Fig 10: Composition of respondents

When considering the internal truck movement within the Jaya Container terminal it has been observed and already experienced that the vessel operations trucks are moreover less impacted by the above two categories. And most of the truckers who engaged under these two categories are registered in port systems where the population for the study is accounted to be around 1300.

With reference to that; the sample for the study has been defined on the following basis.

Target Population	Sample Size	Sample Requirement
• Both import delivery truckers and Inter Terminal trucking (ITT) vehicles at the port	400	Random Sampling $n = \frac{N}{1+Ne2}$
• A group of SLPA employees attached to JCT	50	

Table 2: Projected Sample Plan

3.4.3.3 Data Collection

To identify the most appropriate factors, it is essential to get the views of the key parties involved and get real data from internal sources. Therefore, the data collection was mainly carried out through interviews and questionnaires from the truck drivers and SLPA employees of JCT. The secondary data was collected through the SLPA database, SLPA staff, internal sources, TMS as well as other external sources of available works of literatures of the research area.

3.4.4 Data Analysis

Since truck turnaround time itself outlook the quantitative aspect, the author develops a quantitative relationship between each identified independent variable with the dependent variable of truck turnaround time. And it has to assess the background details on the increased truck turnaround time at the Jaya container terminal. Hence, qualitative analysis was also required.

Both qualitative as well as quantitative analyses are carried out on the study where environmental scanning in terms of SWOT is done in the study. Finally, it is expected to define the below relationship between four identified variables over truck turnaround time through Correlation and regression analysis based on SPSS software.

$$Y= a_1X_1+a_2X_2+a_3X_3+a_4X_4+\ldots\ldots\ldots$$

Y- Truck turnaround time of JCT

X_1- Vessel Arrival & Departure

X_2- Yard Utilization

X_3 -Handling Equipment

X_4- Manning

3.5 Ethical consideration

As discussed in the data collection section, the research is highly dependent upon a questionnaire survey where several key parties will be involved. Furthermore, secondary sources like TMS records as well as the organization's databases are used in getting the details. Hence, the author is to make sure that data ownership of the organization's resources and shared perception of the customers will be ensured and information will be not shared between any competitors.

3.6 Potential Outcomes

As well known to everyone, truck plays a vital role in port logistics where reduced truck turnaround time can make a massive difference in port efficiency as well as on productivity. So it is expected that the research brings the below outcomes which maximize the benefits to a large number of parties in many ways.

- Increase vessel, terminal and finally port productivity
- Reduce port congestion
- Reduce traffic flow disruptions by enhancing the gating efficiency
- Reduce logistics cost
- No demurrage or detentions and so on.

CHAPTER FOUR - DATA ANALYSIS

The Truck Turnaround Time of a Terminal is to be considered as the paramount important factor where it is essentially categorized as a KPI in Jaya Container Terminal in Colombo Port. As stated in the previous chapter, the Analysis is done in two folds; qualitative and quantitative. According to the developed conceptual framework the identified factors are analyzed in the quantities analysis using the Regression techniques. Each parameter's direct or indirect contribution is analyzed. Based on the data gathered from the questionnaire, works of literatures, environmental analysis and well as in-person interviews from the industry professionals; the following graphical interpretations are made to achieve the objectives of the project. And most importantly, expert comments and judgment, from SLPA staff and trucking companies are used where relevant to aid interpretation and to provide confirmation over the outcome of the project.

4.1 Qualitative Analysis

SWOT Analysis

Gurel (2017) defined SWOT analysis as a "tool that is used for defining upon the strategic directions of the organization". Thus, when this comes to Jaya Container Terminal; being a terminal that generally operates in a highly dynamic nature, exploring its internal environment given the high priority of the study which reveals its current status while directing to uplift terminal's performance in future.

Strengths

- Govern the Least deviated government owned container terminal from the main shipping routes
- Well experienced and qualified Team of Management.
- Experienced operational workforce
- Modern Equipment Fleet, State of Art Technological systems(Terminal Management Systems) and Ample of Yard and several logistic facilities
- Attractive service offerings for the customers that other terminals in POC
- Loyal customer base (shipping lines) attached to the JCT

Weaknesses

- A high number of Aging workforce & aging equipment fleet
- Lengthy & complex policy reforms by being a government Terminal
- Lack of infrastructure facilities (road, rail connectivity…etc)
- Inability take swift decisions, complex tender process
- Lack of maintenance in terminal yard area

Enhance strengths by avoiding Weaknesses

- By aligning with the SLPA mission statement that is the **"DELIVERY OF WORLD CLASS SERVICES IN A SUSTAINABLE ENVIRONMENT"** Jaya container terminal also offers number of superior logistics services to its cutomers. So company hold number of strenghts which are appealing to its logistics partners speciallly in terms of yard capacity, TMS as well as equipements facilities.
- But, still there are number of weaknesses which directly impact negatively over making bottlemckes in its logistics flatform. Specially, unavialbility of infrastructure facilities makes delay in sypply chains of both import and export that is going to be addres in the study.

Opportunities

- Development of Indian and African economy enables to capture T/ S business to the Terminal
- Growing trade volumes in East – West shipping route and the high presence of Major shipping lines open up new business
- Growing domestic volumes to earn more revenue
- Growth record of the private terminal (CICT/SAGT) enable POC to be the main icon in global shipping
- Enhanced Inland connectivity on road and Rail Network
- New trends in acquiring the technology for the shipping sector (SMART/ NAVIS port etc.)

Threats

- Intensive competition and price wars among other terminals in POC
- Deployment of Mega container vessels by shipping lines
- Development plans of regional deeper draught ports (Bangladesh/Pakistan/ India/Africa)
- New shipping routes which bypass Equatorial ports (Arctic route/Transpacific)
- Increasing pressure and demand from shipping lines through Mergers and acquisitions

Source: www.slpa.lk (2021), SLPA internal records (HR Division / Operation Division-2020)

Exploiting opportunities by averting threats

- Bearzitti (2013) stated that terminal or a port is considered to be "major node of convergence in international transport and trade, and it is the point of contact between land and sea transport". So since ther are no of of growing opportunities created in the marine fratenity; it is important to trenghthen the integrated logitics platform connenected with JCT. Even, there is a fierce competetion and pressure comming from other terminals in POC; JCT should avert the treats by stramlingning its logistics servicers provide to the customers as a way forward of its future prosperity.

4.2 Quantitative Data Analysis

Quantitative Analysis was done using the data gathered from the Questionnaire survey and the interviews with the truck drivers and from a group of SLPA permanent employees who are attached to the Jaya Container Terminal. The data was gathered in two separate sections; namely, demographic details of the respondent and the data directly related to the factors that could be related to the Truck turnaround time.

4.2.1 Demographic factor Analysis

When selecting the sample for the study; the target number of respondents was 450. However, due to the pandemic situation in the country it was difficult to gather the expected responses and was able to get the views of only 140 participants from the three categories; ITT and import truckers and SLPA employees. Thus, to justify the sample for the total population; a number of demographic factors of the sample have been considered as those factors may have an impact on the outcome of the study. Thus, sample justification can be illustrated as follows.

4.2.1.1 Gender Analysis

Variable	Frequency	Percentage
Male	137	98%
Female	3	2%
Total	140	100%

Table 3: Gender Analysis of the Sample

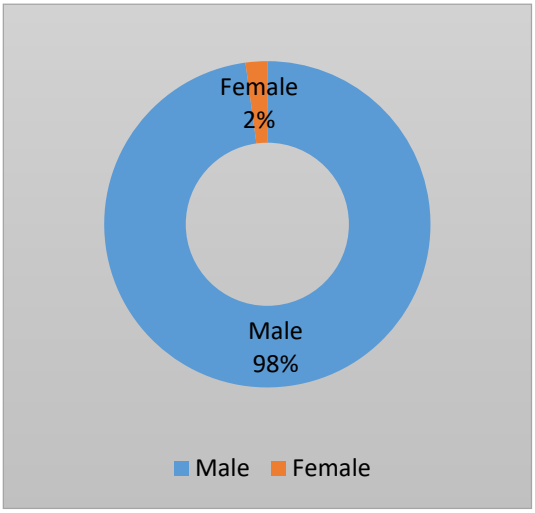


Fig. 11: Gender-wise composition of the respondents

It is quite obvious that the majority of the respondents are Males. Generally, the truck drivers are all males and the 03 female respondents are from the SLPA internal staff. Accordingly, the respondent segregation is 98% males and only 2% females.

4.2.1.2 Age Analysis

Variable	Import	ITT	SLPA	Frequency	Percentage
20-30	00	04	00	04	3%
31-40	18	32	03	53	38%
41-50	11	17	19	47	34%
50+	14	07	15	21	26%
Total	43	60	37	140	100%

Table 4: Age Analysis of the Sample

The above table classified the respondents according to their age group. In the total sample, the majority of the respondents belong to the age groups 31-40 years and 41-50 where the respective percentage values are 38% and 34%. It is evident that middle-aged persons consist mainly of the sample. If we consider the truck drivers only the figures slightly differ as 50 % and 27%. However, in combination, the values represent similar segregation for total and truck drivers as 72% and 76%.

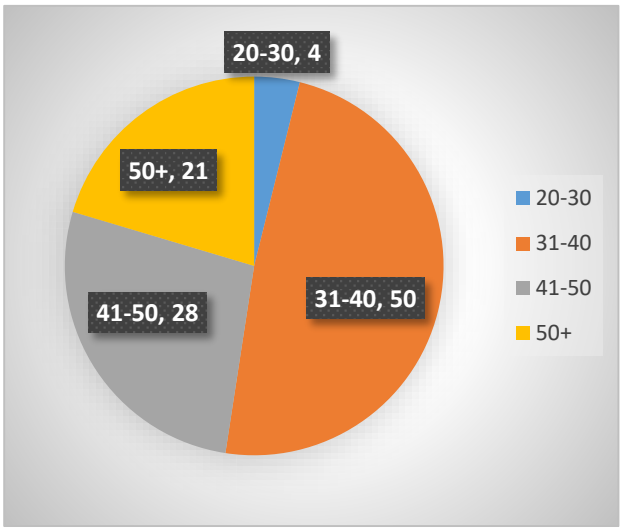


Fig 12: Age Composition

4.2.1.3 Civil Status Analysis

Variable	Frequency	Percentage
Single	15	11%
Married	125	89%
Total	140	100%

Table 5: Civil Status Analysis of the Sample

When considering the civil status of the respondents who participated in the survey; the majority were married who accounted for 89% and only a mere 11% were single. It is quite an acceptable figure when compared with the age levels of the respondents.

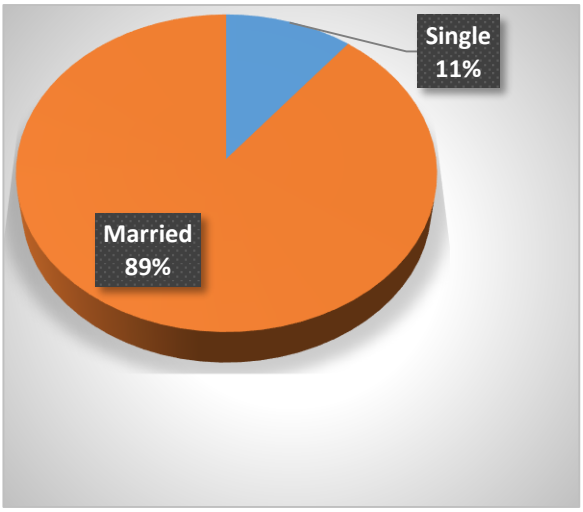


Fig 13: Marital Status of the sample

4.2.1.4 No of Years at Port Analysis

Variable	Truckers	SLPA	Frequency	Percentage
less than 1 yr	11	00	11	8%
1-3 yrs	23	00	23	16%
3-10 yrs	28	01	29	21%
10+ yrs	41	36	77	55%
Total	103	37	140	100%

Table 6: No of Years at Port Analysis of the Sample

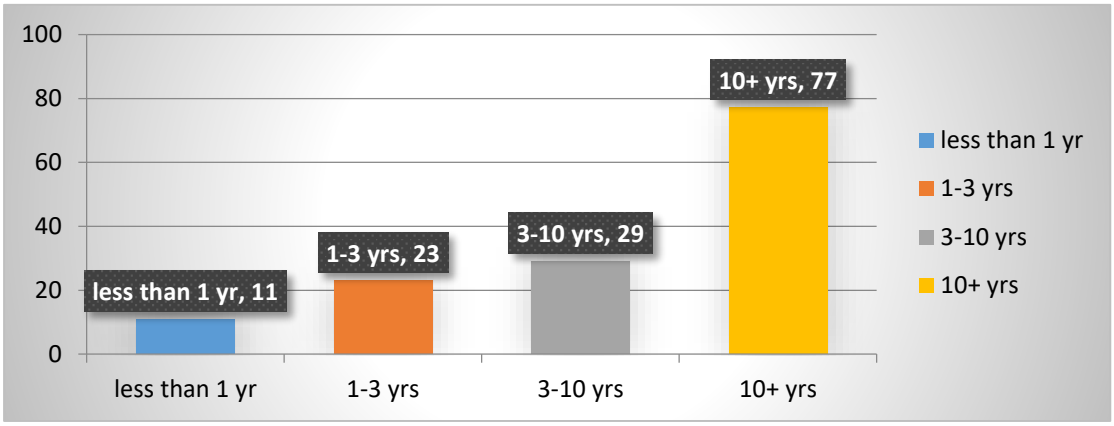


Fig. 14: No. of years at Port

When referring to the knowledge of the overall setup of how the port operations are going on, the similarities or the dissimilarities of the terminals, the years spent at the port are very important. It is to be noted that among the SLPA employees almost all the respondents have been in the port for more than 10 years. And in the overall figure, more than 50% are in that category which shows that they have a good understanding of the work routines inside the terminal.

4.2.1.5 Level of Education Analysis

Variable	Truckers	SLPA	Frequency	Percentage
Below O/ Level	03	00	03	2%
O / Level	51	07	58	41%
A / Level	34	13	47	34%
NVQ / Diploma	15	11	26	19%
Others	00	06	06	4%
Total	103	37	140	100%

Table 7: Level of Education Analysis of the Sample

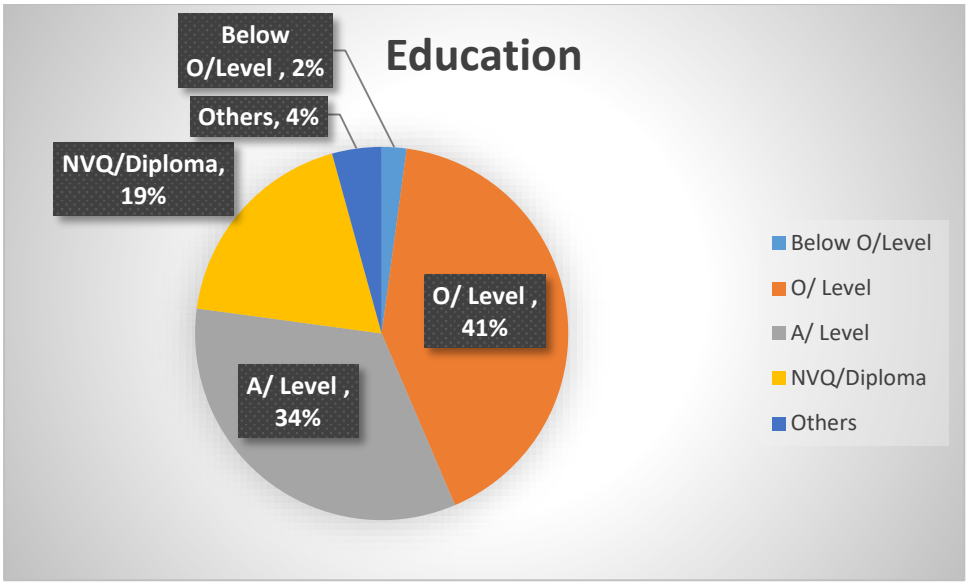


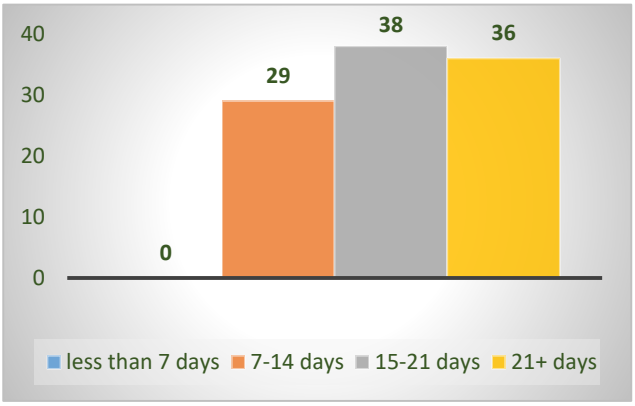
Fig 15: Education level-wise composition of the sample

When analyzing the educational level of the respondents in the sample; the majority have education in the range O / Level and A/Levels where the percentage figures are found to be 41% and 34%. For truck drivers, it is quite an acceptable figure. And SLPA respondents have much higher qualifications up to degrees / post graduate degrees.

4.2.1.6 Monthly Visiting Frequency Analysis

Variable	Frequency	Percentage
less than 7 days	0	0%
7-14 days	29	28%
15-21 days	38	37%
21+ days	36	35%
Total	103	100%

Table 8 , Fig 16: Monthly Visiting Frequency Analysis of the Sample



Since all the SLPA employees are reporting for work more than 21 days in general, let's focus on the visiting pattern of the truck drivers. It is to be noted that all of the respondents are coming into the port more than 7 days per month on average. It is a very important fact that the higher the visiting frequency is for a truck driver the opportunity is there to experience different situations inside the terminal as well as in the port.

4.2.2 Descriptive Analysis of the Sample

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
Vessel_OPs	140	1.67	1.33	3.00	2.1886	.43301	.188
Yard_Utilization	140	1.60	1.40	3.00	2.1629	.39898	.159
Handling_EQs	140	1.50	1.75	3.25	2.4196	.33023	.109
Manning	140	1.25	2.25	3.50	2.7911	.26757	.072
TTT	140	2.00	1.50	3.50	2.4857	.35199	.124
Valid N (listwise)	140						

Table 9: Descriptive Statistics of the sample

As discussed in the Sample selection of the study; views of only 140 truck drivers / SLPA staff were considered as the sample for the study. Thus, to check the reliability over the selected sample; descriptive analysis has been carried out by using SPSS Software as above where all variables of the sample have been thoroughly analyzed.

Accordingly, each variable is comprised of a 140 data set and based on the viewer opinions for sub-questions of each independent variable a mean value is calculated. These mean values vary between 3.5 and 1.33. Thus, it proves that the data set is not contained with outliers of extreme values and the outcome generated from the study can apply to the population in an equal manner. When further refer to the other descriptive values of range, mean and Standard deviation values of a set of variables including both independent and dependent; the sample data set covers all attributes in population that leads to creating justifiable outcome from the study.

4.2.2.1 Correlation and Regression Analysis

Since, Truck Turnaround Time moreover defines in terms of the quantitative aspect of Terminal Operation; it is decided to carry out quantitative analysis for the study in achieving its objectives. Thus, the relationship between each defined independent variable to dependent variable of Truck Turnaround Time has been analyzed in relation with Regression & Correlation Analysis as follows based on the conducted questionnaire survey with truckers.

The major determinant for Truck Turnaround Time

1. Vessel Operation Factors (VOPF)
2. Yard Utilization Factors (YUF)

3. Handling Equipment related Factors (EQF)
4. Manning related Factors (MNF)

Truck Turnaround Time of Terminal =f (VOF, YUF, EQF, MNF)

With explored factors related to the Truck Turnaround Time of JCT; the above functional relationship is made where the data is interpreted as follows.

4.2.2.2 Regression Analysis

With reference to the questionnaire survey of the study, 140 responses relate to the major determinants of Truck Turnaround Time are illustrated through SPSS. Since, TTT is determined by the variables of VOF, YUF, EOF and MNF; the multiple regression method has been used as follows to define its relationship.

Variable	Coefficient	t value	P value
Constant	0.492	2.295	0.023
Vessel Operation Factors (VOPF)	0.094**	1.862	0.065
Yard Utilization Factors (YUF)	0.530**	8.842	0.000
Handling Equipment related Factors (EQF)	-0.087**	-1.793	0.075
Manning related Factors (MNF)	0.306**	4.050	0.000
R2	72.3%		
F Statistics			88.229
(P value)			0.000

Table 10: Regression analysis; **- Significant at 1% Level

4.2.2.2.1 Multiple Regression Equation

Y= 0.094 VOPF + 0.530 YUF – 0.087 EQF +0.306 MNF +0.492

The above equation delineates the positive / negative relationships of each independent variable with relates to the dependent variable of TTT.

- Measuring the significance of the Model

Coefficient of Determination (R Square) = 0.723;

When referring to the table of Model summary of SPPS output; it indicates R Square as 72.3%. Those values prove that; even several other variables can be impacted over the dependent variable of TTT; the dependent variable of Truck Turnaround Time is 72.3% explained by the defined variables of VOPF, YUF, EQF and MNF. Since this is a good percentage; it can expect sound suggestions on improving the TTT by measuring the relationship between selected variables of VOPF, YUF, EQF and MNF in this study.

4.2.2.2.2 Correlation Analysis

Pearson's Correlation is a measure of linear correlation between two sets of data. (Pearson correlation coefficient - Wikipedia, 2021). When referring to the defined dependent and independent variables; the signs of the coefficients and their relationship with the dependent variable are analyzed as follows.

		Truck Turnaround Time (TTT)	**Vessel Operation Factors (VOPF)**	**Yard Utilization Factors (YUF)**	**Handling EQ Factors (EQF)**	**Manning Factors (MNF)**
Truck Turnaround Time (TTT)	Pearson Coefficient	1				
	Sig (2 tailed)					
Vessel Operation Factors (VOPF)	Pearson Coefficient	0.636	1			
	Sig (2 tailed)	0.000				
Yard Utilization Factors (YUF)	Pearson Coefficient	0.816	0.672	1		
	Sig (2 tailed)	0.000	0.000			
Handling EQ Factors (EQF)	Pearson Coefficient	-0.091	-0.053	0.024	1	
	Sig (2 tailed)	0.284	0.534	0.782		
Manning Factors (MNF)	Pearson Coefficient	0.656	0.486	0.601	-0.383	1
	Sig (2 tailed)	0.000	0.000	0.000	0.383	

Table 11: Pearson correlation coefficient

As illustrates above table; the Pearson correlation coefficient of all four independent ascertained with different values of 0.636, 0.816, -0.091 and 0.656 respectively. Here 03 variables of VOPF, YUF and MNF accounted for positive values where the EQF has recorded with a negative figure which indicated that VOPF, YUF and MNF have a positive relationship with the dependent variable of TTT and EQF has a negative relationship with TTT.

4.2.2.2.3 Determining the Coefficient of parameters

The p value of the ANOVA table revealed that; overall P-value = 0.000 < α. Therefore, it can say that all selected variables of VOPF, YUF, EQF and MNF more or less impact the dependent variable of TTT and its level of relationships are illustrated as follows.

4.2.2.2.4 Relationship between Vessel Operation factors with Truck Turnaround Time

When defining the Vessel Operations factors; the main 03 sub-parameters in relates to the VOPF have been defined for the questionnaire and average values of each sub-parameter have been taken into the consideration for the analysis. Finally, Pearson Correlation Coefficient and the P value have been derived through SPSS Software and the results are utilized to test the hypothesis.

$H0_1$ - There is no relationship between Vessel Operation factors with TTT

Ha_1 - There is a relationship between Vessel Operation factors with TTT

Referring to the above table; the **Pearson correlation** of VOPF and TTT is 0.636

Therefore, ρ value = +0.636

Probability value P = 0.000

Since, Probability value; P < 0.05, it proves that the significance level of the alternate hypothesis is achieved and hence, H_1 is accepted to be true.

Hence, it is true that there is a relationship between the Vessel Operation factor with Truck Turnaround Time and since ρ value = +0.636 which falls between + 0.6 and + 1.0; there is a **Strong relationship** between VOPF and TTT.

GGraph

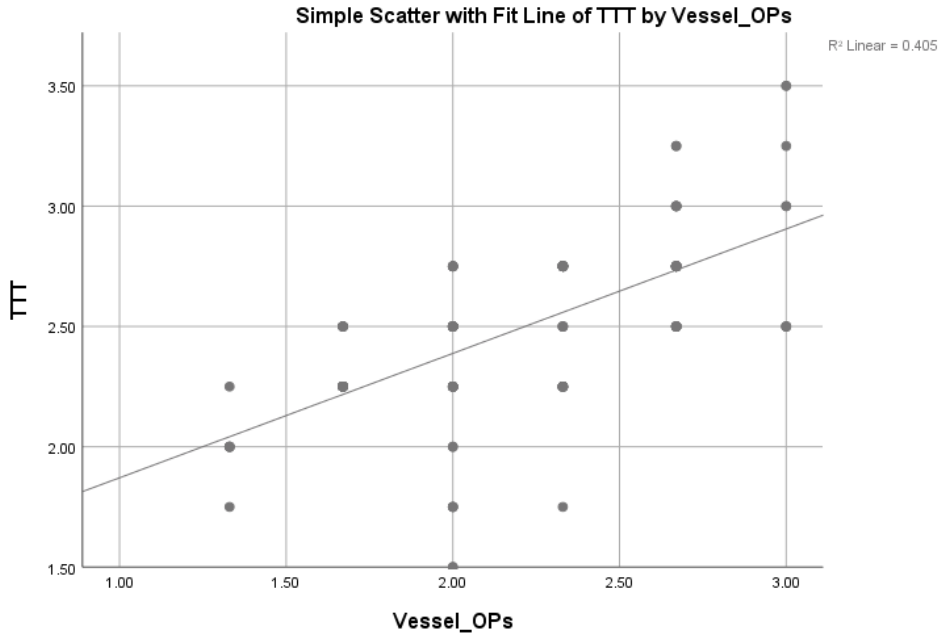


Fig. 17: Fitted Line Scatter graph of TTT vs Vessel Operations

As shown in the above graph; it can be seen that most of the data is scattered around the best-fitted line which showcases the positive relationship between VOPF and TTT.

4.2.2.2.5 Relationship between Yard Utilization Factors (YUF) with Truck Turnaround Time

Yard Utilization related factors of JCT were also analyzed in line with 05 sub-factors and the mean value of the responses of each factor in terms of the Likert scale was considered. And the relationship between the dependent variable of TTT with YUF is derived via Pearson Coefficient analysis by using SPSS software as follows.

Hypothesis defined for TTT with YUF:

$H0_2$ - There is no relationship between Yard Utilization Factors (YUF) with Truck Turnaround Time

Ha_2 - There is a relationship between Yard Utilization Factors (YUF) with Truck Turnaround Time

Pearson correlation between YUF and TTT is 0.816

Therefore, the ρ value = + 0.816

Probability P value = 0.000

Since; Probability value P < 0.05; the significance level of the alternate hypothesis is achieved and rejected the Null Hypothesis while accepting $H_{1\ to}$ be true. So, there is a positive relationship between YUF and TTT. Meanwhile ρ value is 0.816 which falls + 0.6 and + 1.0 and more towards 1. Hence it proves that there is a **high and strong relationship between Yard Utilization factors with Truck Turnaround Time.**

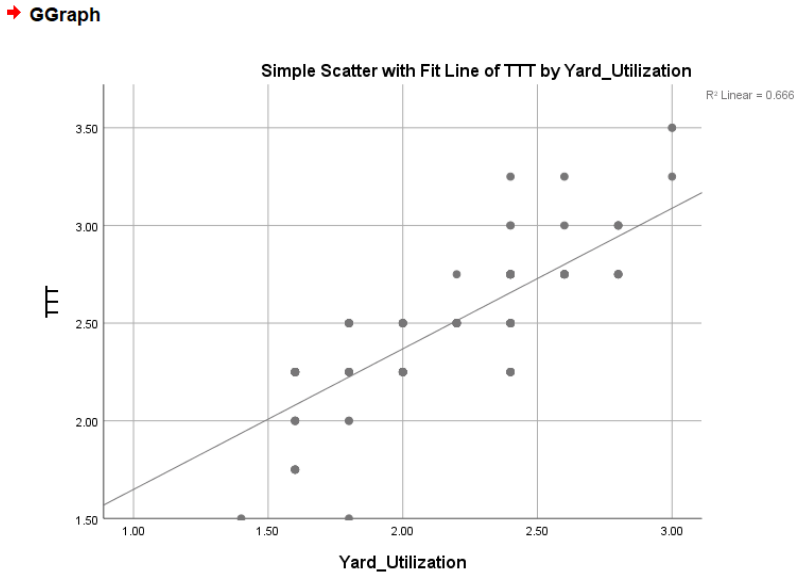


Fig. 18: Fitted Line Scatter graph of TTT vs Yard Utilization

The above graph further illustrates the positive relationship between YUF and TTT by falling most of the scatters along with best-fitted line.

4.2.2.2.6 Relationship between Handling EQ Factors (EQF) with Truck Turnaround Time

The Container Handling Equipment related factors and sub factors are considered against the TTT. The mean value of the viewer responses has been taken in to consideration. Then, the correlation and severity of the relationship are analyzed in terms of the Hypothesis testing as follows.

$H0_3$ - There is no relationship between Handling EQ Factors (EQF) with TTT

Ha_3 - There is a relationship between Handling EQ Factors (EQF) with TTT

Pearson correlation between EOQ and TTT is -0.091

Therefore, the ρ value (ρ) = -0.091

Probability P-Value = 0.284

Not in the other cases; here Probability value P > 0.05 proves that the significance level of the alternate hypothesis is rejected and hence, H_0 is accepted to be true. Thus there is no relationship between the Handling EQ Factors (EQF) with Truck Turnaround Time where ρ value (ρ) accounted to be negative.

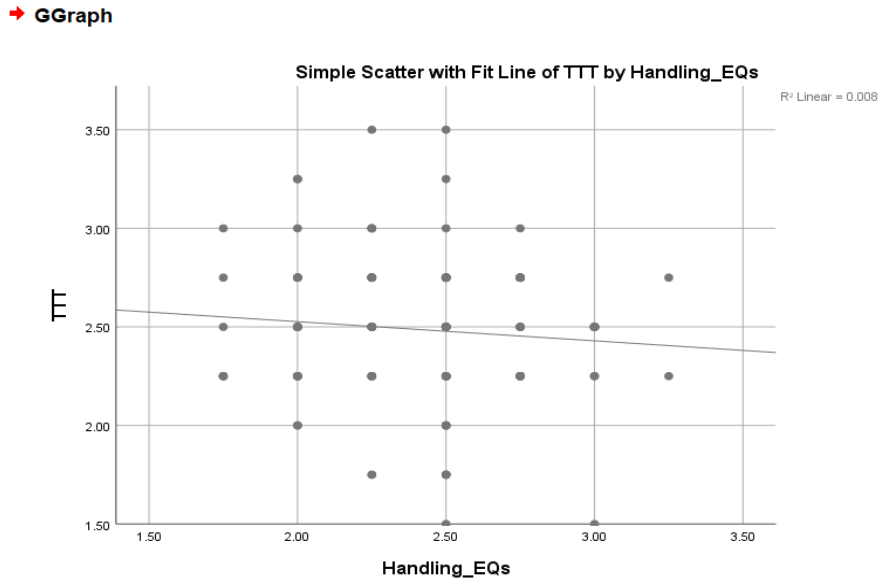


Fig. 19: Fitted Line Scatter graph of TTT vs Handling Equipment

Since all the scatters are distributed all over the graph; it further illustrates that there is no relationship between EQ factors and TTT.

4.2.2.2.7 Relationship between Manning Factors (MNF) with Truck Turnaround Time

Manning factors related to JCT were also analyzed with relates to 04 sub-parameters. As done for other variables; Mean values of these sub-factors are taken into considerations regarding the MNF and the relationship between the dependent variable of TTT and MNF is derived via Pearson Coefficient analysis using SPSS software.

$H0_2$ - There is no relationship between Manning Factors (MNF) with Truck Turnaround Time

Ha_2 - There is a relationship between Manning Factors (MNF) with Truck Turnaround Time

Pearson correlation of MNF and TTT is= 0.656

Therefore, the ρ value = +0.656
Probability P value = 0.000

According to the above derived values; Probability value P > 0.05. And ρ value = +0.656 that falls between +1 to and +0.6. Hence, it illustrates that the significance level of alternative hypothesis is accepted. So there is a relationship between TTT and MNF and which is considered to be a **strong positive relationship.**

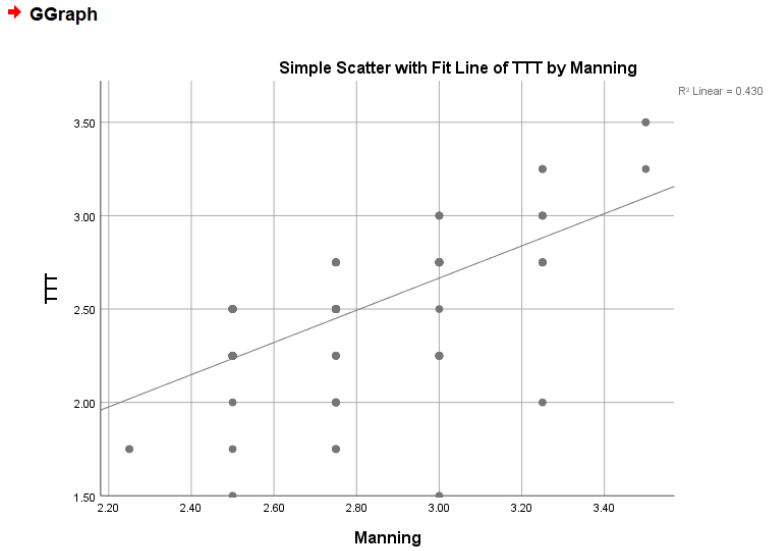


Fig. 20: Fitted Line Scatter graph of TTT vs Manning

According to above; data relates to TTT and MNF distributed along with the best fitted line and it proves the positive relationship between TTT and MNF.

4.2.2.2.8 Summary of the Results

Parameter	Relationship and its Magnitude
TTT with VOPF	Strong Positive Relationship
TTT with YUF	Strong Positive Relationship
TTT with EQF	Negative Relationship
TTT with MNF	Strong Positive Relationship

4.3 Analysis of Actual data from the TMS

The Terminal Management System at JCT has the actual data of the Truck Turnaround Time, the Vessel Productivity and Daily Yard Utilization Volumes. Therefore, the data was obtained on the above variables during January and February 2021 for analysis to get a numerical understanding. To interpret the data with much clarity, based on the intensity of truck movements, the data is categorized into two; Peak hours and Off-Peak hours. The Peak hours are considered from 06.00 pm to 01.00 am of the following day and the remaining hours are categorized under Off-Peak on daily basis.

4.3.1 Peak-time TTT vs Vessel Productivity

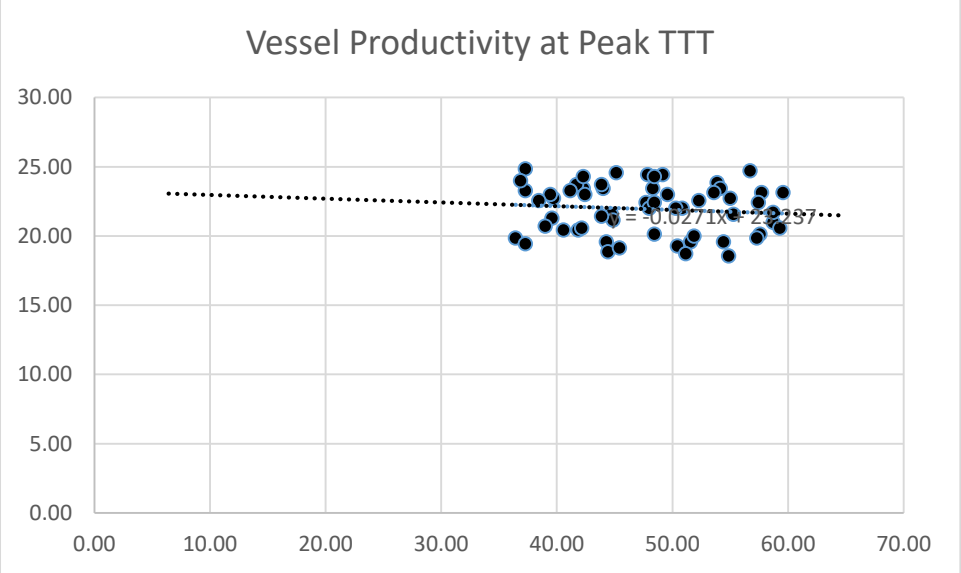


Fig. 21: Vessel Productivity vs. Peak hour - TTT

During the Peak hours considered, the average TTT values had varied between 36.43 min. to 59.57 min., with an overall average of 47.71 min.

During that period the average productivity rates had varied between 18.57 moves per hour to 24.86 moves per hour., with an overall average productivity rate of 21.94 moves per hour.

4.3.2 Off-Peak time TTT vs Vessel Productivity

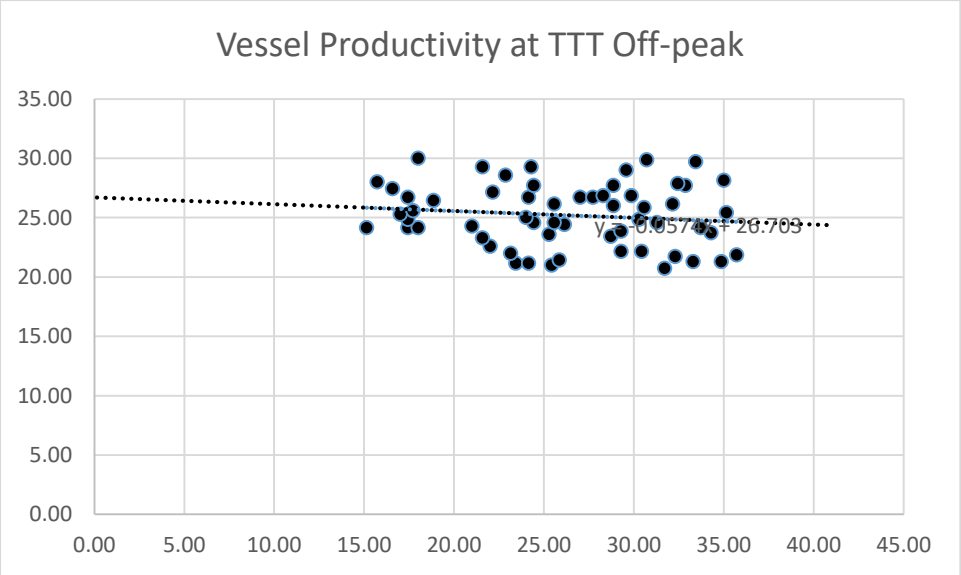


Fig. 22: Vessel Productivity vs. TTT at Off-Peak

During the Off-Peak hours considered, the average TTT values had varied between 15.14min. to 35.71 min., with an overall average of 26.17 min.

During that period the average productivity rates had varied between 20.71 moves per hour to 30.14 moves per hour., with an overall average productivity rate of 25.20 moves per hour.

4.3.3 Yard Volume vs Peak time TTT

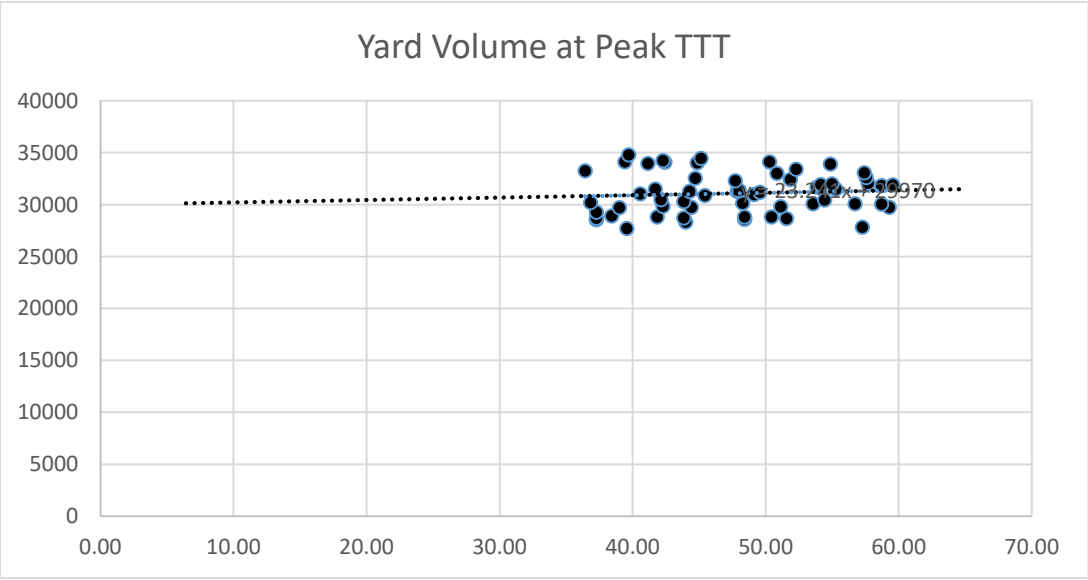


Fig. 23: Yard Volume vs. Peak hour - TTT

During the Peak hours where the average TTT values had varied between 36.43 min. to 59.57 min., the average Yard volume had varied between 27702 TEUs to 34810 TEUs, with an overall average Yard Volume of 31078 TEUs.

4.3.4 Off-Peak time TTT vs Yard Volume

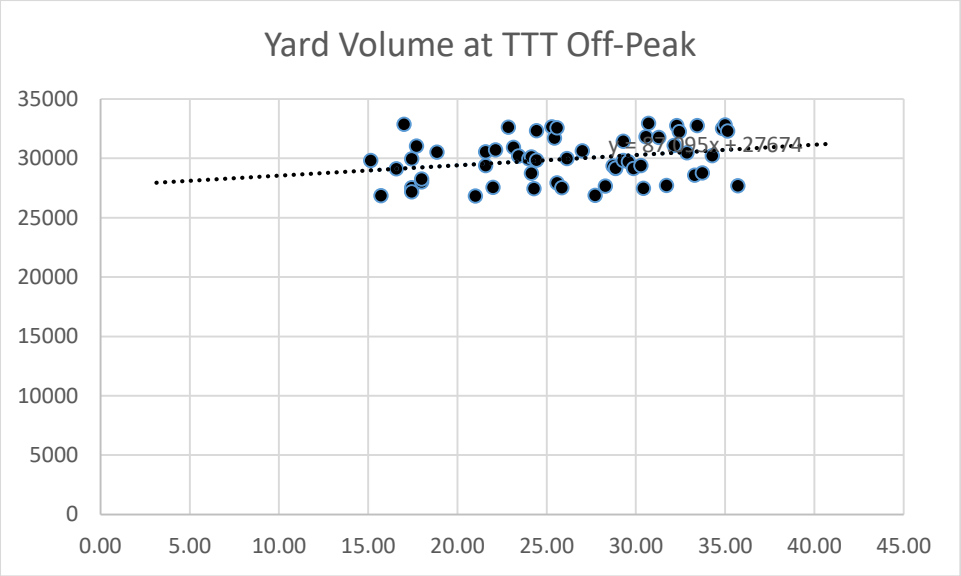


Fig. 24: Yard Volume vs. TTT at Off-Peak

During the Off-Peak hours where the average TTT values had varied between 15.14min. to 35.71 min., the average Yard Volume had varied between 26836 TEUs to 32949 TEUs, with an overall average Yard Volume of 29952 TEUs.

CHAPTER FIVE - DISCUSSION

This chapter discusses the results obtained from qualitative and quantitative analysis of the study. The Truck Turnaround Time (TTT) within a container terminal has a numerical value. However, the study is focused on finding the ways and means of reducing the TTT with reference to the Jaya Container Terminal. Though the study is mainly discussing a matter that seems to be more of quantitative importance, both quantitative and qualitative analysis was done to have a better understanding of the real picture. The qualitative aspects of analysis are detailed in the form of SWOT analysis on the Jaya Container Terminal, in the Qualitative Analysis in Chapter Four.

A more detailed quantitative analysis has been carried out where the relationship with each element of the dependent variables and the Truck Turnaround Time is also analyzed using the Regression techniques based on the data gathered from the Questionnaire survey. Furthermore, the discussed quantitative research findings, it is expected to provide insights based on the degree of the relationship between Truck Turnaround Time and the determinant factors.

5.1 Summary of the Study

The prime focus of the study is to examine the factors that could lead to the reduction of Truck Turnaround Time. Due to the limited availability of researches on this particular subject area, a pilot survey was also done to identify the prominent factors that could be the dependent variables of Truck Turnaround Time. Accordingly, the following main factors were identified and data were gathered from the truck drivers who are the main group of persons who are experiencing the consequences of the TTT. The data was gathered from a Questionnaire survey and interviews. In order to maintain accuracy and to eliminate biasness, the same data were gathered from the internal work staff of the JCT.

5.1.1 Relationship between Vessel Operation Factors and TTT

According to the findings of the study; it is proved that there is a STRONG positive relationship between Vessel Operation factors and Truck Turnaround Time. The Vessel Operation related factors are directly related to internal truck movement and the yard.

Stojakovic and Twrdy (2021) emphasize that the increase in the vessel operational activities in a terminal increases the yard handling intensity. Therefore, it is evident that the Vessel Operational activities can increase the TTT and the analysis output confirms the positive relationship towards the increase of TTT. However, it is to be noted that for a Container Terminal, the most important activity is the Vessel Operation. Therefore, Vessel Operations cannot be compromised to reduce the TTT. Since, the relationship is strong effects it can be very harmful to a better TTT. Therefore, only a strategic approach would only help to reduce the TTT while maintaining the productivity levels.

5.1.2 Relationship between Yard Utilization Factors and TTT

The analysis result of the study shows that there is a strong positive relationship between Yard Utilization factors and TTT. The relationship is much higher than the Vessel Operation factors and TTT. As per the studies of Asperen et.al, (2011) the yard stacking efficiency is very helpful to reduce the truck turnaround time of trucks coming into a terminal. Therefore, it allows great insight that the Yard Utilization factors are the best options where the TTT can be improved.

5.1.3 Relationship between Handling Equipment related factors and TTT

According to the results of the study; it is found out that there is a negative relationship between the Handling Equipment related factors and TTT. The Handling Equipment consists of mainly the Rubber Tyred Gantries (RTG) where colloquially it is referred to as Transfer Cranes at the JCT. Usually, when it comes to the number of RTGs in the yard in operational condition on a given date at JCT an agreed norm is maintained as two RTGs per stacking lane. In addition, to the RTGs, JCT has facilities of Rail Mounted Gantries (RMG) for empty container handling and stacker machines where both laden and empty containers can be handled.

5.1.4 Relationship between Manning related factors and TTT

The other main factor identified in the study that would affect the Truck Turnaround time is Manning or the Human related factors. Though, it too has a positive relationship against the TTT, it has a lesser focus on the TTT than Yard Utilization. JCT is continuously conducting training programs and awareness programs to improve the behavioral and attitudinal changes among the Gate staff and the yard RMG, RTG operators.

5.1.5 Application of study results with the real data

The study results show that the independent variables have relationships with the Truck Turnaround Time. In the context of decision making on the overall terminal operations, the Terminal Management requires to have the knowledge on the acceptable range of TTT values to maintain operation efficiency at an optimum level. Therefore, the real data relating to Vessel Operation productivity, Yard Volume against the TTT is discussed in this section. Since, the pandemic situation changed the operational routines, the real data from the Terminal Management System at JCT had to be taken where the effects are minimal. Therefore, the data was obtained during the months of January, February and March of 2021.

The target levels of Vessel Productivity for the vessel operations at JCT are defined as follows.

- Lower Limit – 20 moves per hour per QC
- Satisfactory Level - 25 moves per hour per QC

The real data figures show that when the TTT increases it has negatively affected the average Vessel Productivity. In numerical terms the Productivity levels are around the lower limit during the Peak hours where TTT is high and the Productivity levels are on par with the Satisfactory level during the Off-Peak hours.

Although the Yard Volumes do not significantly change in between the Peak and Off-peak hours, there is a minor increase in the TTT values when the Yard volume is increased.

5.2 Constraints

5.2.1 Time Plan

Since the project is bound by a certain time frame, all the activities have lined up in accordance with below schedule.

Activity	Jul'20	Aug-Oct'20	Dec'20	Jan-Feb'21	Mar'21	Apr'21	May'21	Jun'21	Jul'21
Developing Research Topic									
Research Proposal									

developing									
Consideration from the supervisor, discussions									
Obtaining Supervisor comment									
Research proposal refining and finalizing									
Proposal submission to the university									
Questionnaire development									
Data collection									
Research report development									
Feedback from the supervisor									
Finalized research report according to supervisor's feedback									
The final submission									

5.2.2 Limitations

The outcome of the research is highly dependent upon the accuracy of data, where it could quite difficult to find secondary sources and researches about the research area. Since the questionnaire respondents consist mainly of truckers who are a little un-educated; getting 100% accurate data cannot be assured.

The main difficulty was in gathering the expected number of respondents participating in the study. Due to the pandemic environment in the country, the physical interactions have been compelled to be limited inside the Port of Colombo. Therefore, the response gathering for the questionnaire survey from the truckers was very difficult. However, the respondents were asked to provide their telephone numbers and were contacted at separate time frames to collect the response. And, finally the sample consisted only of about 11% of the total population, which will limit the holistic view of the whole parties affecting the research.

Further, the change in Terminal System done during early 2021 limited access to the system data. Otherwise, the factor intensity could have been further studied with system data.

CHAPTER SIX – CONCLUSION AND RECOMMENDATIONS

With reference to the details discussed in the previous chapters of the study; it could come out with several important findings where the conclusion is made below.

6.1 Achievement of Primary Objective

The first objective of the study is to determine the main factors that could reduce the Truck Turnaround Time. The research data and the pilot survey were able to find some factors that could relate to TTT. The Analysis outcome confirmed that the factors identified are accurate with the overall dependent variables and TTT has described up to a very satisfactory level of 72%. Inversely, it gives a clear hint that many other factors could affect the TTT.

6.2 Achievement of Secondary Objectives

The second objective of the study is to develop a causal relationship with the identified dependent variables or the determinant factors of Truck Turnaround Time. From the data analysis through the regression analysis techniques using the SPSS software the following linear relationship is uncovered.

Multiple Regression Equation

Y= 0.094 VOPF + 0.530 YUF – 0.087 EQF +0.306 MNF +0.492

6.3 Recommendations

By aligning with the findings of the study finally it needs to say that, the study is very important to the overall productivity aspects of the JCT as well as for the trucking community. Therefore, it is recommended that all four critical parameters have a direct impact on TTT. However, their intensity is varied and except for Handling Equipment related factors, others have a positive relationship with TTT.

6.3.1 Improvements to the Factors

As mentioned earlier in Chapter Five the Vessel Operation factors cannot be compromised to reduce the TTT. Therefore, JCT management could take several remedial measures to reduce TTT by maintaining the Vessel Operations at the required productivity levels.

- Maintaining an optimal level of internal trucks working for the Vessel Operations.
- Use dumping techniques for Discharging operations at all times where possible.
- Allow maximum external truck movement during the time gaps where vessel sailing and berthing occurred.

The Yard Utilization factors were identified as having a much stronger positive relationship with TTT.

- Continuously monitor the yard and arrange yard marshalling whenever there are lesser movements in the yard (less number of vessels at berth, lesser number of trucks coming inside.)
- Use of RF – ID or Position Detecting System (PDS) and auto-stow functions
- Divert loading or discharging point of works whenever there is yard congestion
- Place signboards at turnings or regular distances to guide the truck drivers of the terminal yard layout.

The Handling Equipment related factors have a negative relationship. It is quite obvious that if there are a sufficient number of different handling equipment such as RTG, RMG Stackers, Top lifter, heavy forklifts available them the Handling equipment factor increases and reduce the TTT. In order to maintain a sufficient fleet of handling equipment following is recommended.

- Regular and timely maintenance
- Train operators for best practices in handling heavy equipment with proper care.
- Quick response repair teams for running repairs
- Maintain an adequate amount of spares

The final factor considered was Manning or the Human related factors. The skills of equipment operators and Gate staff are very important. Therefore, the following is recommended to reduce TTT using optimizing the Manning factor.

- Regular training of JCT staff to improve the skills and attitudinal improvements
- Introduce KPIs and incentivize the KPIs to reflect the performance.
- Recognize the high performers.
- Identify the best customer service providers with truck driver feedbacks.

6.4 Future Directions

The study would give higher accuracy with an increasing number of participants as the sample. With more data, the accuracy of the outcome will validate the real scenarios at the JCT. The study could be further expanded to assess the effects of different TTT based on the types of the vessels at berth (Mainline or feeder) which will be more meaningful for the Terminal's Management.

REFERENCES

1. Ahmed E. Azab and Amr B. Eltawil (2016), A Simulation Based Study of the Effect of Truck Arrival Patterns On Truck Turn Time in Container Terminals, [online] Available at:https://www.researchgate.net/publication/303913581_A_Simulation_Based_Study_Of_The_Effect_Of_Truck_Arrival_Patterns_On_Truck_Turn_Time_In_Container_Terminals [Accessed December 2020].
2. Bandara, Y.M., Edirisooriya, T. (2017), An Optimization Strategy for Inter Terminal Transportation (ITT) of Containers: Case of Port of Colombo, [online] Available at: https://www.researchgate.net/publication/321572612_An_Optimization_Strategy_for_Inter_Terminal_Transportation_ITT_of_Containers_Case_of_Port_of_Colombo [Accessed November 2020].
3. Bartošek*, O. Marek (2013), Quay Cranes in Container Terminals, [online] Available at: https://www.researchgate.net/publication/272474150_Quay_Cranes_in_Container_Terminals [Accessed October 2020].
4. Bearzotti, L., Gonzalez, R. and Miranda, P., 2013. The Event Management Problem in a Container Terminal. ScienceDirect, [online] 11(1). Available at: http://ciencedirect.com/science/article/pii/S1665642313715189 [Accessed 2 July 2021].
5. Carlo et al (2014); Carlo, H.J., Vis, I.F.A. & Roodbergen, K.J., Storage yard operations in container terminals: literature overview, trends, and research directions, European Journal of Operational Research 235(2), 412-430 (2014). [online] Available at: https://doi.org/10.1016/j.ejor.2013.10.054 [Accessed December 2020].
6. Chakraborty et al (2016); S. Chakraborty, B. Kumar and A. Malguri, Reducing the Truck Turnaround Time inside a Heavy Manufacturing Industry through Makigami Analysis, [online] Available at: http://www.ijaist.com/wp-content/uploads/2018/08/ReducingtheTruckTurnaroundTimeinsideaHeavyManufacturingIndustrythroughMakigamiAnalysis.pdf [Accessed October 2020].
7. Cobo, P., 2016. *Optimization Of Yard Operations In Container Terminals From An Energy Efficiency Approach*. Universidad Politécnica de Cataluña – Barcelona Tech. [online] Available at: https://www.tesisenred.net/bitstream/handle/10803/620639/TPTC1de1.pdf?sequence=1&isAllowed=y [Accessed 13 June 2021].
8. En.wikipedia.org. 2021. Pearson correlation coefficient - Wikipedia. [online] Available at: https://en.wikipedia.org/wiki/Pearson_correlation_coefficient [Accessed 6 July 2021].

9. Guan, C.(2009), Analysis of marine container terminal gate congestion, truck waiting cost, and system optimization, [online] Available at: https://core.ac.uk/download/pdf/232275113.pdf [Accessed November 2020].
10. Guan, C., 2009. *Analysis of marine container terminal gate congestion, truck waiting cost, and system optimization*. New Jersey Institute of Technology. [online] Available at: https://core.ac.uk/download/pdf/232275113.pdf [Accessed 12 June 2021].
11. Gürel, E., 2017. Swot Analysis: A Theoretical Review. Journal of International Social Research, [online] 10(51), pp.994-1006. Available at: https://www.researchgate.net/publication/319367788_SWOT_ANALYSIS_A_THEORETICAL_REVIEW [Accessed 1 July 2021].
12. International Maritime Organization (IMO), www.imo.org [Accessed January 2021].
13. Jovanovic, R., 2018. Optimizing Truck Visits to Container Terminals with Consideration of Multiple Drays of Individual Drivers. *Journal of Optimization*, [online] 2018, pp.1-8. Available at: <https://www.hindawi.com/journals/jopti/2018/5165124/> [Accessed 3 June 2021].
14. Kavirathna, C., Kawasaki, T. and Hanaoka, S., 2018. Transshipment Hub Port Competitiveness of the Port of Colombo against the Major Southeast Asian Hub Ports*. *The Asian Journal of Shipping and Logistics*, [online] 34(2), pp.71-82. Available at: https://reader.elsevier.com/reader/sd/pii/S2092521218300221?token=AA2D8D9FF297A0191A615503CEAF680FD60DED68951825890D0922F103635CBDE49D7E501642D649DB8C7ED5268590F4&originRegion=eu-west-1&originCreation=20210713065356 [Accessed 3 July 2021].
15. Lange et al; Lange, Ann-Kathrin; Schwientek, Anne Kathrina; Jahn, Carlos (2017), Reducing truck congestion at ports - classification and trends, [online] Available at: https://www.econstor.eu/bitstream/10419/209325/1/hicl-2017-24-037.pdf [Accessed November 2020].
16. Libguides.wits.ac.za. (2020), Libguides: Research Support: Research Methodology. [online] Available at: https://libguides.wits.ac.za/c.php?g=693518&p=4914913 [Accessed August 2020].
17. Maguire, A., Ivey, S., Golias, S. and Lipinski, M., 2009. Relieving Congestion at Intermodal Marine Container Terminals: Review of Tactical/Operational Strategies. [online] Available at: http://file:///C:/Users/admin/Downloads/2010_161_Relieving_Congestion_Marine_Terminals_Strategies.pdf [Accessed 8 July 2021].

18. Marine Insight (2020), Top 10 World's Largest Container Ships In 2021., [online] Available at: https://www.marineinsight.com/know-more/top-10-worlds-largest-container-ships-in-2019/ [Accessed January 2021].
19. Mazen I. Hussein (2012), Container Handling Algorithms and Outbound Heavy Truck Movement Modeling for Seaport Container Transshipment Terminals, [online] Available at:https://dc.uwm.edu/cgi/viewcontent.cgi?referer=https://www.google.com/&httpsredir=1&article=1059&context=etd [Accessed November 2020].
20. Premathlaka, W., 2018. *Determining the factors affecting the turnaround time of container vessels: a case study on Port of Colombo*. World Maritime University. [online]. Available at: https://commons.wmu.se/cgi/viewcontent.cgi?article=1599&context=all_dissertations [Accessed 3 June 2021].
21. Raka Jovanovic (2018), Optimizing Truck Visits to Container Terminals with Consideration of Multiple Drays of Individual Drivers, [online] Available at: https://www.hindawi.com/journals/jopti/2018/5165124/ [Accessed November 2020].
22. Ravichandran. N. and I.V. Subba Rao (2005), A Process oriented Approach to Waiting Line Management in a Large Pilgrimage Center in India: A Case Study. [online] Available at: https://ideas.repec.org/p/iim/iimawp/wp01893.html [Accessed September 2020].
23. Sri Lanka Ports Authority (SLPA), www.slpa.lk [Accessed January 2021].
24. Steenken et al (2004); (Dirk Steenken, Stefan Voß, and Robert Stahlbock), Container terminal operation and operations research - A classification and literature review, [online] Available at: https://www.researchgate.net/publication/225493172_Container_terminal_operation_and_operations_research_-_A_classification_and_literature_review [Accessed October 2020].
25. Stojaković, M. and Twrdy, E., 2021. Determining the optimal number of yard trucks in smaller container terminals. *European Transport Research Review*, [online] 13(1). Available at: https://etrr.springeropen.com/articles/10.1186/s12544-021-00482-6#Sec7 [Accessed 1 June 2021].
26. United Nations Organization, www.un.org [Accessed August 2020].
27. Van Asperen, E., Borgman, B. and Dekker, R., 2011. Evaluating impact of truck announcements on container stacking efficiency. *Flexible Services and Manufacturing Journal*, [online] 25(4), pp.543-556. Available at:

https://www.citethisforme.com/cite/sources/journalautociteconfirm [Accessed 2 June 2021].

28. Yoon, D., (2007), Analysis of Truck Delays at Container Terminal Security Inspection Stations. Faculty of New Jersey Institute of Technology. [online] Available at: http://archives.njit.edu/vol01/etd/2000s/2007/njit-etd2007-059/njit-etd2007-059.pdf [Accessed August 2020].

APPENDIX I - QUESTIONNAIRE FORMAT

Questionnaire – MBA in Supply Chain Management – University of Moratuwa

The following questionnaire is a part of the academic requirement of "MBA in Supply Chain Management" studying on the ways and means of "**Reducing Truck Turnaround Time within a Container Terminal to Improve the Terminal's Internal Movements Efficiency" – with special reference to Jaya Container Terminal (JCT).**

(*Data collected will be utilized only for the research purpose and the confidentiality of the data will be maintained)*

SECTION A: DEMOGRAPHIC DETAILS

Instruction: Please select the relevant answer from the given options

1. Gender
   ☐ Male ☐ Female
2. Age
   ☐ 20-30 ☐ 31-40 ☐ 41-50 ☐ 50+

3. Civil Status
   ☐ Single ☐ Married

4. What kind of containers are you trucking?
   ☐ Inter-terminal transfers (ITT) ☐ Local Imports

5. Number of years as a Port User
   ☐ Less than 1 year ☐ 1-3 years ☐ 3-10 years ☐ 10+ years

6. Level of Education
   ☐ Below O/Level
   ☐ O/ Level
   ☐ A/ Level
   ☐ Diploma
   ☐ Other (Please specify) …….

7. Average no. of days spent inside the port area per a month
   ☐ Below 7 days ☐ 7-14 days ☐ 15-21 days ☐ 21+ days

SECTION B: PLEASE EXPRESS THE EXTENT WHICH YOU AGREE OR DISAGREE WITH BELOW STATEMENTS

1. Strongly Agree **2.** Agree **3.** Neither Agree nor Disagree **4**. Disagree **5**. Strongly Disagree

	8. Vessel Operations					
	Statements	1	2	3	4	5
1	When the no. of vessels at berth increases the truck turnaround time (TTT) for you increases					
2	TTT increases, when there are Main Vessels (i.e. larger vessels with multiple loading ports) at berth than Feeder (smaller vessels with single loading ports) are at berth					
3	Time of day the vessels berthing & sailing could change the TTT					

	9. Yard Utilization					
	Statements	1	2	3	4	5
1	The high volume of containers in the yard increases TTT					
2	Higher no. of terminal gates **decreases** the TTT					
3	The truck moving direction in the yard helps to **reduce** TTT					
4	The container stacking lanes allocated for ITT or import delivery help to **reduce** TTT					
5	RF –ID or similar identification system would **reduce** the TTT					

	10. Handling Equipment					
	Statements	1	2	3	4	5
1	The increase no. of SLPA prime movers moving in the yard would increase TTT					
2	When the no. of operating RTGs increases, TTT **decreases**					
3	Range of different handling equipment (i.e. RTGs, yard stackers, heavy fork lifts, empty stackers) will help to take the delivery quickly					
4	Terminal System supports to **reduce** TTT					

	11. Manning (The people factor)					
	Statements	1	2	3	4	5
1	Skills of the Gate staff help to reduce TTT					
2	Different transactions happening at a gate (eg. ITT and import delivery done at the same gate) would reduce TTT					
3	Change of gate staff at regular work period reduce TTT					
4	Skills of RTG operators help to reduce TTT					

	12. External Factors					
	Statements	1	2	3	4	5
1	Trucks with bad condition lead to a higher TTT					
2	Unawareness of Terminal Stacking Plan or the complicated yard layouts would increase TTT					
3	Traffic rule violation would result in higher TTT					
4	Fatigue or the lesser skills of the truck driver lead to higher TTT					

APPENDIX II - Data Analysis Output of SPSS

Regression

[DataSet0]

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	Manning, Handling_EQs, Vessel_OPs, Yard_Utilization[b]	.	Enter

a. Dependent Variable: TTT

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.850[a]	.723	.715	.18787

a. Predictors: (Constant), Manning, Handling_EQs, Vessel_OPs, Yard_Utilization

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12.456	4	3.114	88.229	.000[b]
	Residual	4.765	135	.035		
	Total	17.221	139			

a. Dependent Variable: TTT

b. Predictors: (Constant), Manning, Handling_EQs, Vessel_OPs, Yard_Utilization

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	.492	.214		2.295	.023
	Vessel_OPs	.094	.050	.115	1.862	.065
	Yard_Utilization	.530	.060	.601	8.842	.000
	Handling_EQs	-.087	.049	-.082	-1.793	.075
	Manning	.306	.076	.233	4.050	.000

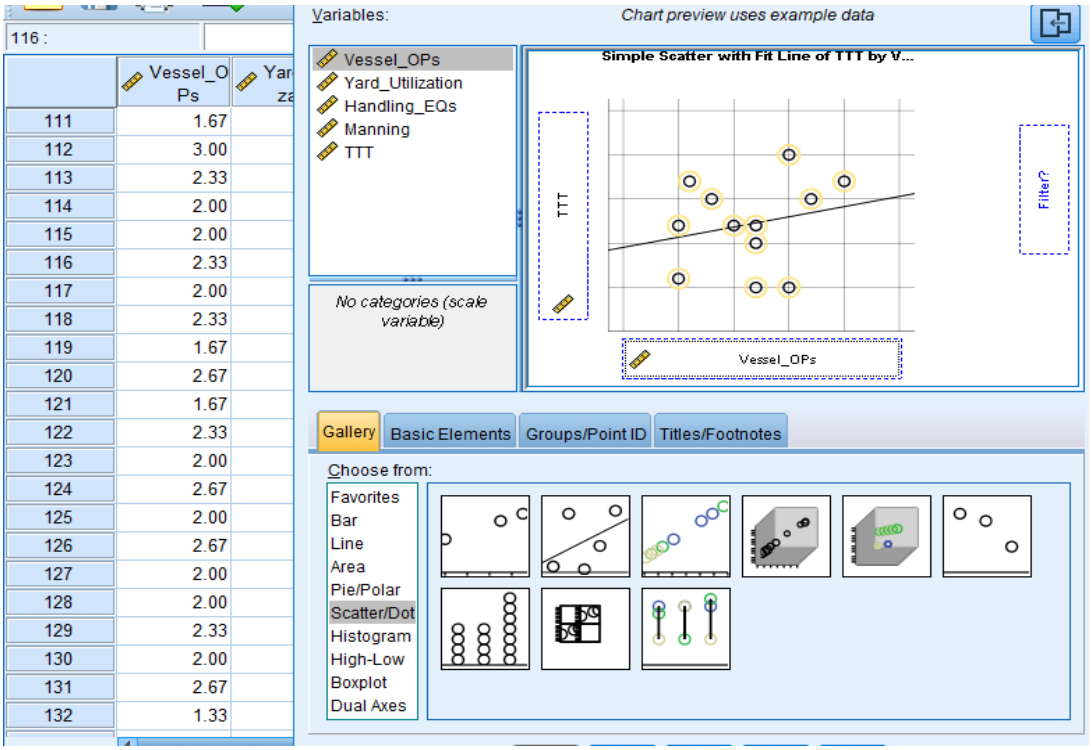
a. Dependent Variable: TTT

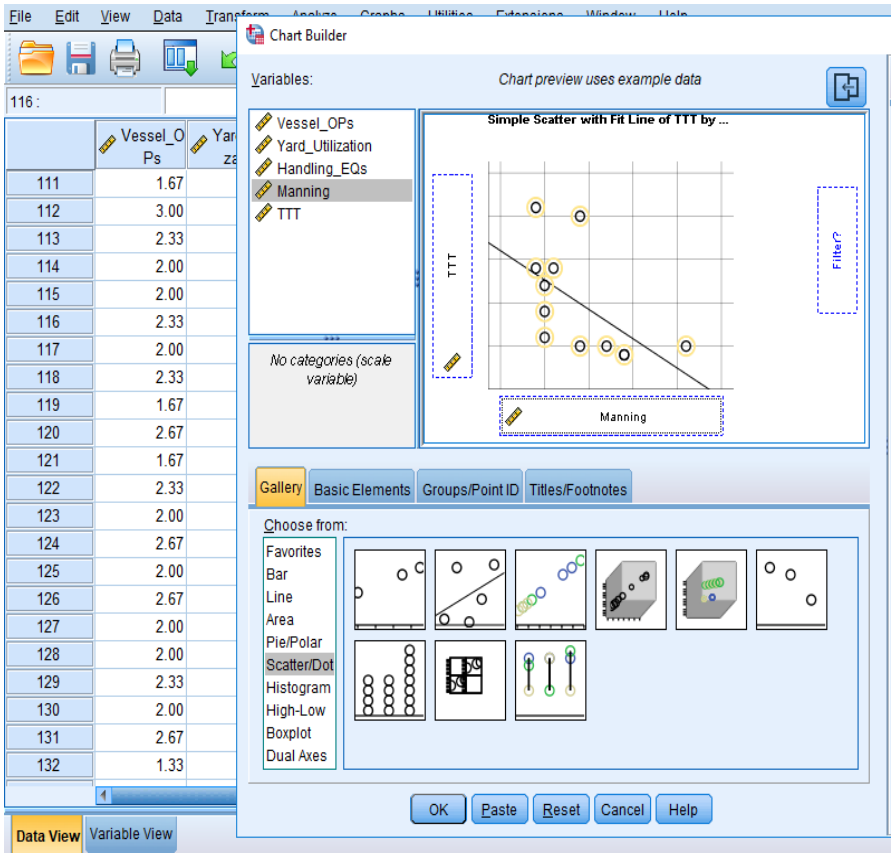
Correlations

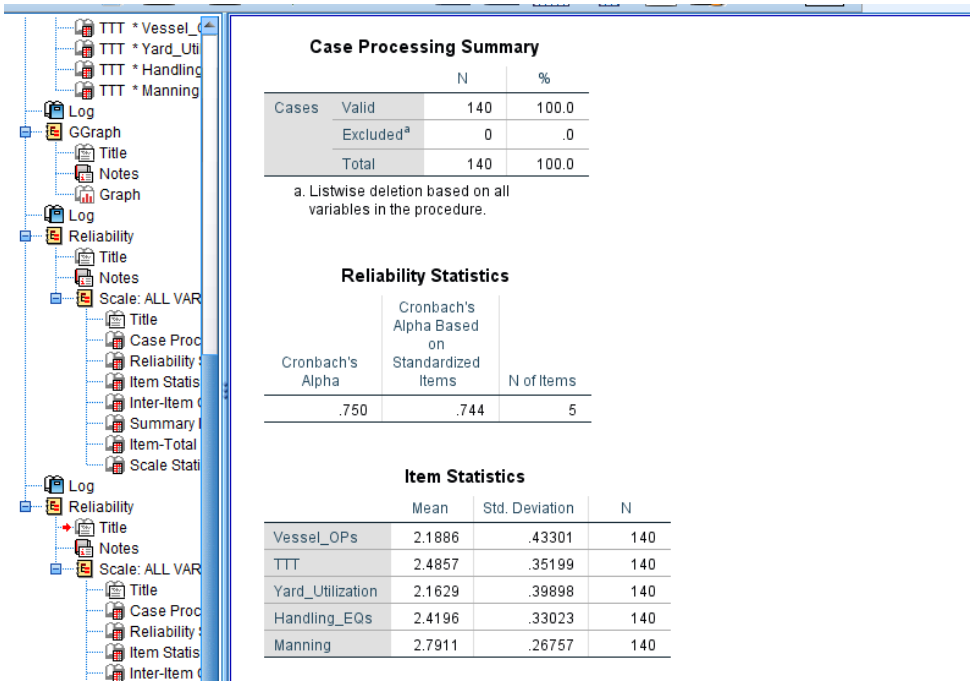
Correlations

		TTT	Vessel_OPs	Yard_Utilization	Handling_EQs	Manning
TTT	Pearson Correlation	1	.636**	.816**	-.091	.656**
	Sig. (2-tailed)		.000	.000	.284	.000
	N	140	140	140	140	140
Vessel_OPs	Pearson Correlation	.636**	1	.672**	-.053	.486**
	Sig. (2-tailed)	.000		.000	.534	.000
	N	140	140	140	140	140
Yard_Utilization	Pearson Correlation	.816**	.672**	1	.024	.601**
	Sig. (2-tailed)	.000	.000		.782	.000
	N	140	140	140	140	140
Handling_EQs	Pearson Correlation	-.091	-.053	.024	1	-.074
	Sig. (2-tailed)	.284	.534	.782		.383
	N	140	140	140	140	140
Manning	Pearson Correlation	.656**	.486**	.601**	-.074	1
	Sig. (2-tailed)	.000	.000	.000	.383	
	N	140	140	140	140	140

**. Correlation is significant at the 0.01 level (2-tailed).







Case Processing Summary

		N	%
Cases	Valid	140	100.0
	Excluded[a]	0	.0
	Total	140	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.750	.744	5

Item Statistics

	Mean	Std. Deviation	N
Vessel_OPs	2.1886	.43301	140
TTT	2.4857	.35199	140
Yard_Utilization	2.1629	.39898	140
Handling_EQs	2.4196	.33023	140
Manning	2.7911	.26757	140