Tomas Bata University in Zlín
Faculty of Management and Economics

Doctoral Thesis

Assessing the factors impacting the shipping container dwell time: A multiport research study

Posouzení různých faktorů ovlivňujících dobu zdržení přepravního kontejneru: Studie napříč několika námořními přístavy

Author:	**Mohan Saini**
Degree Program:	P0488D050003, Industrial Engineering
Supervisor:	prof. Tone Lerher, PhD.
Consultant:	Ing. Denisa Hrušecká, Ph.D.

Zlin, September 2023

Published by **Tomas Bata University in Zlín** in the edition **Doctoral Thesis.**

The publication was issued in the year 2023

Key Words: Marine/Sea/Ocean Port, Port Performance, Shipping container, Dwell Time, Tracking, yard

Klíčová slova: námořní přístav, výkonnost přístavu, přepravní kontejner, doba setrvání, sledování, loděnice

ABSTRACT

Ocean transportation is the most preferred mode of transportation that represents a significant role in global trade. Ocean transportation comprises around 80% of the aggregate worldwide cargo volume. This doctoral thesis focused on investigating the factors that influence the dwell time of shipping containers in ocean transportation. This research study focused on the significance of implementing a continuous track and trace system in the management of shipping containers. The stakeholders in a typical container supply chain involves port operators, shipping lines, transporters, shippers, consignee who operates in silo conditions. These stakeholders must synergize and collaborate by standardizing the information transaction mechanism.

This research thesis is divided into three phases. For the Phase I, the World Bank's secondary dataset for the key economies is extracted, and fuzzy qualitative comparison analysis is carried out. This is accomplished through comprehending the impact of the indicators such as logistics cost (LC) and Logistics performance index (LPI) on economic growth (GDP per capita). The phase I result indicates in determining LPI is the core causal configuration along with track and trace for the positive impact on economic development. For the phase II of the research, terminal operating annual data of the fourteen ports is analysed utilizing ordinary least squares (OLS) with Python as a tool for big data science. The container data amounting to 2.8 million rows was analysed utilizing ordinary least square method and subsequently discussed with port operators through structured interviews. The results shows that continuous track and trace results in the reduced dwell time of the container. The top three ports (A, G and L) were selected based on the lowest RMSE (Root mean square error) 15.6, 15.7, 15.86 % in the phase III of research study for qualitative reasoning.

The prime reasons of free period and gate cut off for cycle (The cut off time before which container must gate in to the port), equipment demand (the demand of equipment 20 feet or 40 feet which is basis the industry in the proximity of ports) and heavy cargo manufacturing for size (the odd dimensional of bulk cargo which can fit in to a specific container size), higher rail frequency, connectivity, sustainability goals and efficient truck docking strategies for mode were identified. Tran shipment ports, along with better pre-inspection clearance steps were few of the major reasons for empty/laden efficient movement. Trade support schemes along with free days due to high competition at CFS (Container Freight Station) were reasons cited by trade for DPD/DPE(Direct Port Delivery/Direct Port Export). The majority of the container which are imported or exported via container freight station have lesser dwell time. A qualitative framework is presented while collating the results from the structured interviews. The research contributed to academia and practice on novel insights of tracking technology impact on the efficiency of container movement and will be of interest to researchers and industry practitioner on evaluating the container movement and operations handling. By continuous monitoring and tracking containers, port operators can manage the shift efficiently leading to the controlled shift timings of operators along with their safety and direct benefits to environment. The varying reasons of dwell time at different ports are presented in the concluding results.

ABSTRAKT

Námořní doprava je nejpreferovanějším způsobem dopravy, který hraje významnou roli v celosvětovém trhu. Námořní přeprava představuje přibližně 80 % celkového celosvětového objemu nákladu. Tato disertační práce je zaměřená na zkoumání faktorů, které ovlivňují dobu zdržení přepravních kontejnerů v námořní dopravě. Tato rešerše se venuje významu implementace systému průběžného sledování a sledování v řízení přepravních kontejnerů. Zúčastněné strany v typickém dodavatelském řetězci kontejnerů zahrnují provozovatele přístavů, lodní linky, přepravce, zasilatele, příjemce, kteří operují v podmínkách sila. Tyto zúčastněné strany se musí spolupracovat prostřednictvím standardizace mechanismu informačních transakcí.

Tato výzkumná práce je rozdělena do tří fází. Pro fázi I je extrahován sekundární soubor dat Světové banky pro klíčové ekonomiky a je provedena fuzzy kvalitativní srovnávací analýza. Toho je dosaženo pochopením dopadu ukazatelů, jako jsou logistické náklady (LC) a index logistického výkonu (LPI) na ekonomický růst (GDP na hlavu). Výsledek fáze I ukazuje, že při určování LPI je hlavní kauzální konfigurace spolu se sledováním pozitivního dopadu na ekonomický rozvoj. Pro fázi II výzkumu jsou roční data provozu terminálu čtrnácti portů analyzována pomocí běžných nejmenších čtverců (OLS) pomoci Pythonu jako nástroje pro vědu o velkých datech. Údaje o kontejnerech ve výši 2,8 milionu řádků byly analyzovány pomocí běžné metody nejmenších čtverců a následně prodiskutovány s provozovateli přístavů prostřednictvím strukturovaných rozhovorů. Výsledky ukazují, že kontinuální sledování vede ke zkrácení doby prodlevy nádoby. Tři nejlepší porty (A, G a L) byly vybrány na základě nejnižší RMSE (Root mean square error) 15,6, 15,7, 15,86 % ve fázi III výzkumné studie pro kvalitativní zdůvodnění.

Hlavní důvody prostoje pro cyklus (čas, před kterým musí kontejner vjet do přístavu), poptávka po zařízení (požadavek na zařízení 20 stop nebo 40 stop, což je základem průmyslu v blízkosti přístavů) a výroba těžkého nákladu pro velikost (lichý rozměr hromadného nákladu, který se vejde do konkrétní velikosti kontejneru), vyšší frekvenci železnic, konektivitu, cíle udržitelnosti a efektivní strategie dokování kamionů pro režim. Přepravní přístavy spolu s lepšími kroky odbavení před inspekcí byly jen málo z hlavních důvodů pro efektivní pohyb prázdný/naložený. Schémata podpory obchodu spolu s volnými dny kvůli vysoké konkurenci na CFS (Container Freight Station) byly důvody uváděné obchodem pro DPD/DPE (Direct Port Delivery/Direct Port Export). Většina kontejnerů, které jsou dováženy nebo vyváženy přes kontejnerovou nákladní stanici, má

kratší dobu zdržení. Při porovnávání výsledků ze strukturovaných rozhovorů je prezentován kvalitativní rámec. Výzkum přispěl akademické obci a praxi k novým poznatkům o dopadu technologie sledování na efektivitu pohybu kontejnerů a bude zajímat výzkumné pracovníky a odborníky v oboru při hodnocení pohybu kontejnerů a manipulace s nimi. Díky nepřetržitému sledování a sledování kontejnerů mohou provozovatelé přístavů efektivně řídit směny, což vede k řízenému načasování směn operátorů spolu s jejich bezpečností a přímými přínosy pro životní prostředí. Různé důvody prodlevy na různých portech jsou uvedeny v závěrečných výsledcích.

ACKNOWLEDGEMENT

I started my PhD studies shortly before the Covid-19 in January 2020, a time marked by numerous challenges and uncertainties. Despite the challenges, I am able to accomplish my thesis with the help of my supervisor, consultant, and the support of all the professors at Faculty of Management and Economics at the Tomas Bata University in Zlin.

I would like to thank my PhD supervisor, prof Tone Lerher, PhD. and my consultant, Ing. Denisa Hrušecká, Ph.D. Their unwavering support, direction, and encouragement have been of immense help throughout the PhD studies. Their support right in the starting from research proposal development to publications, thesis writing, conference participation and many more have been of great support in shaping my research career.

In addition to my supervisor and consultant, I am highly grateful to the professors at FaME. First and foremost, I am grateful for the support of Dean prof. Ing. David Tuček, Ph.D. Extremely grateful to prof. Ing. Boris Popesko, Ph.D., Vice Dean for Research Studies, for his kind support during IGA projects. Extremely appreciative of Vice Dean for Ph.D. studies, Ing. Lubor Homolka, Ph.D. for his consistent support. The support of our department head, Ing. Eva Juřičková, Ph.D., and all of our professors throughout our coursework, publications, and PhD studies., namely prof. Dr. Ing. Drahomíra Pavelková, prof. Ing. Felicita Chromjaková, PhD., and doc. Ing. Roman Bobák, Ph.D., whose encouragement has been a constant source of motivation. The support of Mrs. Martina Drábková for continuous communication, administration and coordination with Research and Professional Procedures Office for ensuring that our PhD is on track with respect to documentation and processes is highly appreciated. As a foreigner, I greatly appreciate Mrs. Pavla Bartošová, Mr. František Brázdilík for assistance with visa renewal and support in MOI. Multiple departments, including conference travel, DOKBAT, finance, Erasmus mobility team and IT, have colleagues who helped us throughout PhD studies. All the colleauges at Faculty of Logistics, University of Maribor, Slovenia supported me a lot in research and data coding.

At this time, I would also like to remember and express my gratitude to the late prof. Ing. Rastislav Rajnoha, PhD. for his assistance throughout coursework. He is deeply missed and may his soul be resting in peace with God.

Lastly, I would like to express my gratitude to my father, mother, sister, wife, and daughter for their belief in my abilities and support. Many thanks for everything everyone.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

1. INTRODUCTION

Ocean shipping containers are the primary storage equipment of choice for ocean transit and movement. A variety of container types are transported in the marine transportation such as general-purpose, reefer, dry, oil, and tank containers. According to research , a significant proportion of global trade, specifically 80% by volume and 30% by value, is facilitated through the utilization of these containers, (Muñuzuri et al., 2020) (UNCTAD, 2018) These numbers are expected to further rise due to the expansion of economies and the process of globalization, (Fruth & Teuteberg, 2017). The cross-border cargo transportation sector, currently valued at USD 10.9 billion in terms of industry capitalization, is seeing a steady growth rate of 8.5%, as depicted in Figure 1. This phenomenon will lead to an increase in the quantity of containers being transported, thus resulting in a significant surge in both the volume and traffic of containers at seaports for handling purposes. According to a research, India, as an emerging country, has experienced a significant increase of 30% in container volume during the period of April to October 2021 (Sam & Whelan, 2021). This rise has consequently led to an escalation in freight rates.

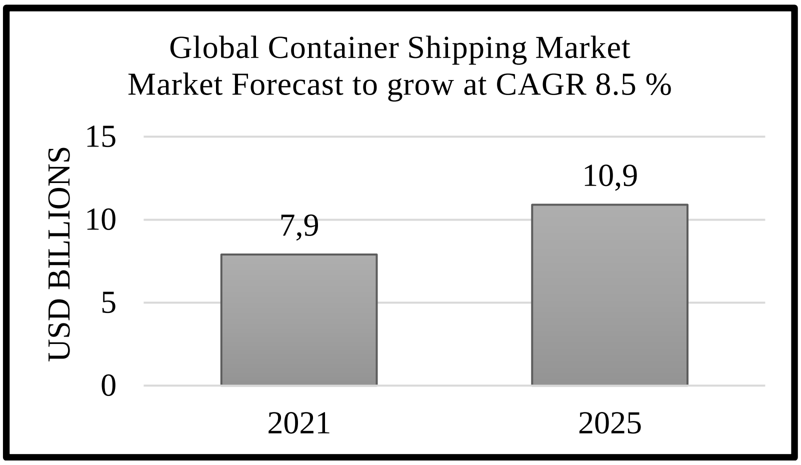


Figure 1 : Container shipping market global (Research and Markets, 2021)

The operational processes involved in container management at different ports worldwide is distinct and unique. The handling of containers involves a range of activities, which are inherently complex due to the large volume of containers involved. The primary containers utilized for global trade are the twenty-foot and forty-foot containers. These containers have the capacity to accommodate cargo volumes ranging from a few grams to 15,000 kilograms. Efficient handling of such substantial container and freight necessitates the utilization of specialized material handling equipment and information technology systems. Therefore, it is imperative to thoroughly research and analyse the intricacies and nuances of container handling operations. The series of activities encompassing vessel berthing to gate out encompasses a range of activities that contribute to the calculation of dwell time. This doctoral thesis researches within the broader scope of the research community and practical application for reasons behind different dwell time at the ocean container ports.

The container handling procedures encompass a range of intricate activities, such as dock crane operations, customs examination, mobile and fixed container scanners, and yard operations. These procedures involve the utilization of diverse handling equipment’s. The temporal limitation associated with each of these operational processes causes the dwell time to be different at different ports. It is also a contributing factor to the duration that a container remains at a given port. Based on the previous researches, it has been established that examination, scanning, and optimal timing are significant factors that contribute to dwell time during the import journey.

The objective of this thesis was to investigate the variability in dwell time and time duration by examining the diverse aspects associated with container specifications. Figure. 2, illustrates the duration of container stays at the prominent ports in India. It is evident that there exists variation in dwell time across ports, even when considering standardized container sizes and handling equipment. The investigation of a significant variation in stay time, spanning from 24 to 72 hours, is of utmost importance.

Port	**Average Import Dwell time (In hours)**
1	39
2	27
3	28
4	26
5	73
6	56
7	23
8	64
9	84
10	58
11	44
12	90
13	32

Figure 2 : Dwell time at major port of India, (Sagar Mala, 2016)

Figure. 2, illustrates the significant variability in the duration of container dwell time at the major ports in India for the import journey for the time period 2019-2020. The similar variation is also evident at the prominent international ocean ports, as depicted in Figure. 3. The primary objective of this doctoral thesis was to evaluate the import and export procedures implemented at the major ports in India, with a specific emphasis on the time taken from the arrival of vessels to the completion of gate out processes.

This doctoral thesis made a unique and valuable contribution to the academic and practice by understanding the various factors and elements that influence shipping container dwell time, with a particular focus on the role of tracking technologies. The qualitative examination of factors influencing stay duration was be conducted through structured interviews with port operators.

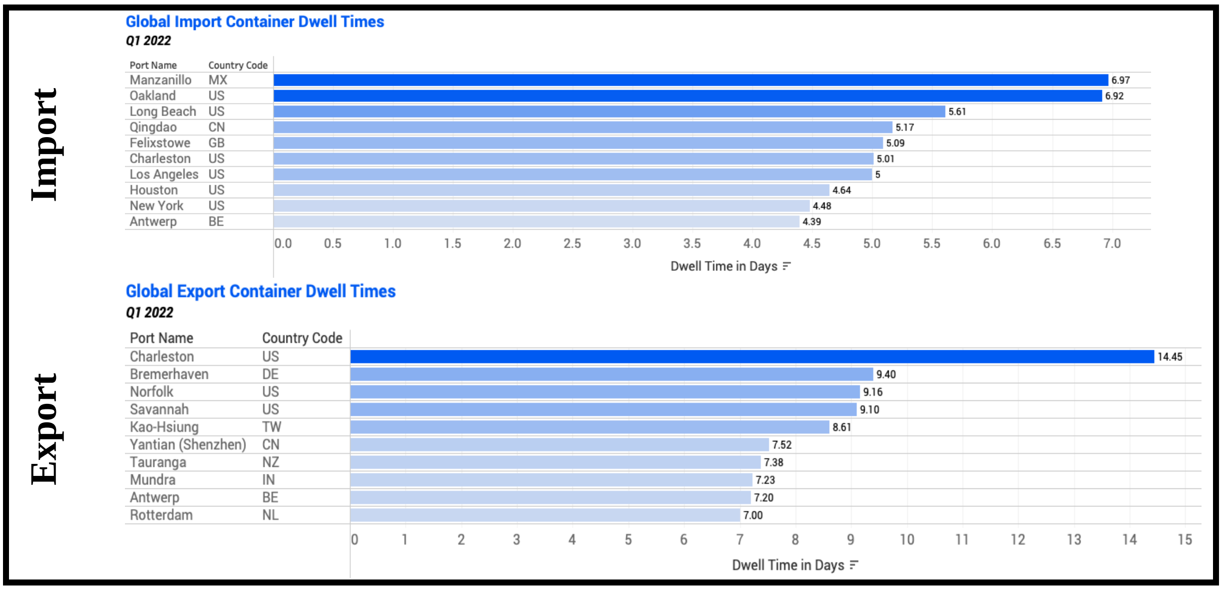


Figure 3: Dwell Time comparison at Global Ports(Cooke James, 2022)

The single window system, as defined by the United Nations Centre for Trade Facilitation and E-Business (UN/CEFACT), refers to a comprehensive service that enables all relevant stakeholders in the container trade and ocean transportation to exchange the data standardization and shipping documents in a prescribed sequence, thereby facilitating the completion of all necessary import and export procedures. The advancement of technology and security protocols in the context of data interchange within the shipping sector is predicated on the utilization of a model build, which aims to redefine the process of tracking and tracing between operators in the container supply chain (Transmetrics, 2021).

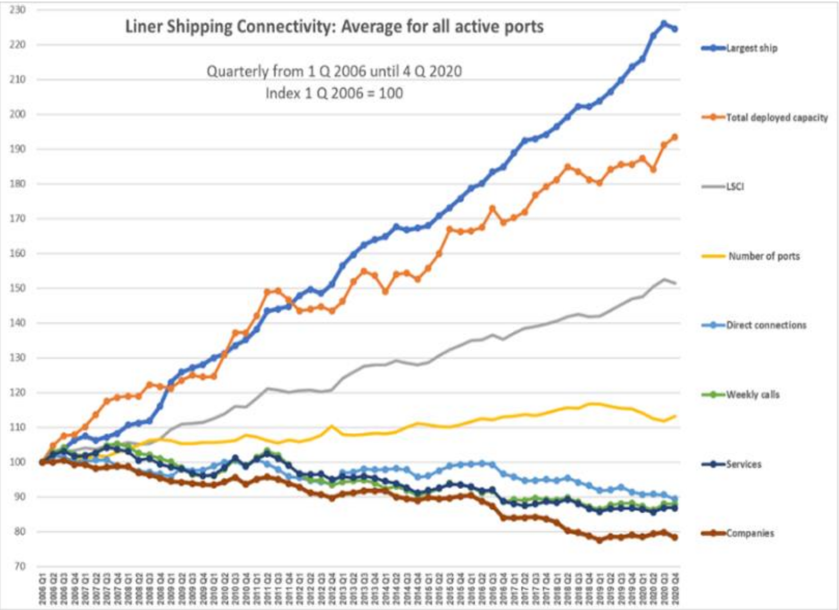
Various researchers have highlighted the importance of multitude criteria's that contribute to the definition of port performance. Performance indicators such as vessel operations time, port throughput, waiting times of truck at the port, dwell time of container, vessel berth in to berth out time, productivity of labour, vessel turnaround, vessel waiting time, and container dwell time have been utilized in previous studies to assess port productivity, (UNCTAD, 1976) (MONIE, 1987) (Tongzon, 1995) (Brooks, 2006) (Nicoll & Nicholson, 2007). Additionally, other indicators of a similar nature, such as the manpower skillsets, stevedoring, loading and unloading of cargo, turnaround times, shipment timeliness of maritime services, (Marlow & Casaca, 2003) This doctoral thesis outline aimed to assess significant logistical performance factors, including LPI and TT, as well as port performance criteria such as dwell time, these parameters were examined for research purposes, as depicted in Table 1.

Table 1: Important researched parameters (Source: Own Research)

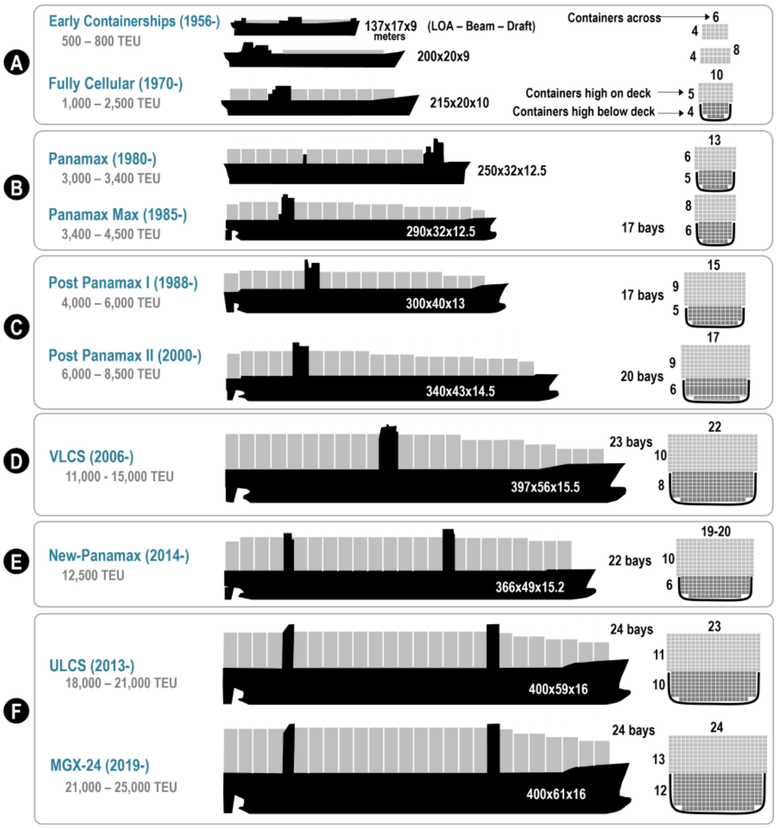
Logistics Performance Index (LPI)	**Tracking and Trace**	**Dwell Time**
The Logistics Performance Index (LPI) is an interactive benchmarking tool created by the World Bank to help countries identify the challenges and opportunities they face in their performance on trade logistics and what they can do to improve their performance (World Bank, 2023)	The ability to track and trace consignments.(World Bank, 2023)	Container dwell time is defined as the periodcontainers stay at the terminal(Mwasenga, 2012)

1.1 Motivation and need for the research study

The size of vessels transporting containers is progressively growing, while the availability of land and space for operations remains constrained or same in size/area. Therefore, it is crucial to implement measures that enhance the efficiency of container handling and streamline operational processes. Figure 4, illustrates the correlation between the average ship size accommodated at the port and the duration in years. This observation demonstrates that the dimensions of vessels are expanding while the available area for port operations remains constant. Therefore, it is imperative for a container port terminal to use optimization strategies in order to ensure the provision and effective management of efficient processes.



Source : (Hoffmann & Hoffmann, 2021)
X – Axis Trimester in years, Y-Axis : Average Size of ship per port



(Rodrigue Jean Paul, 2022)

Figure 4 Average Vessel Size per port at a given trimester and vessel size over a time period

Based on the aforementioned information, and Figure. 4, the optimization of container handling must be achieved through the effective utilization of operating space and the implementation of processes that take into account the following factors:

1. Port infrastructure, such as berth areas, cranes, technology.
2. Lean efficient processes and space optimization.
3. High Investment for expanding the space/land area.
4. Environmental Impact (Saini et al., 2021)

1.2 Reshuffle and Dwell Time

The process of container reshuffling and rehandling is an unavoidable aspect of storing and stacking inbound and outbound containers. The yard operations face numerous cost and efficiency issues as a result of the intricate movement caused by irregular and unscheduled demand, as well as the stacking of container up to multiple tiers. The primary operators of container terminals on a global scale are responsible for managing multiple terminals simultaneously. The research community has conducted studies on different solutions aimed at minimizing container rehandling when stacking containers. In recent years, there has been a growing quantum of researches focused on investigating the correlation between dwell time and container reshuffling.

The role of a container terminal operator can be broadly defined as managing open systems of material flow that involve two external interfaces. The interfaces in question encompasses the quayside, which facilitates the loading and unloading of ships, as well as the landside, where containers are transferred to and from trucks and trains. According to research, the utilization of stacks for storing containers enables the separation of quayside and landside operations, hence aiding the decoupling process (Steenken et al., 2004). Figure 5 illustrates the schematic representation of a container terminal operator.

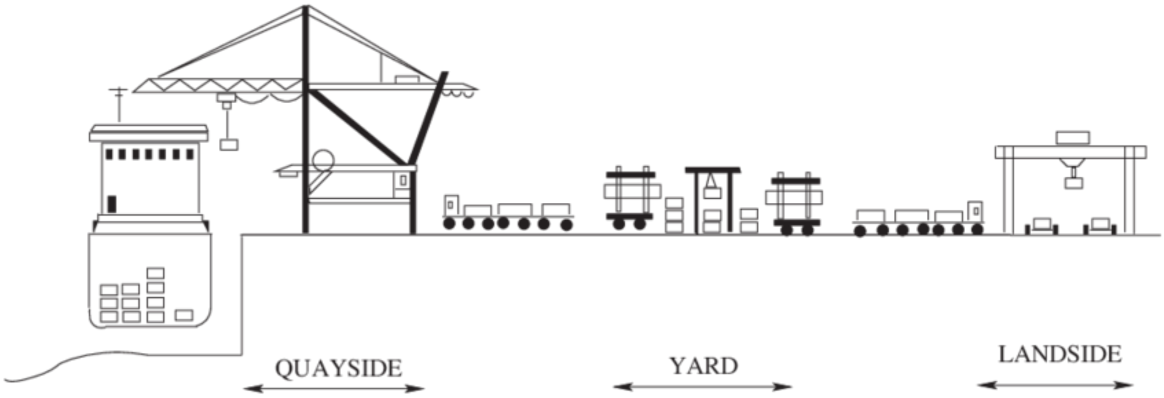


Figure 5 Container Terminal Schema,(Monaco et al., 2009)

During the process of allocating yard storage locations, the operator systematically arranges each section of storage and retrieval into distinct blocks. Figure. 6, depicts the comprehensive blueprint of a standard yard configuration. A block can be defined as the fundamental unit of storage space for a collection of containers. Each block of a certain length and breadth is associated with a predetermined number of bays, which represents the maximum number of containers that can be vertically stacked within it.

Terminal operators often employ the practice of multi-level stacking as a storage solution to effectively address the limited availability of storage capacity. Nevertheless, the act of stacking containers at a higher level necessitates an increased amount of rehandling and reshuffling, resulting in additional operational costs and time requirements. This, in turn, contributes to congestion as containers await storage and retrieval. A strategy based on residence time was employed to arrange containers in the appropriate priority order, ensuring that containers with lower priority are not stacked on top of those with greater priority(Serban & Carp, 2017).

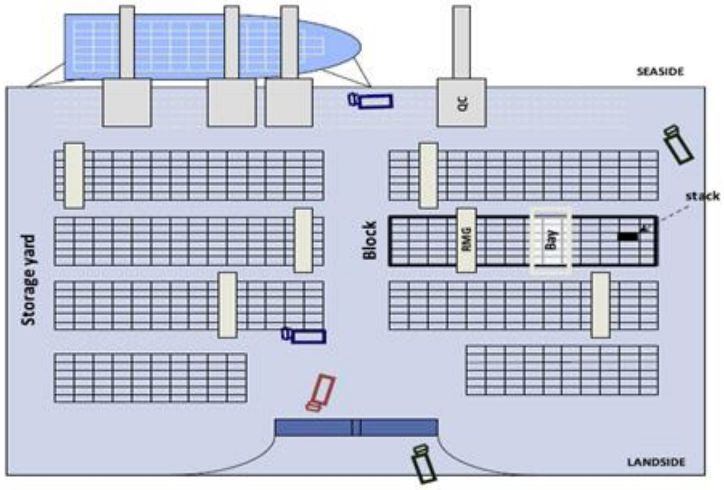


Figure 6 Container yard layout(Sauri & Martin, 2011)

Table 2, presents a brief overview of the research steps undertaken in this doctoral thesis to investigate the factors that influence shipping container dwell duration. This section of the doctoral dissertation highlighted the significance of the maritime sector as a pivotal form of transportation within the confines of the logistics sector. The presence of a diverse range of intricate operational processes at ocean ports contributes to the occurrence of delays in container lead times. The expansion of vessel size has led to limitations in container operations due to the availability of space at ports. Consequently, it is crucial to identify the factors contributing to variations in dwell time and to optimize delays in order to enhance performance efficiencies. This chapter primarily examines the difficulties within the maritime sector that contribute to variations in stay duration. These complexity include factors such as the type of operations, reshuffling and relocation processes, quay crane operations, and yard operational procedures.

Table 2: Summary of research analysis process and steps (Source: Own Research)

Research Objective	Method	Model	Tools
To establish the importance of logistics and track and trace technology	Qualitative	Causal configuration	fsQCA 3.0 fuzzy qualitative comparative analysis
To understand the impact of various variables of port operations such as, (*i*) Cycle, (*ii*) Size, (*iii*) Mode, (*iv*) Status, (*v*) DPD/DPE (*vi*) Tracking Technology	Quantitative	Ordinary Least Squares	Python for Data Science and SPSS
To understand the various reasons of the variation in container dwell time and qualitative reasoning	Qualitative	Qualitative framework	Qualitative coding technique

This research was designed to clarify the primary factors contributing to variations in dwell time across different locations within port operations in India. The study primarily aimed to ascertain the significance of the logistics sector through the implementation of a pilot study employing fsQCA (Fuzzy qualitative comparative analysis). This preliminary investigation established the groundwork for further research by comprehending the significance of the logistics sector in relation to economic development. The Logistics Performance Index (LPI), which was created by the World Bank, serves as a tool for evaluating and ranking economies according to their logistical capacities.

The provided index functions as a great instrument for understanding the importance of logistics. The subsequent evaluation of the track and trace component, which constitutes one of the factors of the logistics performance index (LPI), aims to comprehend its significance and pertinence. The subsequent stages of the research investigation were centred on assessing the influence of diverse components that have an impact such as (*i*)Cycle-Import/Export, (*ii*)Size-20 feet/40 feet, (*iii*)Mode-Truck/Rail, (*iv*)Status-Empty/Laden, (*v*)Delivery-DPD/DPE(Direct Port Delivery or Direct Port Export) ,(*vi*)Tracking Technology Availability -Yes/No, on the container dwell time. The data analysis process involves the application of the statistical technique known as ordinary least squares, which was implemented using Python programming language for handling large datasets, as well as SPSS software. During this phase, the data pertaining to multiple ports in India was subjected to analysis. Subsequently, the top three ports were chosen for qualitative reasoning, based on the criterion of having the least root mean square error.

In the concluding phase of the research, interviews were undertaken with key stakeholders representing the three ports with lowest root mean square error. The objective of conducting these interviews was to get valuable insights into the various reasons that contribute to the variation in container dwell time, observed among the several ports in discussion. This research study is of great importance to both the academic and practical realms, since its objective is to provide a clearer understanding of the factors that contribute to the variability in container dwell time. This enhanced the potential for collaboration between port operators and academia in conducting research on methodologies pertaining to container operational planning and establishing standards for container performance.

This doctoral thesis aimed to assess the factors that influence port operations, with a specific focus on continuous tracking and tracing, and their impact on the dwell time of shipping containers. The problem definition highlights the significance of investigating the collective influence of LPI (Logistics Performance Index) and LC (Logistics Costs) on economic development, as well as the presence or absence of tracking technology on shipping containers. This research is crucial for comprehending the various aspects that contribute to the port performance. This research thesis made a unique contribution to the existing literature by examining the effects of economic and technological factors on container dwell time. This research employed a mixed methodology, encompassing both quantitative and qualitative elements, to examine the impact of Logistics Performance Index (LPI) and Track & Trace systems on economic development. The research community faces a challenge in accessing datasets due to their limited availability, (De Armas Jacomino et al., 2021).

2. THEORETICAL FRAMEWORK

The logistical sector plays a crucial role in facilitating economic growth and exerting substantial effect on several economic sectors, such as ports, infrastructure for transportation, storage facilities, and systems for information and communication, within the subject matter of supply chain management. The establishment of this sector towards becoming a significant component in the development of industry, trade and economy is widely acknowledged. The advancement of the logistics industry plays a pivotal role in facilitating significant transitions in the functioning of businesses and economies, particularly with regards to investments in logistics. Investments of this nature are undertaken within many subsectors of the logistics industry, including ports, warehouses, infrastructure, technology, and standardization. This chapter will provide an overview of the theoretical study conducted on the topics of Logistics Performance Index (LPI), economic development, and Port performance factors, specifically focusing on Dwell time.

2.1 Logistics Performance Index, Ease of doing business and Economic development in research studies

Given the significance of the logistics sector, the World Bank has periodically released a comprehensive Logistics Performance Index (LPI), which assesses economies based on six characteristics, with updates occurring every two years. Numerous economies have achieved economic growth through the strategic expansion of their export-oriented industry activities. The significance of export success is particularly notable in developing economies, which is important for the development of logistics sector(Ruzekova et al., 2020). In their research of specific Asian countries, the authors highlighted a positive correlation between trade liberalization and growth in the economy(Sriyana & Afandi, 2020). In this research it was concluded that, it is imperative that favourable logistics conditions and robust infrastructure are in place to facilitate and sustain the level of trade openness.

The Logistics Performance Index (LPI) acknowledges the strong association and significant impact that exists between the transportation and logistics industry and the development of the economy. The Logistics Performance Index (LPI) was first created by the World Bank in 2007 with the purpose of evaluating and classifying economies according to their performance in the field of logistics. This index and technique are utilized to analyse and measure global economies in relation to one another based on six distinct factors. In a study, the authors examined the significance of logistics from the perspective of importers and exporters in 26 European Union (EU) nations(Puertas et al., 2014). The findings of the research indicated that logistics competence and tracking have emerged as significant determinants within the confines of the Logistics Performance Index (LPI). The LPI (Logistics Performance Index), is a standardized measurement tool used to evaluate and compare countries according to six separate factors, as specified in Table 3.

Table 3 Components of Logistics Performance Index,(World Bank, 2023)

Customs	Efficiency of customs and border management clearing.
Infrastructure	Quality of trade and transport infrastructure.
Logistics competency	Competence and quality of logistics services.
Timeliness	Shipments delivering to within expected delivery times.
Tracking and Tracing	Ability to track and trace consignments
International shipments	Ease of arranging competitively priced shipments

The LPI database is released biennially and has been published for a total of six cycles to date, specifically in the years 2007, 2010, 2012, 2014, 2016, and 2018, 2023. The LPI index is derived from a survey that utilizes a questionnaire to assess respondents' evaluations of eight international markets based on the six fundamental components of logistic performance outlined earlier. The respondents provide ratings using a five-point Likert Scale. In this scale, 1 represents low degree and 5 indicates a very high degree. Subsequently, Logistics performance index is formulated by the application of Principal Component Analysis (PCA), a widely employed statistical methodology. The result obtained by Principal Component Analysis (PCA) is a calculated value that represents a weighted average of scores, similar to the LPI indicator. The reference provides a comprehensive explanation of the approach employed in the LPI, offering a thorough examination and comprehension of the subject matter(World Bank, 2023)

According to another research, the improvement of logistics performance requires the adoption of many measures, such as the development of infrastructure, regulatory enhancements facilitated by the government, the usage of technological innovations, and the development of competent manpower(Jhawar et al., 2017). In order to address this issue, it is imperative for governments to effectively oversee and comprehend the prevailing logistics landscape inside their respective countries. This necessitates the establishment of comprehensive frameworks aimed at optimizing and advancing logistical operations through the implementation of policy reforms.

In a research study, the authors aimed to investigate moderating effect of the GCI (Global Competitiveness index) on the LPI. The results of the research indicated, enhancing the components of logistics performance index such as international shipments, Tracking and Timeliness can lead to the developments in global competitiveness (GCI) (Çemberci et al., 2015). Another research in this dimension explored the integration of the Logistics Performance Index scoring and EPI (Environment Performance Index) scoring while establishing carbon efficient system of green logistics index (Kim & Min, 2011). This novel index yielded a rating that diverged significantly from both the LPI and the EPI rankings. In their study, the authors conducted an evaluation of the logistics performance of countries of the Organization for Economic Cooperation and Development (OECD) by adopting the tool Fuzzy(Yildirim & Adiguzel Mercangoz, 2020).

A research study investigating the relationship between variables infrastructure of the GCI (Global Competitive Index and the LPI (Logistics Performance Index) (Erkan, 2014).The infrastructure components employed GCI encompass the road quality, supply chain value, research and development budget, infrastructure of the ports, air transport. The method of regression analysis was adopted in determining the statistical significance of the Logistics Performance Index score and its respective indicators. The results demonstrated that out of the six characteristics examined, namely Port Infrastructure quality and road development infrastructure infrastructure and quality of road infrastructure, had a statistically association with the overall LPI score.

Another research conducting further study on the correlation between doing business rating, GDP, and other variables that were not previously considered in the analysis. The authors recommended replicating the study to find any emerging trends (Estevão et al., 2020). Hence, it was crucial to conduct comprehensive research to determine to assess the significance of the LPI and the logistics cost in order to determine their respective roles.

According to a survey, an investigation was carried out to examine the many metrics that are taken into account when assessing logistics expenses (Supply Chain Digest, 2006). The findings of a study including 247 participants demonstrate that logistics costs may be classified into three distinct categories: (*i*)Logistics cost as a proportion of net sales, (*ii*)Logistics costs as a proportion of absolute cost, and (*iii*)Logistics costs as a proportion of gross domestic product. The research also demonstrated; the measurements of a firm cannot be directly related to the macro level. Therefore, assessing the cost of logistics presents difficulties and challenges owing to the intricate and multifaceted nature of logistics activities (Farahani et al., 2009);(Havenga, 2010).

Figure 7, presents a comparative analysis of the LPI parameters, logistics cost, and economic development among prominent economies in Asia, Europe, the United States, and the United Kingdom.

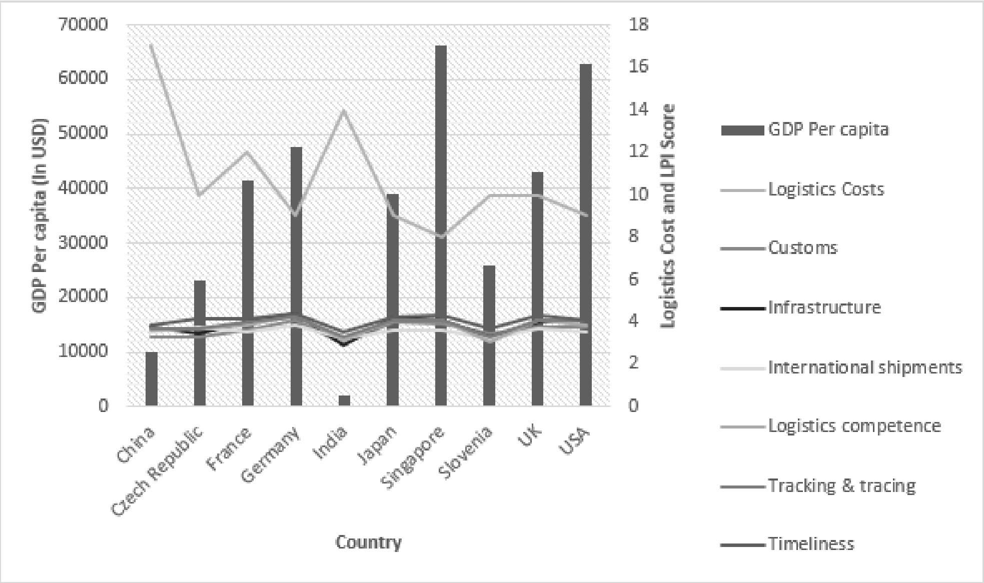


Figure 7 Comparison of Logistics performance index parameters, logistics cost and economic development(Saini & Hrušecká, 2021b)

The ease of doing business index assesses performance of the economies and its regulatory performance over a specific timeframe. Assisting economies in comprehending the disparity between their respective economies and the highest-performing economies within the sample of business practices(World Bank Group, 2020) proves to be beneficial. The primary aim of the ease of doing business index is to facilitate the evaluation of the overall effectiveness of regulatory measures. The process involves comparing the regulatory performance of individual economies to that of the top-performing economy, as determined by the evaluation of each economy's ease of doing business indices.

This tool can be considered as a comparable indexing mechanism to LPI. It undergoes evaluation based on twelve distinct parameters, which encompass initiating a business, navigating construction permit procedures, accessing electricity services, registering property, availability of credit, safeguarding the interests of minority investors, fulfilling tax obligations, engaging in cross-border trade, enforcing contractual agreements, resolving insolvency cases, employing workers, and entering into contracts with governmental entities (World Bank Group, 2020).

The assessment of business environment and economy, including rankings such as ease of doing business and logistics performance index, encompasses a diverse range of intricate factors. Hence, it is crucial to do a comprehensive study to assess the multifaceted effects of economic development. The analysis of research studies is currently undergoing a shift in focus within the realm of secondary research indicators, specifically towards the ease of doing business index as presented by the (World Bank, 2019). The relationship between foreign direct investment (FDI) flow and the business climate has been examined in several additional research, studies (Morris & Aziz, 2011). These studies have explored this relationship by establishing correlations between the ease of doing business (EODB) and FDI.

A research conducted a study examining the impact of Ease of Doing Business (EODB) on the economic development and growth of several Asian economies (Ani, 2015). Based on the analysis of GDP, it was determined that Singapore exhibited the most favourable indicators associated with economic growth. A comparative analysis was conducted on a total of twenty-nine economies across Asia, South East and East Asia continent. While Singapore had strong performance across several positive metrics, it is noteworthy that China exhibited the highest level of economic growth as assessed by several aspects of the Ease of Doing Business (EODB) index. In their study, a revaluation of the Ease of Doing Business (EODB) metric using a methodology that incorporated a weighted approach to account for the benefit of doubt, (Rogge & Archer, 2021). The researchers conducted an evaluation of the modifications made to the version spanning from 2010 to 2019. Their findings indicated significant variations in the Ease of Doing Business (EODB) both across different regions and within them.

The researchers employed a clustering technique to group the various locations and subsequently assessed the performance of the Ease of Doing Business (EODB) metric across these distinct regions. The topic of ease of doing business has been examined in numerous other scholarly works. However, it is worth noting that these studies tend to focus on a single variable in their analysis, (Corcoran & Gillanders, 2015). In another research, a study that examined several approaches to assessing the impact of FDI (Foreign Direct Investments) on growth of the economy within paradigm of globalization, (Tvaronavičiene & Ginevičius, 2003). A novel index was built to assess sustainable development goals (SDGs) by benchmarking against various other measures, including EODB and FDI inflows across twenty-three states of India. The authors identified a strong relationship between SDGs and EODB through econometric analysis, (Ghosh et al., 2019).

Chapter 2.1 of the theoretical review emphasizes on a detailed review of the literature pertaining to the significance of logistics and the various indices that surround the research in this field of study. The World Bank's index is predominantly examined by scholars in the academic community. However, research on this index is often confined to the analysis of individual economies, and there is a lack of comprehensive studies that consider the interplay between this index and other influential factors, such as the ease of doing business. The investigation of the logistics industry, encompassing considerations of costs and efficiency, holds significant importance within the research community. The purpose of this theoretical review in relation to the PhD thesis is to examine the significance of logistics competency, logistics cost, and the sub-parameter of LPI in influencing economic development. The significance of this lies in its ability to encompass a wide range of dimensions for research across many disciplines and sectors.

2.2 Dwell time and Reshuffle as port performance parameter

The act of moving a container in an unproductive manner, with the intention of accessing another container stored beneath it, is commonly referred to as reshuffling or rehandling. The main objective of the container stacking strategy is to minimize the frequency of reshuffles, hence improving the efficiency of terminal operations (Güven & Türsel Eliiyi, 2019). The issue of reshuffling is a persistent challenge that arises when transferring shipping container between different vessels, ports, and container yards. The intricate transportation of containers within the supply chain, coupled with the implementation of space optimization measures by stakeholders, enables the stacking of these containers to a maximum of four or six tiers. The development of models aimed at minimizing reshuffles is of significant importance, as such reshuffles incur additional load due to unnecessary motions and result in time loss and additional cost. Container terminal operations are governed by two crucial factors: the speed at which vessels are turned around and the minimal amount of time containers spend on the yard.

The competitiveness of these criteria is highly pronounced in various terminal operator ports, making it crucial to undertake a comprehensive analysis and research on this reoccurring issue at container yards. In a research study, the container stowage plan with the specific objective of minimizing the need for container reshuffles was extensively researched (Imai et al., 2006). In another research, the authors highlighted the significance of storage locations for inbound containers, with a focus on minimizing the utilization of yard cranes in order to reduce rehandling in yards (Han et al., 2008). The authors demonstrated the effectiveness of mixed integer programming in conjunction with numerous heuristics for optimizing the allocation of storage places in order to decrease the occurrence of shuffling(Wan et al., 2009). In another study various models and heuristics to determine that internal reshuffling within a vessel results in a reduction of vessel handling durations when integrated stowage planning and operations planning are utilized(Meisel & Wichmann, 2010).

In their study, authors devised a set of guidelines for online container stacking, taking into consideration factors such as container departure time and the closeness of containers to entry and exit points(Borgman et al., 2010). The stacking process was further examined in relation to the timing of truck arrivals and departures, with the aim of minimizing the number of reshuffles that occur within the yard(Zhao & Goodchild, 2010). Researchers employed a method known as multistart method to address the allocation of berth and stacking problem of shipping containers(Salido et al., 2011). The methodology employed for determining berth allocation for container stacking was based on heuristic techniques. In a study, the author investigated several storage policies for optimizing the efficiency of quay cranes(Guldogan, 2011). Additionally, a simulation model was developed to assess the performance of the container port.

In their study, the researchers investigated domain-specific heuristics in order to develop an artificial intelligence (AI) technique for effectively addressing stacking of shipping container pertaining to a given set of outgoing containers (Rodriguez-Molins et al., 2012). A flexible space sharing technique that takes into account uncertainties and explores the potential integration of modes with real-time operations in order to effectively control rehandling (Jiang et al., 2013). In another study, a decision tree-based heuristic was employed to determine that shared stacking policies exhibit significantly superior performance compared to dedicated stacking policies(Gharehgozli, Amir Hossein et al., 2014). A novel stochastic dynamic programming model was established, employing decision tree heuristics, with the aim of devising effective stacking policies to address reshuffling problems of considerable magnitude. A polynomial time heuristics model for internal reshuffling was proposed for reducing reshuffling(Liu et al., 2015). This model serves as a complementary approach to double quay crane techniques, aiming to enhance efficiency at a significantly lower cost compared to the previous model developed by another research conducted by (Tang et al., 2015). Liu et al. achieved this by eliminating column relationship variables and introducing a novel heuristic that effectively rationalizes both static and dynamic reshuffling.

The development of a modified model, which addresses the Time-discretized Container Positioning Problem(CPPTz) with z-coordinates was proposed by, (Ahmt et al., 2016). This model offers a novel method to tackling the container positioning problem. A mixed integer programming approach was employed to implement the just-in-time model, with a rolling time horizon, in order to minimize the need for reshuffling containers. Another research conducted a study on truck appointment systems and utilized stochastic dynamic programming to compare the effectiveness of estimates reshuffling index and random selection methods within a specified time window(Ku & Arthanari, 2016). The findings of their research suggest that the estimates reshuffling index approach outperforms the random selection method in terms of efficiency and effectiveness.

In a research study, comparison was made between ship stowage plans, taking into account both stability and internal reshuffles(Zhang & Lee, 2015). A novel model was proposed that utilizes heuristics to estimate the reshuffling derived from historical models(Gharehgozli, Amir et al., 2017). The model specifically focuses on three factors, which were the probability of delay, the reshuffles that occur in the event of a delay, and the call size associated with the delay. A research study assigned priority levels to containers in order to facilitate efficient stacking and reshuffling processes(Serban & Carp, 2017). The proposed design places a higher priority on the arrangement of containers in order to minimize the need for reshuffling containers and shorten the time required by vessels. An analysis of a container sequencing method, specifically examining the factors of tier number, weight, and allowable bay utilization(Guerra-Olivares et al., 2018). Their findings indicate that horizontal-based techniques outperform vertical-based strategies in the context of monitoring reshuffles. In another research study an analysis to find the optimal timing for container transfers for reducing the container relocation operations was proposed (Scholl et al., 2018).

A mathematical model that incorporates a dynamic version of heuristics was proposed by for reducing rehandle movement and the sequence(Guerra-Olivares et al., 2018). This model aims to determine a lower bound for the number of rehandle movements based on the given arrival sequence of container data. The authors assessed the effectiveness of the storage yard in achieving an optimal online assignment of arriving export transit, import, or empty containers(Güven & Türsel Eliiyi, 2019). In their study (He et al., 2020) conducted an analysis to determine the influence of incomplete vessel information on container stacking. Their findings revealed a significant correlation between the availability of vessel information and the occurrence of reshuffles. The study examines the impact of missing information on container stacking by categorizing information into discrete levels and exploring various scenarios.

In this sub chapter an illustration on research conducted on reshuffling and rehandling is observed. Many researchers have expressed the importance of reducing reshuffle to optimize operations and increase efficiencies. There are few research studies which have directly correlated the time spent by a container due to reshuffling and relocation. The main objective of illustrating on various researches performed in this section was to understand, the various facets of operations which can cause the higher dwell time. For example, few researches emphasized the prior information on truck arrival time can reduce reshuffle. Thus, a tracking device will be of paramount to get this information accessed in advance. The gate out time, the size of containers, all of them play a pivotal role in reducing reshuffles. These will be the important variables which are evaluated in this doctoral thesis.

2.3 Dwell time in research studies

The duration of time that cargo or vessels spend at a terminal, commonly referred to as dwell time, is a crucial factor in assessing the effectiveness of operations and the overall capacity of the port. The growing magnitude of global trade and container volume necessitates effective yard management by yard managers in order to optimize terminal efficiency(Chu & Huang, 2005). Given the substantial growth in the cargo volume, the available options are constrained to either expanding operational processing area, or requires a significant investment in acquiring additional land acquisition, or enhancing operational efficiency to minimize dwell time and thus lessen the need for rehandling and reshuffling movements. Container terminal operators are actively working towards minimizing the dwell time of containers by identifying the variables that contribute to its increase, hence reducing dwell time of shipping. In a research study , a framework was developed with the aim of providing guidance to the operators of the ocean container terminals about price structure and tariff for the quanta of time a container stayed in the terminal(Merckx, 2005). Various stakeholders in the container supply chain including forwarding enterprises, shipper and consignee’s often store their cargo within a container yard of freight depot until the need for their utilization arises in the production process(Rodrigue & Notteboom, 2008).

In a research study, a correlation was demonstrated between extended container stay periods and an increase in unproductive motions(Huang et al., 2008). These factors have a detrimental impact on the efficiency of a terminal, hence demonstrating its cost inefficiency. According to a research, the study identifies several key factors that have an impact on dwell time. The determinants include the geographical location of the terminal, the effectiveness of its operation, the regulatory frameworks governing port operations, the protocols followed by customs authorities, the involvement of freight forwarders or shipping firms, the accessibility of inland transportation links, the chosen mode of transport, the nature of the cargo being transported, and the established commercial affiliations among the stakeholders (Moini et al., 2012).

The research employed genetic algorithms as a methodology to assess the primary variables influencing container dwell time and quantified their influence on terminal productivity. One area that has been identified as a potential focus for future research is the collection of data pertaining to landside activities and the nature of the items being transported. The inclusion of this supplementary information is anticipated to improve the capacity to forecast outcomes using the suggested models. An additional significant result of this research investigation involved the establishment of a correlation between gate operations and berth operations at a maritime container terminal through the utilization of analytical and simulation methodologies. In their study (Kourounioti et al., 2015) put forth a methodological framework aimed at integrating various models for the purpose of predicting the dwell duration of containers within a maritime terminal. This framework incorporates a regression model that specifically examines the impact of the consignee of the shipping container and the content of container along with commodity on the dwell time.

Another research conducted by (Zhao & Goodchild, 2010), emphasizes the significance of information pertaining to container discharge and tracking. The researchers employed a model simulating impact of advance information on the operational planning and efficiency for the container terminal. The study's findings demonstrate that having prior knowledge of truck arrival or departure information contributes to a decrease in unnecessary movements. The existing body of research and literature on the factors influencing dwell time, reshuffle, and rehandle is currently limited. However, conducting further research on these parameters, particularly in conjunction with tracking information on container pick up or discharge, will greatly enhance the effectiveness of operational level terminal planning. In their study, (Nooramin et al., 2011), examined the impact of truck congestion time and the reduction of waiting time at terminals on overall efficiency. They focused on a specific aspect of the process in order to assess its effectiveness. Figure 8 depicts the process-wise complexity model, which establishes a relationship between process efficiency and the perspectives of time and complexity.

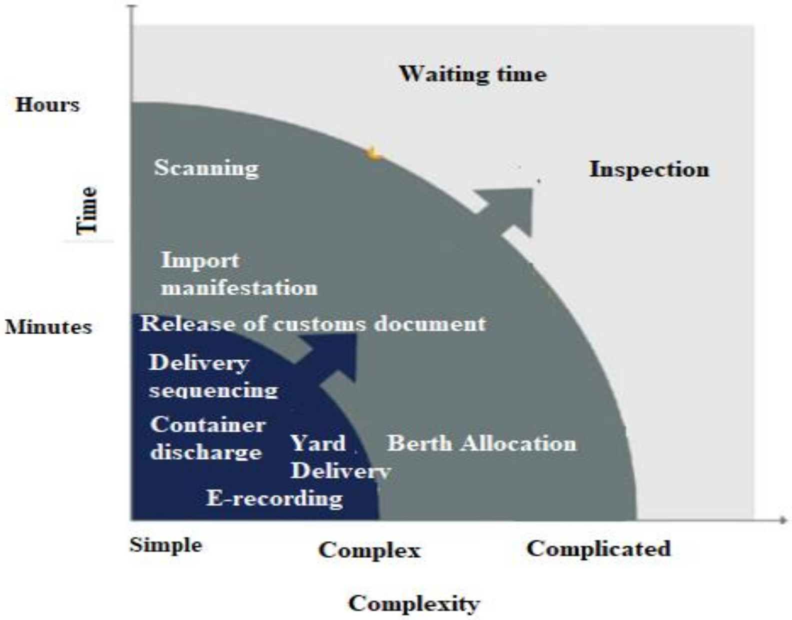


Figure 8 Time Complexity Model, (Saini et al., 2021)

The port management highlighted the challenges for the quay cranes operations for the throughput and moves per hour for container processing. The cranes are performing thirty to thirty-two moves per hour for the container operations. These operations are significantly impacted due to the congestion of truck at the gate and the yard side. According to a study by, (Saini et al., 2021), the port operator in a range of advanced planning techniques for the bay planning and the stowage plan of the berthing vessel. These strategies take into account factors such as the cumulative weight of the stacks, the sequence of loading, and the weight of the container. The presence of several stakeholders leads to various complex challenges, resulting in further inefficiencies in the operations.

Table 4 Summary of dwell time literature review (Source: Own Research)

Variables	**Literature reference**	**Research parameters**
Logistics Performance Index	Erkan (2014), Civelek et al. (2015), Milenkovic et al. (2020), Marti et al. (2014)	LPI, International trade, GCI (Global competitive index), GDP (Gross domestic product)
Logistics Cost	Karri Rantasila and Lauri Ojala (2015), Hayaloglu (2015), Devlin and Yee (2005,	Logistics cost as % of GDP, Sales or turnover and absolute cost.
Tracking and Tracing	Helo et. Al, (2020), Munuzuri et. Al, (2020), Hasan et. Al, 2020), Mirzabeiki et. al, 2016)	RFID, IOT, Cloud based technologies, manufacturing tracking,
Dwell Time	Jacomino et. al (2021), Aminatou Met. al (2018), Kourounioti I get. al (2016), Irannezhad et. al (2019), Zuidwijk et. al (2015), Oey et. al (2017), Sagar et. al (2022), Moini et. al (2012), Goodchild et. al (2005), Merckx (2005), (Rodrique, 2008), Huang (2008), Zhao and Goodchild (2010) Nooramin et. al (2011), Saini et. al, (2021), Zhen et. al (2013)	Crane and terminal operations, Container size, commodity, factors determining dwell time, Tracking, Port performance parameters

Based on the findings of the literature review (Table 4) and the thematic analysis of significant works, it is evident that there were very few or rather none research studies that have specifically examined the analysis of container dwell time, both with and without the utilization of tracking devices. The present doctoral thesis investigates the throughput performance of containers, which constitutes the primary focus of uniqueness in the suggested dissertation. The PhD thesis also examined the correlation between economic factors and industrial engineering in the domain of logistics, shipping, and container dwell time.

This subsection of the theoretical review provides an overview of prior research studies conducted on the subject of dwell time at various ports worldwide. Researchers either conducted study at a single port with limited data or execute the same research in conjunction with another situation that affects port performance parameters. Numerous studies have emphasized the significance of real-time data sets in assessing the efficacy of initiatives aimed at lowering dwell time. This doctoral thesis focuses on the factors that influence dwell time at numerous ports, taking into account the presence of container tracking tools. This study aims to make a novel contribution by examining and establishing relationships among different characteristics in container specifications.

2.4 Keyword search and Analysis of the originality of the topic

The selected keywords for evaluating the novelty of the topic were carefully designed to encompass all potential combinations that precisely depict the subject matter of the study. The searches were conducted on October 18, 2022, using the scientific databases "Scopus" and "Web of Science". The search parameters were set to include the title, abstract, and keywords within the search fields. The examination of originality involves the identification of keywords, which have been carefully selected through a meticulous and rigorous process, Table 5. The following keywords have been selected to be significant in this research:

1. Marine OR Sea OR Ocean AND Ports AND
2. Port Performance AND
3. Shipping container AND
4. Dwell Time AND
5. Tracking AND
6. Yard

Table 5 Keyword Search Analysis Results (Source: Own Research)

Keyword Combination Topic, Title, Abstract, KW	**Databases**	
	Scopus	**Web of Science**
1	23479	12780
2	30167	23008
3	6175	6325
4	19443	30485
5	586862	740631
6	21284	11492
1 + 2	1753	1062
1 + 3	543	535
1 + 5	339	354
1 + 2 + 3	70	84
1 + 2 + 5	55	46
1 + 2 + 3 + 5	1	2
1 + 2 + 5 + 6	1	0
1 + 3 + 4 + 5	1	0
1 + 3 + 4	0	3
2 + 4	33	29
1 + 4 + 5	0	0
1 + 2 + 3 + 4 + 5 + 6	0	0

The data presented in Table 5 indicates that there are very few research studies that integrate the mentioned factors (*i*)Marine OR Sea OR Ocean AND Ports, (*ii*)Port Performance, (*iii*)Shipping container, (*iv*)Dwell Time, (*v*)Tracking, (*vi*) Yard.

2.5 Analysis of thematically similar sources

After performing an extensive review of the scientific literature, it was observed that two papers had resemblance to the thematic focus of this doctoral thesis. Both articles primarily focused on identifying the different elements that influence container dwell time. Several factors such as the size of the container, its weight, and the port of origin, among others, contribute to the overall analysis. The following is a comprehensive summary of similar articles, including in-depth information:

*(i)*Development of models predicting dwell time of import containers in port container terminals – an Artificial Neural Networks application (Authors: Ioanna Kourounioti, Amalia Polydoropoulou, Christos Tsiklidis)

Summary: This research paper focused on identifying the factors which determine the impact on the container dwell time. The data from one container terminal in middle east was evaluated using artificial neural network for the annual data. Various factors such as size and type of container, port of origin was concluded as the important determining factors impacting dwell time of middle eastern port. The research study however suggested to study behavioural models as the future course of research study. This doctoral thesis determined the impacting factors along with their status of laden empty, tracking available or not available for a multi-port data set. The results contributed to the scientific knowledge by providing multi-port data set along with qualitative study on comparison of impacting factors on dwell time.

*(ii)*Identification of container dwell time determinants using aggregate data (Author: Ioanna Kourounioti and Amalia Polydoropoulou)

Summary: This research study focussed on the dataset from three container terminals, two from middle east and one from Asia. Regression models were used to determine the factors impacting container dwell time. The research study concluded that container weight, status, shipping line, seasonality, pick up day of the week, as the major factors impacting dwell time. The study also suggested for collecting information on the commodity and consignee details for better accuracy of models. This enables the port terminals in better decision making and defining policies. However, this study also focussed on limited data from three container terminals with no behavioural focus on ability to track the container.

It can be illustrated from the above section that none of the researches focussed on the multi-port data set while identifying the reasons for varying dwell time. Thus, this doctoral thesis focuses on the multi-dimensional approach of identifying why logistics is important as a sector and the importance of one of its parameter which is tracking and tracing. Subsequently, a detailed study on fourteen ports and the key reasons for their performance in presented in the following chapters.

3. RESEARCH OBJECTIVES, QUESTIONS AND HYPOTHESIS

3.1 Research Objectives

The primary aim of this study, as indicated by the literature review, was to examine the influence of track and trace technology, a significant component of the logistics performance index, on the port performance metric known as container dwell time. The purpose of this study was to investigate the significance of LPI (Logistics Performance Index) and TT (Track and Trace) systems in relation to economic development and port performance indicators, specifically focusing on dwell time. This evaluation is conducted with a specific focus on the following sub-objectives:

RO1: To identify the role of logistics performance index and logistics cost on the economic development.
RO2: To assess the role of track and trace and logistics cost on the economic development.
RO3: To identify the impact of track and track technology of container on the port performance measure such as container dwell time.
RO4: To evaluate the role of container size and port operations location on the container dwell time considering availability and non-availability of track and trace technology.

3.2 Research Questions and hypothesis

The primary aim of this thesis was to investigate the influence of track and trace systems on the dwell time of shipping container. In order to address the current gaps in the literature, the following research questions were formulated.

Research question 1: How do logistics performance index and logistics cost influence economic development?

Justification: The currently available literature has examined the impact of the logistics performance index on economic development. Nevertheless, it is crucial to examine the influence of LPI (Logistics Performance Index) in conjunction with logistics costs on economic development, as these factors constitute the fundamental pillars of any economy. Therefore, it is crucial to examine the collective influence of logistics cost and logistics performance index on economic development.

Research Question 2: Does track and trace and logistics cost impact economic development?

Justification: Based on the current state of studies, there is a lack of research studies that have examined the influence of specific factors of the logistics performance index on both economic development and logistical cost. This study aims to assess the significance of different factors within the logistics performance index, with a specific focus on track and trace. It is crucial to examine the effects and implications of these characteristics.

Research Question 3: What is the impact of activity, mode, size of the container on the container dwell time?

Justification: The multiport data set from fourteen ports was analysed to understand the impact of, (*i*) Cycle-Import/Export, (*ii*)Mode-Truck/Rail, (*iii*)Size 20 feet/40 feet on the shipping container dwell time. For any container performance parameter, it was important to research on the factors associated with container and the reasoning. The qualitative research for the top three ports out of fourteen ports provided insights on the variation of dwell time due to container performance parameter.

Research Question 4: What are the major reasons behind variance in the container dwell time?

Justification: Different ports with same set of technology have high variance in dwell time and port performance parameters despite same set of operations. The research question 4 and 5, will be evaluating the reasons cited by port operators during the multi-port comparative analysis.

Hypothesis 1: Continuous track and trace of containers results in reduced container dwell time.

Justification: In the previous research, there have been study which evaluated the several factors such as container size, commodity, status for the impact on dwell time, however, there have been rarely any study performed which evaluates for the impact along with the availability and non-availability of tracking. Also, this research was performed for the multi-port scenario, which makes it more comprehensive in terms of results to be researched.

4. METHODOLOGY

This doctoral research study employed a mixed method technique for the analysis of data. The research started with a comprehensive examination of the existing literature and theoretical framework pertaining to the logistics performance index, track and trace, and container dwell time. The research purpose and questions outlined in the preceding sections were examined using a three-phase analysis for the study.

During Phase I, a mixed methods approach was employed to assess the significance of LPI (Logistics Performance Index), LC (Logistics Costs), and T & T (Track and Trace). The research was undertaken utilizing analytical techniques, specifically employing fuzzy qualitative comparative analysis. During the second part of the research project, the regression method was utilized to discover and analyse the elements that have an impact on port performance characteristics. The phase III of the research project involved the identification of the factors influencing dwell time through the conduction of multiple discussion interviews with port practitioners. The method utilized for data analysis is as detailed in Table 6.

Table 6: Data analysis steps Phase I, II and III (Source: Own Research)

Phase	**Research phase variables**	**Methodology/method**	**Tool**
I	LPI, LC, EODB and ED	Fuzzy Qualitative Comparative Analysis	fsQCA 3.0
	Impact of tracking on container dwell time	Regression (OLS)	Python data science
II	Impact of (*i*)Cycle (Import/Export), (*ii*)Size (20 feet/40 feet), (*iii*) Status (Empty/Laden), (*iv*)Mode (Truck/Rail), (*v*)Delivery (DPD-Direct Port Delivery or DPE- Direct Port Export), (*vi*)Tracking (Yes/No), on the container dwell time.	Independent Sample T-Test	SPSS

III	Qualitative study of ports having least 3 RMSE (Root mean square error) for impact on dwell time.	Qualitative study through snowball research questions based on results of regression and independent sample t test	Qualitative

4.1 Sample and Data Collection

This study examined the prominent economies situated in Asia (China, India, Japan, and Singapore), Europe (Czech Republic, France, Germany, and Slovenia), as well as the United Kingdom and the United States of America. The data utilized in this study was obtained from secondary sources, specifically the data repository of the World Bank (World Bank, 2023); (World Bank,)(Hofman Bert, 2017). The variables of interest included economic development, logistics cost, and the Logistics Performance Index (LPI).

During the second phase of the research study, the regression method (OLS – Ordinary Least Squares) was utilized to ascertain the components that have an impact on dwell time. The data was obtained from primary sources located in ports, specifically designated for research purposes. During the third part of the research project, the significance of dwell time was determined by the conduction of several discussion interviews with port practitioners.

4.2 Methods for data analysis

4.2.1 Phase I

In the context of data analysis methodology for the Phase I, the utilization of fsQCA (fuzzy qualitative comparative analysis) is employed to ascertain the influence of LPI (Logistics Performance Index), LC (Logistics Cost), and T&T (Tracking and Tracing) on economic development. The fuzzy set qualitative comparative analysis (fsQCA) is a widely employed method across various research domains, primarily utilized in situations characterized by limited sample sizes. The utilization of this analytical approach has been increasingly adopted in several study domains , (Kraus et al., 2018). The fsQCA methodology, as proposed by (Ragin, 2000), is specifically designed to find causal "recipes" rather than focusing on individual independent variables. Causal recipes are formal statements explaining how causally relevant elements combine into configurations associated with outcomes of interest (Park et al., 2020) This results in the establishment of a series of pathways that culminate in the desired outcome, (Park et al., 2017). It is important to note that there is no singular causal configuration that can be deemed as perfect in determining outcomes. Instead, this method elucidates how various attributes come together and converge into diverse paths that ultimately result in the same outcome. This is achieved by examining the presence or absence of certain attributes (Misangyi et al., 2017).

4.2.2 Phase II and Phase III

The Phase II. focused on identifying the impact of (*i*) Cycle : Import or Export, (*ii*) Size : 20 feet or 40 feet, (*iii*) Mode: Truck or Rail, (*iv*) Status : Empty or Laden, (*v*) Delivery : DPD/DPE (Direct Port Delivery or Direct Port Export), (*vi*) Tracking Technology availability : Yes or No on the container dwell time. The research study was conducted based on the combination of the quantitative and qualitative analysis of the data collected from the port terminal systems. Qualitative research involves collecting and analysing non-numerical data from port terminal operating system and quantitative research is the process of collecting and analysing numerical data. The research was conducted following both qualitative and quantitative methodology. The data collected for analysis was coded and analysed with regression statistical analysis tools using Python for data science.

For calculating the impact of track and trace technology on the dwell time on the container dwell time, the well-known technique to identify the dependent variables as weighted sum of the covariates along with coefficients obtained using ordinary least squares will be adopted (Maldonado et al., 2019). Based on the collection of port operations data collected from key sources research for research purpose only. The data was studied for seasonal variations and cyclical fluctuations.

5. PORTS DATA ANALYSIS AND MODELLING

5.1 Phase I

The Phase I largely focused on addressing key research questions pertaining to the significance of logistics, track and trace systems, and the relationship between logistics costs and economic development. The research in Phase I utilized the index produced by the World Bank. The Logistics Performance Index (LPI) was formulated by the World Bank with the objective of assessing the significance of logistics and tracking within the shipping industry. This score provides a complete assessment of an economy's logistics competency. The primary objective of this study was to gain a comprehensive understanding of the significance of logistics, particularly focusing on the sub-variable of Tracking and Tracing technology. This understanding was crucial in identifying the important input variables for the subsequent research studies in Phase II and III. This study examined the key economies situated in Asia (China, India, Japan, Singapore), Europe (Czech Republic, France, Germany, Slovenia), the United Kingdom, and the United States,(Saini & Hrušecká, 2021b).

5.1.1 Phase I: Logistics Performance Index, Logistics Cost and Ease of Doing Business

The phase I of this doctoral dissertation researched on the first and second research questions, with a particular emphasis on the variables of LPI, EODB, and LC. FsQCA, Fuzzy Set Qualitative Comparative Analysis, is a research approach utilized to explore and combine independent variables with the purpose of comprehending their combined influence on a dependent variable. This methodology employs causal recipes to examine and evaluate the associations between variables. The utilization of the fuzzy fsQCA data analysis approach is prevalent among scholars in the discipline of management science (Kraus et al., 2018).The process of converting data into fuzzy scores involves the computation of calibrated scores. The scores are computed by utilizing the maximum, mean, and minimum scores in conjunction with absolute data. Fuzzy scores exhibit a numerical range spanning from 0 to 1.

This process computes scores by utilizing a rating system, hence producing a truth table. The provided truth table, in conjunction with the requisite conditions, demonstrates the membership relation and its impact on the outcome variable for higher values. In a research, authors have observed that various configurations arise from the corresponding outcomes, resulting in either higher or lower levels of GDP per capita (Schneider et al., 2010). These configurations reflect several types of solutions, including complex solutions, parsimonious solutions, and intermediate solutions. The concept of parsimony is employed to determine the essential membership outcomes, while intermediate results are utilized for subsequent study within the field of management science. The outputs manifest as causal configurations rather than assessing the correlation between the variables under investigation, (Kourouthanassis et al., 2017). Scholars from numerous disciplines, particularly those in management and economics, have placed significant emphasis on the crucial relationship of causal configurational analysis in the context of research, (Fiss, 2011).

The primary objective of this fuzzy method is to assess and ascertain the influence of interrelated configurations of LPI, EODB, and LC on higher levels of GDP per capita. The scores for the consistencies and coverage of each independent variable's existence or absence are calculated. Several research studies in the fields of management and economics have examined the requirement of a consistency value exceeding 0.9. However, only a limited number of studies have also acknowledged the necessity of a consistency value of 0.8, (Schneider et al., 2010).

A positive correlation exists between higher levels of Ease of Doing Business (EODB) and Logistics Performance Index (LPI) and higher levels of GDP per capita. The significance of conducting such an analysis lies in the ability to identify the conditions that are consistently required for the occurrence or non-occurrence of higher values in the outcome variable. Table 7 illustrates the results of configurations that represent the higher values of Gross Domestic Product (fzGDP) in the intermediate solution. The examination of necessary circumstances for the intermediate solution is of utmost importance in order to gain a comprehensive grasp of the configurations.

Table 7 Intermediate solution results of LPI, EODB, LC and ED (Saini & Hrušecká, 2021a)

Causal Configuration	**1**	**2**
FzLC (Fuzzy Score Logistics Cost)	Ø	X
FzEODB (Fuzzy Ease of Doing Business)	X	Ø
FzLPI (Fuzzy Score Logistics Performance Index)	●	●
Raw Coverage	0.818882	0.445087
Unique Coverage	0.421965	0.0481696
Consistency	0.889121	0.878327
Overall Solution coverage	0.867052	
Overall Solution consistency	0.862069	

*Notes: ● indicates the presence of a condition; Ø indicates the absence of a condition; **●/Ø** indicates core conditions; ●/ Ø indicates peripheral conditions; X indicates no contribution to configuration.*

Table 7 presents causal configuration 1, which demonstrates that a higher degree of participation in the absence of LC and the presence of LPI is associated with increased values of GDP per capita. Causal configuration 2 reveals that the lack of ease of doing business (EODB) and the presence of logistics performance index (LPI) are factors that contribute to higher levels of gross domestic product (GDP) per capita. The variable LPI is included in the parsimonious models as a key predictor of the outcome variable, with larger values indicating a stronger impact.

It is important to note that the EODB, LPI, and LC parameters taken together are not the primary factors influencing the higher values of GDP per capita. The inclusion of LC in one of the configurations has a detrimental impact on economic development, but LPI is a crucial variable. LPI is included in the parsimonious solution and its presence in both configurations leads to greater values of GDP per capita. The presence of a negative relationship in the logistics cost variable indicates its significance within the study and its inclusion in the Logistics Performance Index (LPI) when evaluating and comparing economies based on their logistics performance.

5.1.2 Phase I: Logistics Performance Index parameters, Logistics Cost and economic development

This section describes research on the variables of logistics performance index along with logistics cost to illustrate on research question II. The data in this section comprises of the individual parameters of the Logistics Performance Index (LPI) such as (*i*) Customs, (*ii*)Logistics Competence, (*iii*)International shipments, (*iv*)Timeliness, (*v*)Track and Trace, (*vi*)Infrastructure and (*vii*)Logistics cost on economic development of ten major economies of Asia, Europe, UK and USA.

Consistent with the findings of Phase I, namely in section 5.1.1, a truth table was produced subsequent to the computation of fuzzy scores in order to facilitate the examination of essential circumstances(Curado et al., 2016). The fuzzy scores in this context are represented on a scale from 0 to 1, with each value indicating the degree of membership of the variables. The present research study examined the complete membership as the highest value, the mean value for partial membership, and the lowest value for absent membership in order to calibrate the data into fuzzy scores. In the context of identifying fuzzy scores, it is common practice to utilize the prefix "fz" when naming variables.

One of the primary advantages associated with the adoption of this technique is the capacity to conduct analysis on smaller sample sizes. The resulting output consists of configurations that can either be present or absent, along by a consistency and coverage score. These clusters of configurations demonstrate the extent to which an independent variable or a group of independent factors impact the higher or lower values of dependent variables.

Other analysis approaches, such as correlation and regression, generally capture overall trends. However, fsQCA (Fuzzy sets qualitative comparative analysis), specifically investigates and demonstrates the presence of factors that are connected with the outcome variable. This study employs an approach that investigates the interconnectedness of a collection of elements within a given sample set.

The primary aim of this study was to ascertain and analyse a collection of interrelated configurations that contribute to a greater GDP per capita. Several studies in the field of management research have examined the importance of a consistency value exceeding 0.9, with a few studies also suggesting that a value of 0.8 is nearly essential (Schneider et al., 2010). There is a positive correlation between the presence of customs, infrastructure, and tracking and tracing, and the GDP per capita. Conversely, a negative correlation exists between logistics cost and GDP per capita. The primary significance of conducting such an analysis lies in determining whether a singular condition is consistently required to ascertain the occurrence or non-occurrence of elevated outcomes. Table 8, displays the results of two configurations that depict the impact on fzGDP (Fuzzy score Gross Domestic Product) in the intermediate solution, specifically focusing on higher levels of GDP.

The research study in this section identified two distinct configurations that are associated with greater levels of GDP per capita. The examination of essential prerequisites is imperative for the determination of the fzGDP's outcome. This demonstrates that the presence of all logistical competitive conditions is not a prerequisite for achieving higher levels of GDP per capita. A comprehensive examination of these configurations, combined with intermediate analysis, reveals that in the first configuration condition fzInfra (Fuzzy Infrastructure), fzTT (Fuzzy Track and Trace), fzLogcomp (Fuzzy Logistics Competence), fzCust (Fuzzy Customs), fzTM (Fuzzy Timeliness), positively contribute to higher values of the outcome variable fzGDP (Fuzzy Gross Domestic Product). Conversely, the variable fzLC (Fuzzy Logistics cost) exhibits an inverse relationship, contributing negatively to higher values of GDP. The current conditions, referred to as fzTM (Fuzzy Timeliness) and fzCust (Fuzzy Customs), represent partial states. In contrast, the international shipping does not contribute to the initial configuration. The parsimonious solution encompasses the conditions fzInfra (Fuzzy Infrastructure), fzTT (Fuzzy Track and Trace), and fzLogcomp(Fuzzy Logistics Competence), which are regarded as the fundamental configuration solutions (●).

In the second configuration, nearly all the requirements are crucial for achieving greater values of GDP per capita, except for fzCust(Fuzzy Customs), which is absent in this configuration. When comparing the two configurations, it is observed that the circumstances fzInfra (Fuzzy Infrastructure), fzTm(Fuzzy Timeliness), fzTT(Fuzzy Track and Trace), and fzLogcomp(Fuzzy Logistics Competence) are significant factors that contribute to greater values of GDP per capita. Conversely, the conditions fzLC(Fuzzy Logistics costs), fzCust(Fuzzy Customs), and fzIntl(Fuzzy International Shipments) exhibit an inverse relationship in two of the configurations. The parsimonious solution includes the fundamental solutions fzTT(Fuzzy Track and Trace), fzInfra(Fuzzy Infrastructure), and fzLogcomp(Fuzzy Logistics competence).

Table 8 : Intermediate solutions results of logistics performance index parameters, logistics cost and economic development (Saini & Hrušecká, 2021b)

Causal Configuration	**1**	**2**
fzLC (Fuzzy Score Logistics Cost)	ø	•
fzCust (Fuzzy Score Customs)	•	ø
fzInfra (Fuzzy Score Infrastructure)	●	●
fzTm (Fuzzy Score Timeliness)	•	•
fzTT (Fuzzy Score Track and Trace)	●	●
fzLog comp (Fuzzy Score Logistics competence)	●	●
fzIntl (Fuzzy score international shipments)	x	•
Raw Coverage	0.782274	0.292871
Unique Coverage	0.535645	0.046243
Consistency	0.906250	0.938272
Overall Solution Coverage	0.828516	
Overall Solution consistency	0.892116	

Notes: ● indicates the presence of a condition; Ø indicates the absence of a condition. ●/Ø indicates core conditions; ●/ Ø indicates peripheral conditions; x indicates no contribution to configuration.

It is significant to highlight that not all aspects of LPI (Logistics Performance Index) are the primary factors influencing greater values of GDP per capita. The inclusion of LC in the set of indicators for evaluating logistics performance can be attributed to its significant impact on the overall economic development of a country. In conclusion, it is imperative for economies to prioritize the enhancement of infrastructure, as well as the implementation of robust tracking and tracing systems, in order to effectively address the logistical aspects of economic development. The condition of labour conditions (LC) for the inverse relations indicates that LC has a significant impact on the economic development of a nation. In order to achieve higher levels of GDP, it is imperative to maintain improved processes, including but not limited to customs, timeliness, and international shipping, while also ensuring that these systems are adequately supported. Previous studies have primarily concentrated on assessing and establishing the correlation between Logistics Performance Index (LPI) and various factors, including environmental indicators, infrastructure weighted indicators, the mediating impact of LPI on economic growth in conjunction with other indices such as global competitiveness index, income, geographical regions, and dimensions of sustainability.

The significance of the results shown in Table 8 and Table 9 demonstrates the combined impact of LC (Logistics Cost), LPI(Logistics Performance Index), and EODB (Ease of doing business) on economic development. The findings of the correlation analysis indicate a positive association between the logistics performance index, ease of doing business, and economic development. Conversely, a negative correlation is shown between logistics costs and economic development. The findings obtained using fsQCA analysis demonstrate the significance of reducing logistical costs, as indicated by a negative coefficient. Additionally, the absence of a condition is observed for higher levels of GDP per capita. The LPI variable is a fundamental component in the fsQCA methodology and has a positive connection with increasing levels of GDP per capita.

Based on the comprehensive comparative analysis, it was inferred that the LPI serves as the primary membership option for countries with greater GDP per capita, while exhibiting an inverse relationship with the LC. However, the Ease of Doing Business (EODB) has yielded varied results according to both Pearson's correlation analysis and the fsQCA study. Future research should aim to expand the scope of this study by including a greater number of nations in order to investigate the significance of the ease of doing business on economic development. This investigation could also consider the combined effects of the Logistics Performance Index (LPI) and the Logistics Cost (LC) in order to provide a more comprehensive analysis. Table 9 presents the collective comparative findings of the research study of this sub section and their cumulative influence on higher levels of GDP per capita.

Table 9 : Comparison of fsQCA results (Source: Own Research)

Outcome Variable	**Variables (Test)**	**Correlation**	**fsQCA**	
			fsQCA Config I	**fsQCA config II**
GDP	LC	Negative	Absent peripheral solution	No relation
	LPI	Positive	Present core solution	Present core solution
	EODB	Positive	No relation	Absent peripheral solution
LPI	Tracking	NA	Present core solution	Present core solution
	Infrastructure	NA	Present core solution	Present core solution
	Logistics Competency	NA	Present core solution	Present core solution

The results of this part of the study have revealed the significant impact of logistics competitiveness and logistics cost on economic development. Based on the findings derived from the fsQCA methodology, it has been determined that among the several aspects of logistics performance indices, namely logistics competence, infrastructure, and tracking and tracing, there is a higher degree of consistency in projecting elevated levels of economic development. Competitive characteristics such as Customs, Timeliness, and International Shipments are integral components of the configurations that contribute to causal relationships.

It has been shown that a decrease in logistics costs is associated with a higher projected growth in GDP per capita. It is additionally proposed that potential expansion in this particular arrangement indicates that, as logistics costs decrease, the cost of goods may also decrease, resulting in cheaper prices and ultimately passing on the advantages to customers at a reduced cost. The findings of this study have significant importance for the field of research. Specifically, the study highlights the importance of including logistics costs as a vital component, which is not currently included in logistics performance indexes. Furthermore, the study provides conclusive conclusions regarding the causative configurations related to logistics costs. This paper presents a fresh approach to enhancing the metrics employed in calculating logistics performance indices, emphasizing the inclusion of cost as a significant component.

5.2 Phase II : Dwell Time Analysis

In the phase II of data analysis, data from fourteen ocean ports was collected for determining the factors impacting shipping container dwell time. Variables which were evaluated for container operations were (*i*) Cycle -Import/Export, (*ii*) Size- 20 feet/40 feet, (*iii*)Mode -Truck/Rail, (*iv*)Status -Empty/Laden, (*v*)Delivery -DPD/DPE (Direct Port Delivery or Direct Port Export) , (*vi*)Tracking Technology Availability -Yes/No. These variables were regressed against the container dwell time. The method utilized for data analysis and result comprehension is as detailed in Table 10.

Table 10: Data analysis steps in Phase II and Phase III (Source: Own Research)

Phase	**Research Study**	**Method**	**Tool**
Phase II	Impact of tracking on container dwell time	Regression (OLS)	Python data science
	Impact of Size, Mode, Status, Delivery, Cycle, tracking on dwell time	Independent Sample T-Test	SPSS
Phase III	Qualititive study of ports having least 3 RMSE (Root mean square error) for impact on dwell time.	Qualtitive study through snowball research questions based on results of regression and independent sample t test	Qualitative

In order to ensure data security, the ports were assigned static values denoted by alphabetical characters from A through N. The trend analysis, correlation analysis, ordinary least squares, and independent sample t-test were conducted to explore and analyse all the ports in relation to their impact on tracking dwell time. The graphical representation of all fourteen ports is illustrated in Figure 9. The trends across parameters such as (*i*)Cycle (Import/Export), (*ii*)Size (20 feet/40 feet), (*iii*)Status (Empty/Laden), (*iv*)Mode (Truck/Rail), (*v*)Delivery (DPD-Direct Port Delivery or DPE- Direct Port Export), (*vi*)Tracking (Yes/No),was important to be researched and dwelled upon in this research.

The data set in the Figure 9, visually representation the dwell time across the aforementioned six variables. The significance of considering the variability among ports and variables must be acknowledged for further study in this doctoral thesis.

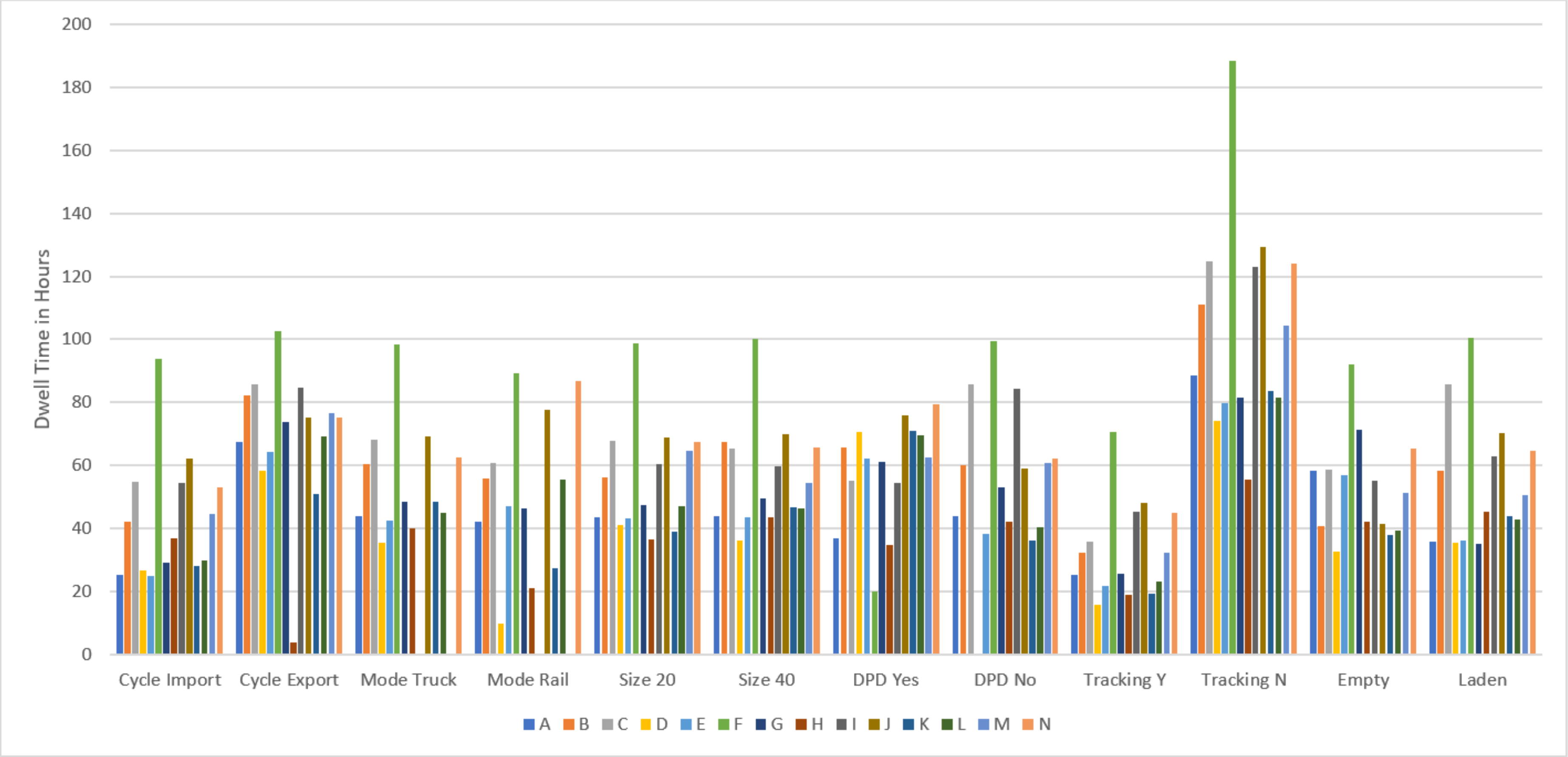


Figure 9 : Graphical summary of mean dwell time at fourteen ports (Source: Own Research)

The data analysis for the respective ports was performed in a sequential manner comprising of (*i*) Plotting view of all the independent variables and dependent variables while overviewing the trends, (*ii*) Correlation analysis was performed to observe the relationship between Time and Tracking, (*iii*) OLS test was performed evaluating on the relationship between time and tracking for illustrating on the H_1, (*iv*) Independent sample T test was performed to illustrate on the mean variance significance of all the independent variables and their relationship with time, (*v*) Lastly the actual versus predicted along with the summary of results are provided for illustrations.

Port A

Figure. 10, depicts the trends of various independent variables , namely (*i*)Cycle (Import/Export), (*ii*)Size (20 feet/40 feet), (*iii*) Status (Empty/Laden), (*iv*)Mode (Truck/Rail), (*v*)Delivery (DPD-Direct Port Delivery or DPE- Direct Port Export), (*vi*)Tracking (Yes/No), in relation to the container dwell time which is the dependent variable. The data is visually depicted on a graph, with the x-axis representing a semiannual time period and the y-axis representing Dwell Time measured in hours. The provided visual representation illustrates the fluctuations in the dwell time variable as a result of alterations in the corresponding independent variables.

It is observed in the Figure. 10, the dwell time in export cycle is more than 2.69 times than in import cycle, 0.96 times in Rail over truck, almost similarly fluctuating in size 40 feet is 1.01 times of 20 feet, 1.19 times for delivery via CFS(container freight stations) over direct deliveries, 3.51 times higher in containers that are not tracked, and 0.61 times lower in laden containers. This variation is important to be researched and is covered in detail in subsequent chapters of this thesis.

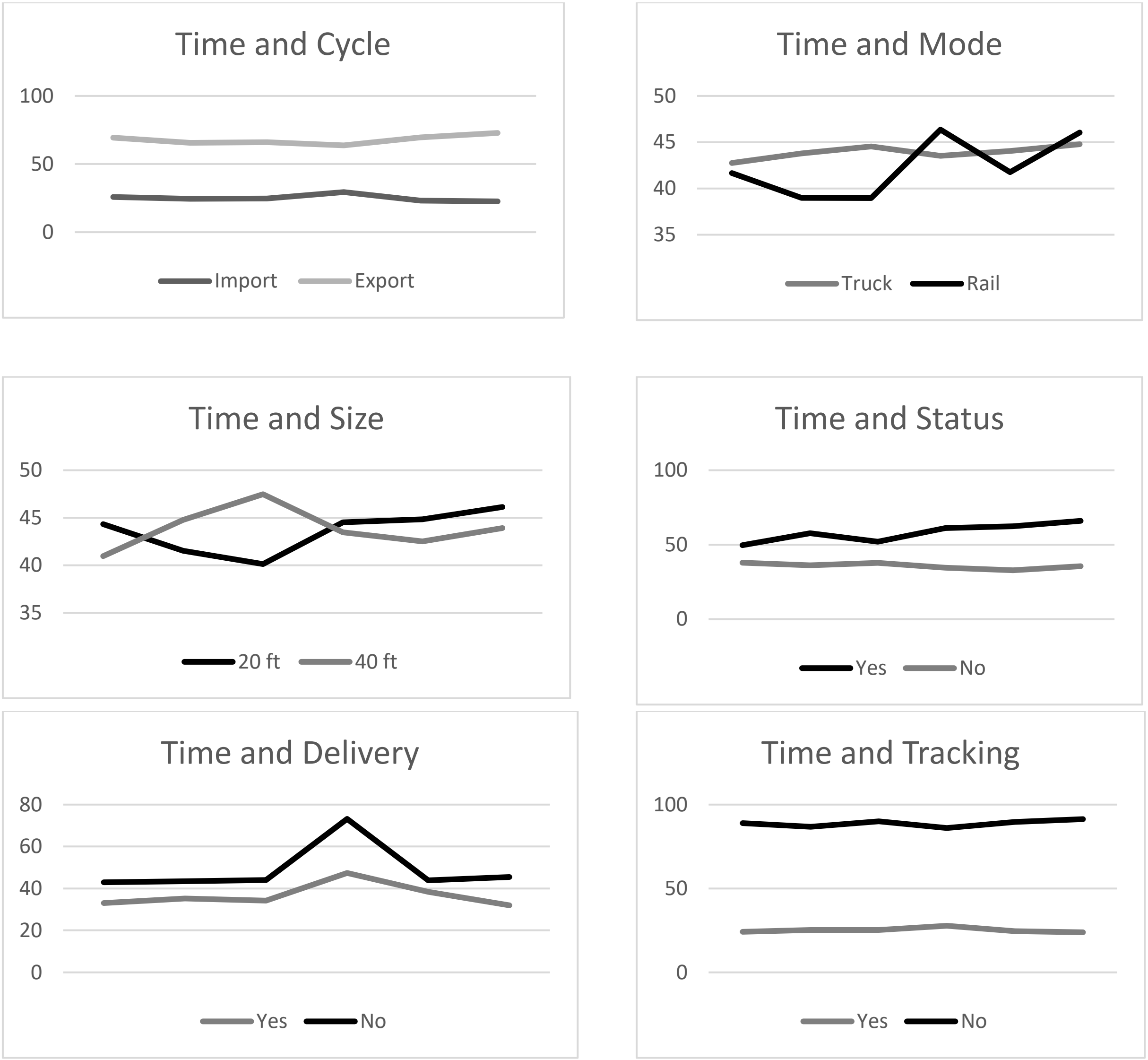


Figure 10 Summary of plotting trends of independent and dependent variables of Port A (Source: Own Research)

Correlation analysis is performed and results of the Pearson correlation indicated, that there was a significant positive association between time and tracking, (r(232730) = .86, p < .001), Figure 11.

Figure 11 Correlation analysis of dependent variable and independent variables of Port A (Source: Own research)

OLS test was utilized to test the impact on dwell time for the determining factors of container operations. Table 11, illustrates the results of the OLS test run on the independent and dependent variable. The overall regression was statistically significant ($R^2 = 0.78$, F(6, 232723)=138737.1, p<=0.001). It was observed that continuous tracking significantly predicted dwell time (β = 53.8, p<=0.001). The model had RMSE (Root mean square error) of 15.6 %. The fitted regression model is Dwell Time = 30.45 + 15.33 (Cycle) + 0.92 (Mode) + 0.70 (Size) - 3.3 (Status) - 7.3 (Delivery) + 53.8 (Tracking).

Table 11 Summary of OLS Test of Port A (Source: Own Research)

==

Dep. Variable: y
Model: OLS
Method: Least Squares
No. Observations: 232720
Df Residuals: 232723

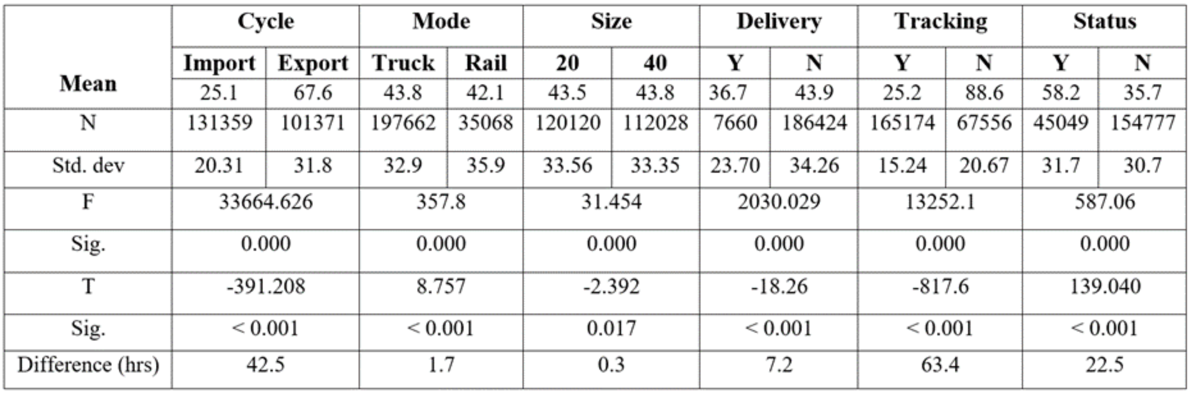
R-squared: 0.747
Adj. R-squared: 0.782
F-statistic: 1.387e + 05
Prob (F-statistic): 0.00
Df Model: 6

==

	Coeff	**Std Err**	**T**	**R>|t|**	**[0.025**	**0.975]**
Const	30.4532	0.203	149.877	0.000	30.055	30.851
Cycle	15.3367	0.081	189.984	0.000	15.178	15.496
Mode	0.9229	0.093	9.968	0.000	70.741	1.104
Size	0.7014	0.065	10.721	0.000	0.573	0.83
Status	-3.3567	0.090	- 37.306	0.000	-3.533	-3.180
Delivery	-7.3105	0.186	-39.263	0.000	-7.675	-6.946
Tracking	53.87	0.086	629.87	0.000	53.709	54.044

Figure. 12, illustrates the results of the independent samples t-tests indicated that there were significant differences in the mean of independent variables

(Cycle, Mode, Size, Delivery, Status, Tracking (t(232730) = (42.5, 1.7, 0.3, 7.2, 63.4, 22.5), p < .001) in the respective order of the Figure 12.



	Cycle		**Mode**		**Size**		**Delivery**		**Tracking**		**Status**	
	Import	**Export**	**Truck**	**Rail**	**20**	**40**	**Y**	**N**	**Y**	**N**	**Y**	**N**
Mean	25.1	67.6	43.8	42.1	43.5	43.8	36.7	43.9	25.2	88.6	58.2	35.7
N	131359	101371	197662	35068	120120	112028	7660	186424	165174	67556	45049	154777
Std. dev	20.31	31.8	32.9	35.9	33.56	33.35	23.70	34.26	15.24	20.67	31.7	30.7
F	33664.626		357.8		31.454		2030.029		13252.1		587.06	
Sig.	0.000		0.000		0.000		0.000		0.000		0.000	
T	-391.208		8.757		-2.392		-18.26		-817.6		139.040	
Sig.	< 0.001		< 0.001		0.017		< 0.001		< 0.001		< 0.001	
Difference (hrs)	42.5		1.7		0.3		7.2		63.4		22.5	

Figure 12 Summary of T test of Port A (Source: Own Research)

Figure 13., illustrates the actual versus predicted data for the model and it can be observed that model is predicting the dependent variable dwell time with a RMSE (15.6 %) and majority of the values fit the model.

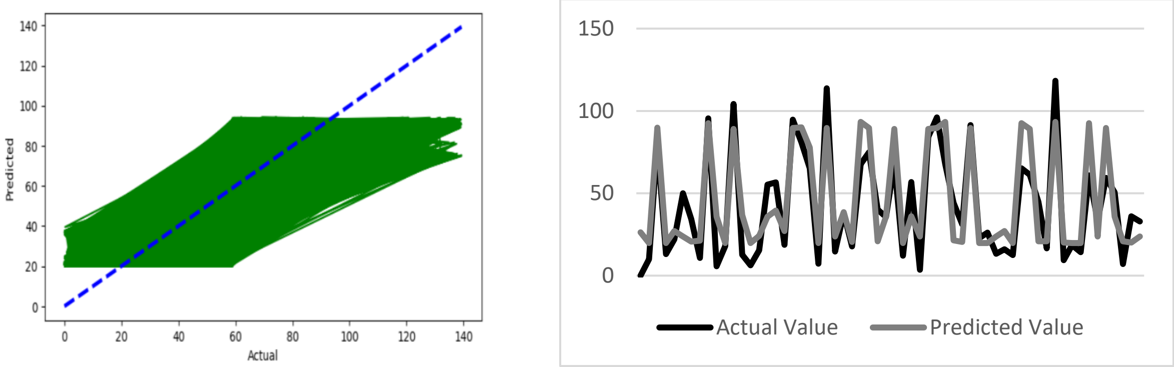
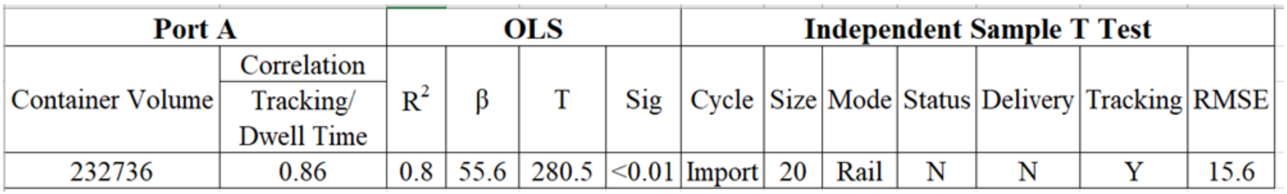


Figure 13 : plt.plot of actual versus predicted of Port A (Source: Own Research)

Figure 14, illustrates the summary of various test performed for the Port A including the container volume, correlation , R^2 , β coefficient , T-value and its significance along with T test and root mean square error for the model.



Port A		**OLS**				**Independent Sample T Test**						
Container Volume	Correlation Tracking/ Dwell Time	R^2	β	T	Sig	Cycle	Size	Mode	Status	Delivery	Tracking	RMSE
232736	0.86	0.8	55.6	280.5	<0.01	Import	20	Rail	N	N	Y	15.6

Figure 14 : Summary of OLS and T test of Port A (Source: Own Research)

Port B

Figure 15, depicts the trends of various independent variables , namely (*i*)Cycle (Import/Export), (*ii*)Size (20 feet/40 feet), (*iii*) Status (Empty/Laden), (*iv*)Mode (Truck/Rail), (*v*)Delivery (DPD-Direct Port Delivery or DPE- Direct Port Export), (*vi*)Tracking (Yes/No), in relation to the container dwell time which is the dependent variable. The data is visually depicted on a graph, with the x-axis representing a semiannual time period and the y-axis representing Dwell Time measured in hours. The provided visual representation illustrates the fluctuations in the dwell time variable as a result of alterations in the corresponding independent variables. It is observed in the Figure. 15, the dwell time is higher by 1.94 times in export cycle, 0.92 times rail over truck, almost similarly fluctuating in size 40 feet is 1.20 times of 20 feet, 0.91 times for delivery via CFS(container freight stations) over direct deliveries, 3.4 times higher in containers that are not tracked, and 1.42 times higher in laden containers. This variation is important to be researched and is covered in detail in subsequent chapters of this thesis.

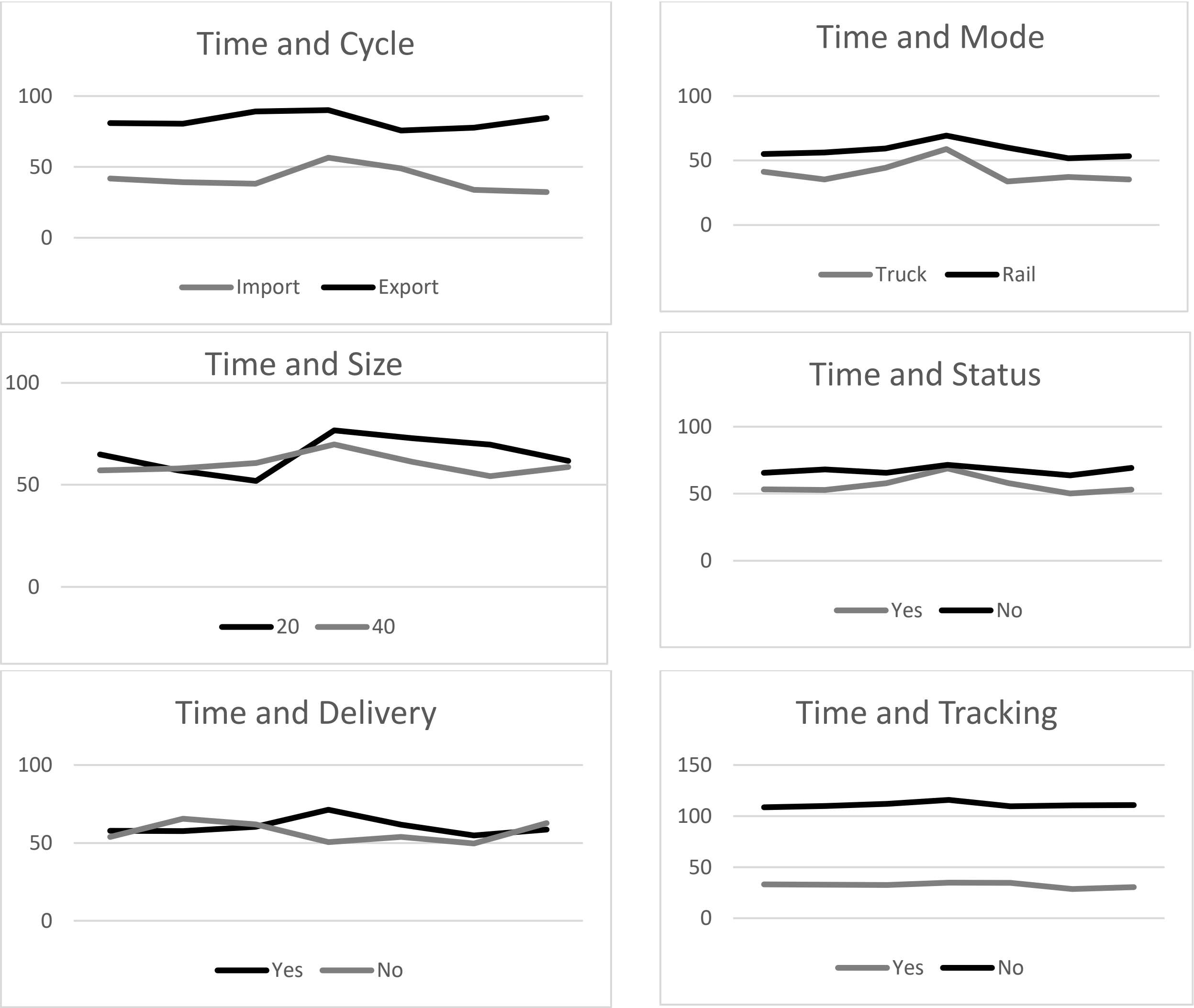


Figure 15 Summary of plotting trends of independent and dependent variables of Port B (Source: Own Research)

Correlation analysis was performed and the results of the Pearson correlation indicated, that there was a significant positive association between time and tracking, (r(155986) = .86, p < .001), Figure 16.

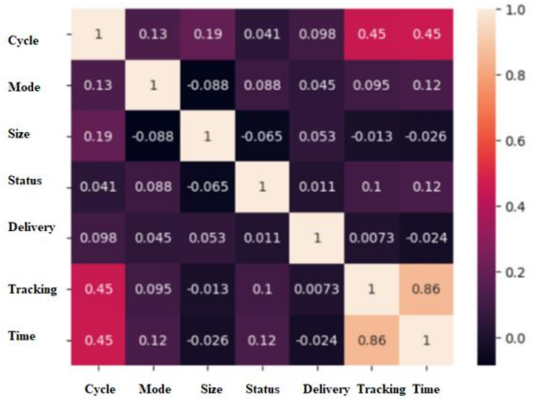


Figure 16 Correlation analysis of dependent variable and independent variables of Port B (Source: Own Research)

OLS Test

OLS test was utilized to test the impact on dwell time for the determining factors of container operations. Table 12, illustrates the results of the OLS test run on the independent and dependent variable. The overall regression was statistically significant ($R^2 = 0.74$, F (6, 155979) = 76890, p<=0.001). It was observed that continuous tracking significantly predicted dwell time ($\beta = 74.4$, p<=0.001). The model had RMSE (Root mean square error) of 19.2 %. The fitted regression model is Dwell Time = 32.04 + 8.19 (Cycle) + 3.74 (Mode) – 5.88 (Size) + 3.12(Status) – 7.46 (Delivery) + 74.4 (Tracking).

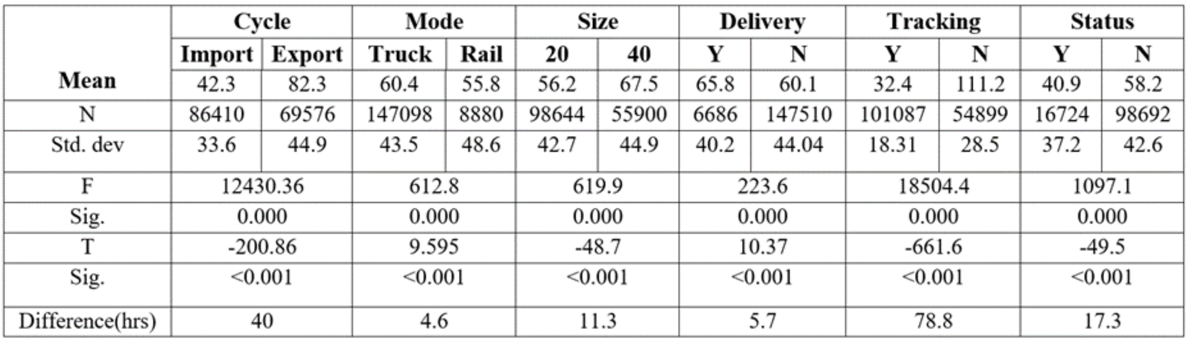
Table 12 Summary of OLS test of Port B (Source: Own Research)

==

Dep. Variable: y	R-squared: 0.747
Model: OLS	Adj. R-squared: 0.747
Method: Least Squares	F-statistic: 7.689e + 04
No. Observations: 155986	Prob (F-statistic): 0.00
Df Residuals: 155979	Df Model: 6

==

	Coeff	**Std Err**	**T**	**R>|t|**	**[0.025**	**0.975]**
Const	32.04	0.332	96.59	0.00	31.400	32.7
Cycle	8.19	0.130	62.83	0.00	7.938	8.449
Mode	3.74	0.188	19.91	0.00	3.373	4.109
Size	-5.88	0.285	-20.630	0.00	-6.440	-5.323
Status	3.120	0.118	26.476	0.00	2.890	3.352
Delivery	-7.464	0.242	-30.775	0.00	-7.940	-6.990
Tracking	74.465	0.132	562.74	0.00	74.2	74.72



	Cycle		Mode		Size		Delivery		Tracking		Status	
	Import	**Export**	**Truck**	**Rail**	**20**	**40**	**Y**	**N**	**Y**	**N**	**Y**	**N**
Mean	42.3	82.3	60.4	55.8	56.2	67.5	65.8	60.1	32.4	111.2	40.9	58.2
N	86410	69576	147098	8880	98644	55900	6686	147510	101087	54899	16724	98692
Std. dev	33.6	44.9	43.5	48.6	42.7	44.9	40.2	44.04	18.31	28.5	37.2	42.6
F	12430.36		612.8		619.9		223.6		18504.4		1097.1	
Sig.	0.000		0.000		0.000		0.000		0.000		0.000	
T	-200.86		9.595		-48.7		10.37		-661.6		-49.5	
Sig.	<0.001		<0.001		<0.001		<0.001		<0.001		<0.001	
Difference(hrs)	40		4.6		11.3		5.7		78.8		17.3	

Figure 17 Summary of T Test of Port B (Source: Own Research)

Results of the independent sample t-tests indicated that there were significant differences in the mean of independent variables (Cycle, Mode, Size, Delivery, Status and Tracking, (t (155986) = (40, 4.6, 11.3, 5.7, 78.8, 17.3), p < .001) in the respective order of the Figure 17.

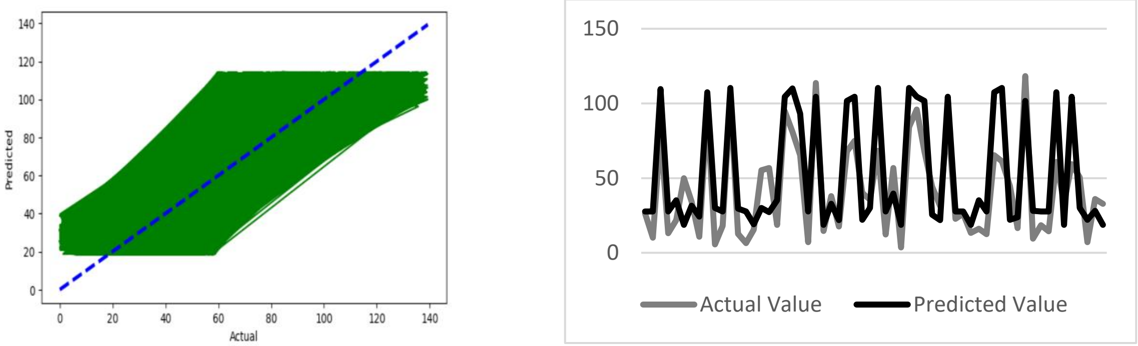
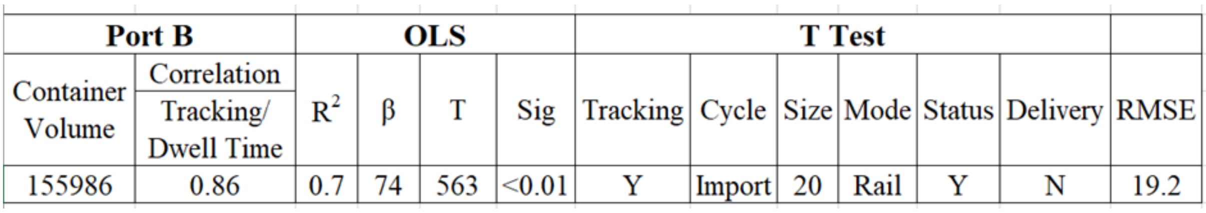


Figure 18 plt.plot of actual versus predicted of Port B (Source: Own Research)

The plots illustrated in Figure 18, depicts the actual versus predicted data for the model and it can be observed that model is predicting the dependent variable dwell time with a RMSE (19.2 %) and majority of the values fit the model.

Figure 19, illustrates the summary of various test performed for the Port B including the container volume, correlation , R^2 , β, T-value and its significance along with T test and root mean square error for the model.



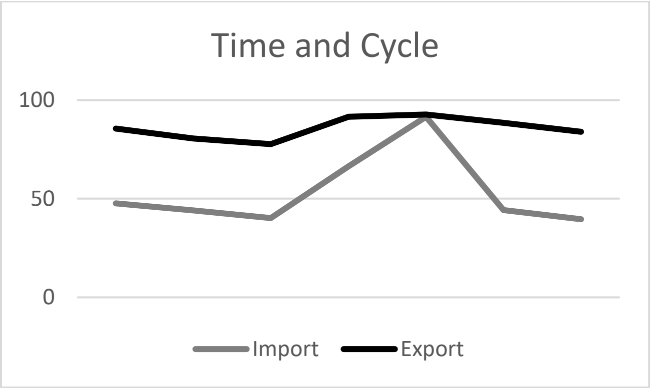
Port B		**OLS**				**T Test**						
Container Volume	Correlation Tracking/ Dwell Time	R^2	β	T	Sig	Tracking	Cycle	Size	Mode	Status	Delivery	RMSE
155986	0.86	0.7	74	563	<0.01	Y	Import	20	Rail	Y	N	19.2

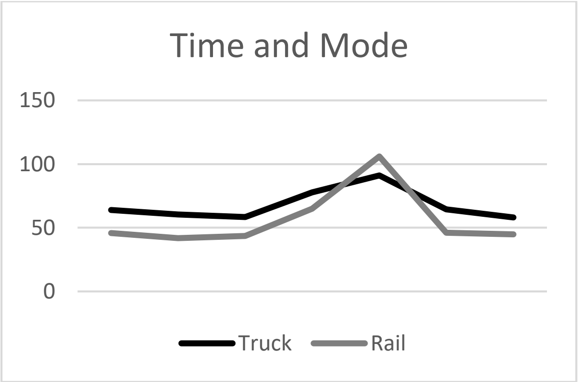
Figure 19 Summary of test results for Port B (Source: Own Research)

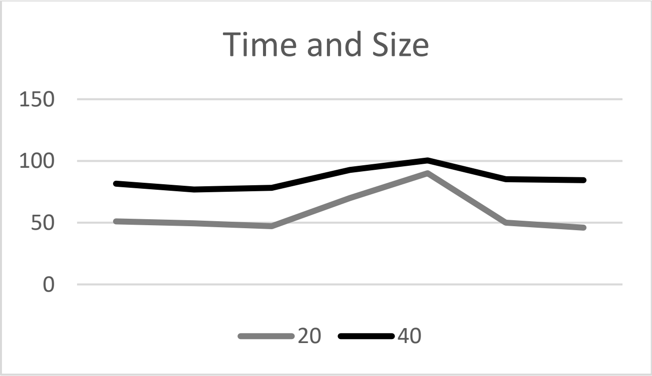
Port C

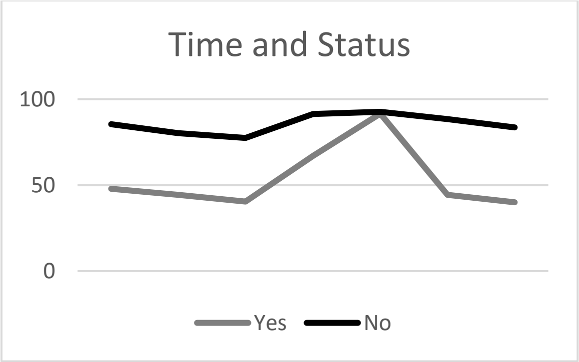
Figure. 20, depicts the trends of various independent variables , namely (*i*)Cycle (Import/Export), (*ii*)Size (20 feet/40 feet), (*iii*) Status (Empty/Laden), (*iv*)Mode (Truck/Rail), (*v*)Delivery (DPD-Direct Port Delivery or DPE- Direct Port Export), (*vi*)Tracking (Yes/No), in relation to the container dwell time which is the dependent variable. The data is visually depicted on a graph, with the x-axis representing a semiannual time period and the y-axis representing Dwell Time measured in hours. The provided visual representation illustrates the fluctuations in the dwell time variable as a result of alterations in the corresponding independent variables.

It is observed in the Figure. 20, the dwell time in export cycle is more than 1.5 times than in import cycle, 0.891 times in Rail over truck, almost similarly fluctuating in size 40 feet is 0.963 times of 20 feet, 1.5 times for delivery via CFS(container freight stations) over direct deliveries, 3.49 times higher in containers that are not tracked, and 1.468 times lower in laden containers. This variation is important to be researched and is covered in detail in subsequent chapters of this thesis.









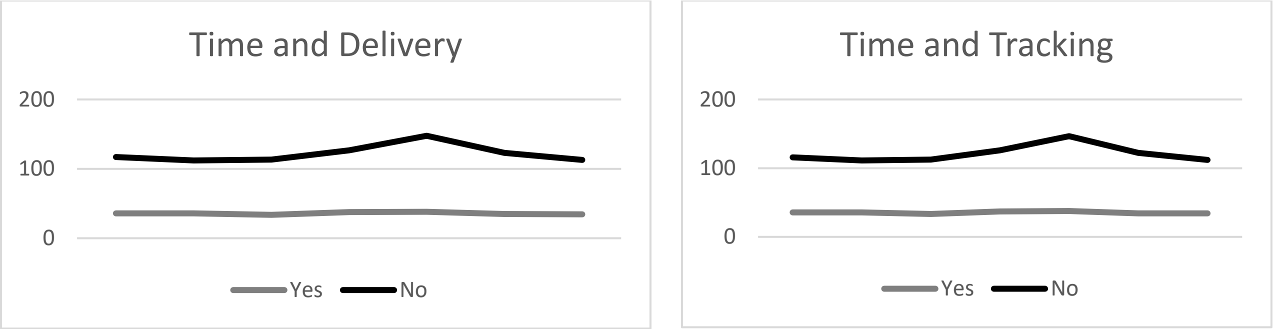


Figure 20 Summary of plotting trends of independent and dependent variables of Port C (Source: Own Research)

Correlation analysis - Results of the Pearson correlation indicated that there was a significant positive association between time and tracking, (r (346857) = 0.75, p < .001), Figure 21.

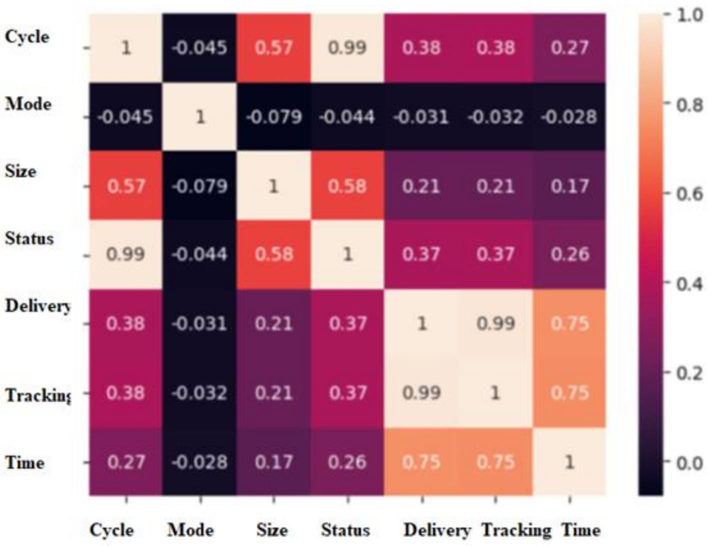
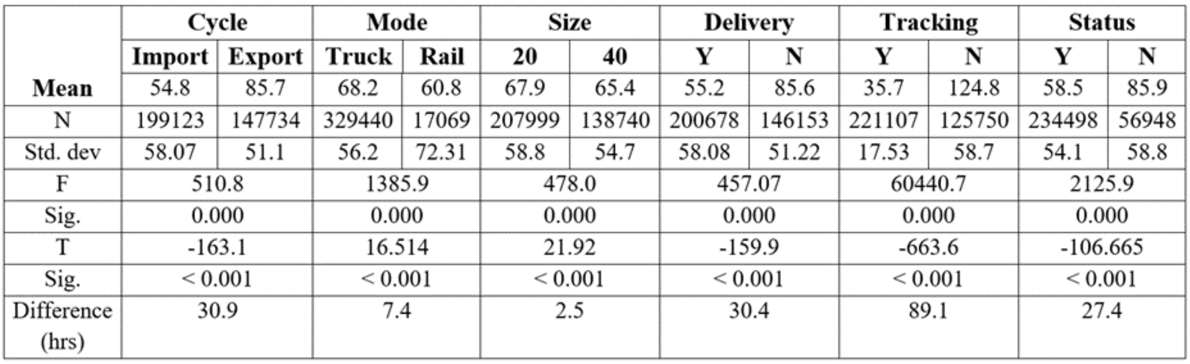


Figure 21 Correlation analysis of dependent and independent variables of Port C (Source: Own Research)

OLS test was utilized to test the impact on dwell time for the determining factors of container operations. Table 13, illustrates the results of the OLS test run on the independent and dependent variable. The overall regression was statistically significant ($R^2 = 0.56$, F (6, 346850) = 74590, p<=0.001). It was observed that continuous tracking significantly predicted dwell time (β = 36.08, p<=0.001). The model had RMSE (Root mean square error) of 34.6 %. The fitted regression model is Dwell Time = 36.01 - 4.7 (Cycle) - 0.75 (Mode) + 6.3 (Size) - 0.58 (Status) + 54.4 (Delivery) + 36.6 (Tracking).

Table 13 Summary of OLS Test for Port C (Source: Own Research)

```
==============================================================
      Dep. Variable: y                 R-squared: 0.563
      Model: OLS                      Adj. R-squared: 0.563
      Method:   Least Squares          F-statistic: 7.459e + 05
      No. Observations: 346857         Prob (F-statistic): 0.00
      Df Residuals: 346850             Df Model: 6
==============================================================
                 Coeff     Std Err   T        P>|t|    [0.025    0.975]
Const            36.01     0.092     391.57   0.000    35.831    36.191
Cycle            -4.70     0.898     -5.241   0.000    -6.466    -2.946
Mode             -0.75     0.298     -2.530   0.110    -1.339    -0.170
Size             6.35      0.217     29.245   0.000    -1.339    -0.170
Status           -0.584    0.899     -0.650   0.000    52.902    56.058
Delivery         54.480    0.805     67.704   0.000    52.902    56.058
Tracking         36.089    0.803     44.963   0.000    34.516    37.662
```



	Cycle		Mode		Size		Delivery		Tracking		Status	
	Import	**Export**	**Truck**	**Rail**	**20**	**40**	**Y**	**N**	**Y**	**N**	**Y**	**N**
Mean	54.8	85.7	68.2	60.8	67.9	65.4	55.2	85.6	35.7	124.8	58.5	85.9
N	199123	147734	329440	17069	207999	138740	200678	146153	221107	125750	234498	56948
Std. dev	58.07	51.1	56.2	72.31	58.8	54.7	58.08	51.22	17.53	58.7	54.1	58.8
F	510.8		1385.9		478.0		457.07		60440.7		2125.9	
Sig.	0.000		0.000		0.000		0.000		0.000		0.000	
T	-163.1		16.514		21.92		-159.9		-663.6		-106.665	
Sig.	< 0.001		< 0.001		< 0.001		< 0.001		< 0.001		< 0.001	
Difference (hrs)	30.9		7.4		2.5		30.4		89.1		27.4	

Figure 22 Summary of T test of Port C (Source: Own Research)

Results of the independent samples t-tests indicated that there were significant differences in the mean of independent variables (Cycle, Mode, Size, Delivery, Status and Tracking, (t(346857) = (30.9, 7.4, 2.5, 30.4, 89.1, 27.4, p < .001) in the respective order of the Figure 22.

Figure 23, illustrates the actual versus predicted data for the model and it can be observed that model is predicting the dependent variable dwell time with a RMSE (34.6 %).

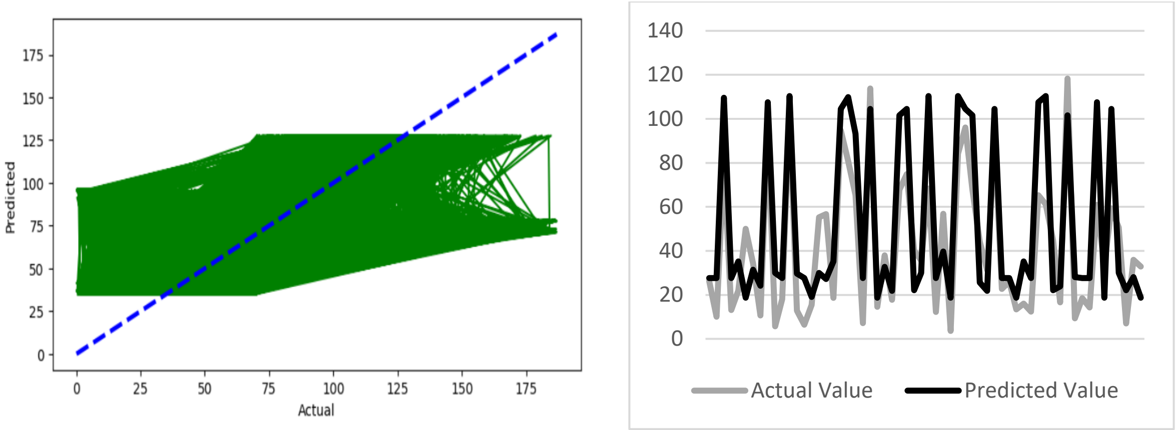
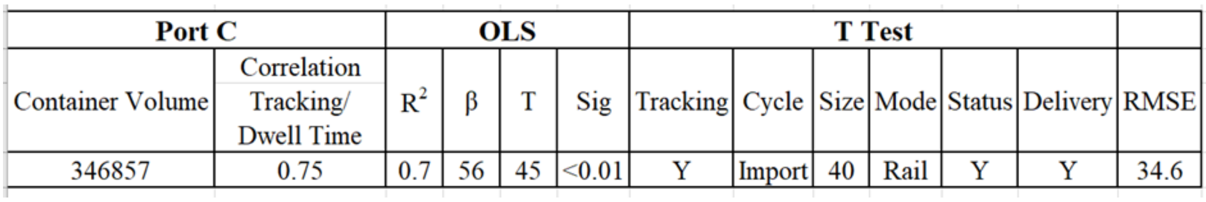


Figure 23 plt.plot of actual versus predicted of Port C (Source: Own Research)

Figure 24, illustrates the summary of various test performed for the Port C including the container volume, correlation, R^2, β, T-value and its significance along with T test and root mean square error for the model.



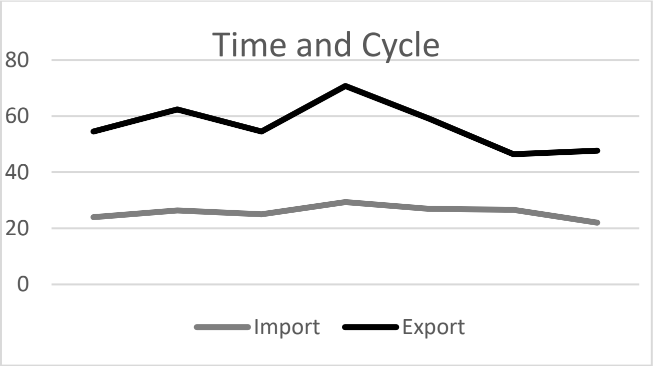
Port C		**OLS**				**T Test**						
Container Volume	Correlation Tracking/ Dwell Time	R^2	β	T	Sig	Tracking	Cycle	Size	Mode	Status	Delivery	RMSE
346857	0.75	0.7	56	45	<0.01	Y	Import	40	Rail	Y	Y	34.6

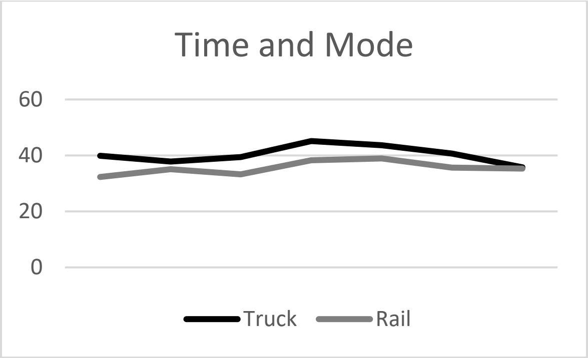
Figure 24 Summary of test results of Port C (Source: Own Research)

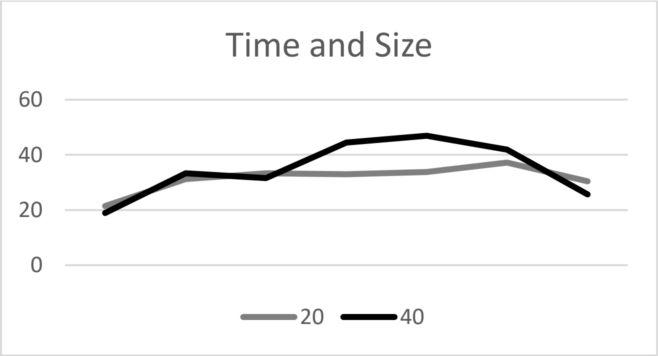
Port D

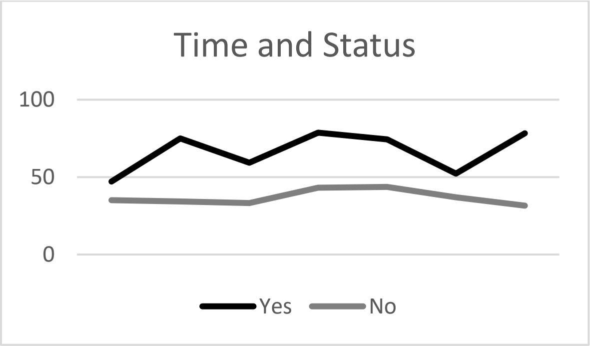
Figure 25, depicts the trends of various independent variables , namely (*i*)Cycle (Import/Export), (*ii*)Size (20 feet/40 feet), (*iii*) Status (Empty/Laden), (*iv*)Mode (Truck/Rail), (*v*)Delivery (DPD-Direct Port Delivery or DPE- Direct Port Export), (*vi*)Tracking (Yes/No), in relation to the container dwell time which is the dependent variable. The data is visually depicted on a graph, with the x-axis representing a semiannual time period and the y-axis representing Dwell Time measured in hours. The provided visual representation illustrates the fluctuations in the dwell time variable as a result of alterations in the corresponding independent variables.

It is observed in the Figure. 25, the dwell time in export cycle is more than 2.18 times than in import cycle, 0.275 times in Rail over truck, almost similarly fluctuating in size 40 feet is 0.88 times of 20 feet, 0.53 times for delivery via CFS(container freight stations) over direct deliveries, 4.71 times higher in containers that are not tracked, and 1.08 times lower in laden containers. This variation is important to be researched and is covered in detail in subsequent chapters of this thesis.









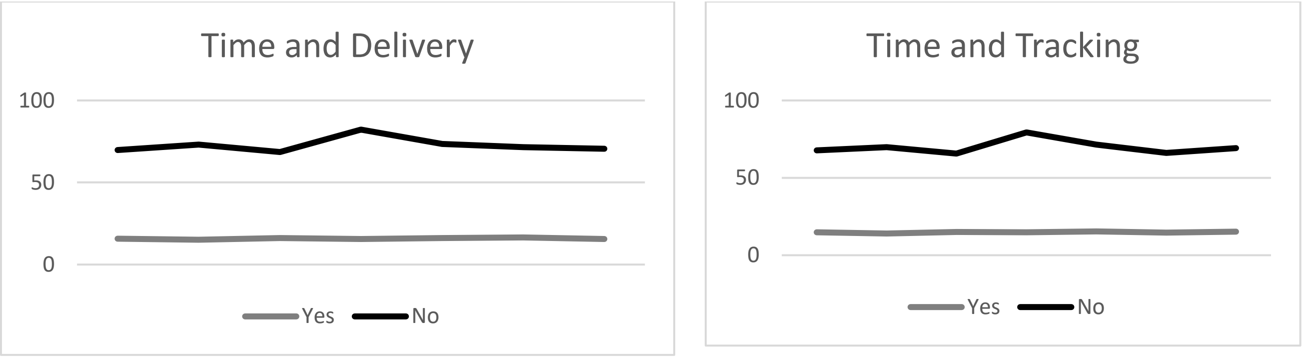


Figure 25 Summary of plotting trends of independent variables and dependent variables (Source: Own Research)

Correlation analysis was performed and results of the Pearson correlation indicated, that there was a significant positive association between time and tracking, (r(97075) = 0.62, p < .001), Figure 26.

	Cycle	Mode	Size	Status	Delivery	Tracking	Time
Cycle	1	0.048	0.003	0.065	0.51	0.51	0.33
Mode	0.048	1	0.13	-0.021	-0.001	0.0041	-0.063
Size	0.003	0.13	1	0.055	0.083	0.093	0.02
Status	0.065	-0.021	0.055	1	-0.079	-0.076	-0.068
Delivery	0.51	-0.001	0.083	-0.079	1	0.94	0.63
Tracking	0.51	0.0041	0.093	-0.076	0.94	1	0.62
Time	0.33	-0.063	0.02	-0.068	0.63	0.62	1

Figure 26 Correlation analysis of dependent variable and independent variables of Port D (Source: Own Research)

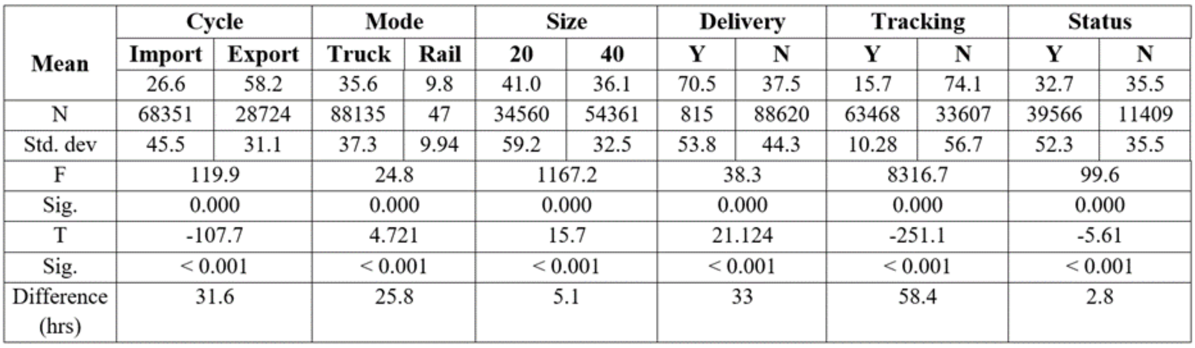
OLS test was utilized to test the impact on dwell time for the determining factors of container operations. Table 14, illustrates the results of the OLS test run on the independent and dependent variable. The overall regression was statistically significant ($R^2 = 0.40$, F(6, 97068)= 11050, p<=0.001). It was observed that continuous tracking significantly predicted dwell time ($\beta = 22.11$, p<=0.001). The model had RMSE (Root mean square error) of 47.3 %. The fitted regression model is Dwell Time = 28.02 + 0.52 (Cycle) - 5.70 (Mode) - 3.95 (Size) - 8.9 (Status) + 37.0 (Delivery) + 22.11 (Tracking).

Table 14 Summary of OLS test for Port D (Source: Own Research)

```
=================================================================
     Dep. Variable: y                    R-squared: 0.406
     Model:      OLS                     Adj. R-squared: 0.406
     Method:   Least Squares             F-statistic: 1.105e + 05
     No. Observations: 97075             Prob (F-statistic): 0.00
     Df Residuals: 97068                 Df Model: 6
=================================================================
```

	Coeff	**Std Err**	**T**	**P>|t|**	**[0.025**	**0.975]**
Const	28.02	1.225	22.875	0.000	25.625	30.427
Cycle	0.5218	0.283	1.843	0.065	-0.033	1.077
Mode	-5.702	0.236	-24.12	0.000	-6.166	-5.239
Size	-3.958	0.368	-10.745	0.000	-4.681	-3.236
Status	-8.965	1.216	-7.374	0.000	-11.348	-6.582
Delivery	37.003	0.674	54.93	0.000	35.668	39.324
Tracking	22.117	0.663	33.353	0.000	20.818	23.417

Results of the independent samples t-tests indicated that there were significant differences in the mean of independent variables (Cycle, Mode, Size, Delivery, Status and Tracking, (t(97075) = (31.6, 25.8, 5.1, 33, 58.4, 2.8 , p < .001) in the respective order of the Figure 27.



Mean	**Cycle**		**Mode**		**Size**		**Delivery**		**Tracking**		**Status**	
	Import	**Export**	**Truck**	**Rail**	**20**	**40**	**Y**	**N**	**Y**	**N**	**Y**	**N**
	26.6	58.2	35.6	9.8	41.0	36.1	70.5	37.5	15.7	74.1	32.7	35.5
N	68351	28724	88135	47	34560	54361	815	88620	63468	33607	39566	11409
Std. dev	45.5	31.1	37.3	9.94	59.2	32.5	53.8	44.3	10.28	56.7	52.3	35.5
F	119.9		24.8		1167.2		38.3		8316.7		99.6	
Sig.	0.000		0.000		0.000		0.000		0.000		0.000	
T	-107.7		4.721		15.7		21.124		-251.1		-5.61	
Sig.	< 0.001		< 0.001		< 0.001		< 0.001		< 0.001		< 0.001	
Difference (hrs)	31.6		25.8		5.1		33		58.4		2.8	

Figure 27 Summary of T test for Port D

Figure. 28, illustrates the actual versus predicted data for the model and it can be observed that model is predicting the dependent variable dwell time with a RMSE (47.3 %).

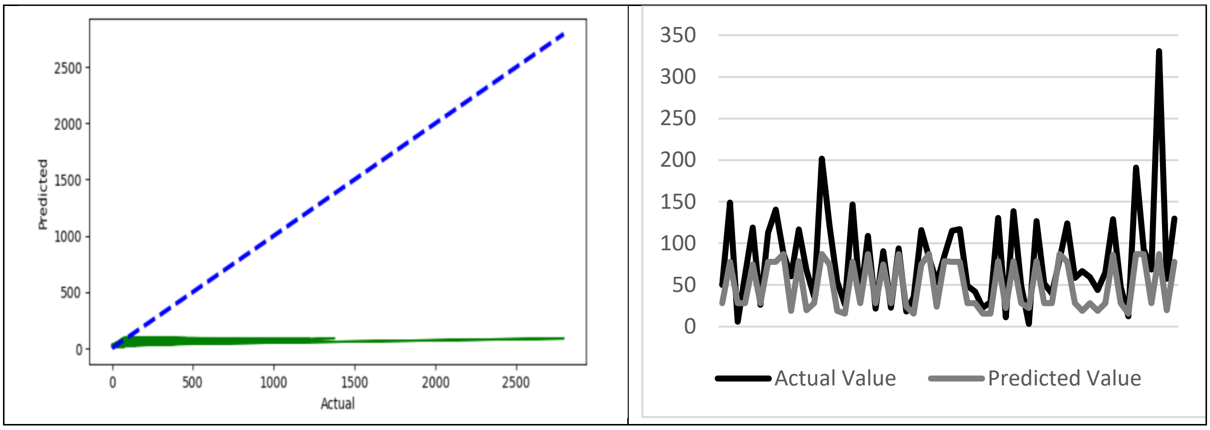
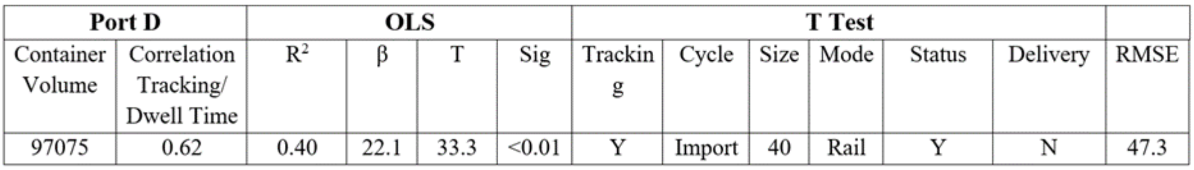


Figure 28 plt.plot of actual versus predicted of Port D (Source: Own Research)

Figure 29, illustrates the summary of various test performed for the Port D including the container volume, correlation , R^2 , β, T-value and its significance along with T test and root mean square error for the model.



Port D		OLS				T Test						
Container Volume	Correlation Tracking/ Dwell Time	R^2	β	T	Sig	Tracking	Cycle	Size	Mode	Status	Delivery	RMSE
97075	0.62	0.40	22.1	33.3	<0.01	Y	Import	40	Rail	Y	N	47.3

Figure 29 Summary of test results for Port D (Source : Own Research)

Port E

Figure 30, depicts the trends of various independent variables , namely (*i*) Cycle (Import/Export), (*ii*)Size (20 feet/40 feet), (*iii*) Status (Empty/Laden), (*iv*)Mode (Truck/Rail), (*v*)Delivery (DPD-Direct Port Delivery or DPE- Direct Port Export), (*vi*)Tracking (Yes/No), in relation to the container dwell time which is the dependent variable. The data is visually depicted on a graph, with the x-axis representing a semiannual time period and the y-axis representing Dwell Time measured in hours. The provided visual representation illustrates the fluctuations in the dwell time variable as a result of alterations in the corresponding independent variables.

It is observed in the Figure. 30, the dwell time in export cycle is more than 2.59 times than in import cycle, 1.11 times in Rail over truck, almost similarly fluctuating in size 40 feet is 1 times of 20 feet, 0.61 times for delivery via CFS(container freight stations) over direct deliveries, 3.64 times higher in containers that are not tracked, and 0.64 times lower in laden containers. This variation is important to be researched and is covered in detail in subsequent chapters of this thesis.

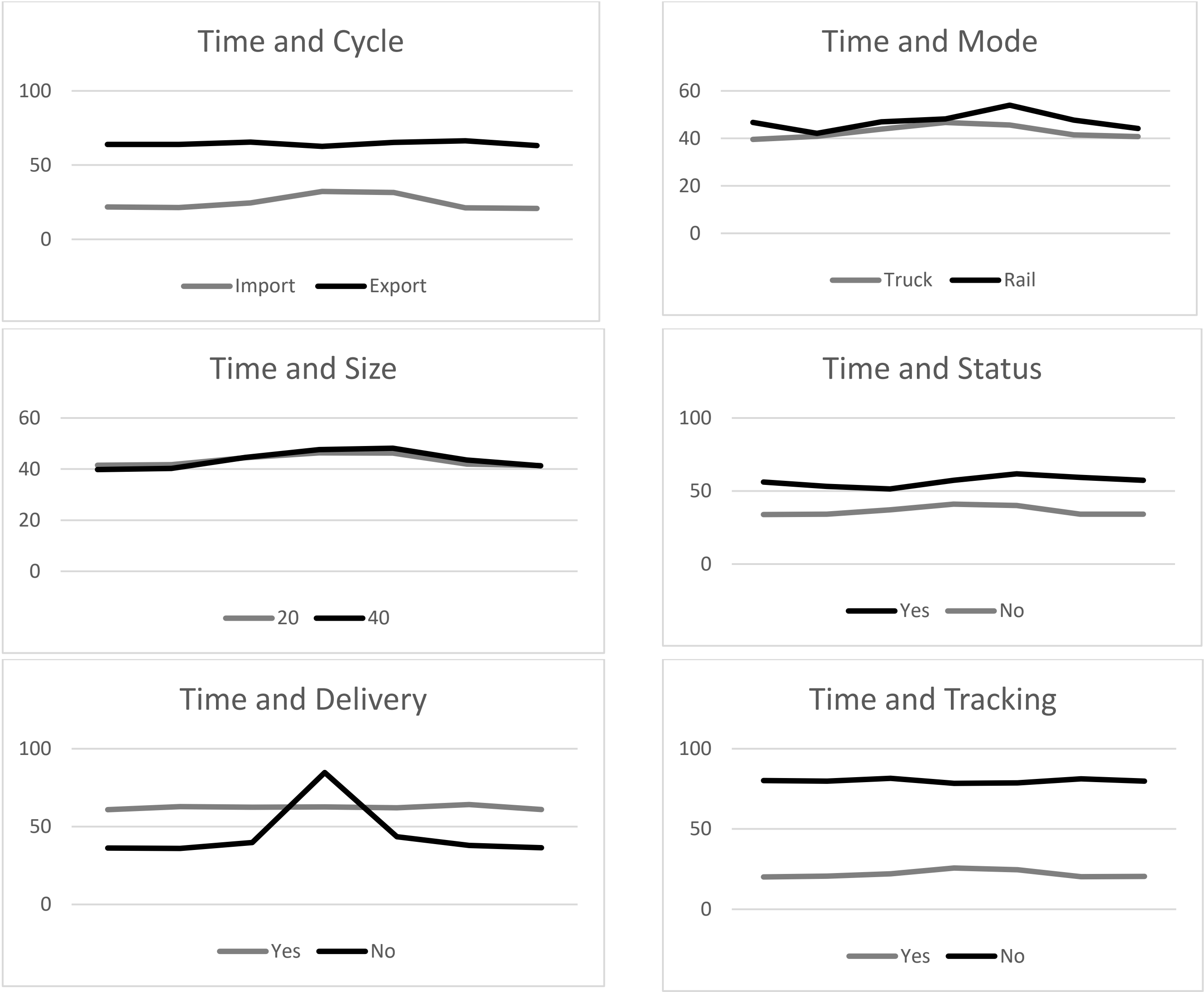


Figure 30 Summary of plotting trends of independent variables and dependent variables of Port E (Source: Own Research)

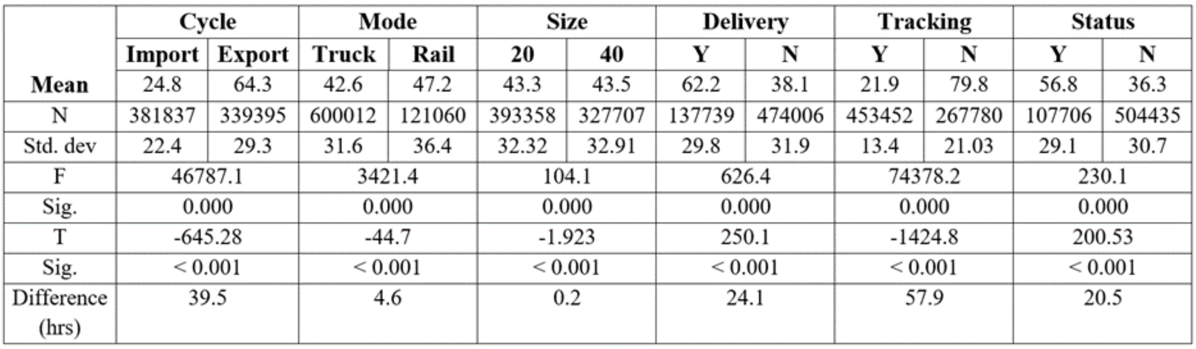
Correlation analysis was performed and the results of the Pearson correlation indicated, that there was a significant positive association between time and tracking, (r(721232) = 0.86, p < .001), Figure 31.

Figure 31 Correlation analysis of dependent variable and independent variables of Port E (Source: Own Research)

OLS test was utilized to test the impact on dwell time for the determining factors of container operations. Table. 15, illustrates the results of the OLS test run on the independent and dependent variable. The overall regression was statistically significant ($R^2 = 0.77$, F(6, 721225)= 407000, p<=0.001). It was observed that continuous tracking significantly predicted dwell time ($\beta = 49.8$, p<=0.001). The model had RMSE (Root mean square error) of 36.9 %. The fitted regression model is Dwell Time = 26.4 + 11.2 (Cycle) + 6.3 (Mode) +0.46 (Size) - 4.7 (Status) – 5.40 (Delivery) + 49.8 (Tracking).

Table 15 OLS test results of Port E (Source: Own Research)

```
============================================================
        Dep. Variable: y                R-squared: 0.772
        Model:      OLS                 Adj. R-squared: 0.772
        Method:   Least Squares         F-statistic: 4.070e + 05
        No. Observations: 721232        Prob (F-statistic): 0.00
        Df Residuals: 721225            Df Model: 6
===========================================================
            Coeff     Std Err   T         P>|t|   [0.025     0.975]
Const       26.48     0.090     294.09    0.000   26.3111    26.664
Cycle       11.26     0.047     239.27    0.000   11.171     11.356
Mode        6.344     0.052     122.84    0.000   0.395      0.540
Size        0.467     0.037     12.62     0.000   0.395      0.540
Status      -4.762    0.059     -81.40    0.000   -4.87      -4.648
Delivery    -5.408    0.056     -97.044   0.000   -5.518     -5.299
Tracking    49.81     0.046     1090.51   0.000   49.727     49.90
```



	Cycle		Mode		Size		Delivery		Tracking		Status	
	Import	Export	Truck	Rail	20	40	Y	N	Y	N	Y	N
Mean	24.8	64.3	42.6	47.2	43.3	43.5	62.2	38.1	21.9	79.8	56.8	36.3
N	381837	339395	600012	121060	393358	327707	137739	474006	453452	267780	107706	504435
Std. dev	22.4	29.3	31.6	36.4	32.32	32.91	29.8	31.9	13.4	21.03	29.1	30.7
F	46787.1		3421.4		104.1		626.4		74378.2		230.1	
Sig.	0.000		0.000		0.000		0.000		0.000		0.000	
T	-645.28		-44.7		-1.923		250.1		-1424.8		200.53	
Sig.	< 0.001		< 0.001		< 0.001		< 0.001		< 0.001		< 0.001	
Difference (hrs)	39.5		4.6		0.2		24.1		57.9		20.5	

Figure 32 Summary of T test results of Port E (Source: Own Research)

Results of the independent samples t-tests indicated that there were significant differences in the mean of independent variables (Cycle, Mode, Size, Delivery, Status and Tracking, (t(721232) = (39.5, 4.6, 0.2, 24.1, 57.9, 20.5, p < .001) in the respective order of the Figure 32.

Figure 33, illustrates the actual versus predicted data for the model and it can be observed that model is predicting the dependent variable dwell time with a RMSE (36.9 %).

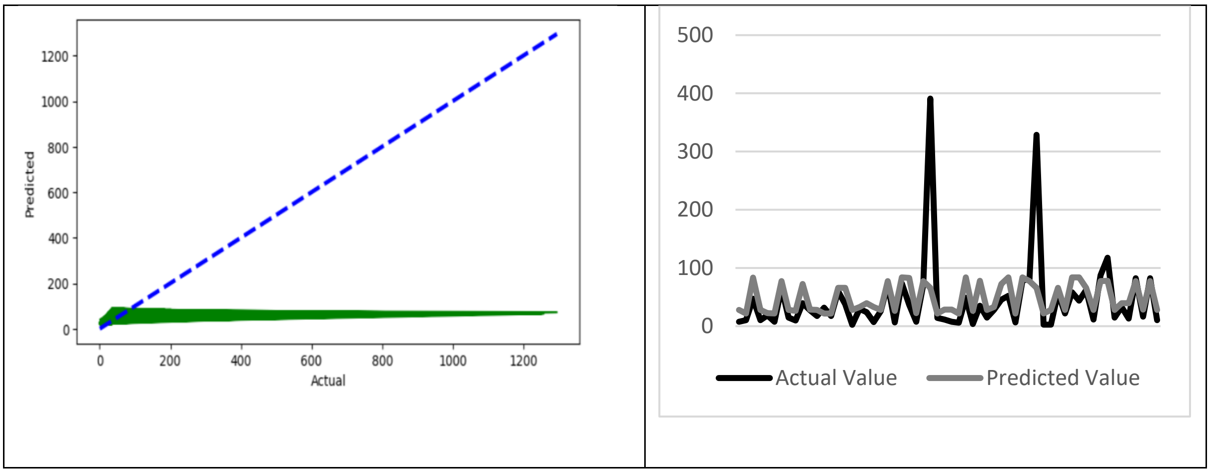
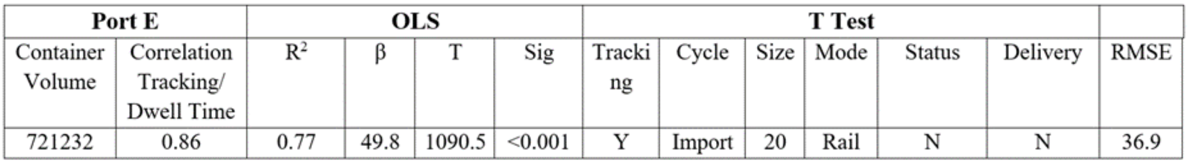


Figure 33 plt.plot of actual versus predicted for Port E (Source: Own Research)

Figure 34, illustrates the summary of various test performed for the Port E including the container volume, correlation , R^2 , β, T-value and its significance along with T test and root mean square error for the model.



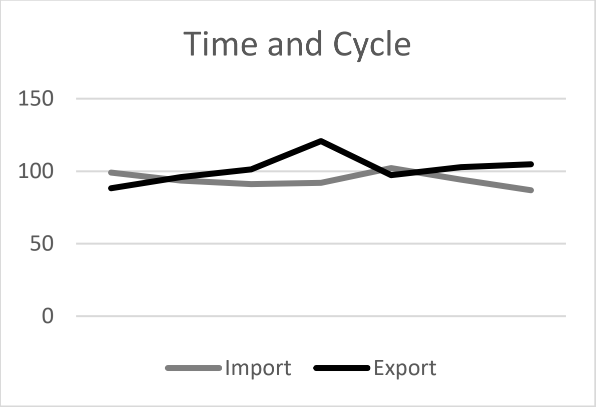
Port E		OLS				T Test						
Container Volume	Correlation Tracking/ Dwell Time	R^2	β	T	Sig	Tracking	Cycle	Size	Mode	Status	Delivery	RMSE
721232	0.86	0.77	49.8	1090.5	<0.001	Y	Import	20	Rail	N	N	36.9

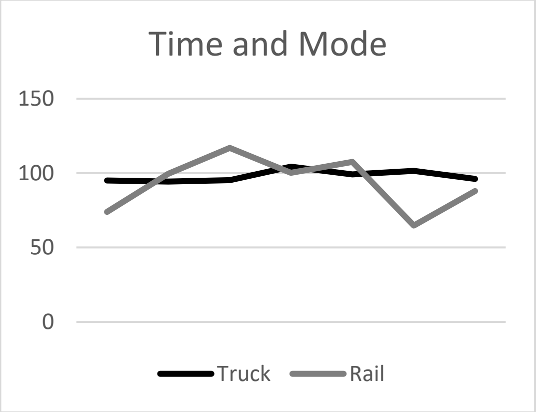
Figure 34 Summary of test results for Port E (Source: Own Research)

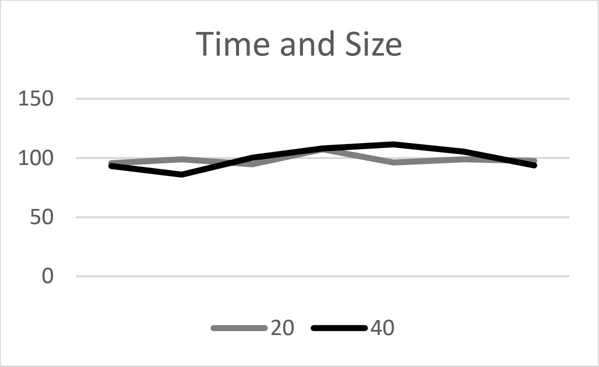
Port F

Figure 35, depicts the trends of various independent variables , namely (*i*) Cycle (Import/Export), (*ii*)Size (20 feet/40 feet), (*iii*) Status (Empty/Laden), (*iv*)Mode (Truck/Rail), (*v*)Delivery (DPD-Direct Port Delivery or DPE- Direct Port Export), (*vi*)Tracking (Yes/No), in relation to the container dwell time which is the dependent variable. The data is visually depicted on a graph, with the x-axis representing a semiannual time period and the y-axis representing Dwell Time measured in hours. The provided visual representation illustrates the fluctuations in the dwell time variable as a result of alterations in the corresponding independent variables.

It is observed in the Figure. 35, the dwell time variation is fluctuating across variables and the variation is substancial for the further research on understanding the reasons. The variation in export cycle is 1.094 time higher than in import cycle, almost similar however 0.90 lesser for rail container, 1.015 times for the 40 feet containers, 4.95 times higher for the container delivered via CFS(container freight stations), 2.67 higher for container that did not have tracking technology and 1.091 for the stuffed containers.


Time and Cycle


Time and Mode


Time and Size

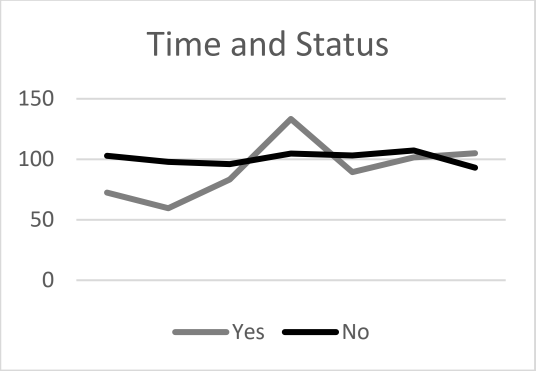
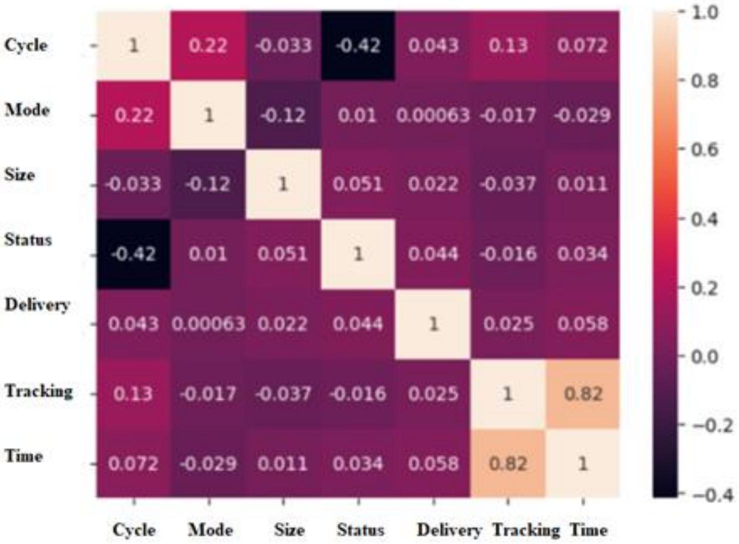

Time and Status

Figure 35 Summary of plotting trends of independent variable and dependent variable of Port F (Source : Own Research)

Correlation analysis was performed and the results of the Pearson correlation indicated, that there was a significant positive association between time and tracking, (r(52443) = 0.82, p < .001), Figure 36.



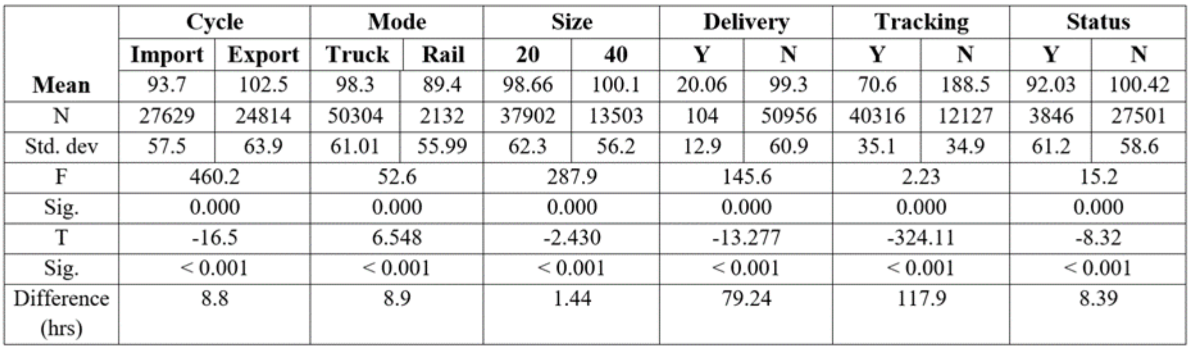
	Cycle	Mode	Size	Status	Delivery	Tracking	Time
Cycle	1	0.22	-0.033	-0.42	0.043	0.13	0.072
Mode	0.22	1	-0.12	0.01	0.00063	-0.017	-0.029
Size	-0.033	-0.12	1	0.051	0.022	-0.037	0.011
Status	-0.42	0.01	0.051	1	0.044	-0.016	0.034
Delivery	0.043	0.00063	0.022	0.044	1	0.025	0.058
Tracking	0.13	-0.017	-0.037	-0.016	0.025	1	0.82
Time	0.072	-0.029	0.011	0.034	0.058	0.82	1

Figure 36 Correlation Analysis of dependent variable and independent variables of Port F (Source: Own Research)

OLS test was utilized to test the impact on dwell time for the determining factors of container operations. Table 16, illustrates the results of the OLS test run on the independent and dependent variable. The overall regression was statistically significant ($R^2 = 0.672$, F(6, 52436)= 17940, p<=0.001). It was observed that continuous tracking significantly predicted dwell time ($\beta = 118.3$, p<=0.001). The model had RMSE (Root mean square error) of 34.82 %. The fitted regression model is Dwell Time = 13.80 - 2.29 (Cycle) - 1.88 (Mode) + 5.29 (Size) +8.67 (Status) + 48.9 (Delivery) + 118.3 (Tracking).

Table 16 Summary of OLS test for Port F (Source: Own Research)

```
=======================================================
      Dep. Variable: y                  R-squared: 0.672
      Model:      OLS                   Adj. R-squared: 0.672
      Method:   Least Squares           F-statistic: 1.794e + 04
      No. Observations: 52443           Prob (F-statistic): 0.00
      Df Residuals: 52446               Df Model: 6
=======================================================
                 Coeff     Std Err   T         P>|t|    [0.025    0.975]
Const            13.80     3.440     4.012     0.000    7.060     20.546
Cycle            -2.29     0.350     -6.566    0.000    -2.981    -1.610
Mode             -1.880    0.801     -2.347    0.019    -3.452    -0.310
Size             5.295     0.353     15.016    0.000    4.604      5.987
Status           8.674     0.666     13.019    0.000    7.368     9.980
Delivery         48.969    3.431     14.272    0.000    42.245    55.695
Tracking         118.35    0.365     324.27    0.000    117.63    119.06
```



	Cycle		Mode		Size		Delivery		Tracking		Status	
	Import	**Export**	**Truck**	**Rail**	**20**	**40**	**Y**	**N**	**Y**	**N**	**Y**	**N**
Mean	93.7	102.5	98.3	89.4	98.66	100.1	20.06	99.3	70.6	188.5	92.03	100.42
N	27629	24814	50304	2132	37902	13503	104	50956	40316	12127	3846	27501
Std. dev	57.5	63.9	61.01	55.99	62.3	56.2	12.9	60.9	35.1	34.9	61.2	58.6
F	460.2		52.6		287.9		145.6		2.23		15.2	
Sig.	0.000		0.000		0.000		0.000		0.000		0.000	
T	-16.5		6.548		-2.430		-13.277		-324.11		-8.32	
Sig.	< 0.001		< 0.001		< 0.001		< 0.001		< 0.001		< 0.001	
Difference (hrs)	8.8		8.9		1.44		79.24		117.9		8.39	

Figure 37 Summary of T test for Port F (Source : Own Research)

Results of the independent samples t-tests indicated that there were significant differences in the mean of independent variables (Cycle, Mode, Size, Delivery, Status, Tracking, (t(52443) = (8.8, 8.9, 1.44, 79.24, 117.9, 8.39 , p < .001) in the respective order of the Figure 37.

Figure 38, illustrates the actual versus predicted data for the model and it can be observed that model is predicting the dependent variable dwell time with a RMSE (34.82 %).

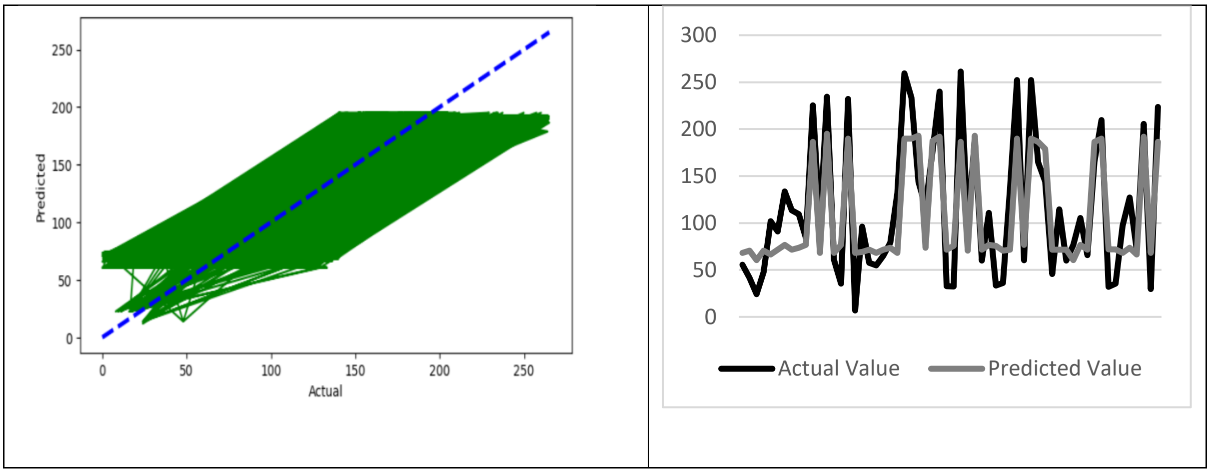
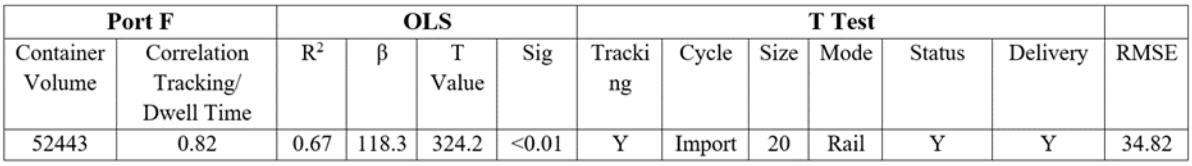


Figure 38 plt.plot of actual versus predicted of Port F (Source : Own Research)

Figure 39, illustrates the summary of various test performed for the Port F including the container volume, correlation , R^2 , β, T-value and its significance along with T test and root mean square error for the model.



Port F		OLS				T Test						
Container Volume	Correlation Tracking/ Dwell Time	R^2	β	T Value	Sig	Tracking	Cycle	Size	Mode	Status	Delivery	RMSE
52443	0.82	0.67	118.3	324.2	<0.01	Y	Import	20	Rail	Y	Y	34.82

Figure 39 Summary of test results for Port F (Source : Own Research)

Port G

Figure 40, depicts the trends of various independent variables , namely (*i*) Cycle (Import/Export), (*ii*)Size (20 feet/40 feet), (*iii*) Status (Empty/Laden), (*iv*)Mode (Truck/Rail), (*v*)Delivery (DPD-Direct Port Delivery or DPE- Direct Port Export), (*vi*)Tracking (Yes/No), in relation to the container dwell time which is the dependent variable. The data is visually depicted on a graph, with the x-axis representing a semiannual time period and the y-axis representing Dwell Time measured in hours. The provided visual representation illustrates the fluctuations in the dwell time variable as a result of alterations in the corresponding independent variables.

It is observed in the Figure. 40, the dwell time variation is fluctuating across variables and the variation is substancial for the further research on understanding the reasons. The variation in export cycle is 2.5 times higher than in import cycle, almost similar however 0.96 lesser for rail container, 1.04 times for the 40 feet containers, 0.87 times lesser for the container delivered via CFS(container freight stations), 3.19 higher for container that did not have tracking technology and 0.49 times lesser for the stuffed containers.

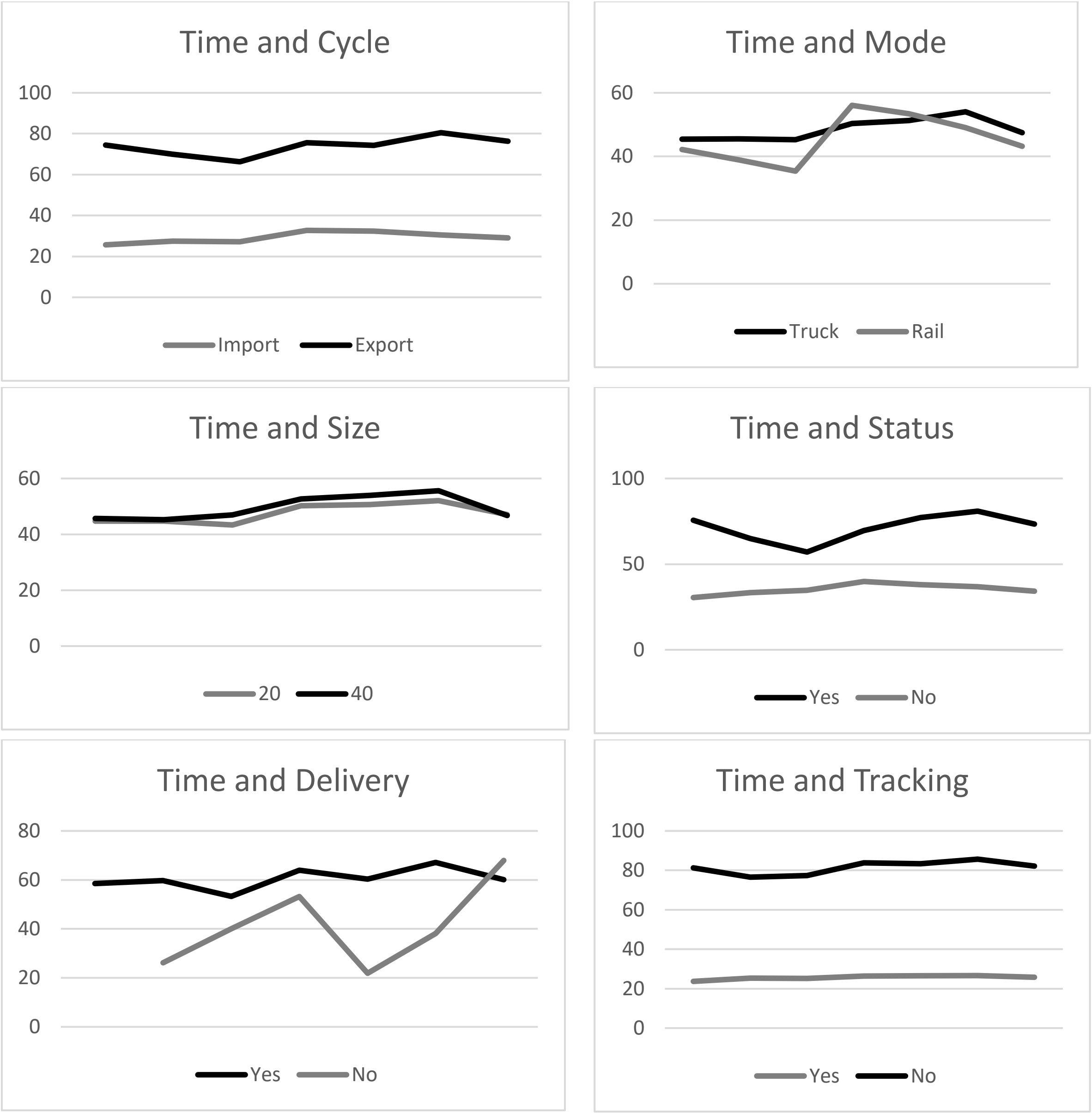


Figure 40 Summary of plotting trends of independent variable and dependent variable of Port G (Source : Own Research)

Correlation analysis was performed and the results of the Pearson correlation indicated, that there was a significant positive association between time and tracking, (r(226441) = 0.85, p < .001), Figure 41.

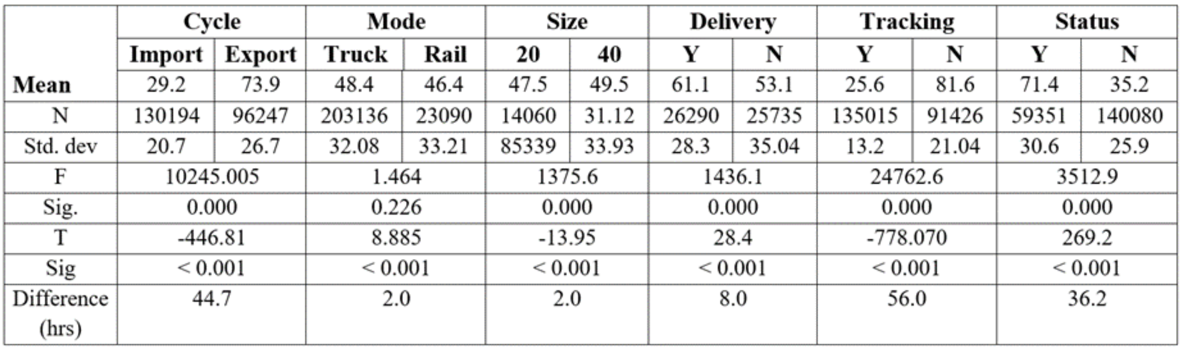
Figure 41 Correlation analysis of dependent variable and independent variables of Port G (Source : Own Research)

OLS test was utilized to test the impact on dwell time for the determining factors of container operations. Table. 17, illustrates the results of the OLS test run on the independent and dependent variable. The overall regression was statistically significant ($R^2 = 0.761$, $F(6, 226441)= 120200$, $p<=0.001$). It was observed that continuous tracking significantly predicted dwell time ($\beta = 45.8$, $p<=0.001$). The model had RMSE (Root mean square error) of 15.76 %. The fitted regression model is Dwell Time = 26.86 + 12.69 (Cycle) + 4.26 (Mode) + 0.80(Size) – 5.191 (Status) + 0.799 (Delivery) + 45.82 (Tracking).

Table 17 Summary of OLS test of Port G (Source: Own Research)

```
===========================================================
       Dep. Variable: y                  R-squared: 0.761
       Model:      OLS                   Adj. R-squared: 0.761
       Method:   Least Squares           F-statistic: 1.202e + 05
       No. Observations: 226441          Prob (F-statistic): 0.00
       Df Residuals: 226434              Df Model: 6
===========================================================
                Coeff     Std Err   T         P>|t|    [0.025    0.975]
Const           26.865    0.150     179.35    0.000    26.571    27.15
Cycle           12.695    0.101     125.48    0.000    12.497    4.483
Mode            4.2622    0.112     37..907   0.000    4.042     4.483
Size            0.804     0.069     11.687    0.000    0.669     0.939
Status          -5.191    0.148     5.387     0.000    0.509     1.090
Delivery        0.799     0.148     5.387     0.000    0.509     1.090
Tracking        45.82     0.090     511.18    0.0000   45.650    46.002
```

Results of the independent samples t-tests indicated that there were significant differences in the mean of independent variables (Cycle, Mode, Size, Delivery, Status, Tracking, (t(226441) = (44.7, 2, 2, 8, 56, 36.2 , p < .001) in the respective order of the Figure 42.



	Cycle		Mode		Size		Delivery		Tracking		Status	
	Import	Export	Truck	Rail	20	40	Y	N	Y	N	Y	N
Mean	29.2	73.9	48.4	46.4	47.5	49.5	61.1	53.1	25.6	81.6	71.4	35.2
N	130194	96247	203136	23090	14060	31.12	26290	25735	135015	91426	59351	140080
Std. dev	20.7	26.7	32.08	33.21	85339	33.93	28.3	35.04	13.2	21.04	30.6	25.9
F	10245.005		1.464		1375.6		1436.1		24762.6		3512.9	
Sig.	0.000		0.226		0.000		0.000		0.000		0.000	
T	-446.81		8.885		-13.95		28.4		-778.070		269.2	
Sig	< 0.001		< 0.001		< 0.001		< 0.001		< 0.001		< 0.001	
Difference (hrs)	44.7		2.0		2.0		8.0		56.0		36.2	

Figure 42 Summary of T test results for Port G (Source : Own Research)

Figure 43, illustrates the actual versus predicted data for the model and it can be observed that model is predicting the dependent variable dwell time with a RMSE (15.7 %).

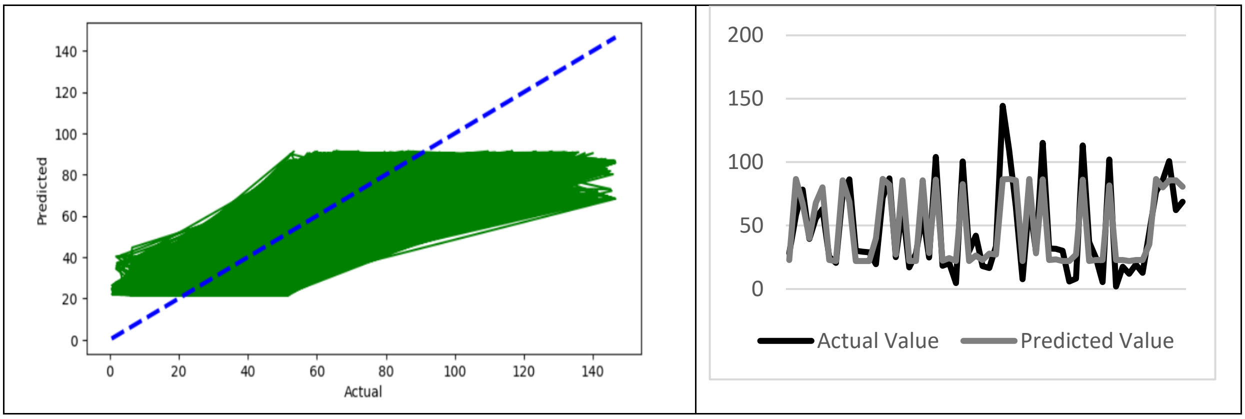


Figure 43 plt.plot of actual versus predicted of Port G (Source : Own Research)

Figure 44, illustrates the summary of various test performed for the Port G including the container volume, correlation , R^2 , β, T-value and its significance along with T test and root mean square error for the model.

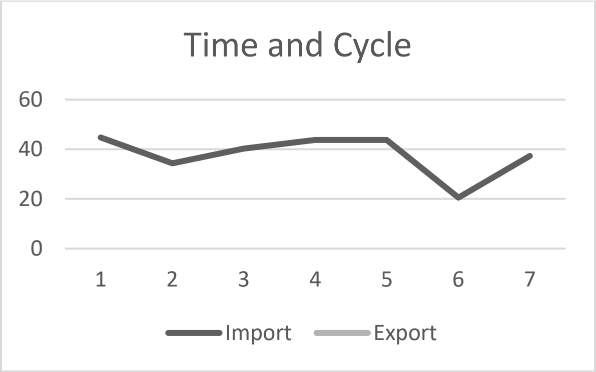
Port G		OLS				T Test						
Container Volume	Correlation Tracking/Dwell Time	R^2	β	T Value	Sig	Tracking	Cycle	Size	Mode	Is_Empty	Is_ DPD/DPE	RMSE
226441	0.85	0.761	45.8	511.18	<0.001	Y	Import	20	Rail	N	N	15.7

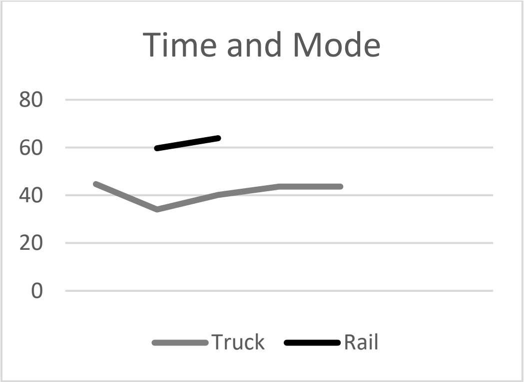
Figure 44 Summary of test results for Port G (Source : Own Research)

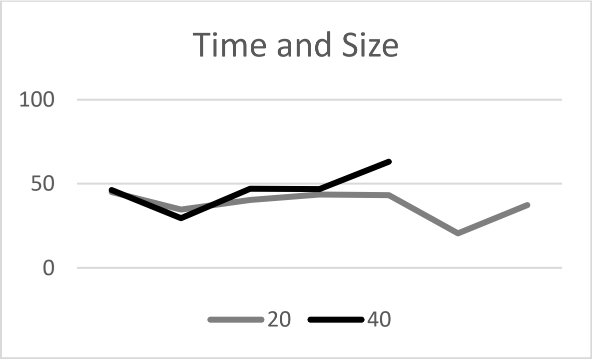
Port H

Figure 45, depicts the trends of various independent variables , namely (*i*) Cycle (Import/Export), (*ii*)Size (20 feet/40 feet), (*iii*) Status (Empty/Laden), (*iv*)Mode (Truck/Rail), (*v*)Delivery (DPD-Direct Port Delivery or DPE- Direct Port Export), (*vi*)Tracking (Yes/No), in relation to the container dwell time which is the dependent variable. The data is visually depicted on a graph, with the x-axis representing a semiannual time period and the y-axis representing Dwell Time measured in hours. The provided visual representation illustrates the fluctuations in the dwell time variable as a result of alterations in the corresponding independent variables.

It is observed in the Figure. 45, the dwell time variation is fluctuating across variables and the variation is substancial for the further research on understanding the reasons. The variation in cycle was non calculable due to sporadic container cycle, 0.52 lesser for rail container, 1.19 times higher for the 40 feet containers, 1.21 higher for the containers delivered via CFS(container freight stations), 2.92 higher for container that did not have tracking technology and 1.07 times higher for the stuffed containers.







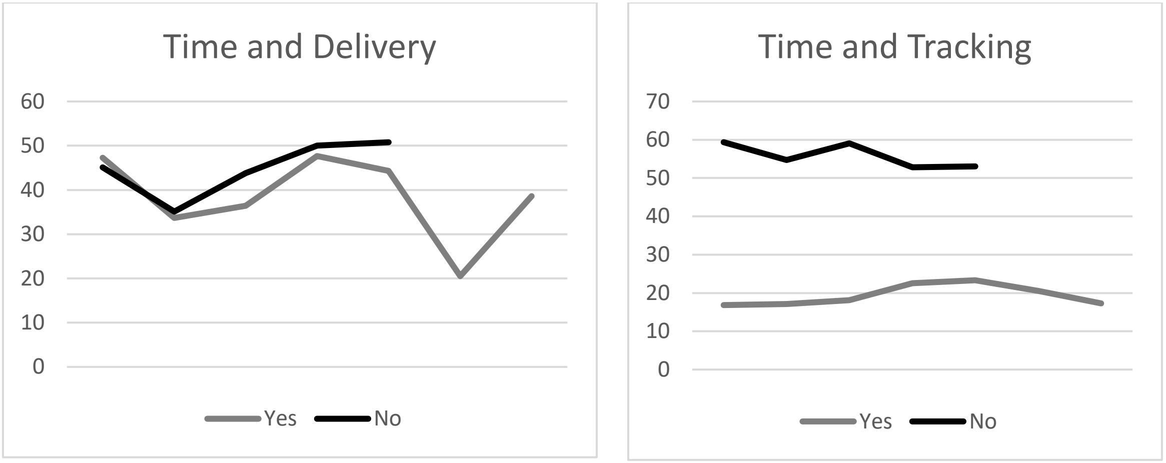
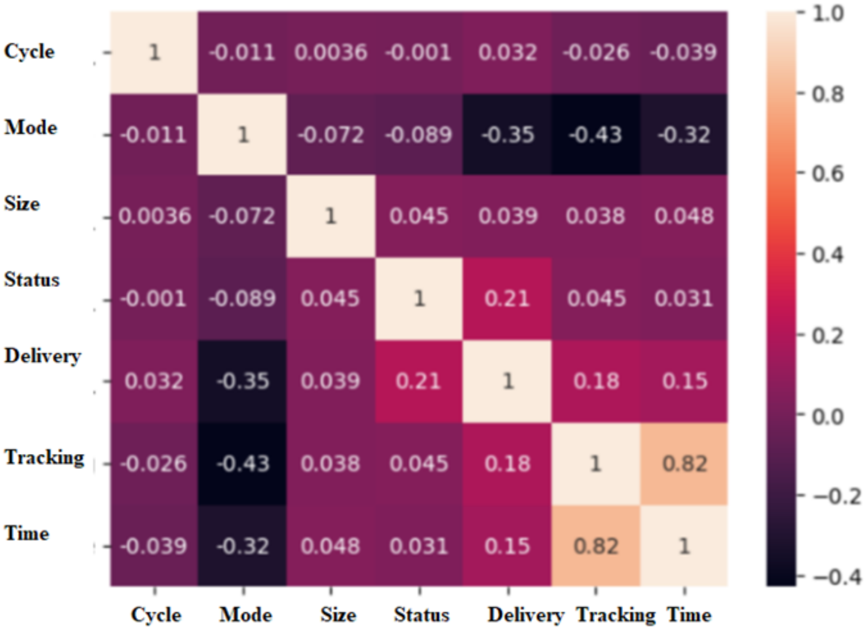


Figure 45 Summary of plotting trends of independent and dependent variables (Source: Own Research)

Correlation analysis was performed and the results of the Pearson correlation indicated that there was a significant positive association between time and tracking, (r(62705) = 0.82, p < .001), Figure 46.



	Cycle	Mode	Size	Status	Delivery	Tracking	Time
Cycle	1	-0.011	0.0036	-0.001	0.032	-0.026	-0.039
Mode	-0.011	1	-0.072	-0.089	-0.35	-0.43	-0.32
Size	0.0036	-0.072	1	0.045	0.039	0.038	0.048
Status	-0.001	-0.089	0.045	1	0.21	0.045	0.031
Delivery	0.032	-0.35	0.039	0.21	1	0.18	0.15
Tracking	-0.026	-0.43	0.038	0.045	0.18	1	0.82
Time	-0.039	-0.32	0.048	0.031	0.15	0.82	1

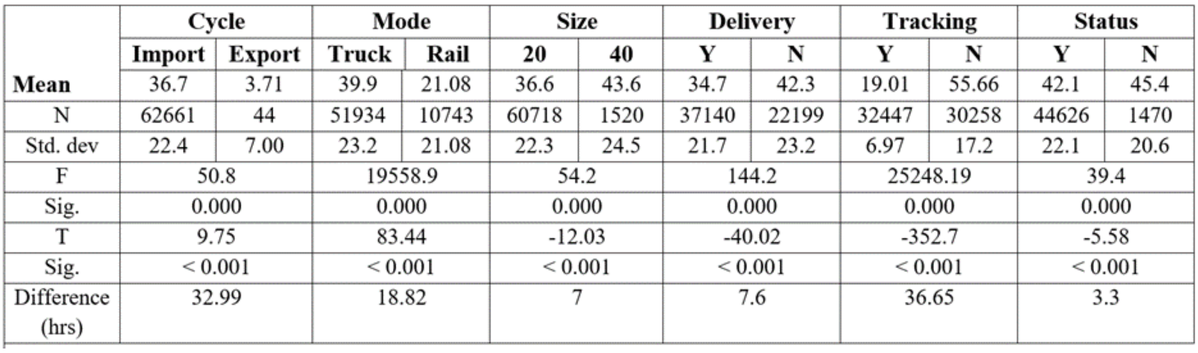
Figure 46 Correlation analysis of dependent and independent variables of Port H (Source: Own Research)

OLS test was utilized to test the impact on dwell time for the determining factors of container operations. Table 18, illustrates the results of the OLS test run on the independent and dependent variable. The overall regression was statistically significant (R^2 = 0.667, F(6, 62698)= 20950, p<=0.001). It was observed that continuous tracking significantly predicted dwell time (β = 37.3, p<=0.001). The model had RMSE (Root mean square error) of 31.3 %. The fitted regression model is Dwell Time = 17.9 – 14.9 (Cycle) + 2.78 (Mode) + 2.83(Size) – 0.86 (Status) + 0.62 (Delivery) + 37.3 (Tracking).

Table 18 Summary of OLS Test for Port H (Source: Own Research)

```
=================================================================
      Dep. Variable: y                  R-squared: 0.667
      Model:     OLS                    Adj. R-squared: 0.667
      Method:   Least Squares           F-statistic: 2.905e + 05
      No. Observations: 62705          Prob (F-statistic): 0.00
      Df Residuals: 62698              Df Model: 6
 ================================================================
                  Coeff     Std Err  T         P>|t|    [0.025    0.975]
 Const            17.90     0.102    175.71    0.000    17.705    18.105
 Cycle            -14.91    1.956    -7.62     0.000    -18.75    -11.08
 Mode             2.782     0.160    17.363    0.000    2.469     3.097
 Size             2.83      0.338    8.38      0.000    2.170     3.49
 Status           -0.86     0.352    -2.46     0.014    -1.556    -0.178
 Delivery         0.62      0.120    5.23      0.000    0.392     0.861
 Tracking         37.3      0.115    325.7     0.000    37.17     37.62
```

Results of the independent samples t-tests indicated that there were significant differences in the mean of independent variables (Cycle, Mode, Size, Delivery, Status, Tracking, (t(62705) = (32.9, 18.8, 7, 7.6, 36.6, 3.3 , p < .001) in the respective order of the Figure 47.



	Cycle		**Mode**		**Size**		**Delivery**		**Tracking**		**Status**	
	Import	**Export**	**Truck**	**Rail**	**20**	**40**	**Y**	**N**	**Y**	**N**	**Y**	**N**
Mean	36.7	3.71	39.9	21.08	36.6	43.6	34.7	42.3	19.01	55.66	42.1	45.4
N	62661	44	51934	10743	60718	1520	37140	22199	32447	30258	44626	1470
Std. dev	22.4	7.00	23.2	21.08	22.3	24.5	21.7	23.2	6.97	17.2	22.1	20.6
F	50.8		19558.9		54.2		144.2		25248.19		39.4	
Sig.	0.000		0.000		0.000		0.000		0.000		0.000	
T	9.75		83.44		-12.03		-40.02		-352.7		-5.58	
Sig.	< 0.001		< 0.001		< 0.001		< 0.001		< 0.001		< 0.001	
Difference (hrs)	32.99		18.82		7		7.6		36.65		3.3	

Figure 47 Summary of T test for Port H (Source : Own Research)

Figure 48, Illustrates the actual versus predicted data for the model and it can be observed that model is predicting the dependent variable dwell time with a RMSE (31.3 %).

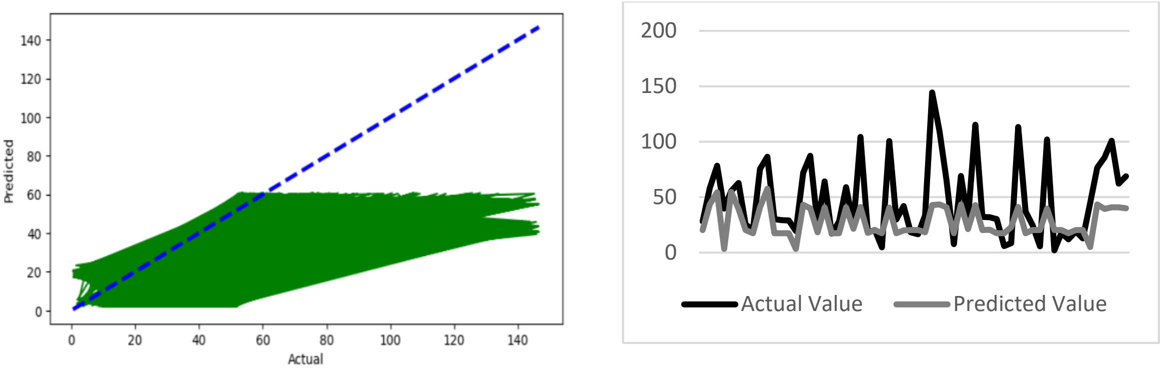


Figure 48 plt.plot of actual versus predicted for Port H Source : Own Research

Figure 49, illustrates the summary of various test performed for the Port H including the container volume, correlation , R^2 , β , T-value and its significance along with T test and root mean square error for the model.

Port H		OLS				T Test						
Container Volume	Correlation Tracking/ Dwell Time	R^2	β	T Value	Sig	Tracking	Cycle	Size	Mode	Is_Empty	Is_ DPD/DPE	RMSE
62705	0.82	0.667	37.3	325.7	<0.001	Y	Export	20	Rail	Y	Y	31.3

Figure 49 Summary of test results for Port H (Source: Own Research)

Port I

Figure 50, depicts the trends of various independent variables , namely (*i*) Cycle (Import/Export), (*ii*)Size (20 feet/40 feet), (*iii*) Status (Empty/Laden), (*iv*)Mode (Truck/Rail), (*v*)Delivery (DPD-Direct Port Delivery or DPE- Direct Port Export), (*vi*)Tracking (Yes/No), in relation to the container dwell time which is the dependent variable. The data is visually depicted on a graph, with the x-axis representing a semiannual time period and the y-axis representing Dwell Time measured in hours. The provided visual representation illustrates the fluctuations in the dwell time variable as a result of alterations in the corresponding independent variables.

It is observed in the Figure. 50, the dwell time variation is fluctuating across variables and the variation is substancial for the further research on understanding the reasons. The variation in cycle and mode is sporadic , almost similar for size wherein 40 feet is 0.99 times lesser, 1.54 times higher for delivery via CFS (Container freight station), 2.71 times higher for containers with no tracking technology and 1.13 times higher for laden containers.

Figure 50 Summary of plotting trends of indepedent and dependent variables of Port I (Source: Own Research)

Correlation analysis was performed and the results of the Pearson correlation indicated, that there was a significant positive association between time and tracking, (r(76402) = 0.82, p < .001), Figure 51.

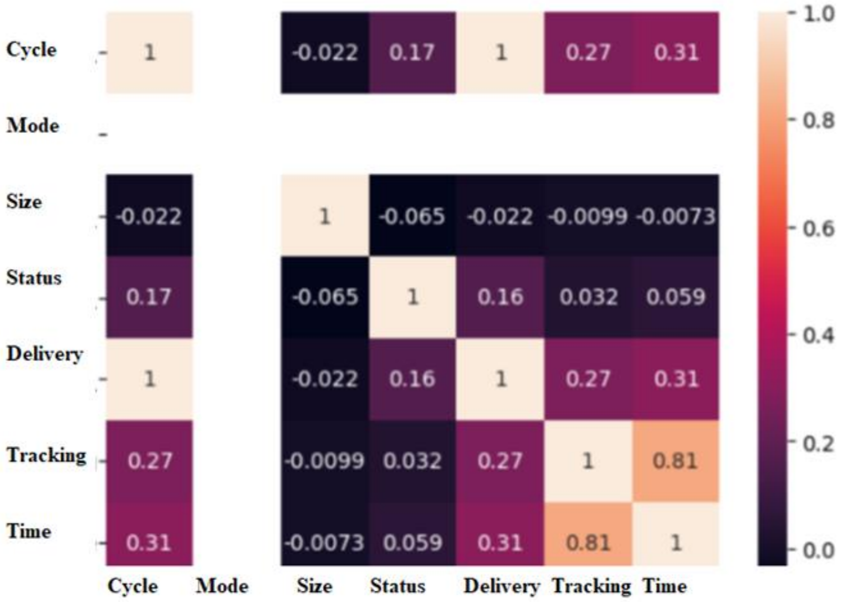


Figure 51 Correlation analysis of dependent variable and independent variable of Port I (Source: Own Research)

OLS test was utilized to test the impact on dwell time for the determining factors of container operations. Table 19, illustrates the results of the OLS test run on the independent and dependent variable. The overall regression was statistically significant (R^2 = 0.670, F(6, 76396)= 30980, p<=0.001). It was observed that continuous tracking significantly predicted dwell time (β = 75.2, p<=0.001). The model had RMSE (Root mean square error) of 21.5 %. The fitted regression model is Dwell Time = 43.7 + 11.64 (Cycle) + 0.28(Size) +2.3 (Status) – 2.91 (Delivery) + 75.2 (Tracking).

Table 19 Summary of OLS test for Port I (Source: Own Research)

```
=====================================================
       Dep. Variable: y                     R-squared: 0.670
       Model:      OLS                      Adj. R-squared: 0.670
       Method:   Least Squares              F-statistic: 3.098e + 04
       No. Observations: 76402              Prob (F-statistic): 0.00
       Df Residuals: 76396                  Df Model: 6
=====================================================
                Coeff       Std Err     T        P>|t|   [0.025      0.975]
Const           43.7        0.128       342.77   0.000   43.493      43.994
Cycle           11.64       4.678       2.490    0.000   2.480       20.818
Mode            -5.3e-15    7.26e-16    -7.35    0.000   -6.75e-15   -3.91e-15
Size            0.2801      0.157       1.783    0.075   -0.028      0.588
Status          2.38        0.265       8.998    0.000   1.868       2.909
Delivery        -2.917      4.675       -0.624   0.533   -12.080     6.244
Tracking        75.25       0.206       364.64   0.000   74.853      75.662
```

Results of the independent samples t-tests indicated that there were significant differences in the mean of independent variables (Cycle, Mode, Size, Delivery, Status and Tracking, (t(76402) = (30, NA, 0.5, 29.9, 77.6, 7.6 , p < .001) in the respective order of the Figure 52.

Mean	Cycle		Mode		Size		Delivery		Tracking		Status	
	Import	**Export**	**Truck**	**Rail**	**20**	**40**	**Y**	**N**	**Y**	**N**	**Y**	**N**
	54.6	84.6	NA	NA	60.3	59.8	54.6	84.5	45.3	122.9	55.3	62.9
N	62707	13695	NA	NA	35691	39805	62683	13714	61923	14479	53699	7754
Std. dev	34.7	39.1	NA	NA	37.7	37.1	34.7	39.19	22.5	17.9	35.5	36.6
F	951.3		NA		15.6		954.9		974.4		28.2	
Sig.	0.000		NA		0.000		0.000		0.000		0.000	
T	-89.3		NA		2.002		-89.2		-386.2		-17.3	
Sig	< 0.001		NA		< 0.001		< 0.001		< 0.001		< 0.001	
Diff (hrs)	30		NA		0.5		29.9		77.6		7.6	

Figure 52 Summary of T test for Port I (Source: Own Research)

Figure 53, illustrates the actual versus predicted data for the model and it can be observed that model is predicting the dependent variable dwell time with a RMSE (21.5 %).

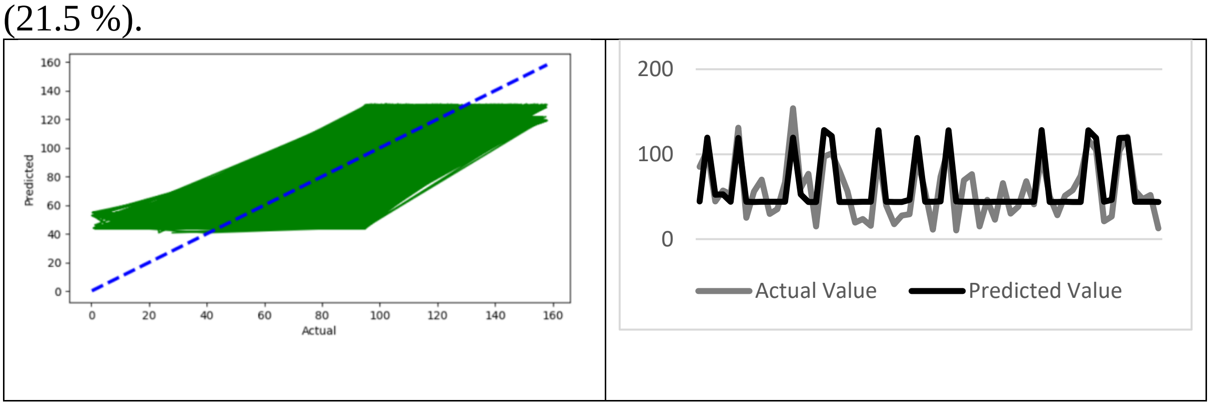


Figure 53 plt.plot of actual versus predicted for Port I (Source: Own Research)

Figure 54, illustrates the summary of various test performed for the Port I including the container volume, correlation , R^2 , β, T-value and its significance along with T test and root mean square error for the model.

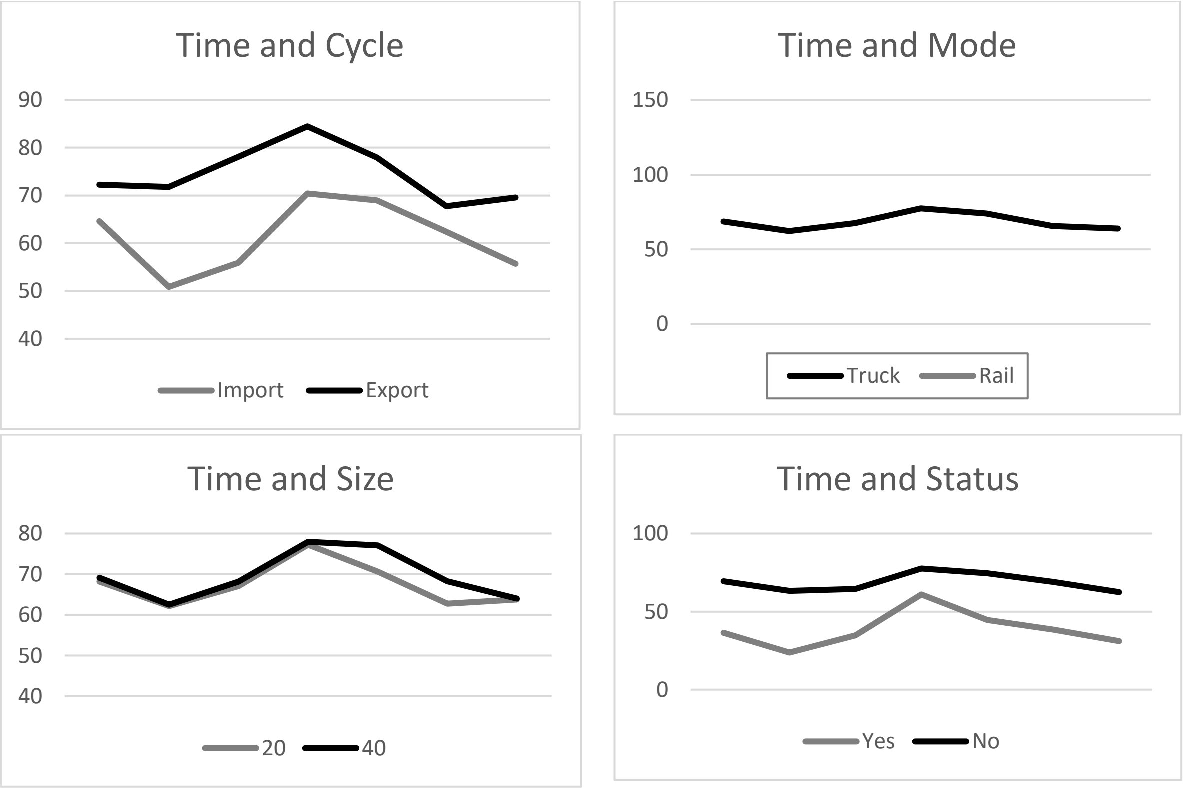
Port I		**OLS**				**T Test**						
Container Volume	Correlation Tracking/ Dwell Time	R^2	β	T Value	Sig	Tracking	Cycle	Size	Mode	Is_Empty	Is_ DPD/DPE	RMSE
76402	0.81	0.67	75.2	364.6	<0.001	Y	Import	40	NA	Y	Y	21.5

Figure 54 Summary of test results for Port I (Source: Own Research)

Port J

Figure 55, depicts the trends of various independent variables , namely (*i*) Cycle (Import/Export), (*ii*)Size (20 feet/40 feet), (*iii*) Status (Empty/Laden), (*iv*)Mode (Truck/Rail), (*v*)Delivery (DPD-Direct Port Delivery or DPE- Direct Port Export), (*vi*)Tracking (Yes/No), in relation to the container dwell time which is the dependent variable. The data is visually depicted on a graph, with the x-axis representing a semiannual time period and the y-axis representing Dwell Time measured in hours. The provided visual representation illustrates the fluctuations in the dwell time variable as a result of alterations in the corresponding independent variables.

It is observed in the Figure. 55, the dwell time variation is fluctuating across variables and the variation is substancial for the further research on understanding the reasons. The variation in export cycle is 1.2 times higher than in import cycle, a bit sporadic in mode, 1.01 times higher for the 40 feet containers, 0.78 times lesser for the container delivered via CFS(container freight stations), 2.69 higher for container that did not have tracking technology and 1.69 times lesser for the stuffed containers.



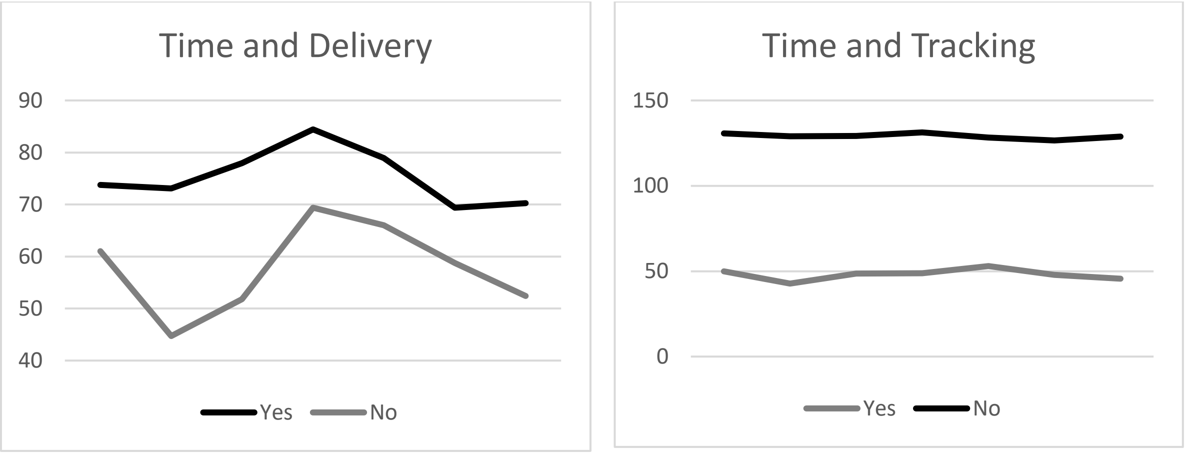
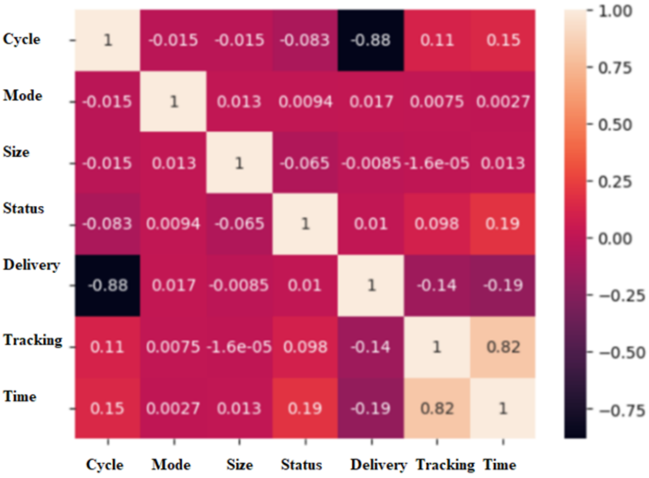


Figure 55 Summary of Plotting trends of independent and dependent variables of Port J (Source: Own Research)

Correlation analysis was performed and the results of the Pearson correlation indicated, that there was a significant positive association between time and tracking, (r(106225) = 0.81, p < .001), Figure 56.



	Cycle	Mode	Size	Status	Delivery	Tracking	Time
Cycle	1	-0.015	-0.015	-0.083	-0.88	0.11	0.15
Mode	-0.015	1	0.013	0.0094	0.017	0.0075	0.0027
Size	-0.015	0.013	1	-0.065	-0.0085	-1.6e-05	0.013
Status	-0.083	0.0094	-0.065	1	0.01	0.098	0.19
Delivery	-0.88	0.017	-0.0085	0.01	1	-0.14	-0.19
Tracking	0.11	0.0075	-1.6e-05	0.098	-0.14	1	0.82
Time	0.15	0.0027	0.013	0.19	-0.19	0.82	1

Figure 56 Correlation Analysis of dependent variable and independent variables of Port J (Source: Own Research)

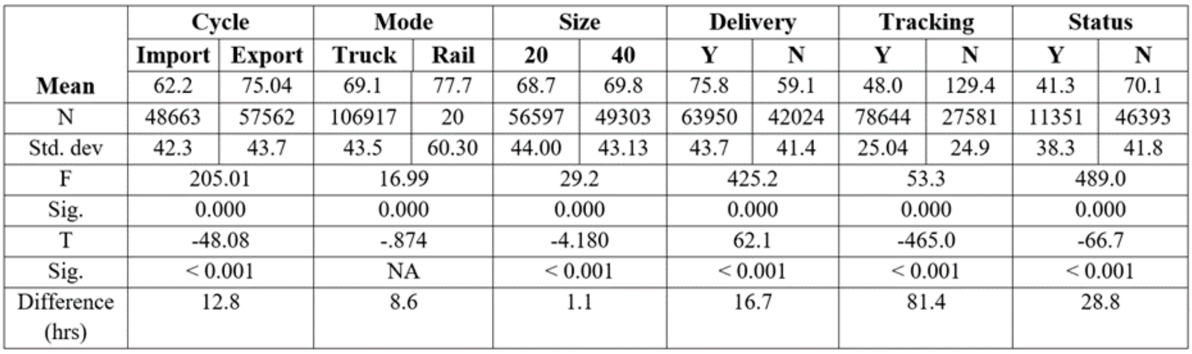
OLS Test

OLS test was utilized to test the impact on dwell time for the determining factors of container operations. Table 20, illustrates the results of the OLS test run on the independent and dependent variable. The overall regression was statistically significant ($R^2 = 0.689$, F(6, 106218)= 39190, p<=0.001). It was observed that continuous tracking significantly predicted dwell time (β = 79.2, p<=0.001). The model had RMSE (Root mean square error) of 23.4 %. The fitted regression model is Dwell Time = 36.1 + 0.44 (Cycle) -10.9 (Mode) + 1.7(Size) + 17.2 (Status) – 6.09 (Delivery) + 79.2 (Tracking).

Table 20 Summary of OLS test results of Port J (Source: Own Research)

```
====================================================================
      Dep. Variable: y                  R-squared: 0.689
      Model:      OLS                   Adj. R-squared: 0.689
      Method:   Least Squares           F-statistic: 3.919e + 04
      No. Observations: 106225          Prob (F-statistic): 0.00
      Df Residuals: 106218              Df Model: 6
====================================================================
                Coeff       Std Err   T         P>|t|   [0.025    0.975]
Const           36.1        0.408     88.72     0.000   35.38     36.97
Cycle           0.4466      0.323     1.37      0.168   -0.188    1.079
Mode            -10.90      5.43      -2.005    0.045   -21.56    -0.244
Size            1.745       0.150     11.605    0.000   1.450     2.040
Status          17.25       0.260     66.45     0.000   16.75     17.76
Delivery        -6.09       0.329     -18.507   0.000   -6.744    -5.452
Tracking        79.2        0.173     458.36    0.000   78.89     79.57
```

Results of the independent samples t-tests indicated that there were significant differences in the mean of independent variables (Cycle, Mode, Size, Delivery, Status, and Tracking, (t(106225) = (12.8, 8.6, 1.1, 16.7, 81.4, 28.8 , p < .001) in the respective order of the Figure 57.



	Cycle		**Mode**		**Size**		**Delivery**		**Tracking**		**Status**	
	Import	**Export**	**Truck**	**Rail**	**20**	**40**	**Y**	**N**	**Y**	**N**	**Y**	**N**
Mean	62.2	75.04	69.1	77.7	68.7	69.8	75.8	59.1	48.0	129.4	41.3	70.1
N	48663	57562	106917	20	56597	49303	63950	42024	78644	27581	11351	46393
Std. dev	42.3	43.7	43.5	60.30	44.00	43.13	43.7	41.4	25.04	24.9	38.3	41.8
F	205.01		16.99		29.2		425.2		53.3		489.0	
Sig.	0.000		0.000		0.000		0.000		0.000		0.000	
T	-48.08		-.874		-4.180		62.1		-465.0		-66.7	
Sig.	< 0.001		NA		< 0.001		< 0.001		< 0.001		< 0.001	
Difference (hrs)	12.8		8.6		1.1		16.7		81.4		28.8	

Figure 57 Summary of T test results of Port J (Source : Own Research)

Figure 58, illustrates the actual versus predicted data for the model and it can be observed that model is predicting the dependent variable dwell time with a RMSE (23.4 %).

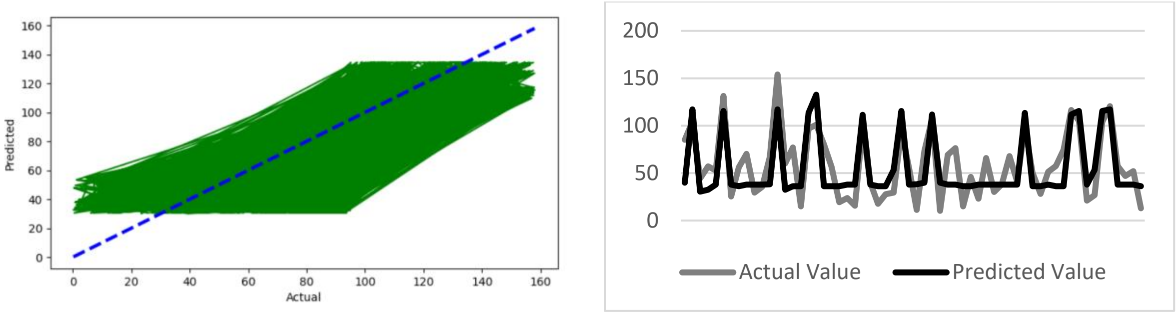


Figure 58 plt.plot of actual versus predicted of Port J (Source: Own Research)

Figure 59, illustrates the summary of various test performed for the Port J including the container volume, correlation , R^2 , β, T-value and its significance along with T test and root mean square error for the model.

Port J		**OLS**				**T Test**						
Container Volume	Correlation Tracking/ Dwell Time	R^2	β	T Value	Sig	Tracking	Cycle	Size	Mode	Is_Empty	Is_ DPD/DPE	RMSE
106225	0.82	0.68	79.2	458.3	<0.001	Y	Import	20	Truck	N	Y	23.4

Figure 59 Summary of test results for Port J (Source: Own Research)

Port K

Figure 60, depicts the trends of various independent variables , namely (*i*) Cycle (Import/Export), (*ii*)Size (20 feet/40 feet), (*iii*) Status (Empty/Laden), (*iv*)Mode (Truck/Rail), (*v*)Delivery (DPD-Direct Port Delivery or DPE- Direct Port Export), (*vi*)Tracking (Yes/No), in relation to the container dwell time which is the dependent variable. The data is visually depicted on a graph, with the x-axis representing a semi-annual time period and the y-axis representing Dwell Time measured in hours. The provided visual representation illustrates the fluctuations in the dwell time variable as a result of alterations in the corresponding independent variables.

It is observed in the Figure. 60, the dwell time variation is fluctuating across variables and the variation is substantial for the further research on understanding the reasons. The variation in export cycle is 1.8 times higher than in import cycle, 0.5 times lesser in Rail mode, 1.2 times higher for the 40 feet containers, 0.5 times lesser for the container delivered via CFS(container freight stations), 4.3 higher for container that did not have tracking technology and 1.16 times lesser for the stuffed containers.

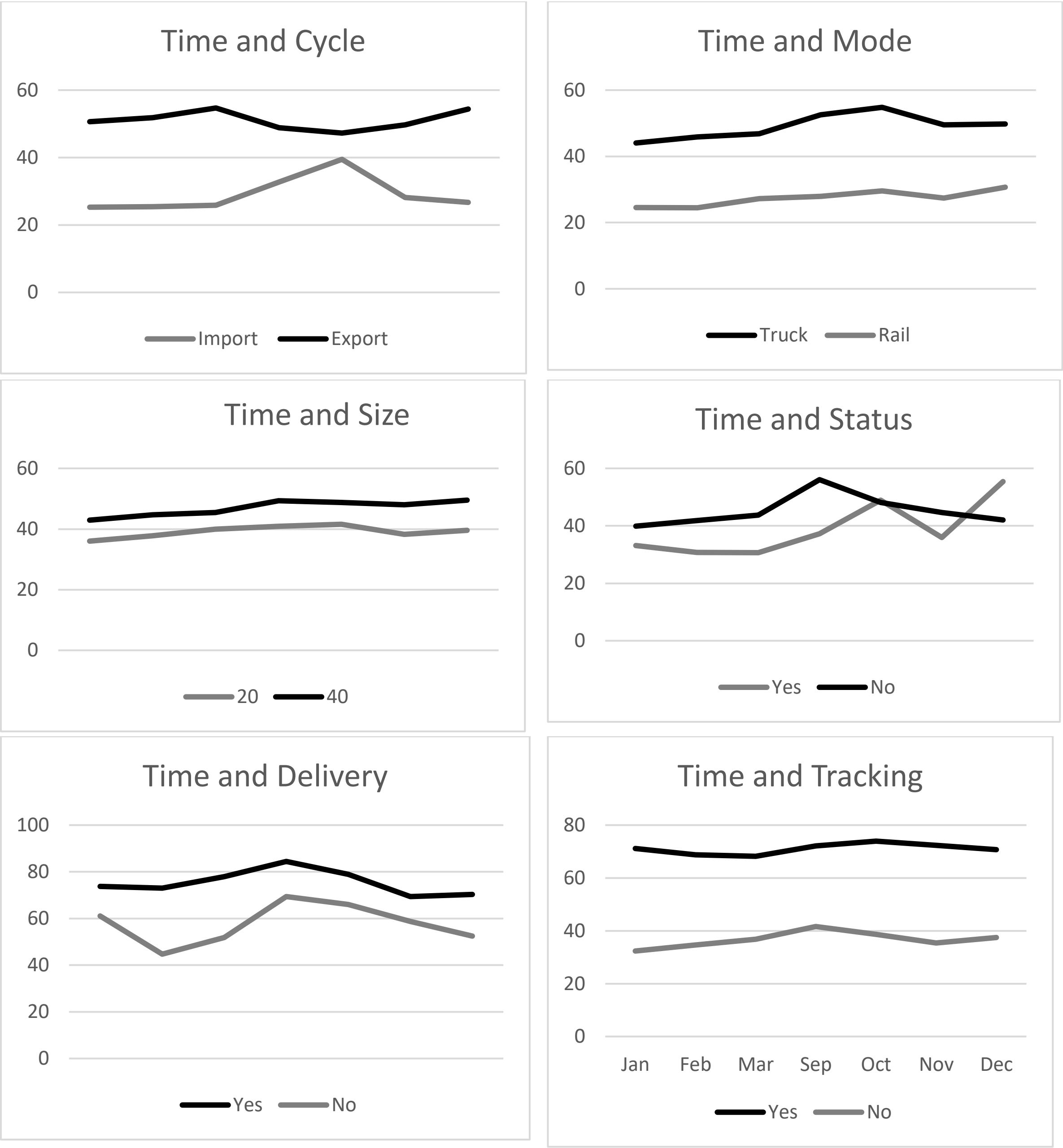
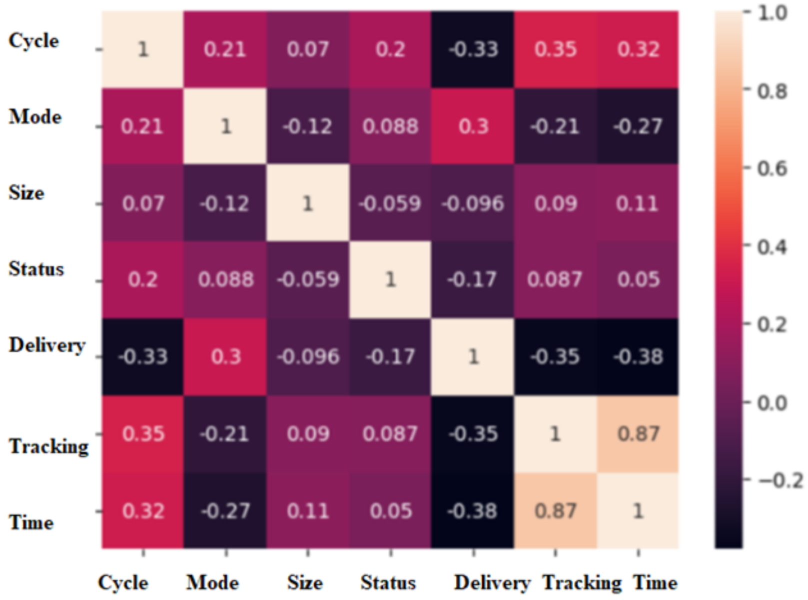


Figure 60 Summary of plotting trends of independent and dependent variables of Port K (Source: Own Research)

Correlation analysis was performed and the results of the Pearson correlation indicated that there was a significant positive association between time and tracking, (r(213612) = 0.87, p < .001), Figure 61.



	Cycle	Mode	Size	Status	Delivery	Tracking	Time
Cycle	1	0.21	0.07	0.2	-0.33	0.35	0.32
Mode	0.21	1	-0.12	0.088	0.3	-0.21	-0.27
Size	0.07	-0.12	1	-0.059	-0.096	0.09	0.11
Status	0.2	0.088	-0.059	1	-0.17	0.087	0.05
Delivery	-0.33	0.3	-0.096	-0.17	1	-0.35	-0.38
Tracking	0.35	-0.21	0.09	0.087	-0.35	1	0.87
Time	0.32	-0.27	0.11	0.05	-0.38	0.87	1

Figure 61 Correlation analysis of dependent and independent variables of Port K (Source: Own Research)

OLS Test

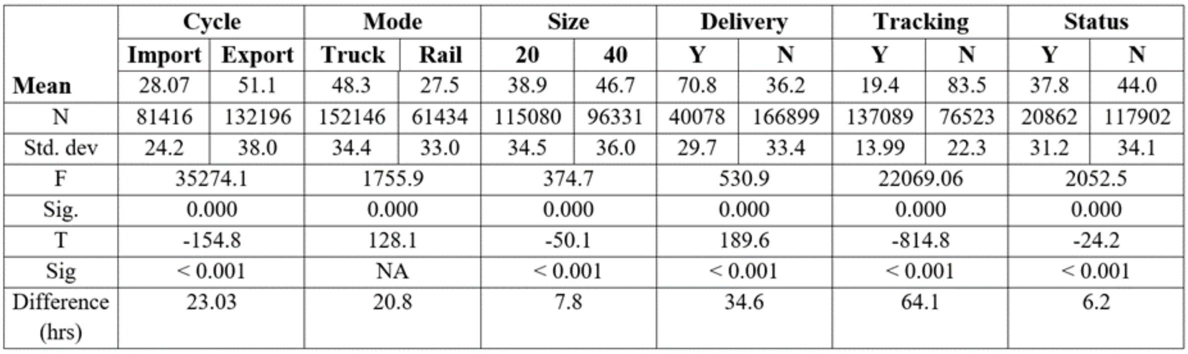
OLS test was utilized to test the impact on dwell time for the determining factors of container operations. Table 21, illustrates the results of the OLS test run on the independent and dependent variable. The overall regression was statistically significant (R^2 = 0.770, F(6, 213605)= 11900, p<=0.001). It was observed that continuous tracking significantly predicted dwell time (β = 60.5, p<=0.001). The model had RMSE (Root mean square error) of 16.9 %., The fitted regression model is Dwell Time = 27.6 + 2.70 (Cycle) – 6.55 (Mode) + 0.97(Size) – 3.6 (Status) – 5.04 (Delivery) + 60.53 (Tracking).

Table 21 Summary of OLS test results of Port K (Source: Own Research)

```
==================================================
      Dep. Variable: y                    R-squared: 0.770
      Model:      OLS                     Adj. R-squared: 0.770
      Method:   Least Squares             F-statistic: 1.1903 + 05
      No. Observations: 213612            Prob (F-statistic): 0.00
      Df Residuals: 213605                Df Model: 6
 =================================================
              Coeff       Std Err   T          P>|t|    [0.025      0.975]
 Const        27.60       0.173     159.76     0.000    27.26       27.93
 Cycle        2.703       0.090     29.87      0.000    2.526       2.880
 Mode         -6.55       0.094     -70.03     0.000    -6.73       -6.36
 Size         0.97        0.075     13.01      0.000    0.831       1.126
 Status       -3.63       0.132     -27.56     0.000    -3.894      -3.377
 Delivery     -5.04       0.112     -45.099    0.000    -5.25       -4.82
```

Tracking	60.53	0.087	696.18	0.000	60.36	60.70

Results of the independent samples t-tests indicated that there were significant differences in the mean of independent variables (Cycle, Mode, Size, Delivery, Status and Tracking, (t(213612) = (23.03, 20.8, 7.8, 34.6, 64.1, 6.2 , p < .001) in the respective order of the Figure 62.



	Cycle		Mode		Size		Delivery		Tracking		Status	
	Import	Export	Truck	Rail	20	40	Y	N	Y	N	Y	N
Mean	28.07	51.1	48.3	27.5	38.9	46.7	70.8	36.2	19.4	83.5	37.8	44.0
N	81416	132196	152146	61434	115080	96331	40078	166899	137089	76523	20862	117902
Std. dev	24.2	38.0	34.4	33.0	34.5	36.0	29.7	33.4	13.99	22.3	31.2	34.1
F	35274.1		1755.9		374.7		530.9		22069.06		2052.5	
Sig.	0.000		0.000		0.000		0.000		0.000		0.000	
T	-154.8		128.1		-50.1		189.6		-814.8		-24.2	
Sig	< 0.001		NA		< 0.001		< 0.001		< 0.001		< 0.001	
Difference (hrs)	23.03		20.8		7.8		34.6		64.1		6.2	

Figure 62 Summary of T test results of Port K (Source: Own Research)

Figure 63, illustrates the actual versus predicted data for the model and it can be observed that model is predicting the dependent variable dwell time with a RMSE (16.9 %).

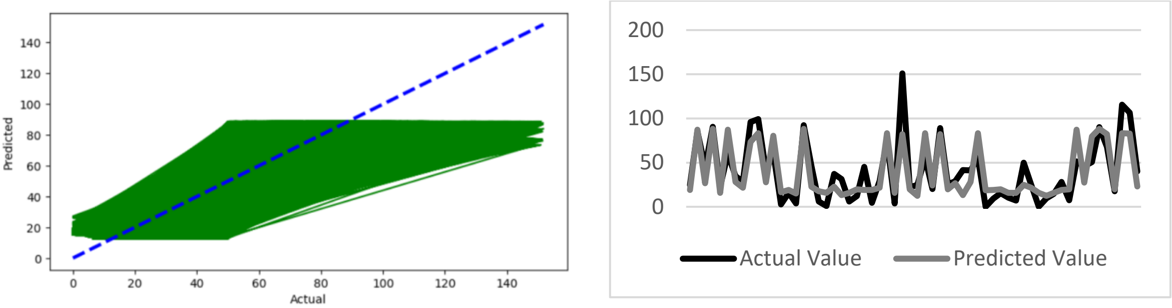
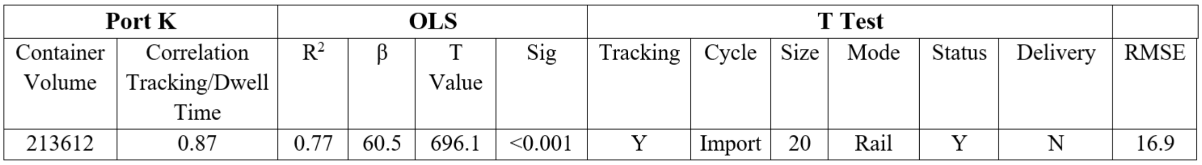


Figure 63 plt.plot of actual versus predicted of Port K (Source: Own Research)

Figure 64, illustrates the summary of various test performed for the Port K including the container volume, correlation , R^2 , β, T-value and its significance along with T test and root mean square error for the model.



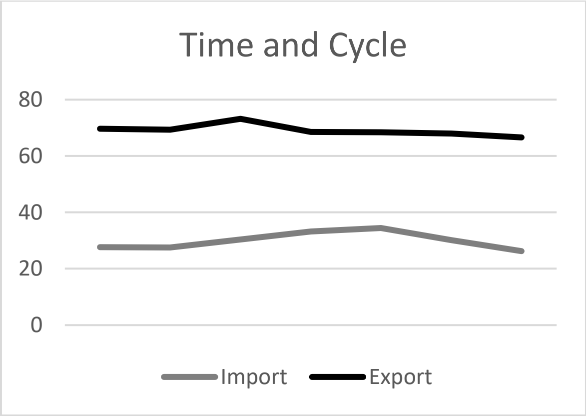
Port K		OLS				T Test						
Container Volume	Correlation Tracking/Dwell Time	R^2	β	T Value	Sig	Tracking	Cycle	Size	Mode	Status	Delivery	RMSE
213612	0.87	0.77	60.5	696.1	<0.001	Y	Import	20	Rail	Y	N	16.9

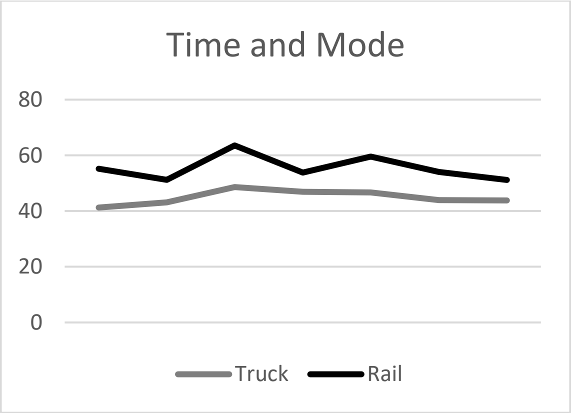
Figure 64 Summary of test results of Port K (Source: Own Research)

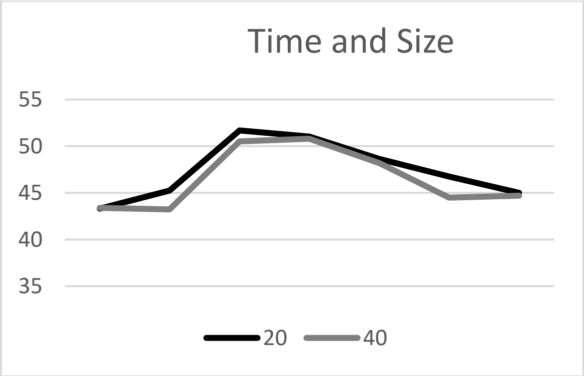
Port L

Figure 65, depicts the trends of various independent variables , namely (*i*) Cycle (Import/Export), (*ii*)Size (20 feet/40 feet), (*iii*) Status (Empty/Laden), (*iv*)Mode (Truck/Rail), (*v*)Delivery (DPD-Direct Port Delivery or DPE- Direct Port Export), (*vi*)Tracking (Yes/No), in relation to the container dwell time which is the dependent variable. The data is visually depicted on a graph, with the x-axis representing a semi-annual time period and the y-axis representing Dwell Time measured in hours. The provided visual representation illustrates the fluctuations in the dwell time variable as a result of alterations in the corresponding independent variables.

It is observed in the Figure. 65, the dwell time variation is fluctuating across variables and the variation is substantial for the further research on understanding the reasons. The variation in export cycle is 2.3 times higher than in import cycle, 1.23 times higher in Rail mode, almost similar for sizes with 0.98 times lesser for the 40 feet containers, 0.5 times lesser for the container delivered via CFS(container freight stations), 3.5 higher for container that did not have tracking technology and 1.16 times higher for the stuffed containers.







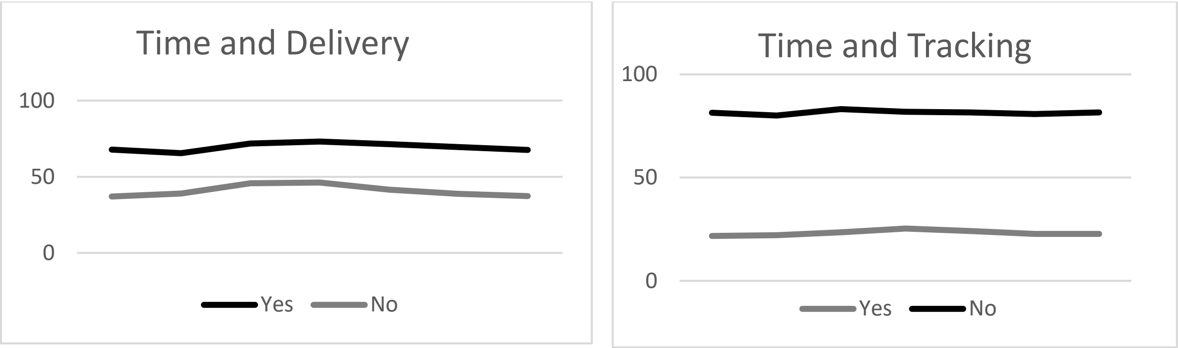


Figure 65 Summary of plotting trends of independent and dependent variables of Port L (Source: Own Research)

Correlation analysis - Results of the Pearson correlation indicated that there was a significant positive association between time and tracking, (r(311269) = 0.86, p < .001), Figure 66.

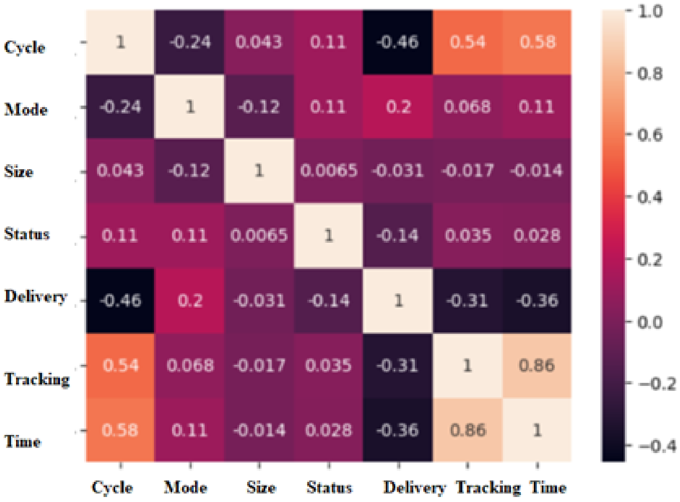


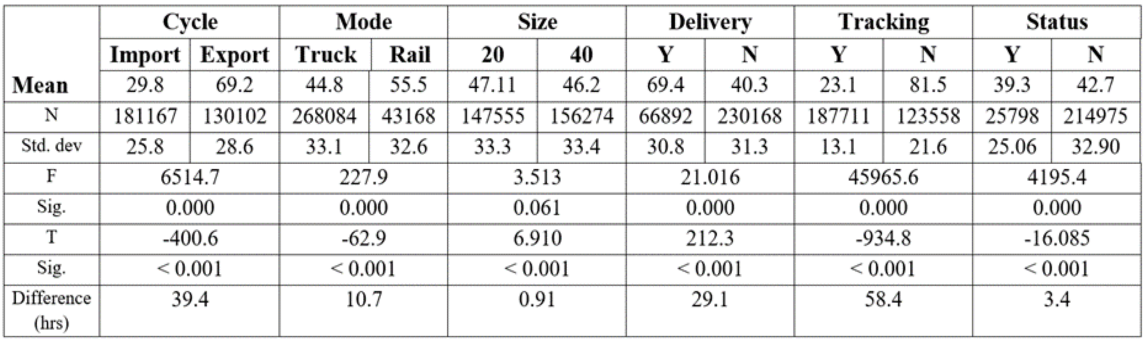
Figure 66 Correlation analysis of dependent variable and independent variable of Port L (Source: Own Research)

OLS test was utilized to test the impact on dwell time for the determining factors of container operations. Table 22, illustrates the results of the OLS test run on the independent and dependent variable. The overall regression was statistically significant (R^2 = 0.773, F(6, 311262)= 176800, p<=0.001). It was observed that continuous tracking significantly predicted dwell time (β = 49.2, p<=0.001). The model had RMSE (Root mean square error) of 16.9 %. The fitted regression model is Dwell Time = 29.08 + 12.86 (Cycle) + 12.44 (Mode) + 0.30(Size) - 5.46 (Status) - 6.10 (Delivery) + 49.2 (Tracking).

Table 22 Summary of OLS test results of Port L (Source: Own Research)

```
==============================================================================
    Dep. Variable: y                        R-squared: 0.773
    Model:     OLS                          Adj. R-squared: 0.773
    Method:   Least Squares                 F-statistic: 1.768e + 05
    No. Observations: 311269                Prob (F-statistic): 0.00
    Df Residuals: 311262                    Df Model: 6
==============================================================================
              Coeff      Std Err   T         P>|t|    [0.025      0.975]
Const         29.08      0.134     216.5     0.000    28.81       29.346
Cycle         12.86      0.077     167.04    0.000    12.268      12.620
Mode          12.44      0.090     138.37    0.000    12.268      12.620
Size          0.304      0.058     5.254     0.000    0.191       0.419
Status        -5.46      0.107     -50.85    0.000    -5.667      -5.255
Delivery      -6.10      -.080     -76.455   0.000    -6.261      -5.948
Tracking      49.29      0.072     683.35    0.000    49.15       49.43
```

Results of the independent samples t-tests indicated that there were significant differences in the mean of independent variables (Cycle, Mode, Size, Delivery, Status and Tracking, (t(311269) = (39.4, 10.7, 0.91, 29.1, 58.4, 3.4 , p < .001) in the respective order of the Figure 67.



	Cycle		Mode		Size		Delivery		Tracking		Status	
	Import	**Export**	**Truck**	**Rail**	**20**	**40**	**Y**	**N**	**Y**	**N**	**Y**	**N**
Mean	29.8	69.2	44.8	55.5	47.11	46.2	69.4	40.3	23.1	81.5	39.3	42.7
N	181167	130102	268084	43168	147555	156274	66892	230168	187711	123558	25798	214975
Std. dev	25.8	28.6	33.1	32.6	33.3	33.4	30.8	31.3	13.1	21.6	25.06	32.90
F	6514.7		227.9		3.513		21.016		45965.6		4195.4	
Sig.	0.000		0.000		0.061		0.000		0.000		0.000	
T	-400.6		-62.9		6.910		212.3		-934.8		-16.085	
Sig.	< 0.001		< 0.001		< 0.001		< 0.001		< 0.001		< 0.001	
Difference (hrs)	39.4		10.7		0.91		29.1		58.4		3.4	

Figure 67 Summary of T test results of Port L(Source: Own Research)

Figure 68, illustrates the actual versus predicted data for the model and it can be observed that model is predicting the dependent variable dwell time with a RMSE (15.86 %).

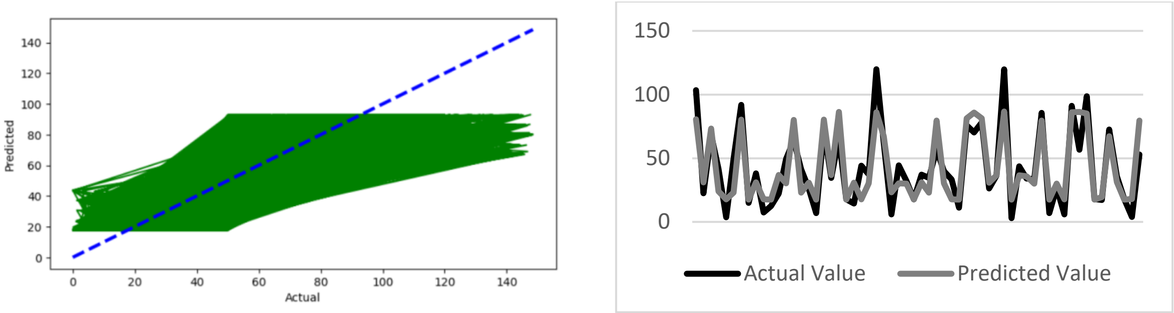
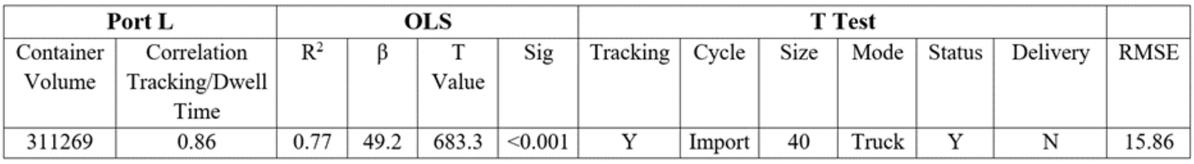


Figure 68 plt.plot of actual versus predicted of Port L(Source: Own Research)

Figure 69, illustrates the summary of various test performed for the Port L including the container volume, correlation , R^2 , β coefficient, T-value and its significance along with T test and root mean square error for the model.



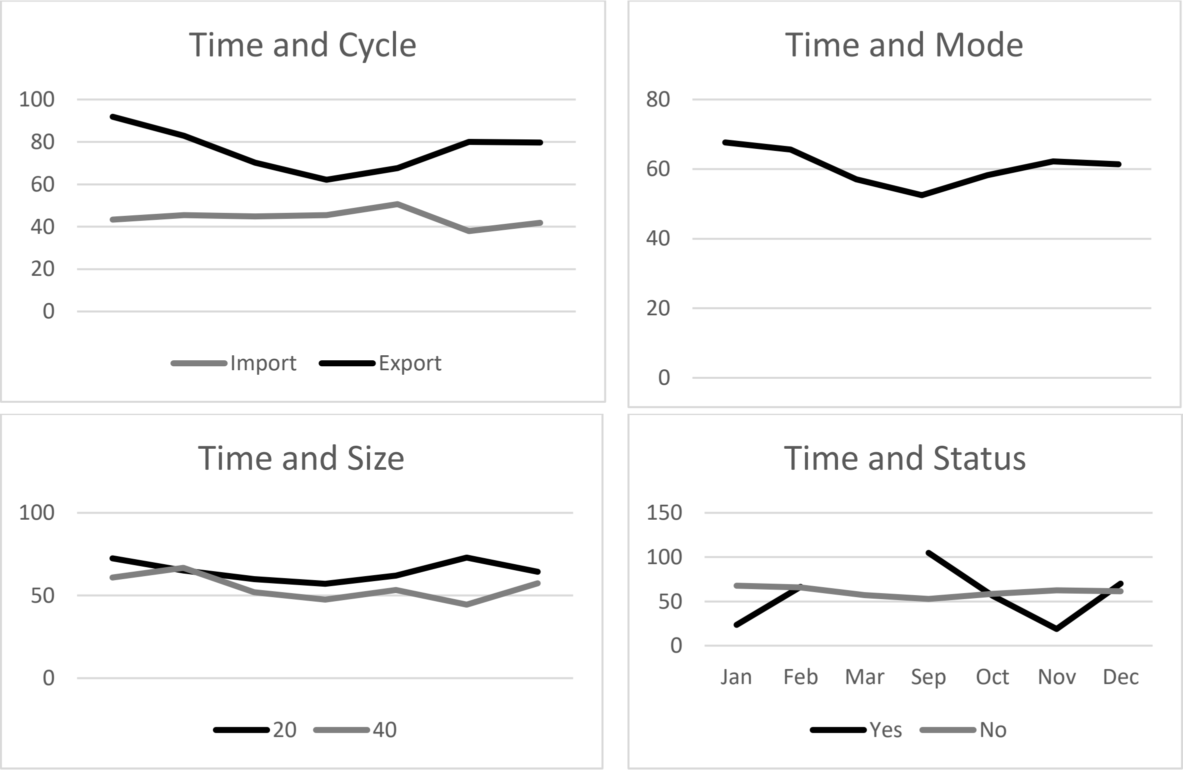
Port L		**OLS**				**T Test**						
Container Volume	Correlation Tracking/Dwell Time	R^2	β	T Value	Sig	Tracking	Cycle	Size	Mode	Status	Delivery	RMSE
311269	0.86	0.77	49.2	683.3	<0.001	Y	Import	40	Truck	Y	N	15.86

Figure 69 Summary of test results of Port L (Source: Own Research)

Port M

Figure 70, depicts the trends of various independent variables , namely (*i*) Cycle (Import/Export), (*ii*)Size (20 feet/40 feet), (*iii*) Status (Empty/Laden), (*iv*)Mode (Truck/Rail), (*v*)Delivery (DPD-Direct Port Delivery or DPE- Direct Port Export), (*vi*)Tracking (Yes/No), in relation to the container dwell time which is the dependent variable. The data is visually depicted on a graph, with the x-axis representing a semi-annual time period and the y-axis representing Dwell Time measured in hours. The provided visual representation illustrates the fluctuations in the dwell time variable as a result of alterations in the corresponding independent variables.

The Figure 70 demonstrates the presence of varying dwell duration variance among factors, indicating a significant variation that warrants more investigation to comprehend the underlying causes. The level of variation is 1.7 times greater during the export cycle, exhibiting some degree of irregularity in its distribution. The variation is nearly equivalent across different container sizes, with a decrease of 0.84 times observed for 40 feet containers. Similarly, a decrease of 0.96 times is observed for containers delivered via CFS (container freight stations). In contrast, containers lacking tracking technology exhibit a significantly higher variation of 3.21 times. Lastly, stuffed containers demonstrate a slight decrease in variation, with a reduction of 0.98 times.



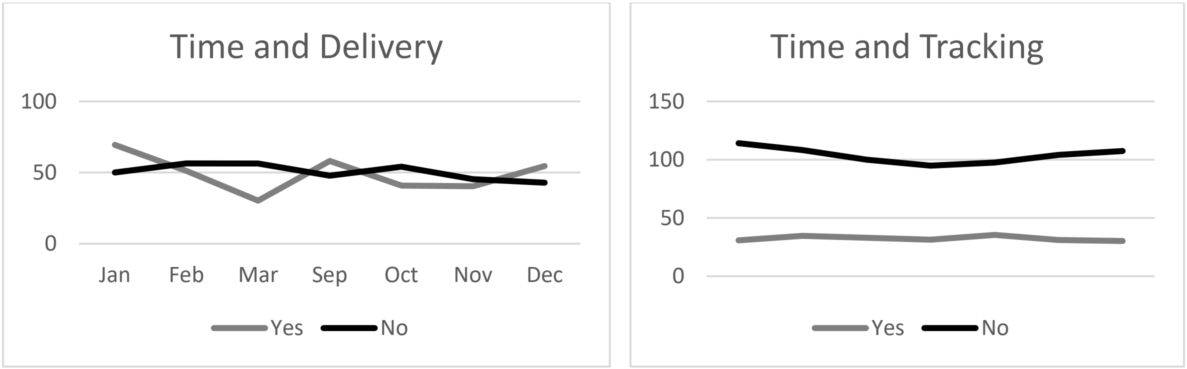
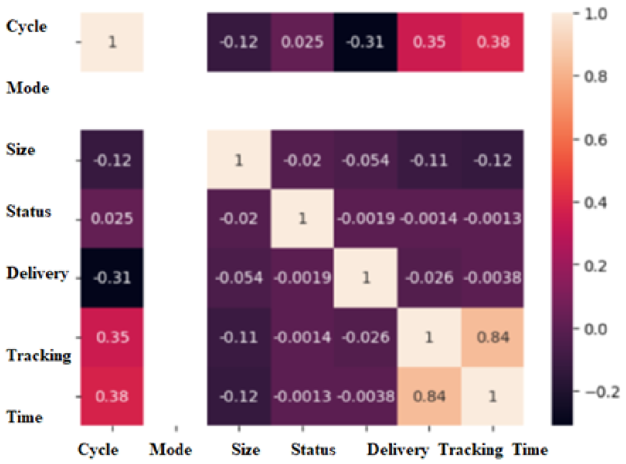


Figure 70 Summary of plotting trends of independent variables and dependent variables of Port M (Source: Own Research)

Correlation analysis - Results of the Pearson correlation indicated that there was a significant positive association between time and tracking, (r(50044) = 0.84, p < .001), Figure 71.



	Cycle	Mode	Size	Status	Delivery	Tracking	Time
Cycle	1		-0.12	0.025	-0.31	0.35	0.38
Mode							
Size	-0.12		1	-0.02	-0.054	-0.11	-0.12
Status	0.025		-0.02	1	-0.0019	-0.0014	-0.0013
Delivery	-0.31		-0.054	-0.0019	1	-0.026	-0.0038
Tracking	0.35		-0.11	-0.0014	-0.026	1	0.84
Time	0.38		-0.12	-0.0013	-0.0038	0.84	1

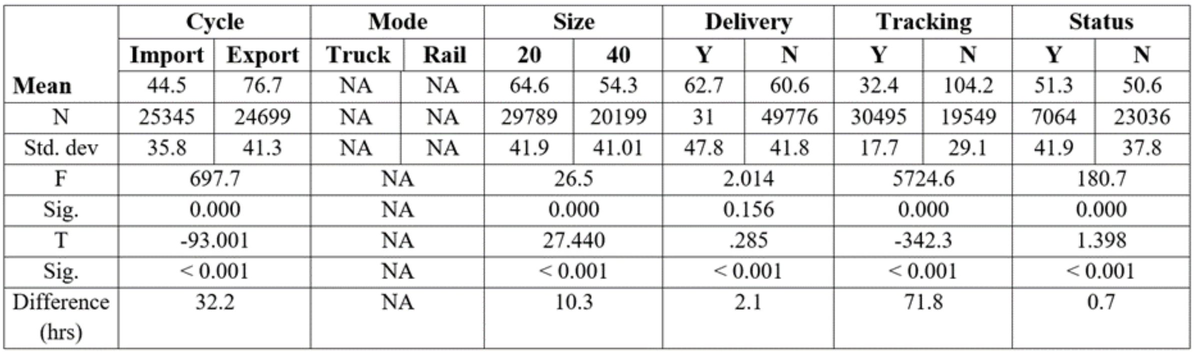
Figure 71 : Correlation analysis of dependent variable and independent variables of Port M (Source: Own Research)

OLS test was utilized to test the impact on dwell time for the determining factors of container operations. Table 23, illustrates the results of the OLS test run on the independent and dependent variable. The overall regression was statistically significant (R^2 = 0.714, F(6, 50038)= 24980, p<=0.001). It was observed that continuous tracking significantly predicted dwell time (β = 69.08, p<=0.001). The model had RMSE (Root mean square error) of 23.15 %. The fitted regression model is Dwell Time = 30.01 + 10.34 (Cycle) – 1.62(Size) – 5.9 (Status) + 6.8 (Delivery) + 68.0 (Tracking).

Table 23 Summary of OLS test of Port M (Source: Own Research)

```
=======================================================
      Dep. Variable: y                     R-squared: 0.714
      Model:      OLS                      Adj. R-squared: 0.714
      Method:   Least Squares              F-statistic: 2.498e + 04
      No. Observations: 50044              Prob (F-statistic): 0.00
      Df Residuals: 50038                  Df Model: 6
 ======================================================
              Coeff        Std Err    T          P>|t|    [0.025       0.975]
Const         30.06        4.03       7.440      0.000    22.10        37.92
Cycle         10.34        0.227      45.58      0.000    9.902        10.792
Mode          1551e-14     3.42e-1    45.36      0.000    1.48e-14     1.62e-14
Size          -1.6210      0.207      -7.833     0.000    -2.027       -1.215
Status        -5.903       4.-24      -1.467     0.142    -13.791      1.985
Delivery      6.89         0.323      21.35      0.000    6.26         7.53
Tracking      68.08        0.220      309.45     0.000    67.65        68.51
```

Results of the independent samples t-tests indicated that there were significant differences in the mean of independent variables (Cycle, Size, Delivery, Status, and Tracking, (t(50044) = (32.2, 10.3, 2.1, 71.8, 0.7 , p < .001) in the respective order of the Figure 72.



	Cycle		Mode		Size		Delivery		Tracking		Status	
	Import	Export	Truck	Rail	20	40	Y	N	Y	N	Y	N
Mean	44.5	76.7	NA	NA	64.6	54.3	62.7	60.6	32.4	104.2	51.3	50.6
N	25345	24699	NA	NA	29789	20199	31	49776	30495	19549	7064	23036
Std. dev	35.8	41.3	NA	NA	41.9	41.01	47.8	41.8	17.7	29.1	41.9	37.8
F	697.7		NA		26.5		2.014		5724.6		180.7	
Sig.	0.000		NA		0.000		0.156		0.000		0.000	
T	-93.001		NA		27.440		.285		-342.3		1.398	
Sig.	< 0.001		NA		< 0.001		< 0.001		< 0.001		< 0.001	
Difference (hrs)	32.2		NA		10.3		2.1		71.8		0.7	

Figure 72 Summary of T test results of Port M (Source: Own Research)

Figure. 73. illustrates the actual versus predicted data for the model and it can be observed that model is predicting the dependent variable dwell time with a RMSE (23.15 %).

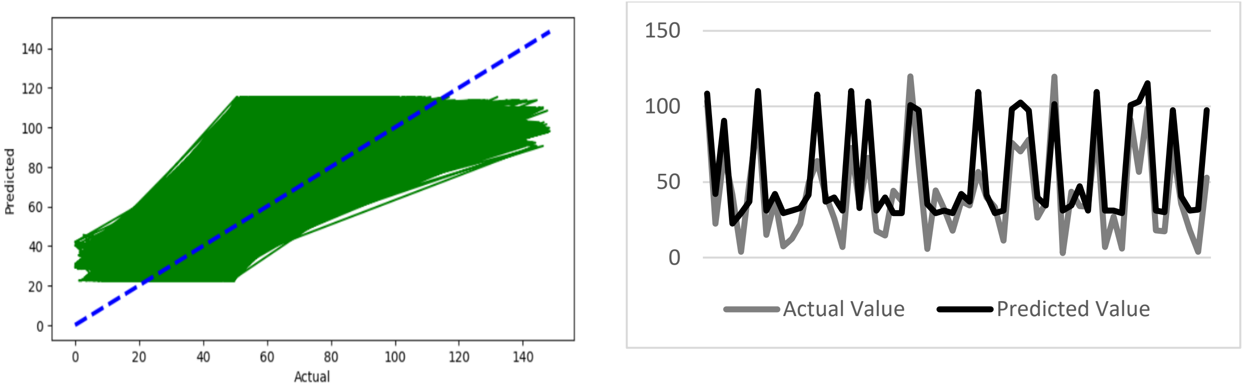


Figure 73 plt.plot of actual versus predicted of Port M (Source: Own Research)

Figure 74, illustrates the summary of various test performed for the Port M including the container volume, correlation , R^2 , β coefficient, T-value and its significance along with T test and root mean square error for the model.

Port M		**OLS**				**T Test**						
Container Volume	Correlation Tracking/ Dwell Time	R^2	β	T Value	Sig	Tracking	Cycle	Size	Mode	Is_Empty	Is_ DPD/DPE	RMSE
50044	0.84	0.71	68.0	309.4	<0.001	Y	Import	40	NA	N	N	23.15

Figure 74 Summary of test results for Port M (Source: Own Research)

Port N

Figure 75, depicts the trends of various independent variables , namely (*i*) Cycle (Import/Export), (*ii*)Size (20 feet/40 feet), (*iii*) Status (Empty/Laden), (*iv*)Mode (Truck/Rail), (*v*)Delivery (DPD-Direct Port Delivery or DPE- Direct Port Export), (*vi*)Tracking (Yes/No), in relation to the container dwell time which is the dependent variable. The data is visually depicted on a graph, with the x-axis representing a semi-annual time period and the y-axis representing Dwell Time measured in hours. The provided visual representation illustrates the fluctuations in the dwell time variable as a result of alterations in the corresponding independent variables.

It is observed in the Figure. 75, the dwell time variation is fluctuating across variables and the variation is substantial for the further research on understanding the reasons. The variation in export cycle is 1.41 times higher than in import cycle, 1.3 times higher in Rail mode, almost similar for sizes with 0.97 times lesser for the 40 feet containers, 0.78 times lesser for the container delivered via CFS(container freight stations), 2.7 higher for container that did not have tracking technology and 0.98 lesser for the stuffed containers.

Figure 75 Summary of plotting trends of independent variables and dependent variables of Port N (Source: Own Research)

Correlation analysis - Results of the Pearson correlation indicated that there was a significant positive association between time and tracking, (r(167374) = 0.83, p < .001), Figure 76.

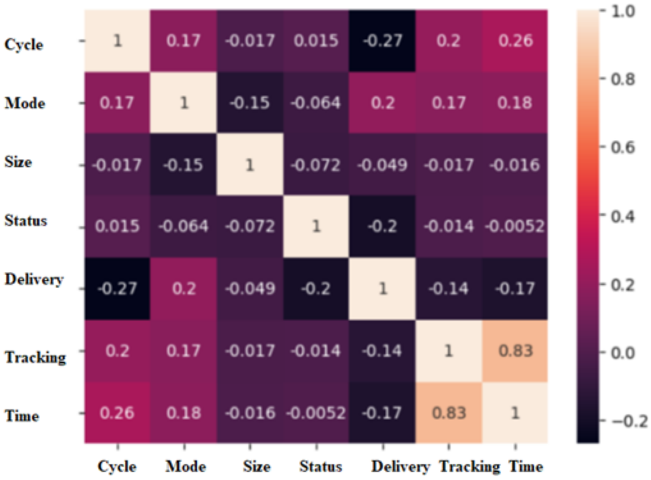


Figure 76 Correlation analysis of dependent variable and independent variables of Port N (Source: Own Research)

OLS test was utilized to test the impact on dwell time for the determining factors of container operations. Table 24, illustrates the results of the OLS test run on the independent and dependent variable. The overall regression was statistically significant ($R^2 = 0.707$, F(6, 167367)= 674300, p<=0.001). It was observed that continuous tracking significantly predicted dwell time (β = 76.4, p<=0.001). The model had RMSE (Root mean square error) of 22.3 %. The fitted regression model is Dwell Time = 45.1 + 6.81 (Cycle) + 5.04 (Mode) + 0.199 (Size) – 0.34 (Status) - 4.7 (Delivery) + 76.4 (Tracking).

Table 24 Summary of OLS test results of Port N (Source: Own Research)

```
==================================================================
      Dep. Variable: y                    R-squared: 0.707
      Model:       OLS                    Adj. R-squared: 0.707
      Method:   Least Squares             F-statistic: 6.743e + 04
      No. Observations: 50044            Prob (F-statistic): 0.00
      Df Residuals: 50038                 Df Model: 6
==================================================================
              Coeff       Std Err   T         P>|t|    [0.025      0.975]
Const         45.1        0.264     171.3     0.000    44.64       45.67
Cycle         6.81        0.119     57.47     0.000    6.584       7.049
Mode          5.045       0.194     25.95     0.000    4.664       5.426
Size          0.199       0.143     1.391     0.164    -0.082      0.481
Status        -0.345      0.240     -1.442    0.149    -0.815      0.124
Delivery      -4.76       0.149     -31.970   0.000    -5.05       -4.472
Tracking      76.47       0.131     585.107   0.000    76.222      76.734
```

Results of the independent samples t-tests indicated that there were significant differences in the mean of independent variables (Cycle, Size, Mode, Delivery, Status, and Tracking, (t(50044) = (22, 24.3, 1.7, 17.3, 79.2, 0.8 , $p < .001$) in the respective order of the Figure 77.

	Cycle		Mode		Size		Delivery		Tracking		Status	
	Import	**Export**	**Truck**	**Rail**	**20**	**40**	**Y**	**N**	**Y**	**N**	**Y**	**N**
Mean	53.1	75.1	62.5	86.8	67.3	65.6	79.5	62.2	44.8	124.0	65.3	64.5
N	76831	90543	149942	17117	114264	32226	36402	113628	124717	42657	11686	42672
Std. dev	37.4	41.9	40.07	46.33	42.1	40.6	42.1	41.04	22.5	23.8	43.4	40.1
F	2430.4		1520.7		110.6		195.5		361.4		155.2	
Sig.	0.000		0.000		0.000		0.000		0.000		0.000	
T	-112.192		-73.881		6.628		69.8		-618.3		2.048	
Sig.	< 0.001		<0.001		< 0.001		< 0.001		< 0.001		< 0.001	
Difference (hrs	22		24.3		1.7		17.3		79.2		0.8	

Figure 77 Summary of test results of Port N (Source: Own Research)

Figure. 78, illustrates the actual versus predicted data for the model and it can be observed that model is predicting the dependent variable dwell time with a RMSE (22.3 %).

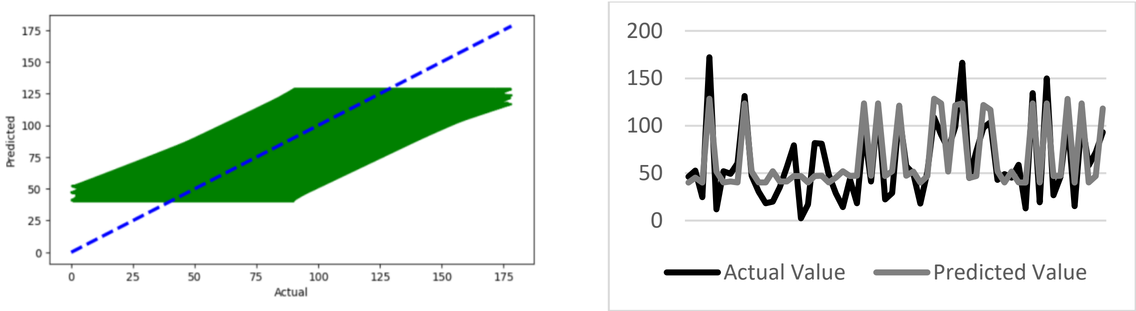


Figure 78 plt.plot of actual versus predicted of Port N (Source: Own Research)

Figure 79, illustrates the summary of various test performed for the Port N including the container volume, correlation , R^2 , β coefficient, T-value and its significance along with T test and root mean square error for the model.

Port N		OLS				T Test						
Container Volume	Correlation Tracking/ Dwell Time	R^2	β	T Value	Sig	Tracking	Cycle	Size	Mode	Status	Delivery	RMSE
167374	0.83	0.70	76.4	585.1	<0.001	Y	Import	40	Truck	N	N	22.3

Figure 79 Summary of test results for Port N (Source: Own Research)

5.3 Phase III : Qualitative Analysis and discussion with Port Operators

In this phase III, the results from phase II are discussed with the port operators to understand the variance in container dwell time. For conducting the discussion rounds, a set of questions were devised to illustrate on the varying reasons of container dwell time. The list of discussion interviews is detailed below:

List of major and key questions during qualitative analysis after data analysis of Phase II

1. What are the reasons for your performance for the dwell time across cycle, size, mode, empty/laden, tracking, DPD/DPE?
2. What are the customer split of your region for size and cycle?
3. Is tracking an important factor for port performance parameter?
4. What is the ocean split of FCL/LCL cargo movement?
5. Does volume play a role in defining port performance parameters?
6. How does lesser dwell time impacts your performance and customer experience?
7. Along with dwell time, what are the other parameters which defines your ports success?
8. How do you think, you are competing against competitor when it comes to dwell time?
9. The results of statistical analysis shows tracking is an important factor, does it impact the other variable in study ?
10. What are the skillset, management practices do you think are important for a port to outperform competition?

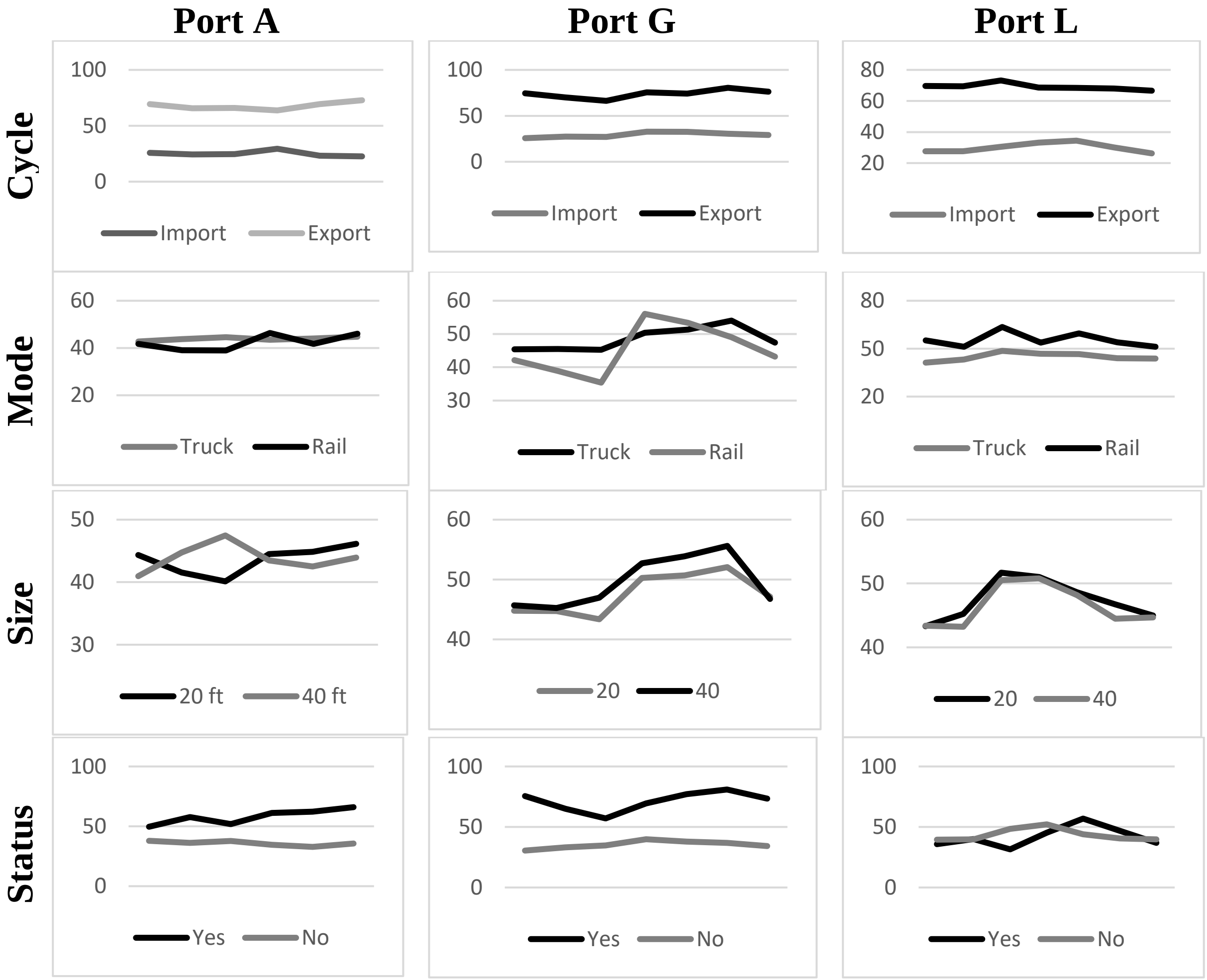
The summary of data analysis for all the fourteen ports along with RMSE (Root mean square errors) are illustrated in the Table 25. The objective of this analysis was to understand the correlation and R^2 for the relation between dwell time and port performance parameters. The OLS test to understand, if the tracking has an impact on dwell time is performed. The independent sample T test is performed for the parameters to evaluate on the difference in means. Afterwards, root mean square error is calculated and top three ports are selected for qualitative reasoning.

Table 25 Summary of OLS and T test for all fourteen ports (Source: Own Research)

	OLS						**Independent T Test**						
Port	**Volume**	**ρ: Tracking and Dwell Time**	**R^2**	**β**	**T**	**Sig. Tracking**	**Track**	**Cycle**	**Size**	**Mode**	**Status**	**Delivery**	**RMSE**
A	232731	0.86	0.78	55.56	280.51	<0.001	Y	Import	20	Rail	N	Y	15.6
G	226441	0.85	0.761	45.82	511.18	<0.001	Y	Import	20	Rail	N	N	15.7
L	311269	0.86	0.77	49.2	683.3	<0.001	Y	Import	40	Truck	Y	N	15.86
K	213612	0.87	0.77	60.5	696.1	<0.001	Y	Import	20	Rail	Y	N	16.9
B	155986	0.86	0.74	74.4	562.7	<0.001	Y	Import	20	Rail	Y	N	19.2
I	76402	0.81	0.67	75.2	364.6	<0.001	Y	Import	40	NA	Y	Y	21.5
N	167374	0.83	0.7	76.4	585.1	<0.001	Y	Import	40	Truck	N	N	22.3
M	50044	0.84	0.71	68.08	309.4	<0.001	Y	Import	40	NA	N	N	23.15
J	106225	0.82	0.68	79.2	458.3	<0.001	Y	Import	20	Truck	N	Y	23.4
H	62705	0.82	0.667	37.3	325.7	<0.001	Y	Export	20	Rail	Y	Y	31.3
C	346857	0.75	0.74	56.3	44.9	<0.001	Y	Import	40	Rail	Y	Y	34.6
F	52443	0.82	0.67	118.3	324.2	<0.001	Y	Import	20	Rail	Y	Y	34.82
E	721232	0.86	0.77	49.8	1090.5	<0.001	Y	Import	20	Rail	N	N	36.9
D	97076	0.62	0.4	22.11	33.33	<0.001	Y	Import	40	Rail	Y	N	47.3

The summary of data analysis for all the fourteen ports along with RMSE (Root mean square errors) are illustrated in the Table 25. The objective of this analysis was to understand the correlation and R^2 for the relation between dwell time and port performance parameters. The OLS test to understand, if the tracking has an impact on dwell time is performed. The independent sample T test is performed for the parameters to evaluate on the difference in means. Afterwards, root mean square error is calculated and top three ports (Port A, Port G and Port L) were selected for qualitative reasoning. The data is illustrated across the half yearly container volume and represents six months (time period) in the x- axis and Dwell Time (In hours) in the y-axis. The following graphical representation depicts the plotting variation in the Time variable with every change in the respective independent variables.

The results of observing trends for top three ports (Port A, Port G and Port L) are illustrated in the Figure 80. In majority of the cases, we can observe that dwell time variation is impacted with cycle, size, mode, and other parameters. The graphical representation is performance to understand the trend and variation in dwell time as per the variation in the port performance parameter.



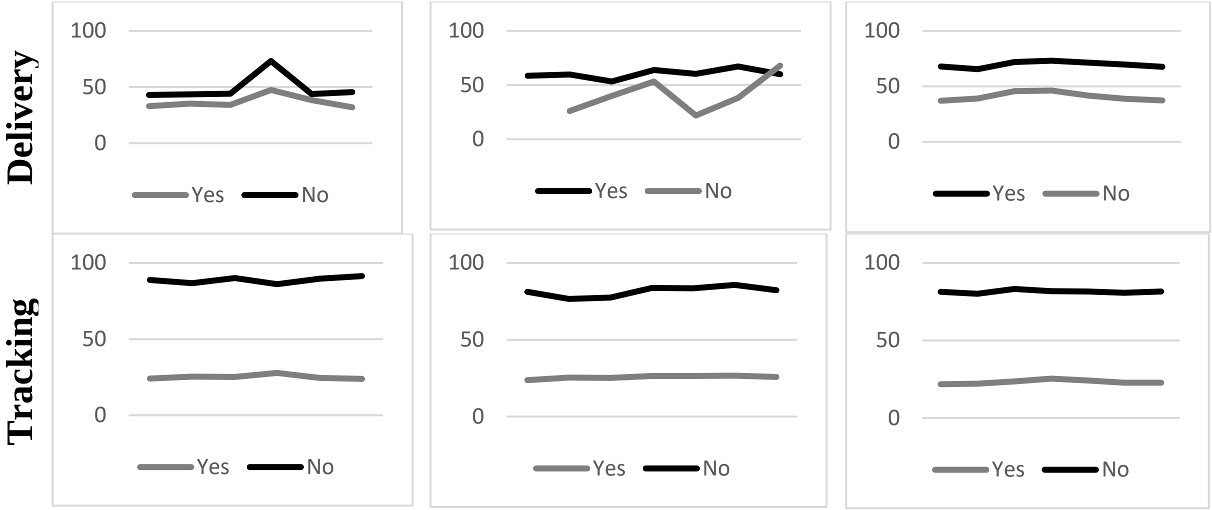
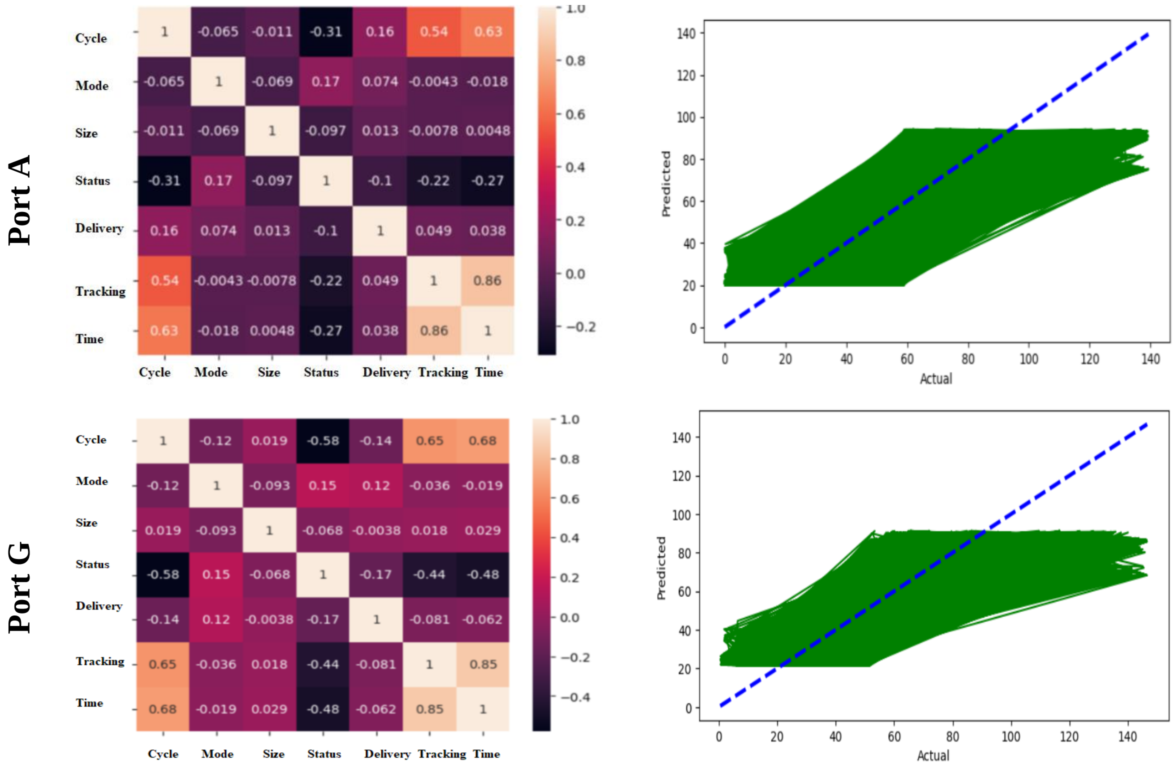


Figure 80 Summary of trends of top 3 ports (Source: Own Research)

Figure. 81, illustrates the heat map of correlation between container performance parameters and dwell time for Port A, G and L. These are the ports with the lowest RMSE (Root mean square error) for which qualitative reasoning is performed for the variation in dwell time.



Port A

	Cycle	Mode	Size	Status	Delivery	Tracking	Time
Cycle	1	-0.065	-0.011	-0.31	0.16	0.54	0.63
Mode	-0.065	1	-0.069	0.17	0.074	-0.0043	-0.018
Size	-0.011	-0.069	1	-0.097	0.013	-0.0078	0.0048
Status	-0.31	0.17	-0.097	1	-0.1	-0.22	-0.27
Delivery	0.16	0.074	0.013	-0.1	1	0.049	0.038
Tracking	0.54	-0.0043	-0.0078	-0.22	0.049	1	0.86
Time	0.63	-0.018	0.0048	-0.27	0.038	0.86	1

Port G

	Cycle	Mode	Size	Status	Delivery	Tracking	Time
Cycle	1	-0.12	0.019	-0.58	-0.14	0.65	0.68
Mode	-0.12	1	-0.093	0.15	0.12	-0.036	-0.019
Size	0.019	-0.093	1	-0.068	-0.0038	0.018	0.029
Status	-0.58	0.15	-0.068	1	-0.17	-0.44	-0.48
Delivery	-0.14	0.12	-0.0038	-0.17	1	-0.081	-0.062
Tracking	0.65	-0.036	0.018	-0.44	-0.081	1	0.85
Time	0.68	-0.019	0.029	-0.48	-0.062	0.85	1

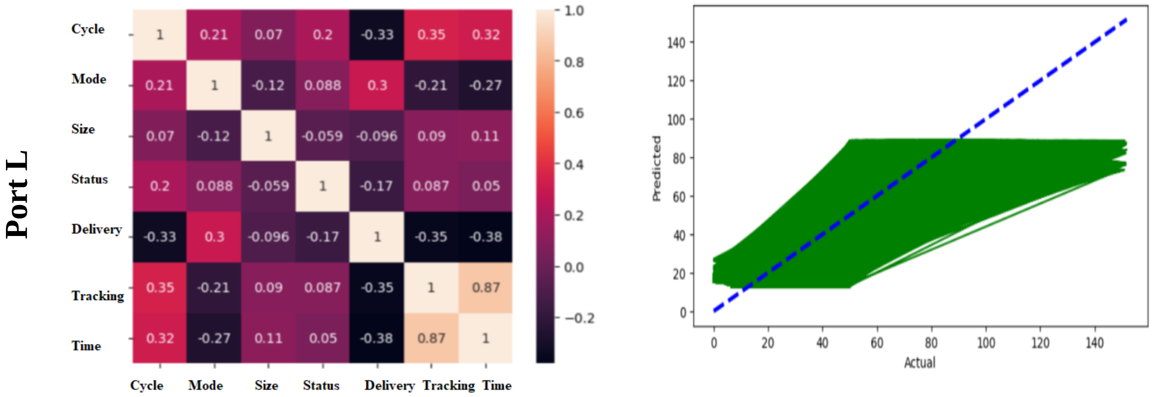


Figure 81 Correlation heat map and actual/versus predicted for top 3 ports (Source: Own Research)

The data for the phase III of qualitative research study was performed by structured interviews with the key operations resources of the port terminal. The questions were prepared from the quantitative analysis performed in the phase II. Total eleven resources across the three ports with lowest RMSE were interviewed for the reasons of varying reasons of dwell time for each of the variable such as (*i*)Cycle(Import/Export), (*ii*)Size(20 feet/40 feet), (*iii*)Status(Empty/Laden), (*iv*) Mode(Truck/Rail), (*v*)Delivery(DPD-Direct Port Delivery or DPE- Direct Port Export),(*vi*)Tracking(Yes/No).The snowball approach for discussion interviews and expert responses was adopted which can provide key details for the information gathering. The selection of discussion respondents was based on the level and their connection with the operations of the container transportation sector. Data analysis for the structured interviews was performed using the methodical approach of the selective coding technique, (Strauss & Corbin, 1990), (Saldaña, 2021). This approach was primarily selected to maintain qualitative consistency and structure. This also ensured to address the concerns and challenges of structuring and analysing interview discussion data. This research study had the objective of understanding the varying reasons of dwell time across major ports in the container transportation. This was classified by presenting data of Phase II, reviewing discussion and interview transcripts, and identifying actions on varying dwell time. Responses that were open-ended were analysed by mapping and integrating along with refining excerpts into categories for conceptual similarity. This led to deriving insightful relations while analysing the results by reducing data into aggregate categories.

Figure 82,represents a graphical illustration of the initial, intermediate, and advanced levels of aggregation, as well as the potential benefits and opportunities associated with the outcomes derived from the collection of data inputs during the qualitative analysis of variance in dwell time. Based on the interviews conducted with port operators, it was found that several key aspects played a crucial role in understanding the variation in container dwell time. These factors included first-order affordances such as the provision of a free period, gate cut off, the demand of equipment, the rail connectivity, the pre inspection process and transhipment nature of ports, the prevalent trade schemes along with free days provided by CFS for container stay.

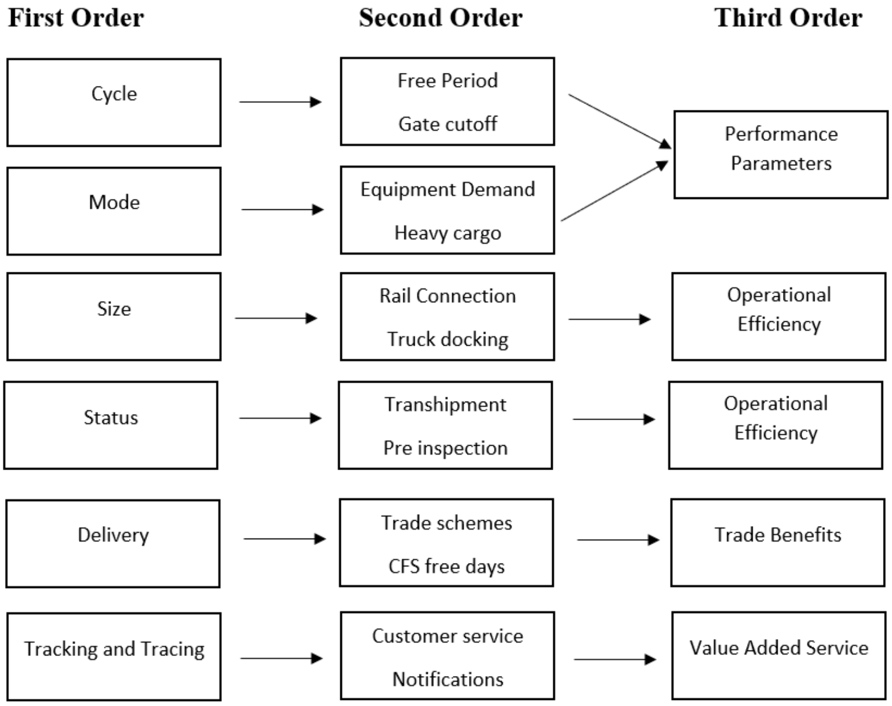


Figure 82 Qualitative aggregates for discussions (Source: Own Research)

The discussion with the top three ports A, G and L (with lowest root mean square error), was held and the qualitative reasoning for one port optimizing and performing better than other on a specific parameter was gathered. Figure 83, illustrates the reasoning for the port optimization and port performance parameters such as (*i*)Cycle(Import/Export), (*ii*)Size(20 feet/40 feet), (*iii*)Status (Empty/Laden), (*iv*)Mode (Truck/Rail), (*v*)Delivery (DPD-Direct Port Delivery or DPE- Direct Port Export), (*vi*)Tracking (Yes/No). It was understood that all the ports performed better in the import cycle due to the demurrage charges imposed on the importers or handling CFS by the terminal operators. Thus, during the import journey the dwell time was better for all the ports. Also, during the export journey due to gate cut off timings prior to vessel departure, container is to be gated in four days in advance, thus the higher dwell time at ports.

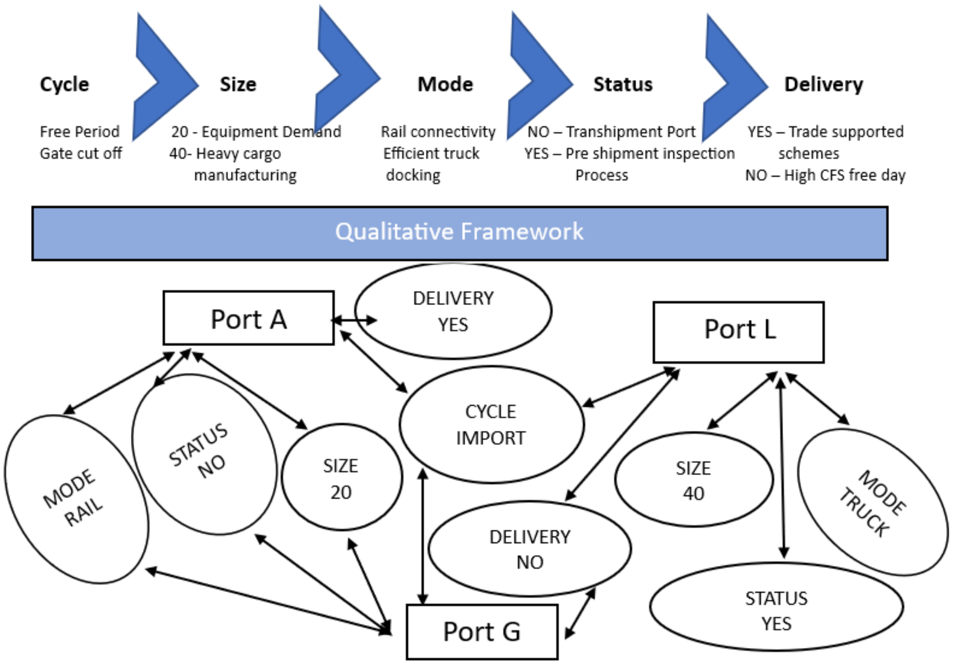


Figure 83 Qualitative framework for dwell time variation (Source: Own Research)

For the container size parameters, it was understood that due to the nature of operations and equipment demand, Port A and G were doing good in twenty-foot size and industries or manufacturing units in the vicinity of Port L were producing bulk/heavy cargo to be stuffed in forty feet container. For the mode category Port, A and Port G has good infrastructure for rail connectivity and had sustainability goals as part of their organizational objectives where Port L had faster turnaround times for truck due to efficiency docking strategies. Due to the transhipment nature of Port A and G, the containers which were laden with cargo efficiently planned for movement and further connection to port of destinations. Also, the pre-inspection process was quite efficient at these locations to enable faster clearance. In the case of Port L, majority of the empty containers were transacted for relocation and repositioning, Figure 83.

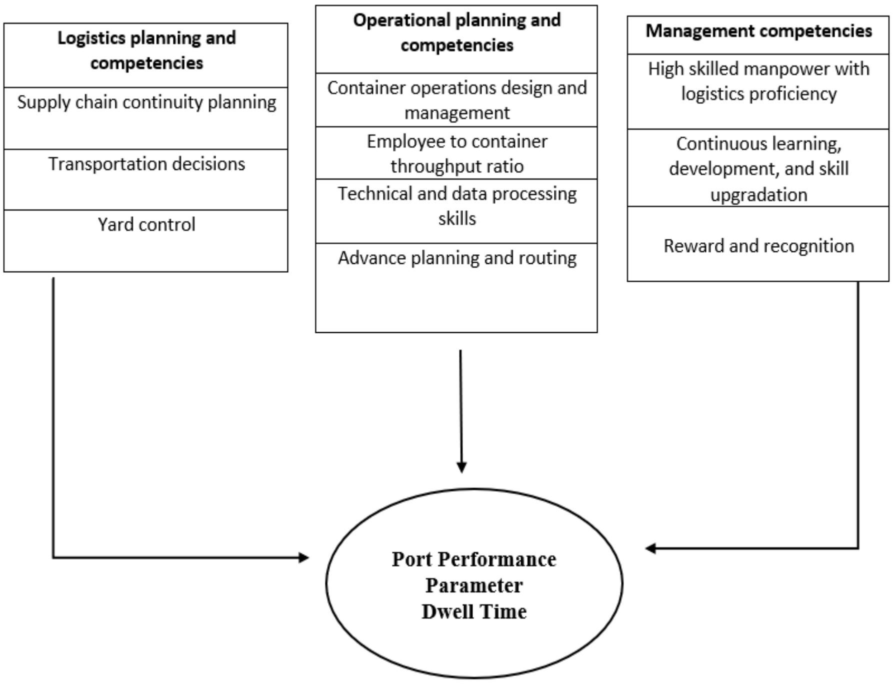


Figure 84 Competency summarization of top 3 ports (Source: Own Research)

Figure 84, details the competency summarization of management perspective and discussion with the port terminals. Basis the qualitative discussion, it was observed that the common interpretation of results with the port managers focussed on supply chain planning and operational routing advance planning for their major success to outperform competition. High skilled manpower with focussed learning, training and development on logistics related concepts leads to the efficiency which is backed by rewards and recognition methods. The results of research questions and hypothesis are listed in table 28 along with the detailed reasoning and observation/outcome of discussion with port teams.

The Table 26, illustrates the results of the research conducted in this doctoral thesis. Research question and hypothesis wise results are tabulated in the Table 26. Through the fuzzy QCA comparison in the phase I, it was resulted that both LPI and Tracking and Tracing are the core causal configurations that impact the economic development. This test was performed for the major economies across Asia, Europe, UK and UK. The results illustrated that for any economy to perform well, they must be logistically advanced with high infrastructure parameters including technology dimensions such as tracking and tracing.

Various container specification parameter such as size, cycle, mode, status and tracking impact the dwell time of the container. Major reasons listed for the top three ports are illustrated in the Figure 83.

Table 26 Summary of results/observations of research questions and hypothesis (Source: Own Research)

Research Question	Associated Hypothesis	Result/Observation
How do logistics performance index and logistics cost influence economic development?		Logistics Performance index (LPI) has a significant positive impact on the economic development. Logistics costs has a significant negative impact on the economic development.
Does track and trace impact economic development?		Track and trace have a significant positive impact on the economic development along with other parameters of LPI, viz. Infrastructure and Logistics competency on the economy.
Is there any impact of location of port, size of container on dwell time?		The location of port, size of container significantly impacts the container dwell time. The reason commensurate various factors around trade facilitation schemes, free periods, and equipment balancing.
What are the major reasons behind the variance in container dwell time?		The variance in dwell time is due to region specific concerns commensurate to size, cycle, mode etc. The free periods, gate cut offs, trade related schemes, docking strategies are the prime reasons.
What is the impact of track and trace on container dwell time?	Continuous track and trace of container results in reduced dwell time	Continuous track and trace significantly result in reduced container dwell time. Various factors including operational efficiencies and planning augments in port performance parameters.

Continuous tracking is an important dimension on controlling the dwell time of the container and stay time at any port. This can be coupled with various employee centric activities on learning and development along with reward and recognition for ensuring performance on this aspect of parameter.

6. CONTRIBUTIONS

The thesis contributed to the academics and practice as per the section illustrated below:

6.1 Academic contribution to the theory and knowledge

This doctoral research contributed to the theory by examining and researching on the introduction of tracking technological factors to the container port operations. The research on port performance parameters with the presence or absence of tracking technology is rare, and most of the studies that are conducted focuses on single port dataset scenario(De Armas Jacomino et al., 2021). This research study evaluated the data on multi-port scenario while focusing on the core impact of the presence of tracking on the shipping container. As technology penetration in port sector is an emerging field, this research contributed by providing empirical study on the port performance parameters.

This research also contributed to the field of social science and management by illustrating on factors which can decrease the dwell time of the containers and thus assisting workforce on the better planning of shift times and thus reducing the overtime working hours leading, to unhealthy prolonged working hours.

6.2 Contribution to Practice

The port sector is on the cusp of the technological transformation and automation is necessary for competing with global ports. This research study contributed to the practice by providing results for improvising port performance parameters such as dwell time by incorporating various data analytics tool. Various factors across multiple ports emphasizes on customizing region-specific operations and advance planning port operations for ensuring efficiency in operations.

7. LIMITATIONS

Role of tracking was considered from terminal port to next immediate hinterland which is container freight station.

Determining factors of dwell time was considered for the terminal and container freight station.

Data and modelling was performed on the Indian subcontinent ports.

8. CONCLUSION

The main objective of this doctoral thesis was to understand the varying reasons of dwell time at container ports. The research was initiated by developing an understanding on the importance of logistics for the research and economy. To establish this relationship, a fuzzy QCA method was performed on the selected economics of Asia, Europe, US and UK. The data from the secondary data base of World bank was selected. The analysis of LPI, LC, EODB and the parameters of LPI was performed to establish this relationship and the impact on economic development. The results showed that both LPI and Tracking and tracing are the core causal configuration with positive impact on the economic development.

The phase II performed analysis on the variation in dwell time due to the major port performance parameters. The data analysis was performed on the 2.8 million container entries utilizing python for data sciences and SPSS software for independent T test. Dwell time which is one of the major port performance parameters varies due to certain reasons which are important for the research and practice. The study is conducted at the fourteen major ports of India with an objective to qualitatively analyses the reasoning for variance along with objectifying the standardization tools for further research.

The result illustrated on the data analysis of fourteen ports shows that continuous tracking has an impact on reduced dwell time, where in port managers efficiently pre-plan the containers to be offloaded and onloaded on a vessel with accurate load planning. The major factors of cycle, size, mode, empty/laden showed that due to the geographical circumstances and port specific strategies there is a considerable variance in dwell time at the ports. The top three ports (A, G and L) were short listed based on lowest RMSE (Root mean square error) 15.6, 15.7, 15.86 % for qualitative reasoning. The prime reasons of free period and gate cut off for cycle, equipment demand and heavy cargo manufacturing for size, higher rail frequency, connectivity, sustainability goals and efficient truck docking strategies for mode were identified. Tran shipment ports, along with better pre-inspection clearance steps were few of the major reasons for empty/laden efficient movement. Trade support schemes along with free days due to high competition at CFS were reasons cited by trade for DPD/DPE.

The research contributed to science by providing research on a large multi-port data set along with feature of tracking and tracing which is one of the important factors in logistics performance index. Further study will focus on sourcing data around commodity, port of loading and destination. The study will also focus on developing a product for practice to have a real time idea of which port is performing on which parameter for the shortlisting of moving container via that port for its onward journey. The practice will be highly benefited by such approach and will foster in bridging the gap between academia and practice. The practice can utilize the results to identify and ship cargo by observing which factor is best performing factor for one port.

REFERENCES

Ahmt, J., Sigtenbjerggaard, J. S., Lusby, R. M., Larsen, J., & Ryan, D. (2016). A new approach to the Container Positioning Problem. *Flexible Services and Manufacturing Journal, 28*, 617-643.

Ani, T. G. (2015). Effect of ease of doing business to economic growth among selected countries in Asia. *Asia Pacific Journal of Multidisciplinary Research, 3*(5), 139-145.

Borgman, B., Van Asperen, E., & Dekker, R. (2010). Online rules for container stacking. OR Spectrum, 32, 687-716. https://doi.org/10.1007/s00291-010-0205-4

Brooks, M. R. (2006). Issues in measuring port devolution program performance: a managerial perspective. Research in Transportation Economics, 17, 599-629.

Çemberci, M., Civelek, M. E., & Canbolat, N. (2015). The moderator effect of global competitiveness index on dimensions of logistics performance index. Procedia-Social and Behavioral Sciences, 195, 1514-1524.

Chu, C., & Huang, W. (2005). Determining container terminal capacity on the basis of an adopted yard handling system. Transport Reviews, 25(2), 181-199.
Cooke James. (2022). *2022 update the worst major ports for congestion.* (). https://www.project44.com/blog/2022-update-the-worst-major-ports-for-congestion

Corcoran, A., & Gillanders, R. (2015). Foreign direct investment and the ease of doing business. Review of World Economics, 151, 103-126.

Curado, C., Henriques, P. L., Oliveira, M., & Matos, P. V. (2016). A fuzzy-set analysis of hard and soft sciences publication performance. Journal of Business Research, 69(11), 5348-5353.

De Armas Jacomino, L., Medina-Pérez, M. A., Monroy, R., Valdes-Ramirez, D., Morell-Pérez, C., & Bello, R. (2021). Dwell time estimation of import containers as an ordinal regression problem. Applied Sciences, 11(20), 9380.

Erkan, B. (2014). The importance and determinants of logistics performance of selected countries. Journal of Emerging Issues in Economics, Finance and Banking, 3(6), 1237-1254.

Estevão, J., Lopes, J. D., Penela, D., & Soares, J. M. (2020). The doing business ranking and the GDP. A qualitative study. Journal of Business Research, 115, 435-442. https://doi.org/10.1016/j.jbusres.2019.11.067

Farahani, R. Z., Asgari, N., & Davarzani, H. (2009). Supply chain and logistics in national, international and governmental environment: concepts and models. Springer Science & Business Media.

Fiss, P. C. (2011). Building better causal theories: A fuzzy set approach to typologies in organization research. Academy of Management Journal, 54(2), 393-420.

Fruth, M., & Teuteberg, F. (2017). Digitization in maritime logistics—What is there and what is missing? Cogent Business & Management, 4(1), 1411066.

Gharehgozli, A. H., Yu, Y., de Koster, R., & Udding, J. T. (2014). A decision-tree stacking heuristic minimising the expected number of reshuffles at a container terminal. International Journal of Production Research, 52(9), 2592-2611.

Gharehgozli, A., Mileski, J. P., & Duru, O. (2017). Heuristic estimation of container stacking and reshuffling operations under the containership delay factor and mega-ship challenge. Maritime Policy & Management, 44(3), 373-391.

Ghosh, N., Saha, R., & Bhowmick, S. (2019). SDG Index and Ease of Doing Business in India: A sub-national study. Occasional Papers, (199)

Guerra-Olivares, R., Smith, N. R., González-Ramírez, R. G., García-Mendoza, E., & Cárdenas-Barrón, L. E. (2018). A heuristic procedure for the outbound container space assignment problem for small and midsize maritime terminals. International Journal of Machine Learning and Cybernetics, 9, 1719-1732.

Guldogan, E. U. (2011). Simulation-based analysis for hierarchical storage assignment policies in a container terminal. Simulation, 87(6), 523-537.

Güven, C., & Türsel Eliiyi, D. (2019). Modelling and optimisation of online container stacking with operational constraints. Maritime Policy & Management, 46(2), 201-216.

Han, Y., Lee, L. H., Chew, E. P., & Tan, K. C. (2008). A yard storage strategy for minimizing traffic congestion in a marine container transshipment hub. OR Spectrum, 30, 697-720.

Havenga, J. (2010). Logistics costs in South Africa–The case for macroeconomic measurement. South African Journal of Economics, 78(4), 460-476.

He, Y., Wang, A., & Su, H. (2020). The impact of incomplete vessel arrival information on container stacking. International Journal of Production Research, 58(22), 6934-6948.

Hofman Bert. (2017). Performance and Prospects of Global Logistics: Keynote speech at the CaiNiao Global Smart Logistics Conference. (). https://www.worldbank.org/en/news/speech/2017/05/22/performance-and-prospects-of-global-logistics

Huang, S. Y., Hsu, W., Chen, C., Ye, R., & Nautiyal, S. (2008). Capacity analysis of container terminals using simulation techniques. International Journal of Computer Applications in Technology, 32(4), 246-253.

Imai, A., Sasaki, K., Nishimura, E., & Papadimitriou, S. (2006). Multi-objective simultaneous stowage and load planning for a container ship with container rehandle in yard stacks. European Journal of Operational Research, 171(2), 373-389.

Jhawar, A., Garg, S. K., & Khera, S. N. (2017). Improving logistics performance through investments and policy intervention: a causal loop model. International Journal of Productivity and Quality Management, 20(3), 363-391.

Kim, I., & Min, H. (2011). Measuring supply chain efficiency from a green perspective. Management Research Review, 34(11), 1169-1189.

Kourounioti, I., Polydoropoulou, A., & Tsiklidis, C. (2015). Development of a methodological framework for the dwell time of containers in Marine Terminals-First results. Proceeding ICTR,

Kourouthanassis, P. E., Mikalef, P., Pappas, I. O., & Kostagiolas, P. (2017). Explaining travellers online information satisfaction: A complexity theory approach on information needs, barriers, sources and personal characteristics. Information & Management, 54(6), 814-824.

Kraus, S., Ribeiro-Soriano, D., & Schüssler, M. (2018). Fuzzy-set qualitative comparative analysis (fsQCA) in entrepreneurship and innovation research–the rise of a method. International Entrepreneurship and Management Journal, 14, 15-33.

Ku, D., & Arthanari, T. S. (2016). Container relocation problem with time windows for container departure. European Journal of Operational Research, 252(3), 1031-1039.

Liu, M., Chu, F., Zhang, Z., & Chu, C. (2015). A polynomial-time heuristic for the quay crane double-cycling problem with internal-reshuffling operations. Transportation Research Part E: Logistics and Transportation Review, 81, 52-74.

Maldonado, S., González-Ramírez, R. G., Quijada, F., & Ramírez-Nafarrate, A. (2019). Analytics meets port logistics: A decision support system for container stacking operations. Decision Support Systems, 121, 84-93. https://doi.org/10.1016/j.dss.2019.04.006

Marlow, P. B., & Casaca, A. C. P. (2003). Measuring lean ports performance. International Journal of Transport Management, 1(4), 189-202.

Meisel, F., & Wichmann, M. (2010). Container sequencing for quay cranes with internal reshuffles. OR Spectrum, 32, 569-591.

Merckx, F. (2005). The issue of dwell time charges to optimize container terminal capacity. Paper presented at the Proceedings IAME 2005 Annual Conference, Limassol, Cyprus, 23-25 June 2005, CD-ROM 21.

Misangyi, V. F., Greckhamer, T., Furnari, S., Fiss, P. C., Crilly, D., & Aguilera, R. (2017). Embracing causal complexity: The emergence of a neo-configurational perspective. Journal of Management, 43(1), 255-282.

Moini, N., Boile, M., Theofanis, S., & Laventhal, W. (2012). Estimating the determinant factors of container dwell times at seaports. Maritime Economics & Logistics, 14, 162-177.

Monaco, M. F., Moccia, L., & Sammarra, M. (2009). Operations Research for the management of a transhipment container terminal: The Gioia Tauro case. Maritime Economics & Logistics, 11(1), 7-35. https://doi.org/10.1057/mel.2008.21

MONIE, D. E. (1987). Measuring and evaluating port performance and productivity. (UNCTAD) Monographs on Port Management, 6

Morris, R., & Aziz, A. (2011). Ease of doing business and FDI inflow to Sub-Saharan Africa and Asian countries. Cross Cultural Management: An International Journal, 18(4), 400-411.

Muñuzuri, J., Onieva, L., Cortés, P., & Guadix, J. (2020). Using IoT data and applications to improve port-based intermodal supply chains. Computers & Industrial Engineering, 139, 105668.

Mwasenga, H. (2012). Port performance indicators: A case of Dar es Salaam port. Paper presented at the UNCTAD, Ad Hoc Expert Meeting on Assessing Port Performance,

Nicoll, J., & Nicholson, D. (2007). Container Tracking System–Dwell Time and Transit Time Management at the Port of Halifax.

Nooramin, A. S., Ahouei, V. R., & Sayareh, J. (2011). A Six Sigma framework for marine container terminals. International Journal of Lean Six Sigma, 2(3), 241-253.

Park, Y., El Sawy, O. A., & Fiss, P. (2017). The role of business intelligence and communication technologies in organizational agility: a configurational approach. Journal of the Association for Information Systems, 18(9), 1.

Park, Y., Fiss, P. C., & El Sawy, O. A. (2020). Theorizing the multiplicity of digital phenomena: The ecology of configurations, causal recipes, and guidelines for applying QCA. Management of Information Systems Quarterly, 44, 1493-1520. https://doi.org/10.25300/MISQ/2020/13879

Puertas, R., Martí, L., & García, L. (2014). Logistics performance and export competitiveness: European experience. Empirica, 41, 467-480.

Ragin, C. C. (2000). Fuzzy-set social science. University of Chicago Press.

Research and Markets. (2021, May). Global Container Shipping Market - Growth, Trends, COVID-19 Impact, and Forecasts (2021 - 2026). https://www.researchandmarkets.com/reports/5332809/global-container-shipping-market-growth

Rodrigue Jean Paul. (2022, Generations of Containerships. http://transportgeography.org/generations-of-containerships-update/

Rodrigue, J., & Notteboom, T. (2008). The terminalization of supply chains. Paper presented at the Proceedings of the IAME 2008 Conference, https://doi.org/10.1080/03088830902861086

Rodriguez-Molins, M., Salido, M. A., & Barber, F. (2012). Intelligent planning for allocating containers in maritime terminals. Expert Systems with Applications, 39(1), 978-989.

Rogge, N., & Archer, G. (2021). Measuring and analyzing country change in establishing ease of doing business using a revised version of World Bank's ease of doing business index. European Journal of Operational Research, 290(1), 373-385.

Ruzekova, V., Kittova, Z., & Steinhauser, D. (2020). Export performance as a measurement of competitiveness. Journal of Competitiveness, 12(1), 145.

Sagar Mala. (2016). Sagar Mala. (). https://sagarmala.gov.in/about-sagarmala/sagarmala-reports

Saini, M., Efimova, A., & Chromjaková, F. (2021). Value stream mapping of ocean import containers: A process cycle efficiency perspective. Acta Logistica,

Saini, M., & Hrušecká, D. (2021a). Comparative impact of logistics performance index, ease of doing business and logistics cost on economic development: a fuzzy QCA analysis. Journal of Business Economics and Management, 22(6), 1577-1592. https://doi.org/10.3846/jbem.2021.15586

Saini, M., & Hrušecká, D. (2021b). Influence of logistics competitiveness and logistics cost on economic development: an FsQCA qualitative approach. E & M Ekonomie a Management, https://doi.org/10.15240/tul/001/2021-2-004

Saldaña, J. (2021). The coding manual for qualitative researchers. sage.

Salido, M. A., Rodriguez-Molins, M., & Barber, F. (2011). Integrated intelligent techniques for remarshaling and berthing in maritime terminals. Advanced Engineering Informatics, 25(3), 435-451.

Sam, & Whelan. (2021, Nov, 18,). India's container market is cooling, but 'kinks' in supply chains persist. https://theloadstar.com/indias-container-market-is-cooling-but-kinks-in-supply-chains-persist/

Sauri, S., & Martin, E. (2011). Space allocating strategies for improving import yard performance at marine terminals. Transportation Research Part E: Logistics and Transportation Review, 47(6), 1038-1057. https://doi.org/10.1016/j.tre.2011.04.005

Schneider, M. R., Schulze-Bentrop, C., & Paunescu, M. (2010). Mapping the institutional capital of high-tech firms: A fuzzy-set analysis of capitalist variety and export performance. Journal of International Business Studies, 41, 246-266.

Scholl, J., Boywitz, D., & Boysen, N. (2018). On the quality of simple measures predicting block relocations in container yards. International Journal of Production Research, 56(1-2), 60-71. https://doi.org/10.1080/00207543.2017.1394595

Serban, C., & Carp, D. (2017). A Genetic Algorithm for Solving a Container Storage Problem Using a Residence Time Strategy. Studies in Informatics and Control, 26(1), 60.

Sriyana, J., & Afandi, A. (2020). Asymmetric effects of trade openness on economic growth in selected ASEAN countries.

Steenken, D., Voß, S., & Stahlbock, R. (2004). Container terminal operation and operations research-a classification and literature review. OR Spectrum, 26, 3-49. https://doi.org/10.1007/s00291-003-0157-z

Strauss, A., & Corbin, J. (1990). Basics of qualitative research. Sage publications. https://doi.org/10.5072/genderopen-develop-7

Supply Chain Digest. (2006, Logistics Cost Survey - 2006. http://www.scdigest.com/assets/reps/SCDigest_Logistics_Cost_Survey_2006.pdf

Tang, L., Jiang, W., Liu, J., & Dong, Y. (2015). Research into container reshuffling and stacking problems in container terminal yards. IIE Transactions, 47(7), 751-766.

Tongzon, J. L. (1995). Determinants of port performance and efficiency. Transportation Research Part A: Policy and Practice, 29(3), 245-252.

Transmetrics. (2021). Logistics Data Standards: Challenges and Benefits. (). https://www.transmetrics.ai/blog/logistics-data-standards/#:~:text=Transmetrics'%20standard%20data%20model%20contains,with%20the%20shipments%20in%20reality.

Tvaronavičiene, M., & Ginevičius, R. (2003). Analysis of foreign direct investments and its' impact on restructuring of Lithuanian economy. Journal of Business Economics and Management, 4(3), 184-197.

UNCTAD. (1976, Review of maritime transport. https://unctad.org/topic/transport-and-trade-logistics/review-of-maritime-transport

UNCTAD. (2018). Review of Maritime Transport. (). https://unctad.org/system/files/official-document/rmt2018_en.pdf

Wan, Y., Liu, J., & Tsai, P. (2009). The assignment of storage locations to containers for a container stack. Naval Research Logistics (NRL), 56(8), 699-713.

World Bank.World Bank - World Bank national accounts data, and OECD National Accounts data files. (). https://data.worldbank.org/indicator/NY.GDP.PCAP.CD

World Bank. (2019). Doing Business Indicators. (). https://databank.worldbank.org/source/doing-business

World Bank. (2023). Logistics Performance Index. (). https://lpi.worldbank.org/

World Bank Group. (2020). Doing Business 2020. (). https://openknowledge.worldbank.org/bitstream/handle/10986/32436/9781464814402.pdf

Yildirim, B. F., & Adiguzel Mercangoz, B. (2020). Evaluating the logistics performance of OECD countries by using fuzzy AHP and ARAS-G. Eurasian Economic Review, 10(1), 27-45. https://doi.org/10.1007/s40822-019-00131-3

Zhang, Z., & Lee, C. (2015). Multiobjective approaches for the ship stowage planning problem considering ship stability and container rehandles. IEEE Transactions on Systems, Man, and Cybernetics: Systems, 46(10), 1374-1389.

Zhao, W., & Goodchild, A. V. (2010). The impact of truck arrival information on container terminal rehandling. Transportation Research Part E: Logistics and Transportation Review, 46(3), 327-343.

stylefix

APPENDICES

The data analysis supporting from the port data analysis and modelling is depicted below as per below dummy coding:

OLS x1 =Cycle, x2 =Mode, x3 =Size, x4 =Status, x5 =Delivery, x6 = Tracking
y = Dwell Time

1.PORT A: OLS data analysis and independent sample T test results

```
In [24]: data_lm.summary()
Out[24]:
```

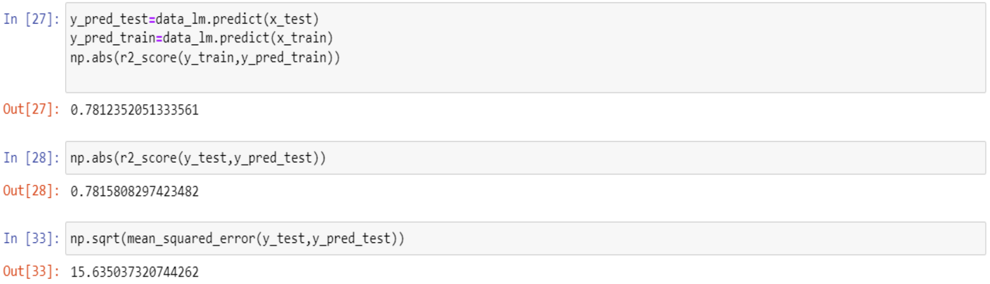
OLS Regression Results

Dep. Variable:	y	**R-squared:**	0.782
Model:	OLS	**Adj. R-squared:**	0.782
Method:	Least Squares	**F-statistic:**	1.387e+05
Date:	Mon, 12 Dec 2022	**Prob (F-statistic):**	0.00
Time:	10:33:00	**Log-Likelihood:**	-9.7015e+05
No. Observations:	232730	**AIC:**	1.940e+06
Df Residuals:	232723	**BIC:**	1.940e+06
Df Model:	6		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P>|t|**	**[0.025**	**0.975]**
const	30.4532	0.203	149.877	0.000	30.055	30.851
x1	15.3367	0.081	189.084	0.000	15.178	15.496
x2	0.9229	0.093	9.968	0.000	0.741	1.104
x3	0.7014	0.065	10.721	0.000	0.573	0.830
x4	-3.3567	0.090	-37.306	0.000	-3.533	-3.180
x5	-7.3105	0.186	-39.263	0.000	-7.675	-6.946
x6	53.8767	0.086	629.878	0.000	53.709	54.044

Omnibus:	7497.235	**Durbin-Watson:**	1.840
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	8243.187
Skew:	0.459	**Prob(JB):**	0.00
Kurtosis:	3.074	**Cond. No.**	14.6

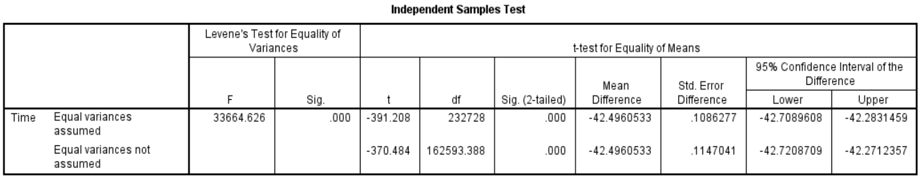
Summary of OLS Test of Port A



```
In [27]: y_pred_test=data_lm.predict(x_test)
         y_pred_train=data_lm.predict(x_train)
         np.abs(r2_score(y_train,y_pred_train))

Out[27]: 0.7812352051333561

In [28]: np.abs(r2_score(y_test,y_pred_test))

Out[28]: 0.7815808297423482

In [33]: np.sqrt(mean_squared_error(y_test,y_pred_test))

Out[33]: 15.635037320744262
```

RMSE and R^2 of test and train data of Port A

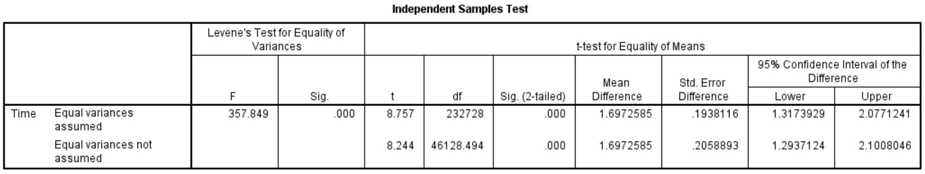
Cycle



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	33664.626	.000	-391.208	232728	.000	-42.4960533	.1086277	-42.7089608	-42.2831459
	Equal variances not assumed			-370.484	162593.388	.000	-42.4960533	.1147041	-42.7208709	-42.2712357

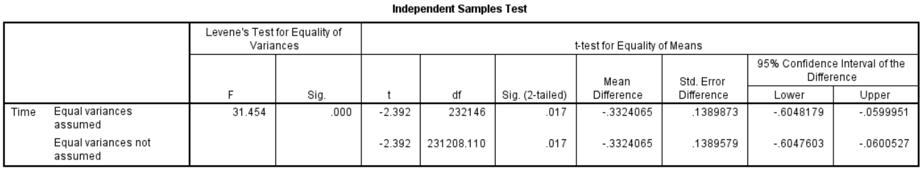
Mode



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	357.849	.000	8.757	232728	.000	1.6972585	.1938116	1.3173929	2.0771241
	Equal variances not assumed			8.244	46128.494	.000	1.6972585	.2058893	1.2937124	2.1008046

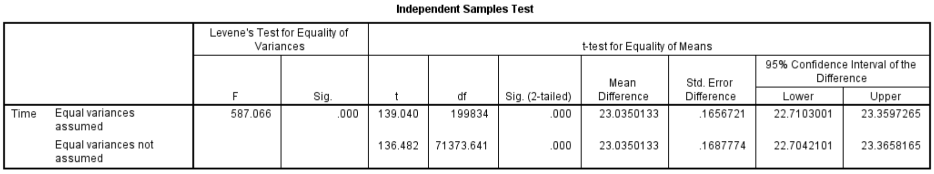
Size



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	31.454	.000	-2.392	232146	.017	-.3324065	.1389873	-.6048179	-.0599951
	Equal variances not assumed			-2.392	231208.110	.017	-.3324065	.1389579	-.6047603	-.0600527

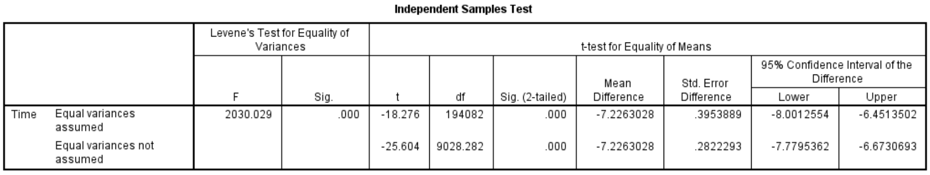
Status



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	587.066	.000	139.040	199834	.000	23.0350133	.1656721	22.7103001	23.3597265
	Equal variances not assumed			136.482	71373.641	.000	23.0350133	.1687774	22.7042101	23.3658165

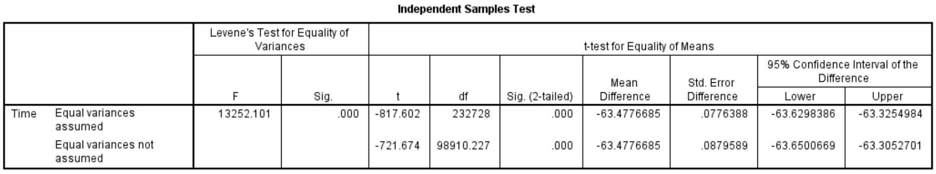
Delivery



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	2030.029	.000	-18.276	194082	.000	-7.2263028	.3953889	-8.0012554	-6.4513502
	Equal variances not assumed			-25.604	9028.282	.000	-7.2263028	.2822293	-7.7795362	-6.6730693

Tracking

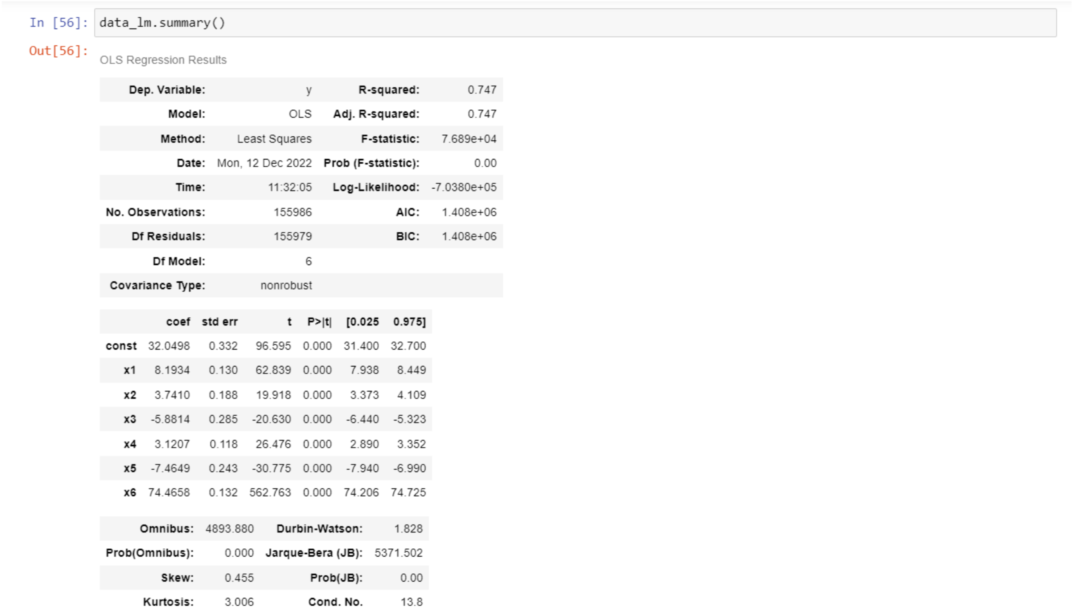


Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	13252.101	.000	-817.602	232728	.000	-63.4776685	.0776388	-63.6298386	-63.3254984
	Equal variances not assumed			-721.674	98910.227	.000	-63.4776685	.0879589	-63.6500669	-63.3052701

T test for the independent variables for Port A

2.<u>Port B OLS data analysis and Independent sample T test results</u>



```
In [56]: data_lm.summary()
Out[56]:
```

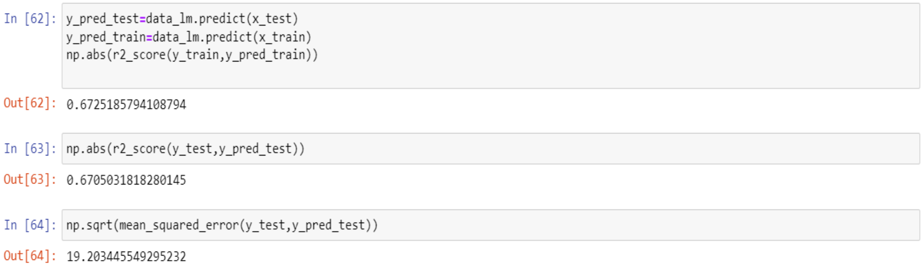
OLS Regression Results

Dep. Variable:	y	**R-squared:**	0.747
Model:	OLS	**Adj. R-squared:**	0.747
Method:	Least Squares	**F-statistic:**	7.689e+04
Date:	Mon, 12 Dec 2022	**Prob (F-statistic):**	0.00
Time:	11:32:05	**Log-Likelihood:**	-7.0380e+05
No. Observations:	155986	**AIC:**	1.408e+06
Df Residuals:	155979	**BIC:**	1.408e+06
Df Model:	6		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	32.0498	0.332	96.595	0.000	31.400	32.700
x1	8.1934	0.130	62.839	0.000	7.938	8.449
x2	3.7410	0.188	19.918	0.000	3.373	4.109
x3	-5.8814	0.285	-20.630	0.000	-6.440	-5.323
x4	3.1207	0.118	26.476	0.000	2.890	3.352
x5	-7.4649	0.243	-30.775	0.000	-7.940	-6.990
x6	74.4658	0.132	562.763	0.000	74.206	74.725

Omnibus:	4893.880	**Durbin-Watson:**	1.828
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	5371.502
Skew:	0.455	**Prob(JB):**	0.00
Kurtosis:	3.006	**Cond. No.**	13.8

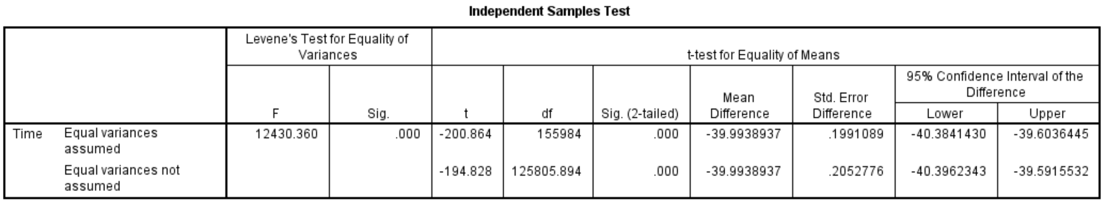
Summary of OLS Test of Port B



```
In [62]: y_pred_test=data_lm.predict(x_test)
         y_pred_train=data_lm.predict(x_train)
         np.abs(r2_score(y_train,y_pred_train))

Out[62]: 0.6725185794108794

In [63]: np.abs(r2_score(y_test,y_pred_test))

Out[63]: 0.6705031818280145

In [64]: np.sqrt(mean_squared_error(y_test,y_pred_test))

Out[64]: 19.203445549295232
```

RMSE and R^2 of test and train data of Port B

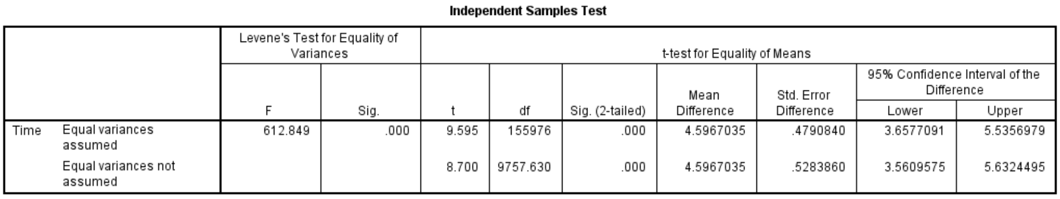
Cycle



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	12430.360	.000	-200.864	155984	.000	-39.9938937	.1991089	-40.3841430	-39.6036445
	Equal variances not assumed			-194.828	125805.894	.000	-39.9938937	.2052776	-40.3962343	-39.5915532

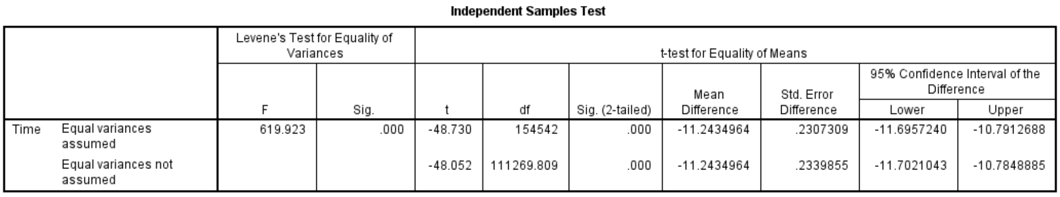
Mode



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	612.849	.000	9.595	155976	.000	4.5967035	.4790840	3.6577091	5.5356979
	Equal variances not assumed			8.700	9757.630	.000	4.5967035	.5283860	3.5609575	5.6324495

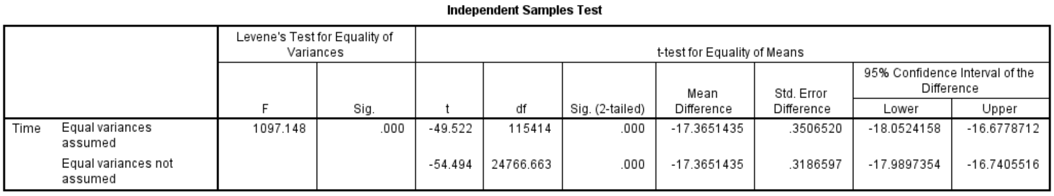
Size



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	619.923	.000	-48.730	154542	.000	-11.2434964	.2307309	-11.6957240	-10.7912688
	Equal variances not assumed			-48.052	111269.809	.000	-11.2434964	.2339855	-11.7021043	-10.7848885

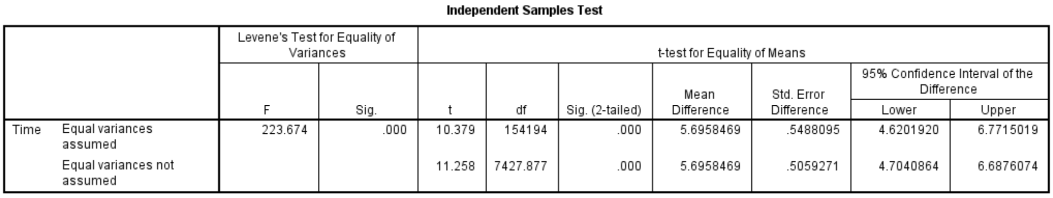
Status



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	1097.148	.000	-49.522	115414	.000	-17.3651435	.3506520	-18.0524158	-16.6778712
	Equal variances not assumed			-54.494	24766.663	.000	-17.3651435	.3186597	-17.9897354	-16.7405516

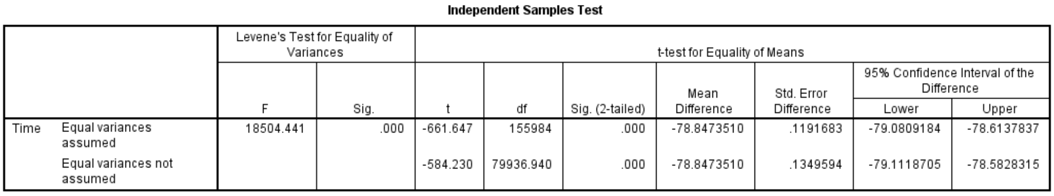
Delivery



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	223.674	.000	10.379	154194	.000	5.6958469	.5488095	4.6201920	6.7715019
	Equal variances not assumed			11.258	7427.877	.000	5.6958469	.5059271	4.7040864	6.6876074

Tracking

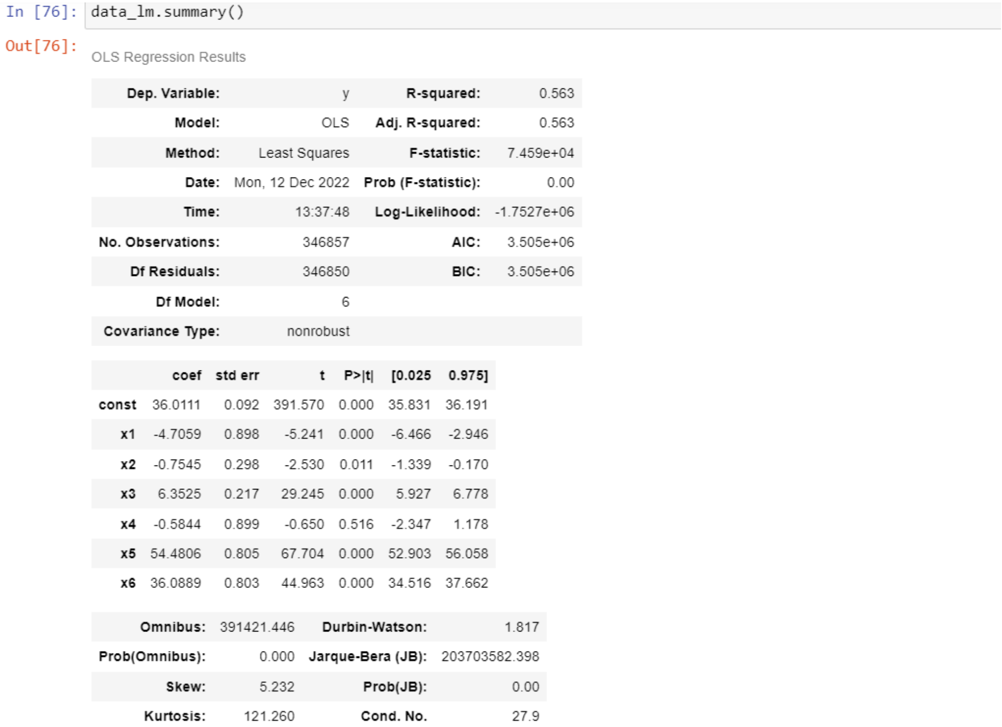


Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	18504.441	.000	-661.647	155984	.000	-78.8473510	.1191683	-79.0809184	-78.6137837
	Equal variances not assumed			-584.230	79936.940	.000	-78.8473510	.1349594	-79.1118705	-78.5828315

T test for the independent variables for Port B

3.Port C OLS data analysis and Independent sample T test results



```
In [76]: data_lm.summary()

Out[76]:
```

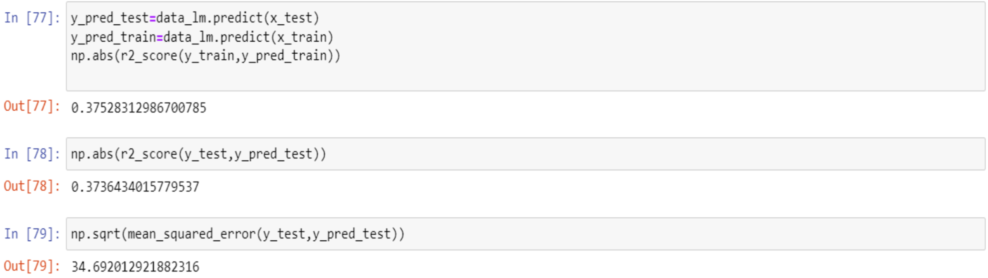
OLS Regression Results

Dep. Variable:	y	**R-squared:**	0.563
Model:	OLS	**Adj. R-squared:**	0.563
Method:	Least Squares	**F-statistic:**	7.459e+04
Date:	Mon, 12 Dec 2022	**Prob (F-statistic):**	0.00
Time:	13:37:48	**Log-Likelihood:**	-1.7527e+06
No. Observations:	346857	**AIC:**	3.505e+06
Df Residuals:	346850	**BIC:**	3.505e+06
Df Model:	6		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P>|t|**	**[0.025**	**0.975]**
const	36.0111	0.092	391.570	0.000	35.831	36.191
x1	-4.7059	0.898	-5.241	0.000	-6.466	-2.946
x2	-0.7545	0.298	-2.530	0.011	-1.339	-0.170
x3	6.3525	0.217	29.245	0.000	5.927	6.778
x4	-0.5844	0.899	-0.650	0.516	-2.347	1.178
x5	54.4806	0.805	67.704	0.000	52.903	56.058
x6	36.0889	0.803	44.963	0.000	34.516	37.662

Omnibus:	391421.446	**Durbin-Watson:**	1.817
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	203703582.398
Skew:	5.232	**Prob(JB):**	0.00
Kurtosis:	121.260	**Cond. No.**	27.9

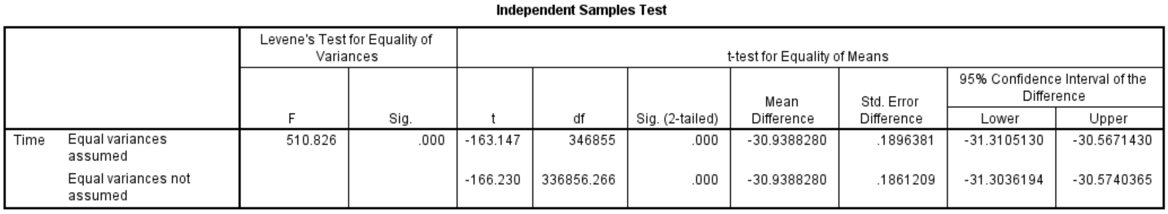
Summary of OLS Test of Port C



```
In [77]: y_pred_test=data_lm.predict(x_test)
         y_pred_train=data_lm.predict(x_train)
         np.abs(r2_score(y_train,y_pred_train))

Out[77]: 0.37528312986700785

In [78]: np.abs(r2_score(y_test,y_pred_test))

Out[78]: 0.3736434015779537

In [79]: np.sqrt(mean_squared_error(y_test,y_pred_test))

Out[79]: 34.692012921882316
```

RMSE and R^2 of test and train data of Port C

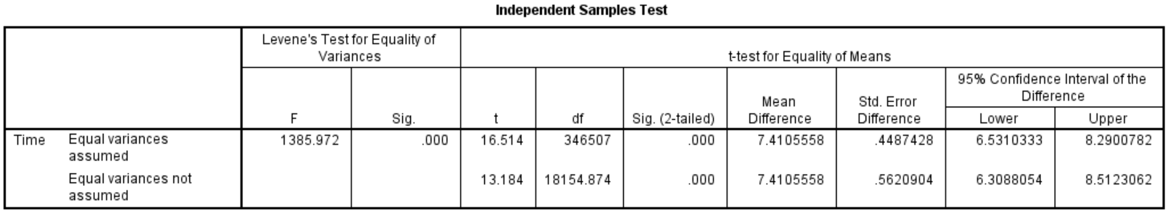
Cycle



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	510.826	.000	-163.147	346855	.000	-30.9388280	.1896381	-31.3105130	-30.5671430
	Equal variances not assumed			-166.230	336856.266	.000	-30.9388280	.1861209	-31.3036194	-30.5740365

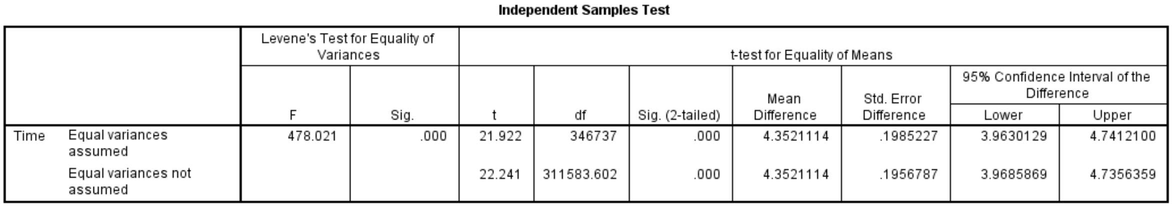
Mode



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	1385.972	.000	16.514	346507	.000	7.4105558	.4487428	6.5310333	8.2900782
	Equal variances not assumed			13.184	18154.874	.000	7.4105558	.5620904	6.3088054	8.5123062

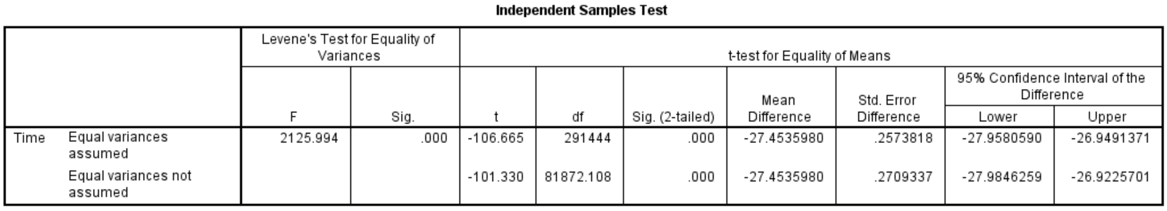
Size



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	478.021	.000	21.922	346737	.000	4.3521114	.1985227	3.9630129	4.7412100
	Equal variances not assumed			22.241	311583.602	.000	4.3521114	.1956787	3.9685869	4.7356359

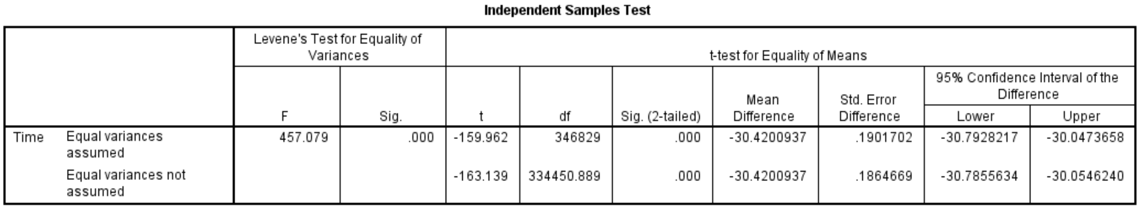
Status



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	2125.994	.000	-106.665	291444	.000	-27.4535980	.2573818	-27.9580590	-26.9491371
	Equal variances not assumed			-101.330	81872.108	.000	-27.4535980	.2709337	-27.9846259	-26.9225701

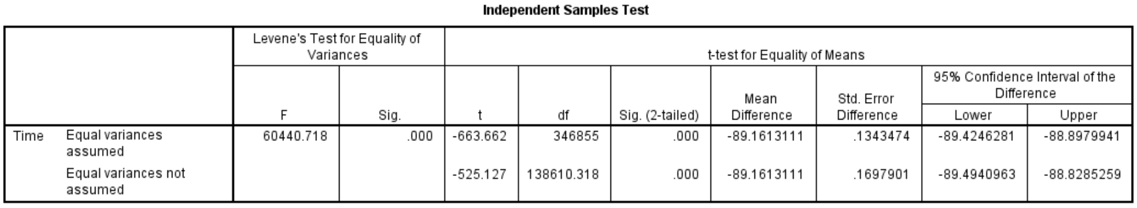
Delivery



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	457.079	.000	-159.962	346829	.000	-30.4200937	.1901702	-30.7928217	-30.0473658
	Equal variances not assumed			-163.139	334450.889	.000	-30.4200937	.1864669	-30.7855634	-30.0546240

Tracking

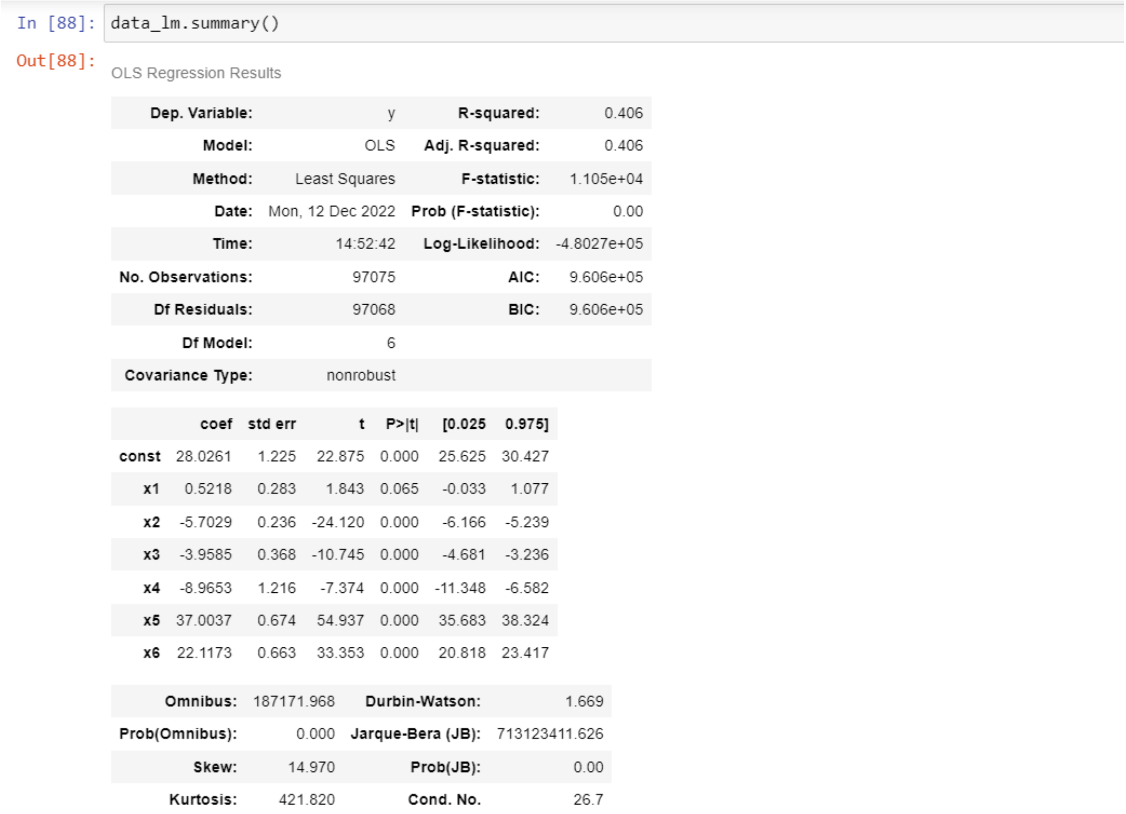


Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	60440.718	.000	-663.662	346855	.000	-89.1613111	.1343474	-89.4246281	-88.8979941
	Equal variances not assumed			-525.127	138610.318	.000	-89.1613111	.1697901	-89.4940963	-88.8285259

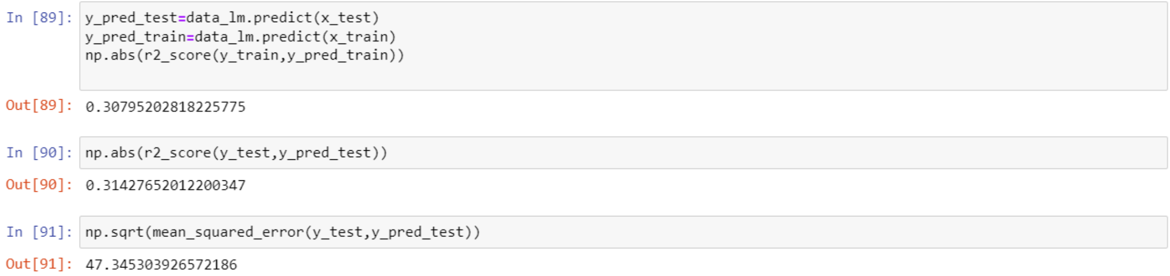
T test for the independent variables for Port C

4.Port D OLS data analysis and independent sample T test results



```
In [88]: data_lm.summary()

Out[88]:
OLS Regression Results

   Dep. Variable:                 y        R-squared:        0.406
           Model:               OLS    Adj. R-squared:       0.406
          Method:     Least Squares       F-statistic:   1.105e+04
            Date:  Mon, 12 Dec 2022  Prob (F-statistic):      0.00
            Time:          14:52:42    Log-Likelihood: -4.8027e+05
No. Observations:             97075               AIC:   9.606e+05
    Df Residuals:             97068               BIC:   9.606e+05
        Df Model:                 6
 Covariance Type:         nonrobust

          coef  std err        t  P>|t|   [0.025  0.975]
const  28.0261    1.225   22.875  0.000   25.625  30.427
   x1   0.5218    0.283    1.843  0.065   -0.033   1.077
   x2  -5.7029    0.236  -24.120  0.000   -6.166  -5.239
   x3  -3.9585    0.368  -10.745  0.000   -4.681  -3.236
   x4  -8.9653    1.216   -7.374  0.000  -11.348  -6.582
   x5  37.0037    0.674   54.937  0.000   35.683  38.324
   x6  22.1173    0.663   33.353  0.000   20.818  23.417

      Omnibus: 187171.968     Durbin-Watson:         1.669
Prob(Omnibus):      0.000  Jarque-Bera (JB): 713123411.626
         Skew:     14.970          Prob(JB):          0.00
     Kurtosis:    421.820          Cond. No.          26.7
```

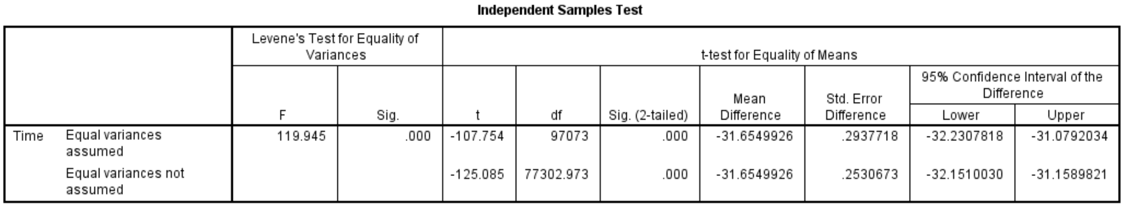
Summary of OLS Test of Port D



```
In [89]: y_pred_test=data_lm.predict(x_test)
         y_pred_train=data_lm.predict(x_train)
         np.abs(r2_score(y_train,y_pred_train))

Out[89]: 0.30795202818225775

In [90]: np.abs(r2_score(y_test,y_pred_test))

Out[90]: 0.31427652012200347

In [91]: np.sqrt(mean_squared_error(y_test,y_pred_test))

Out[91]: 47.345303926572186
```

RMSE and R^2 of test and train data of Port D

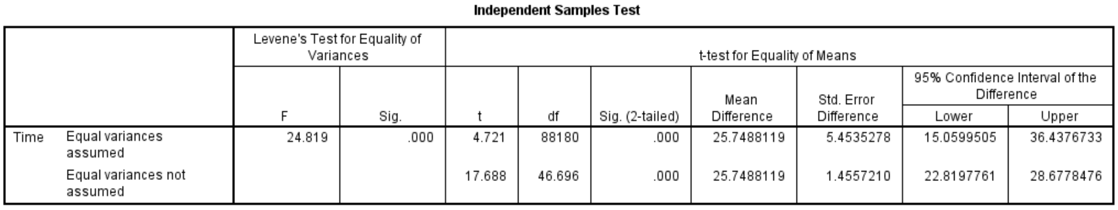
Cycle



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	119.945	.000	-107.754	97073	.000	-31.6549926	.2937718	-32.2307818	-31.0792034
	Equal variances not assumed			-125.085	77302.973	.000	-31.6549926	.2530673	-32.1510030	-31.1589821

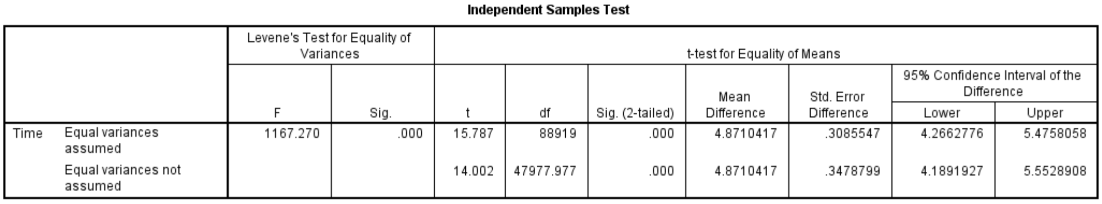
Mode



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	24.819	.000	4.721	88180	.000	25.7488119	5.4535278	15.0599505	36.4376733
	Equal variances not assumed			17.688	46.696	.000	25.7488119	1.4557210	22.8197761	28.6778476

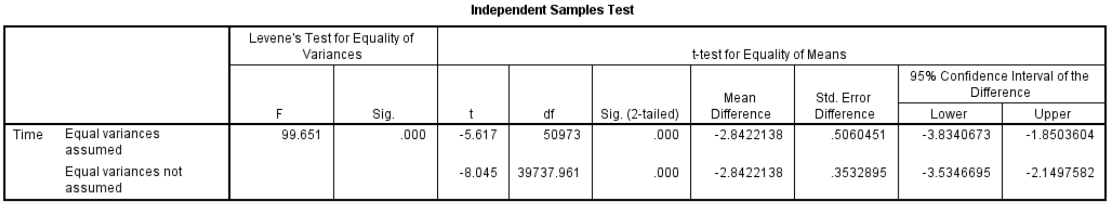
Size



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	1167.270	.000	15.787	88919	.000	4.8710417	.3085547	4.2662776	5.4758058
	Equal variances not assumed			14.002	47977.977	.000	4.8710417	.3478799	4.1891927	5.5528908

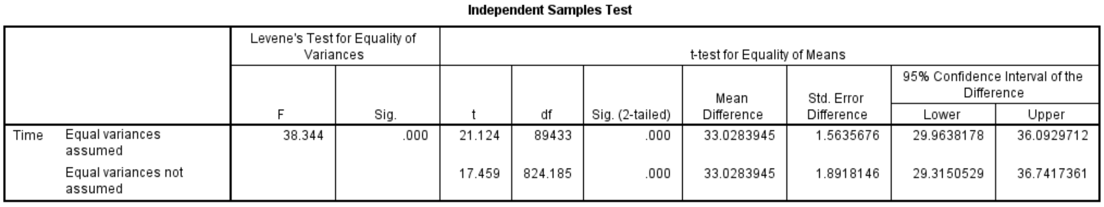
Status



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	99.651	.000	-5.617	50973	.000	-2.8422138	.5060451	-3.8340673	-1.8503604
	Equal variances not assumed			-8.045	39737.961	.000	-2.8422138	.3532895	-3.5346695	-2.1497582

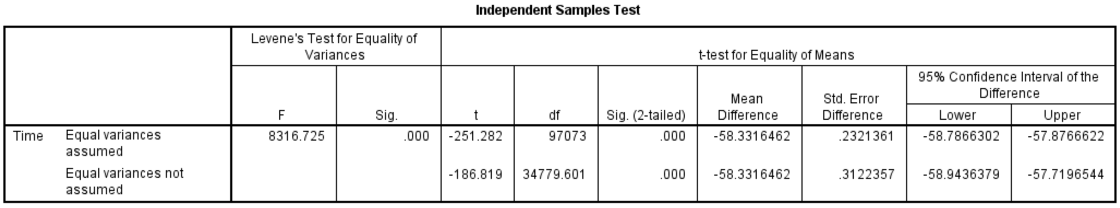
Delivery



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	38.344	.000	21.124	89433	.000	33.0283945	1.5635676	29.9638178	36.0929712
	Equal variances not assumed			17.459	824.185	.000	33.0283945	1.8918146	29.3150529	36.7417361

Tracking

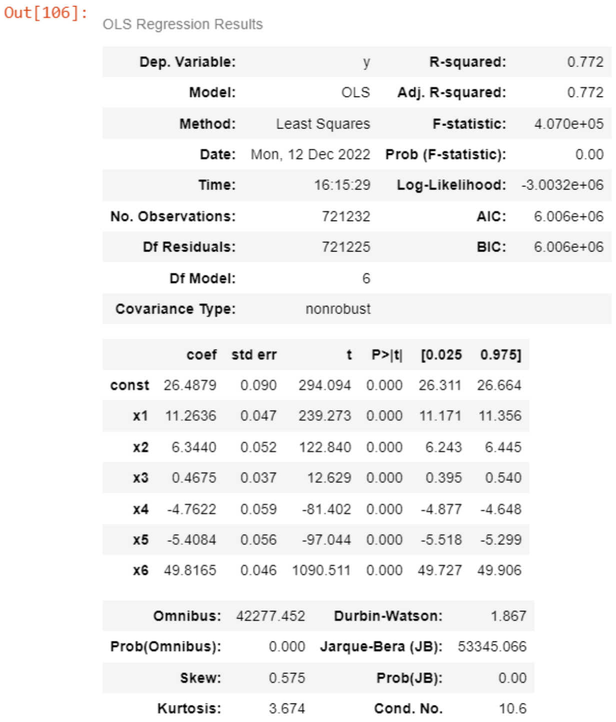


Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	8316.725	.000	-251.282	97073	.000	-58.3316462	.2321361	-58.7866302	-57.8766622
	Equal variances not assumed			-186.819	34779.601	.000	-58.3316462	.3122357	-58.9436379	-57.7196544

T test for the independent variables for Port D

5.Port E OLS data analysis and Independent sample T test results



Out[106]:

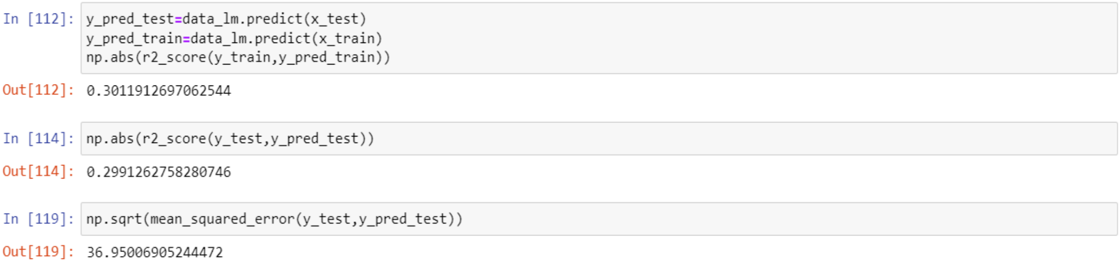
OLS Regression Results

Dep. Variable:	y	**R-squared:**	0.772
Model:	OLS	**Adj. R-squared:**	0.772
Method:	Least Squares	**F-statistic:**	4.070e+05
Date:	Mon, 12 Dec 2022	**Prob (F-statistic):**	0.00
Time:	16:15:29	**Log-Likelihood:**	-3.0032e+06
No. Observations:	721232	**AIC:**	6.006e+06
Df Residuals:	721225	**BIC:**	6.006e+06
Df Model:	6		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	26.4879	0.090	294.094	0.000	26.311	26.664
x1	11.2636	0.047	239.273	0.000	11.171	11.356
x2	6.3440	0.052	122.840	0.000	6.243	6.445
x3	0.4675	0.037	12.629	0.000	0.395	0.540
x4	-4.7622	0.059	-81.402	0.000	-4.877	-4.648
x5	-5.4084	0.056	-97.044	0.000	-5.518	-5.299
x6	49.8165	0.046	1090.511	0.000	49.727	49.906

Omnibus:	42277.452	**Durbin-Watson:**	1.867
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	53345.066
Skew:	0.575	**Prob(JB):**	0.00
Kurtosis:	3.674	**Cond. No.**	10.6

Summary of OLS Test of Port E

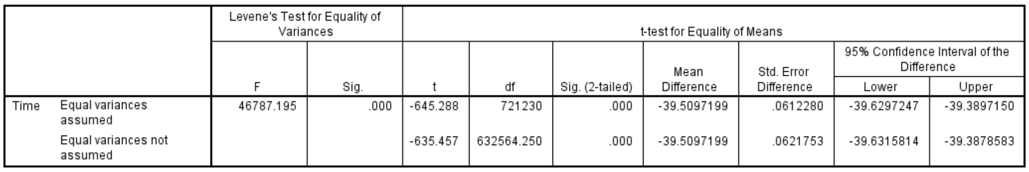


```
In [112]: y_pred_test=data_lm.predict(x_test)
          y_pred_train=data_lm.predict(x_train)
          np.abs(r2_score(y_train,y_pred_train))

Out[112]: 0.3011912697062544

In [114]: np.abs(r2_score(y_test,y_pred_test))

Out[114]: 0.2991262758280746

In [119]: np.sqrt(mean_squared_error(y_test,y_pred_test))

Out[119]: 36.95006905244472
```

RMSE and R^2 of test and train data of Port E

Cycle

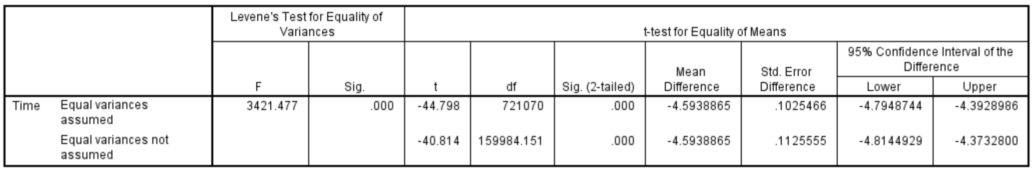
Independent Samples Test



		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Time	Equal variances assumed	46787.195	.000	-645.288	721230	.000	-39.5097199	.0612280	-39.6297247	-39.3897150
	Equal variances not assumed			-635.457	632564.250	.000	-39.5097199	.0621753	-39.6315814	-39.3878583

Mode

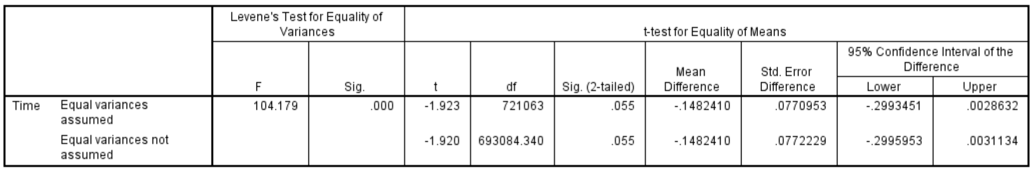
Independent Samples Test



		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Time	Equal variances assumed	3421.477	.000	-44.798	721070	.000	-4.5938865	.1025466	-4.7948744	-4.3928986
	Equal variances not assumed			-40.814	159984.151	.000	-4.5938865	.1125555	-4.8144929	-4.3732800

Size

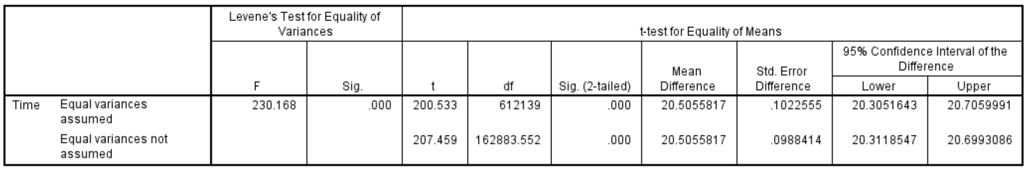
Independent Samples Test



		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Time	Equal variances assumed	104.179	.000	-1.923	721063	.055	-.1482410	.0770953	-.2993451	.0028632
	Equal variances not assumed			-1.920	693084.340	.055	-.1482410	.0772229	-.2995953	.0031134

Status

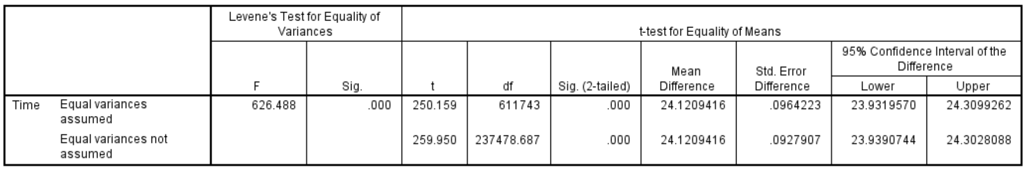
Independent Samples Test



		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Time	Equal variances assumed	230.168	.000	200.533	612139	.000	20.5055817	.1022555	20.3051643	20.7059991
	Equal variances not assumed			207.459	162883.552	.000	20.5055817	.0988414	20.3118547	20.6993086

Delivery

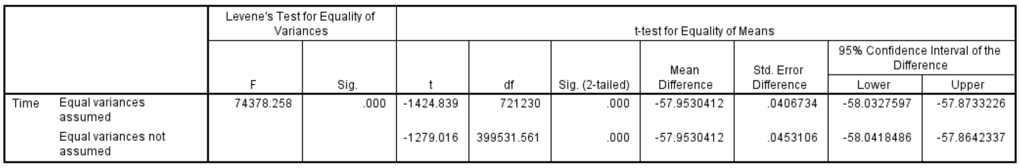
Independent Samples Test



		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Time	Equal variances assumed	626.488	.000	250.159	611743	.000	24.1209416	.0964223	23.9319570	24.3099262
	Equal variances not assumed			259.950	237478.687	.000	24.1209416	.0927907	23.9390744	24.3028088

Tracking

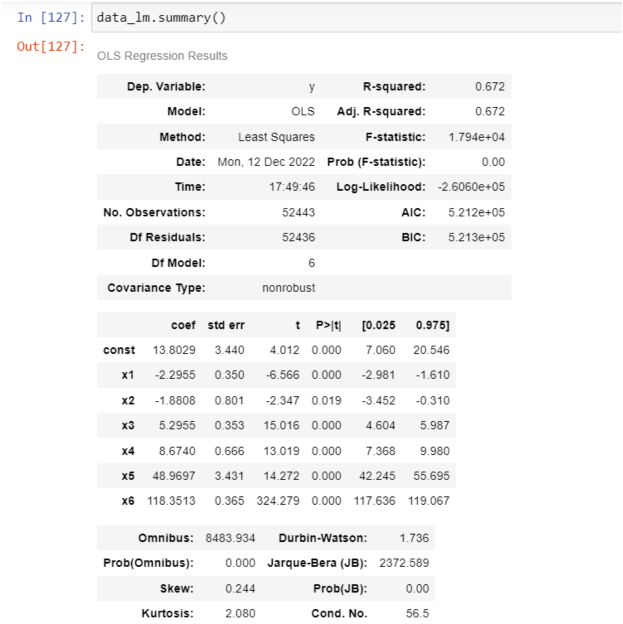
Independent Samples Test



		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Time	Equal variances assumed	74378.258	.000	-1424.839	721230	.000	-57.9530412	.0406734	-58.0327597	-57.8733226
	Equal variances not assumed			-1279.016	399531.561	.000	-57.9530412	.0453106	-58.0418486	-57.8642337

T test for the independent variables for Port E

6.Port F OLS data analysis and Independent sample T test results



```
In [127]: data_lm.summary()
Out[127]:
```

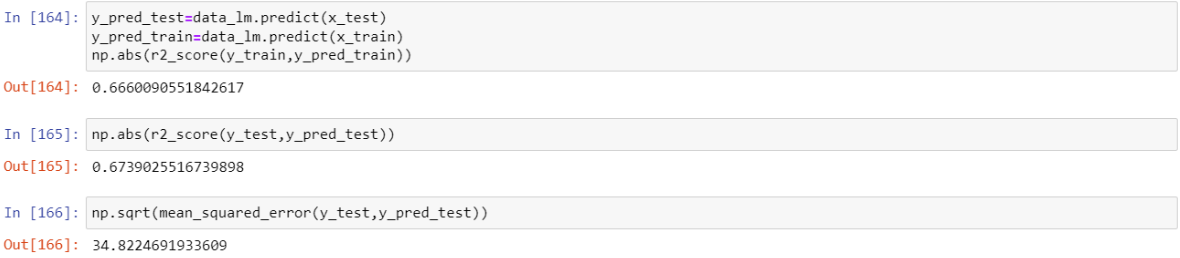
OLS Regression Results

Dep. Variable:	y	**R-squared:**	0.672
Model:	OLS	**Adj. R-squared:**	0.672
Method:	Least Squares	**F-statistic:**	1.794e+04
Date:	Mon, 12 Dec 2022	**Prob (F-statistic):**	0.00
Time:	17:49:46	**Log-Likelihood:**	-2.6060e+05
No. Observations:	52443	**AIC:**	5.212e+05
Df Residuals:	52436	**BIC:**	5.213e+05
Df Model:	6		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P>|t|**	**[0.025**	**0.975]**
const	13.8029	3.440	4.012	0.000	7.060	20.546
x1	-2.2955	0.350	-6.566	0.000	-2.981	-1.610
x2	-1.8808	0.801	-2.347	0.019	-3.452	-0.310
x3	5.2955	0.353	15.016	0.000	4.604	5.987
x4	8.6740	0.666	13.019	0.000	7.368	9.980
x5	48.9697	3.431	14.272	0.000	42.245	55.695
x6	118.3513	0.365	324.279	0.000	117.636	119.067

Omnibus:	8483.934	**Durbin-Watson:**	1.736
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	2372.589
Skew:	0.244	**Prob(JB):**	0.00
Kurtosis:	2.080	**Cond. No.**	56.5

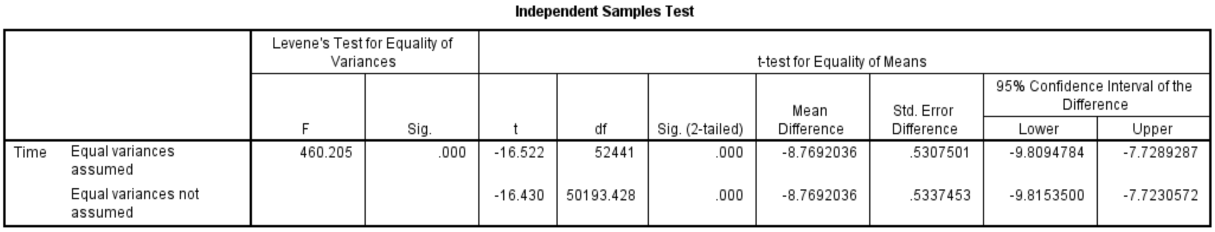
Summary of OLS Test of Port F



```
In [164]: y_pred_test=data_lm.predict(x_test)
          y_pred_train=data_lm.predict(x_train)
          np.abs(r2_score(y_train,y_pred_train))

Out[164]: 0.6660090551842617

In [165]: np.abs(r2_score(y_test,y_pred_test))

Out[165]: 0.6739025516739898

In [166]: np.sqrt(mean_squared_error(y_test,y_pred_test))

Out[166]: 34.8224691933609
```

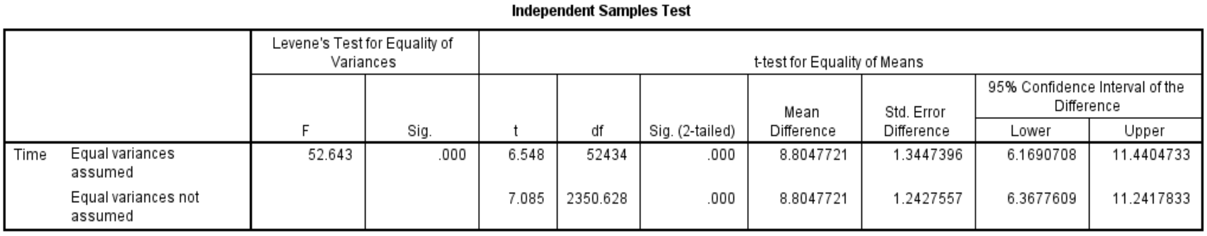
RMSE and R^2 of test and train data of Port F

Cycle


Independent Samples Test

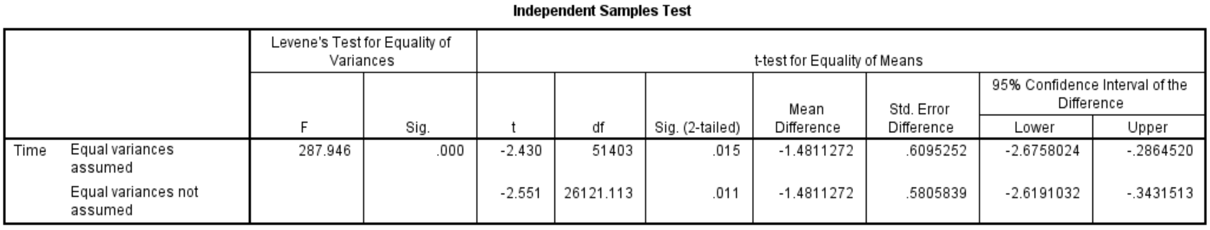
		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	460.205	.000	-16.522	52441	.000	-8.7692036	.5307501	-9.8094784	-7.7289287
	Equal variances not assumed			-16.430	50193.428	.000	-8.7692036	.5337453	-9.8153500	-7.7230572

Mode


Independent Samples Test

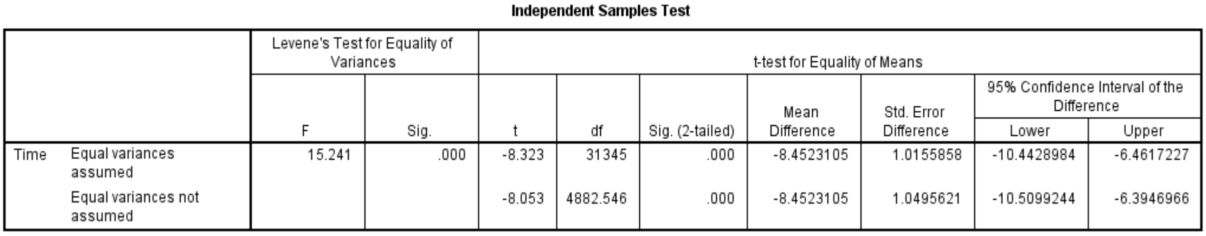
		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	52.643	.000	6.548	52434	.000	8.8047721	1.3447396	6.1690708	11.4404733
	Equal variances not assumed			7.085	2350.628	.000	8.8047721	1.2427557	6.3677609	11.2417833

Size


Independent Samples Test

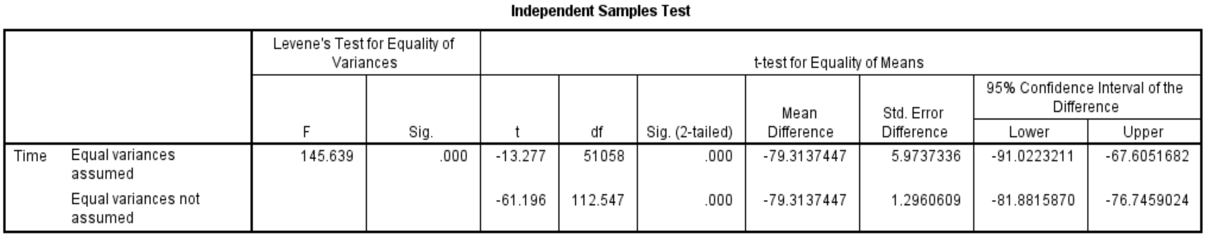
		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	287.946	.000	-2.430	51403	.015	-1.4811272	.6095252	-2.6758024	-.2864520
	Equal variances not assumed			-2.551	26121.113	.011	-1.4811272	.5805839	-2.6191032	-.3431513

Status


Independent Samples Test

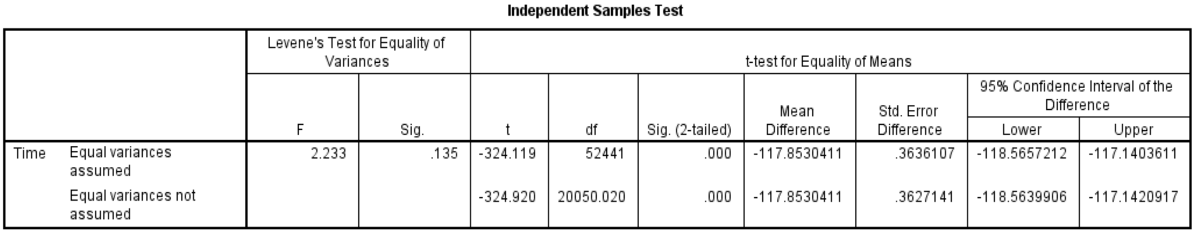
		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	15.241	.000	-8.323	31345	.000	-8.4523105	1.0155858	-10.4428984	-6.4617227
	Equal variances not assumed			-8.053	4882.546	.000	-8.4523105	1.0495621	-10.5099244	-6.3946966

Delivery


Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	145.639	.000	-13.277	51058	.000	-79.3137447	5.9737336	-91.0223211	-67.6051682
	Equal variances not assumed			-61.196	112.547	.000	-79.3137447	1.2960609	-81.8815870	-76.7459024

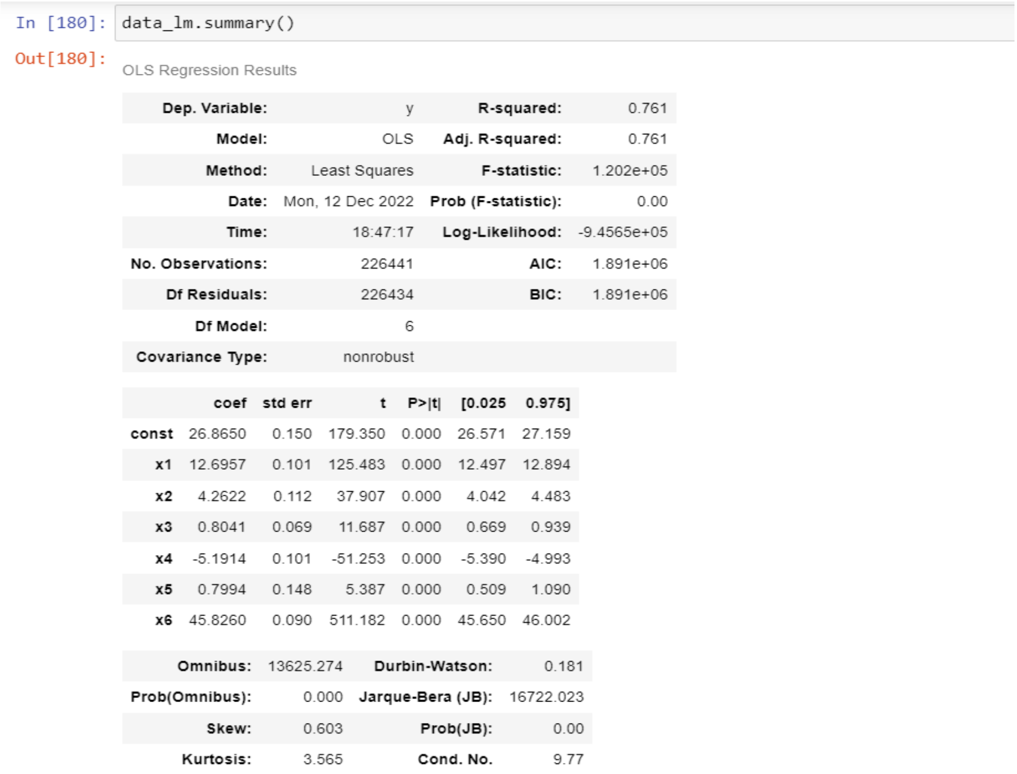
Tracking


Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	2.233	.135	-324.119	52441	.000	-117.8530411	.3636107	-118.5657212	-117.1403611
	Equal variances not assumed			-324.920	20050.020	.000	-117.8530411	.3627141	-118.5639906	-117.1420917

T test for the independent variables for Port F

7.Port G OLS data analysis and Independent sample T test results



```
In [180]: data_lm.summary()
Out[180]:
```

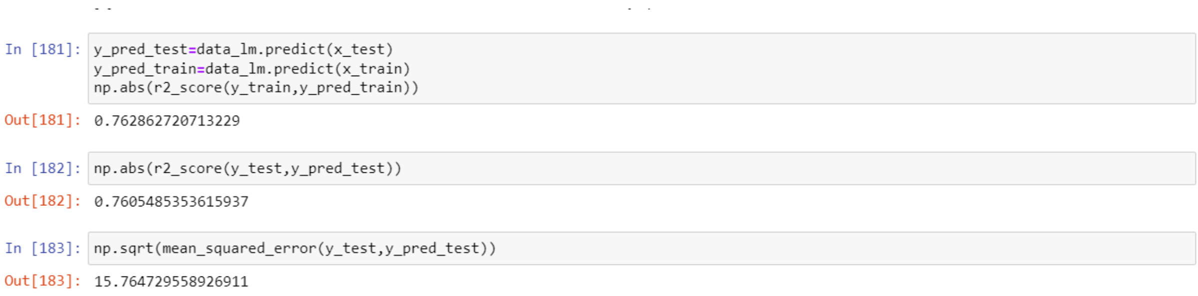
OLS Regression Results

Dep. Variable:	y	**R-squared:**	0.761
Model:	OLS	**Adj. R-squared:**	0.761
Method:	Least Squares	**F-statistic:**	1.202e+05
Date:	Mon, 12 Dec 2022	**Prob (F-statistic):**	0.00
Time:	18:47:17	**Log-Likelihood:**	-9.4565e+05
No. Observations:	226441	**AIC:**	1.891e+06
Df Residuals:	226434	**BIC:**	1.891e+06
Df Model:	6		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P>|t|**	**[0.025**	**0.975]**
const	26.8650	0.150	179.350	0.000	26.571	27.159
x1	12.6957	0.101	125.483	0.000	12.497	12.894
x2	4.2622	0.112	37.907	0.000	4.042	4.483
x3	0.8041	0.069	11.687	0.000	0.669	0.939
x4	-5.1914	0.101	-51.253	0.000	-5.390	-4.993
x5	0.7994	0.148	5.387	0.000	0.509	1.090
x6	45.8260	0.090	511.182	0.000	45.650	46.002

Omnibus:	13625.274	**Durbin-Watson:**	0.181
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	16722.023
Skew:	0.603	**Prob(JB):**	0.00
Kurtosis:	3.565	**Cond. No.**	9.77

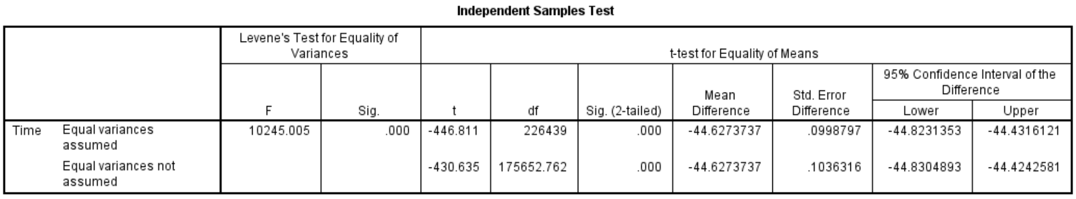
Summary of OLS Test of Port G



```
In [181]: y_pred_test=data_lm.predict(x_test)
          y_pred_train=data_lm.predict(x_train)
          np.abs(r2_score(y_train,y_pred_train))

Out[181]: 0.762862720713229

In [182]: np.abs(r2_score(y_test,y_pred_test))

Out[182]: 0.7605485353615937

In [183]: np.sqrt(mean_squared_error(y_test,y_pred_test))

Out[183]: 15.764729558926911
```

RMSE and R^2 of test and train data of Port G

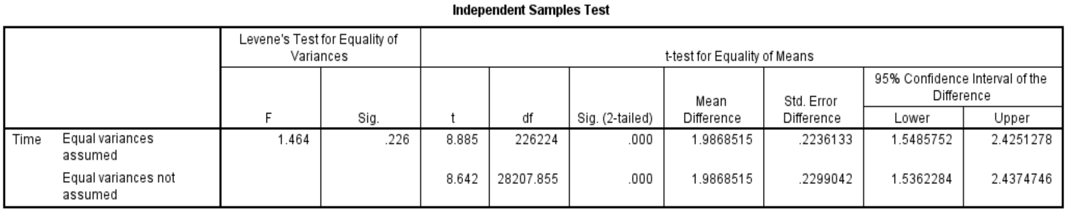
Cycle



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	10245.005	.000	-446.811	226439	.000	-44.6273737	.0998797	-44.8231353	-44.4316121
	Equal variances not assumed			-430.635	175652.762	.000	-44.6273737	.1036316	-44.8304893	-44.4242581

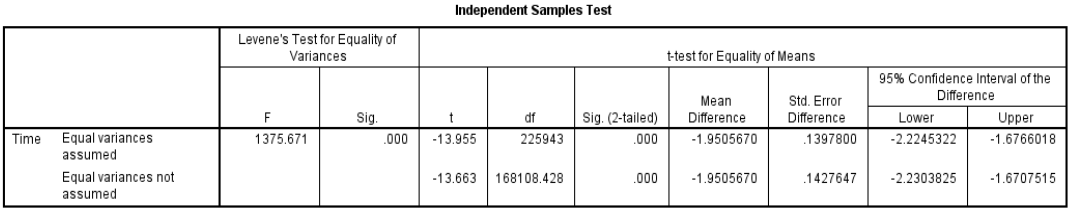
Mode



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	1.464	.226	8.885	226224	.000	1.9868515	.2236133	1.5485752	2.4251278
	Equal variances not assumed			8.642	28207.855	.000	1.9868515	.2299042	1.5362284	2.4374746

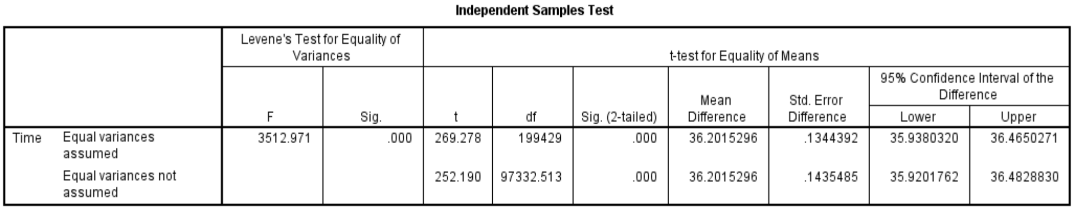
Size



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	1375.671	.000	-13.955	225943	.000	-1.9505670	.1397800	-2.2245322	-1.6766018
	Equal variances not assumed			-13.663	168108.428	.000	-1.9505670	.1427647	-2.2303825	-1.6707515

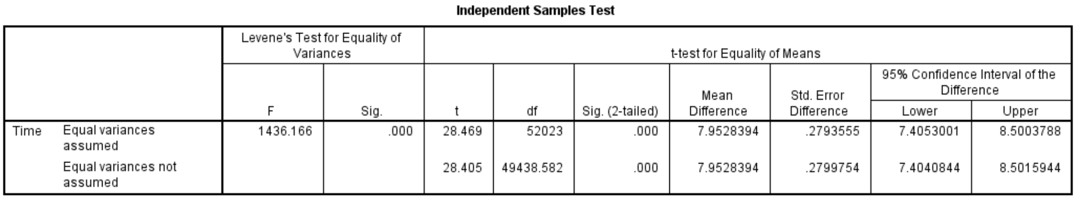
Status



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	3512.971	.000	269.278	199429	.000	36.2015296	.1344392	35.9380320	36.4650271
	Equal variances not assumed			252.190	97332.513	.000	36.2015296	.1435485	35.9201762	36.4828830

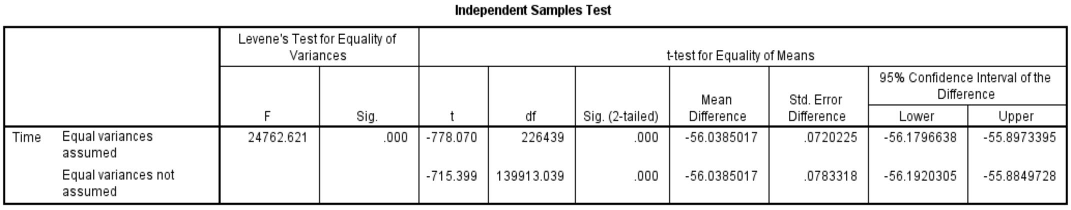
Delivery



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	1436.166	.000	28.469	52023	.000	7.9528394	.2793555	7.4053001	8.5003788
	Equal variances not assumed			28.405	49438.582	.000	7.9528394	.2799754	7.4040844	8.5015944

Tracking

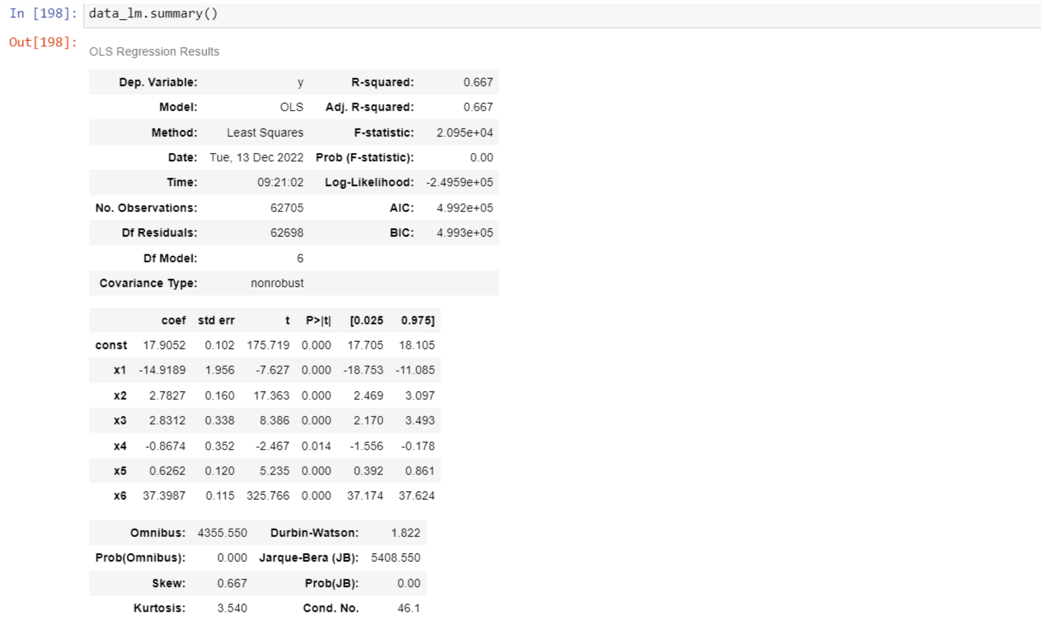


Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	24762.621	.000	-778.070	226439	.000	-56.0385017	.0720225	-56.1796638	-55.8973395
	Equal variances not assumed			-715.399	139913.039	.000	-56.0385017	.0783318	-56.1920305	-55.8849728

T test for the independent variables for Port G

8.Port H OLS data analysis and Independent sample T test results



```
In [198]: data_lm.summary()
Out[198]:
```

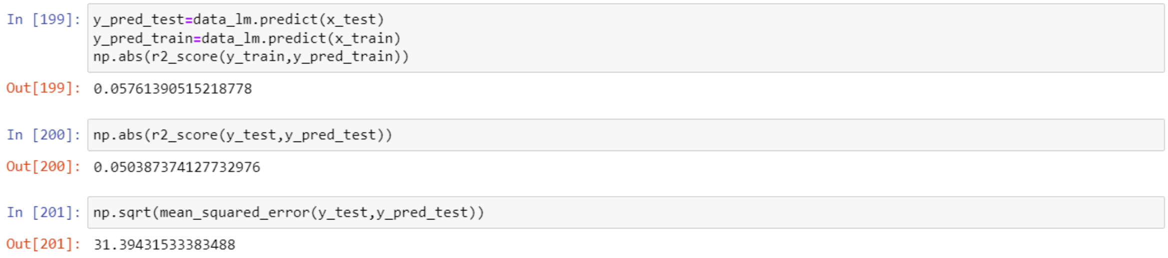
OLS Regression Results

Dep. Variable:	y	**R-squared:**	0.667
Model:	OLS	**Adj. R-squared:**	0.667
Method:	Least Squares	**F-statistic:**	2.095e+04
Date:	Tue, 13 Dec 2022	**Prob (F-statistic):**	0.00
Time:	09:21:02	**Log-Likelihood:**	-2.4959e+05
No. Observations:	62705	**AIC:**	4.992e+05
Df Residuals:	62698	**BIC:**	4.993e+05
Df Model:	6		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P>|t|**	**[0.025**	**0.975]**
const	17.9052	0.102	175.719	0.000	17.705	18.105
x1	-14.9189	1.956	-7.627	0.000	-18.753	-11.085
x2	2.7827	0.160	17.363	0.000	2.469	3.097
x3	2.8312	0.338	8.386	0.000	2.170	3.493
x4	-0.8674	0.352	-2.467	0.014	-1.556	-0.178
x5	0.6262	0.120	5.235	0.000	0.392	0.861
x6	37.3987	0.115	325.766	0.000	37.174	37.624

Omnibus:	4355.550	**Durbin-Watson:**	1.822
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	5408.550
Skew:	0.667	**Prob(JB):**	0.00
Kurtosis:	3.540	**Cond. No.**	46.1

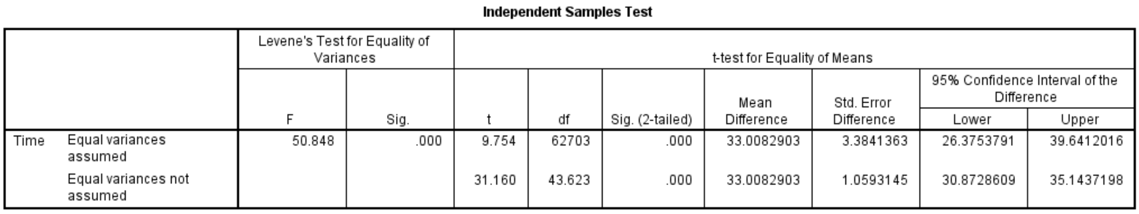
Fig 68: Summary of OLS Test of Port H



```
In [199]: y_pred_test=data_lm.predict(x_test)
          y_pred_train=data_lm.predict(x_train)
          np.abs(r2_score(y_train,y_pred_train))

Out[199]: 0.05761390515218778

In [200]: np.abs(r2_score(y_test,y_pred_test))

Out[200]: 0.050387374127732976

In [201]: np.sqrt(mean_squared_error(y_test,y_pred_test))

Out[201]: 31.39431533383488
```

RMSE and R^2 of test and train data of Port H

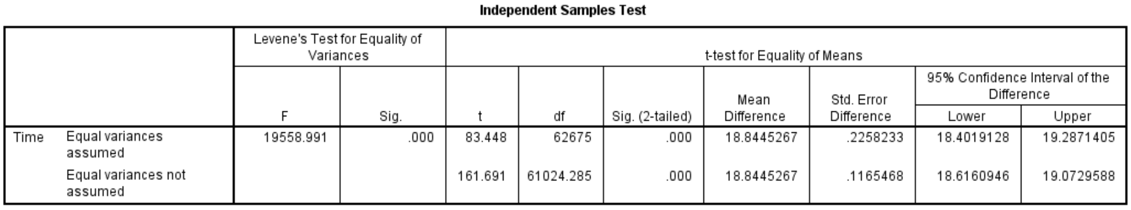
Cycle



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	50.848	.000	9.754	62703	.000	33.0082903	3.3841363	26.3753791	39.6412016
	Equal variances not assumed			31.160	43.623	.000	33.0082903	1.0593145	30.8728609	35.1437198

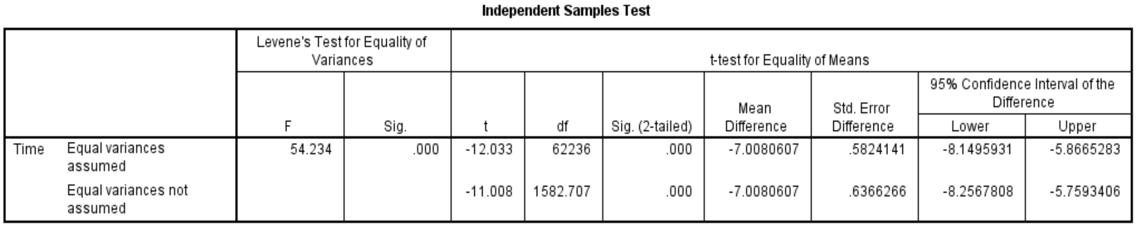
Mode



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	19558.991	.000	83.448	62675	.000	18.8445267	.2258233	18.4019128	19.2871405
	Equal variances not assumed			161.691	61024.285	.000	18.8445267	.1165468	18.6160946	19.0729588

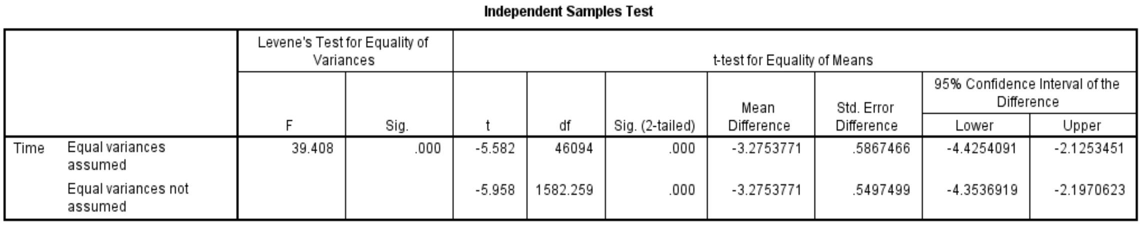
Size



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	54.234	.000	-12.033	62236	.000	-7.0080607	.5824141	-8.1495931	-5.8665283
	Equal variances not assumed			-11.008	1582.707	.000	-7.0080607	.6366266	-8.2567808	-5.7593406

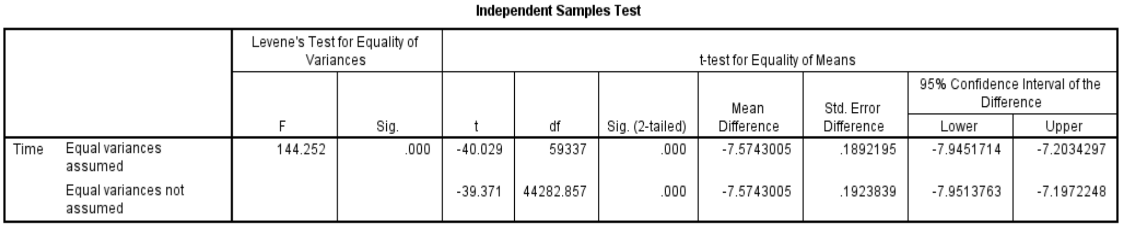
Status



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	39.408	.000	-5.582	46094	.000	-3.2753771	.5867466	-4.4254091	-2.1253451
	Equal variances not assumed			-5.958	1582.259	.000	-3.2753771	.5497499	-4.3536919	-2.1970623

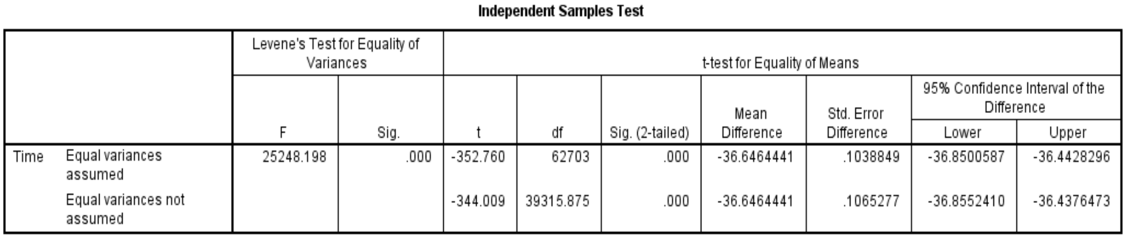
Delivery



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	144.252	.000	-40.029	59337	.000	-7.5743005	.1892195	-7.9451714	-7.2034297
	Equal variances not assumed			-39.371	44282.857	.000	-7.5743005	.1923839	-7.9513763	-7.1972248

Tracking

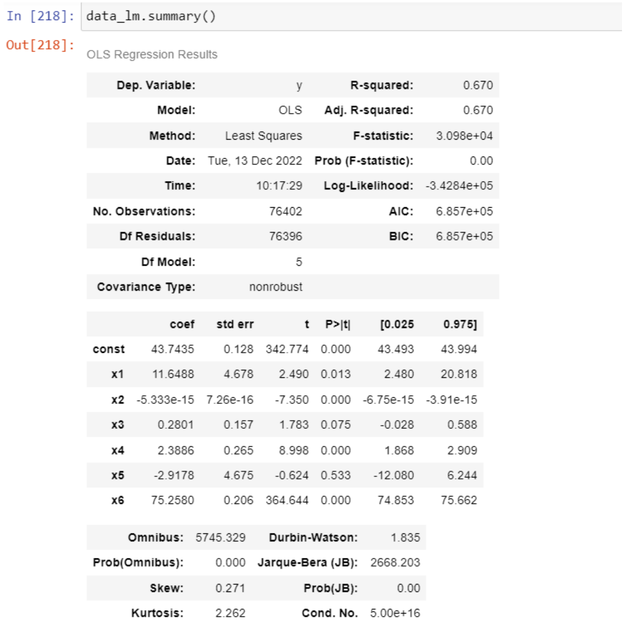


Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	25248.198	.000	-352.760	62703	.000	-36.6464441	.1038849	-36.8500587	-36.4428296
	Equal variances not assumed			-344.009	39315.875	.000	-36.6464441	.1065277	-36.8552410	-36.4376473

T test for the independent variables for Port H

9. Port I OLS data analysis and Independent sample T test results



```
In [218]: data_lm.summary()
Out[218]:
```

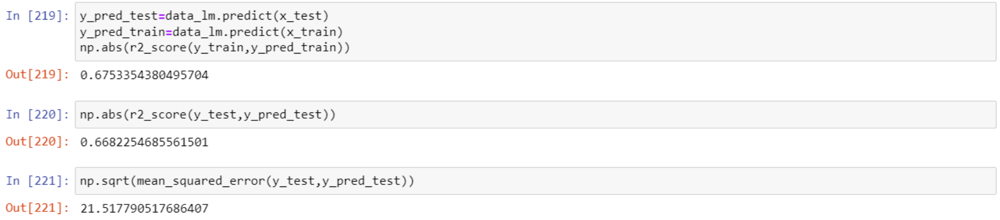
OLS Regression Results

Dep. Variable:	y	**R-squared:**	0.670
Model:	OLS	**Adj. R-squared:**	0.670
Method:	Least Squares	**F-statistic:**	3.098e+04
Date:	Tue, 13 Dec 2022	**Prob (F-statistic):**	0.00
Time:	10:17:29	**Log-Likelihood:**	-3.4284e+05
No. Observations:	76402	**AIC:**	6.857e+05
Df Residuals:	76396	**BIC:**	6.857e+05
Df Model:	5		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	43.7435	0.128	342.774	0.000	43.493	43.994
x1	11.6488	4.678	2.490	0.013	2.480	20.818
x2	-5.333e-15	7.26e-16	-7.350	0.000	-6.75e-15	-3.91e-15
x3	0.2801	0.157	1.783	0.075	-0.028	0.588
x4	2.3886	0.265	8.998	0.000	1.868	2.909
x5	-2.9178	4.675	-0.624	0.533	-12.080	6.244
x6	75.2580	0.206	364.644	0.000	74.853	75.662

Omnibus:	5745.329	**Durbin-Watson:**	1.835
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	2668.203
Skew:	0.271	**Prob(JB):**	0.00
Kurtosis:	2.262	**Cond. No.**	5.00e+16

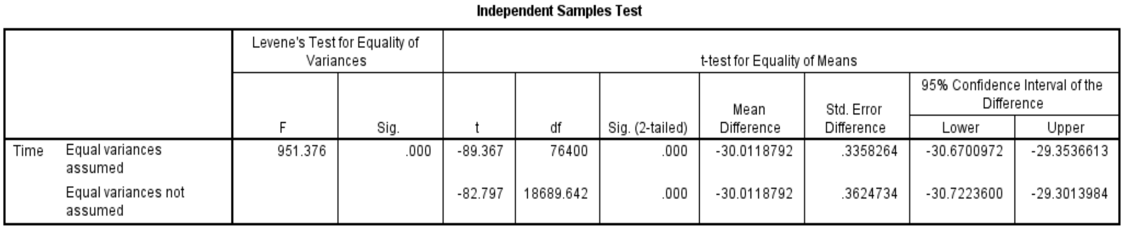
Summary of OLS Test of Port I



```
In [219]: y_pred_test=data_lm.predict(x_test)
          y_pred_train=data_lm.predict(x_train)
          np.abs(r2_score(y_train,y_pred_train))
Out[219]: 0.6753354380495704

In [220]: np.abs(r2_score(y_test,y_pred_test))
Out[220]: 0.6682254685561501

In [221]: np.sqrt(mean_squared_error(y_test,y_pred_test))
Out[221]: 21.517790517686407
```

RMSE and R^2 of test and train data of Port I

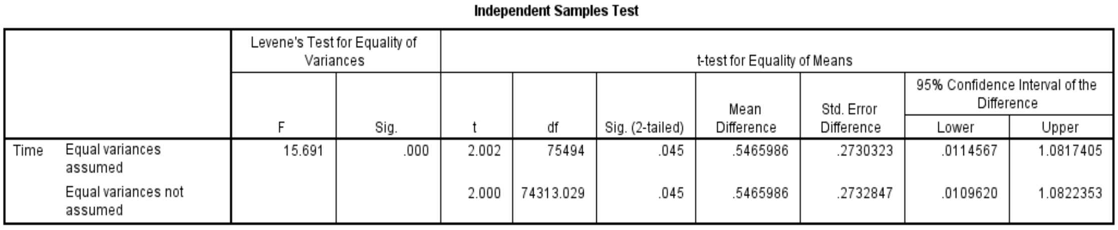
Cycle



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	951.376	.000	-89.367	76400	.000	-30.0118792	.3358264	-30.6700972	-29.3536613
	Equal variances not assumed			-82.797	18689.642	.000	-30.0118792	.3624734	-30.7223600	-29.3013984

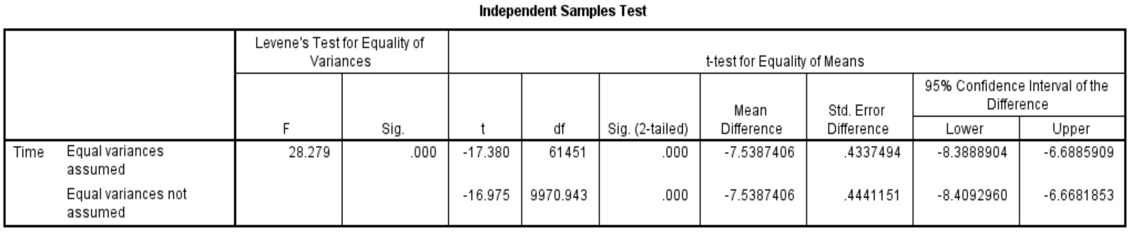
Size



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	15.691	.000	2.002	75494	.045	.5465986	.2730323	.0114567	1.0817405
	Equal variances not assumed			2.000	74313.029	.045	.5465986	.2732847	.0109620	1.0822353

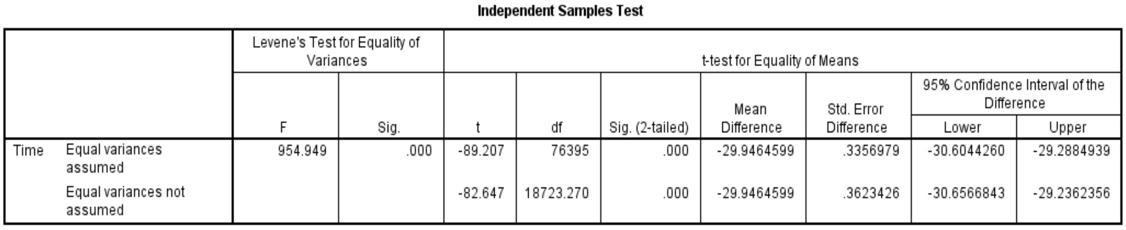
Status



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	28.279	.000	-17.380	61451	.000	-7.5387406	.4337494	-8.3888904	-6.6885909
	Equal variances not assumed			-16.975	9970.943	.000	-7.5387406	.4441151	-8.4092960	-6.6681853

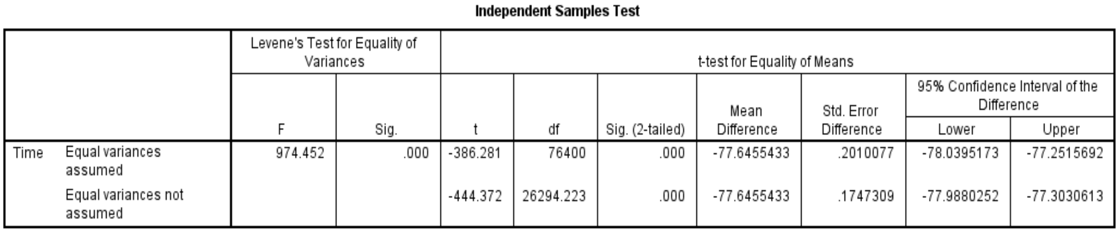
Delivery



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	954.949	.000	-89.207	76395	.000	-29.9464599	.3356979	-30.6044260	-29.2884939
	Equal variances not assumed			-82.647	18723.270	.000	-29.9464599	.3623426	-30.6566843	-29.2362356

Tracking



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	974.452	.000	-386.281	76400	.000	-77.6455433	.2010077	-78.0395173	-77.2515692
	Equal variances not assumed			-444.372	26294.223	.000	-77.6455433	.1747309	-77.9880252	-77.3030613

T test for the independent variables for Port I

10. Port J OLS data analysis and independent sample T test results

```
In [232]: data_lm.summary()
Out[232]:
```

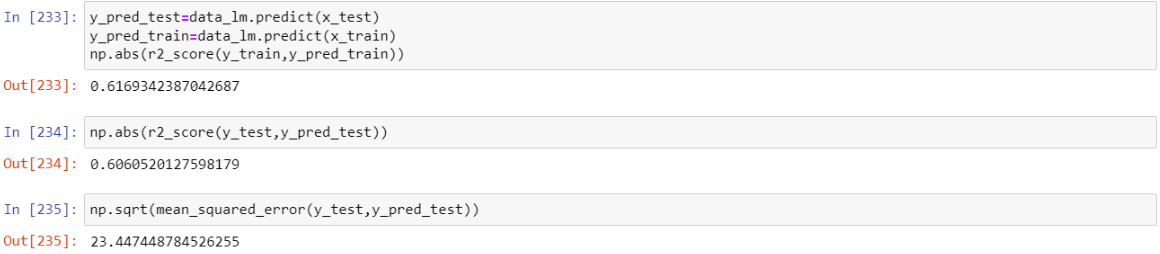
OLS Regression Results

Dep. Variable:	y	**R-squared:**	0.689
Model:	OLS	**Adj. R-squared:**	0.689
Method:	Least Squares	**F-statistic:**	3.919e+04
Date:	Tue, 13 Dec 2022	**Prob (F-statistic):**	0.00
Time:	10:47:54	**Log-Likelihood:**	-4.8969e+05
No. Observations:	106225	**AIC:**	9.794e+05
Df Residuals:	106218	**BIC:**	9.795e+05
Df Model:	6		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P>|t|**	**[0.025**	**0.975]**
const	36.1799	0.408	88.727	0.000	35.381	36.979
x1	0.4455	0.323	1.378	0.168	-0.188	1.079
x2	-10.9045	5.439	-2.005	0.045	-21.565	-0.244
x3	1.7452	0.150	11.605	0.000	1.450	2.040
x4	17.2596	0.260	66.455	0.000	16.751	17.769
x5	-6.0978	0.329	-18.507	0.000	-6.744	-5.452
x6	79.2352	0.173	458.360	0.000	78.896	79.574

Omnibus:	9256.543	**Durbin-Watson:**	1.807
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	3789.344
Skew:	0.249	**Prob(JB):**	0.00
Kurtosis:	2.221	**Cond. No.**	114.

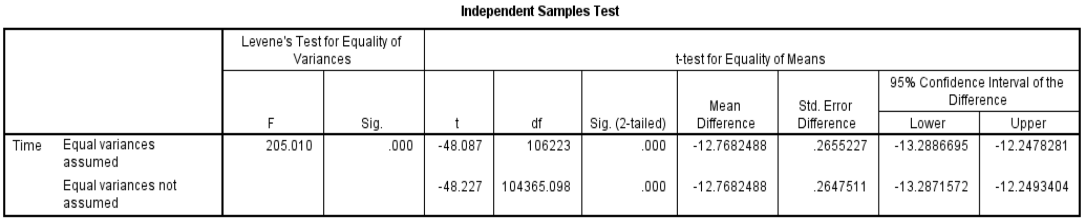
Summary of OLS Test of Port J



```
In [233]: y_pred_test=data_lm.predict(x_test)
          y_pred_train=data_lm.predict(x_train)
          np.abs(r2_score(y_train,y_pred_train))

Out[233]: 0.6169342387042687

In [234]: np.abs(r2_score(y_test,y_pred_test))

Out[234]: 0.6060520127598179

In [235]: np.sqrt(mean_squared_error(y_test,y_pred_test))

Out[235]: 23.447448784526255
```

RMSE and R^2 of test and train data of Port J

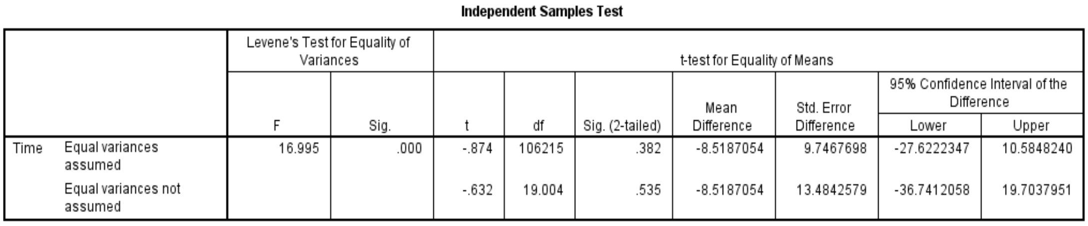
Cycle



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	205.010	.000	-48.087	106223	.000	-12.7682488	.2655227	-13.2886695	-12.2478281
	Equal variances not assumed			-48.227	104365.098	.000	-12.7682488	.2647511	-13.2871572	-12.2493404

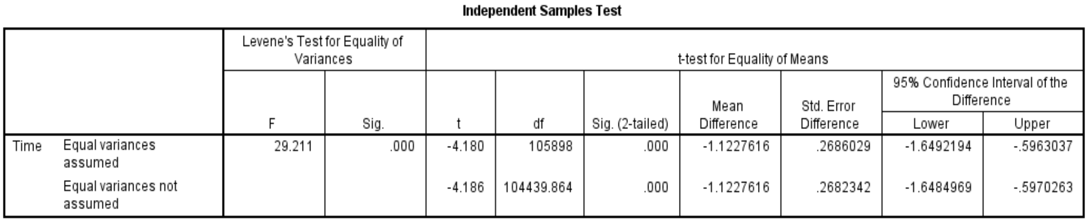
Mode



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	16.995	.000	-.874	106215	.382	-8.5187054	9.7467698	-27.6222347	10.5848240
	Equal variances not assumed			-.632	19.004	.535	-8.5187054	13.4842579	-36.7412058	19.7037951

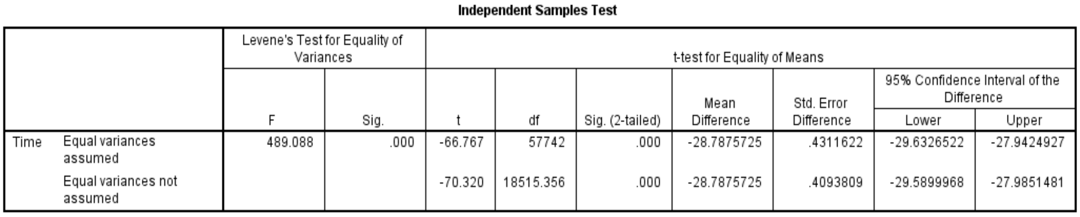
Size



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	29.211	.000	-4.180	105898	.000	-1.1227616	.2686029	-1.6492194	-.5963037
	Equal variances not assumed			-4.186	104439.864	.000	-1.1227616	.2682342	-1.6484969	-.5970263

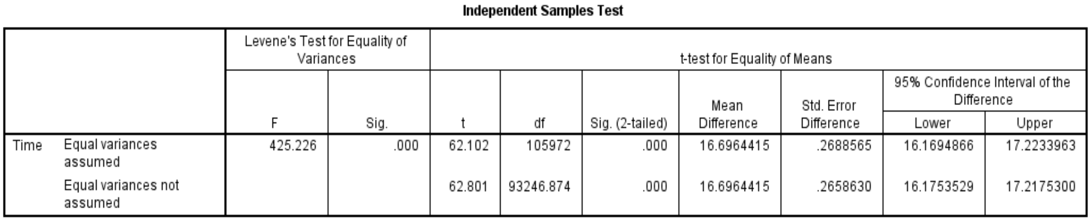
Status



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	489.088	.000	-66.767	57742	.000	-28.7875725	.4311622	-29.6326522	-27.9424927
	Equal variances not assumed			-70.320	18515.356	.000	-28.7875725	.4093809	-29.5899968	-27.9851481

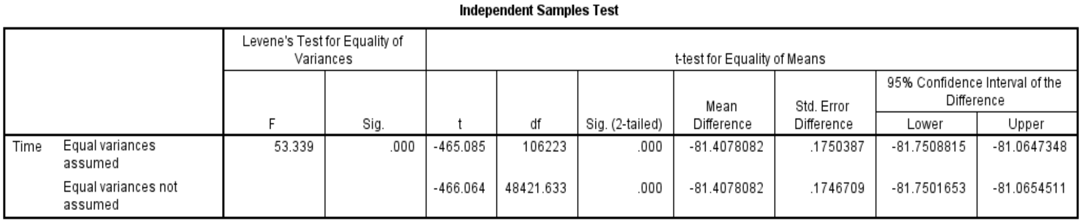
Delivery



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	425.226	.000	62.102	105972	.000	16.6964415	.2688565	16.1694866	17.2233963
	Equal variances not assumed			62.801	93246.874	.000	16.6964415	.2658630	16.1753529	17.2175300

Tracking



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	53.339	.000	-465.085	106223	.000	-81.4078082	.1750387	-81.7508815	-81.0647348
	Equal variances not assumed			-466.064	48421.633	.000	-81.4078082	.1746709	-81.7501653	-81.0654511

T test for the independent variables for Port J

11. Port K OLS data analysis and Independent sample T test results

```
In [254]: data_lm.summary()
Out[254]:
```

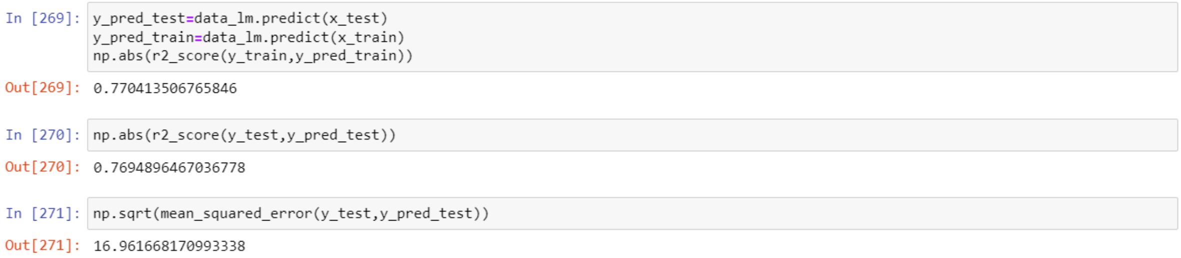
OLS Regression Results

Dep. Variable:	y	**R-squared:**	0.770
Model:	OLS	**Adj. R-squared:**	0.770
Method:	Least Squares	**F-statistic:**	1.190e+05
Date:	Tue, 13 Dec 2022	**Prob (F-statistic):**	0.00
Time:	12:22:58	**Log-Likelihood:**	-9.0783e+05
No. Observations:	213612	**AIC:**	1.816e+06
Df Residuals:	213605	**BIC:**	1.816e+06
Df Model:	6		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	27.6006	0.173	159.762	0.000	27.262	27.939
x1	2.7030	0.090	29.870	0.000	2.526	2.880
x2	-6.5522	0.094	-70.039	0.000	-6.736	-6.369
x3	0.9782	0.075	13.011	0.000	0.831	1.126
x4	-3.6355	0.132	-27.569	0.000	-3.894	-3.377
x5	-5.0400	0.112	-45.099	0.000	-5.259	-4.821
x6	60.5376	0.087	696.186	0.000	60.367	60.708

Omnibus:	17134.679	**Durbin-Watson:**	1.725
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	22939.319
Skew:	0.693	**Prob(JB):**	0.00
Kurtosis:	3.810	**Cond. No.**	10.6

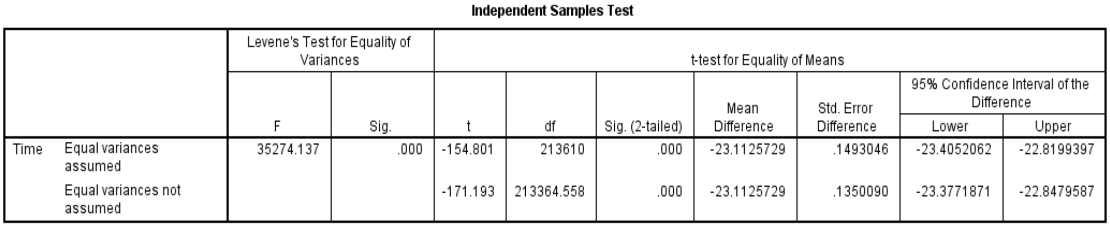
Summary of OLS Test of Port K



```
In [269]: y_pred_test=data_lm.predict(x_test)
          y_pred_train=data_lm.predict(x_train)
          np.abs(r2_score(y_train,y_pred_train))
Out[269]: 0.770413506765846

In [270]: np.abs(r2_score(y_test,y_pred_test))
Out[270]: 0.7694896467036778

In [271]: np.sqrt(mean_squared_error(y_test,y_pred_test))
Out[271]: 16.961668170993338
```

RMSE and R^2 *of test and train data of Port K*

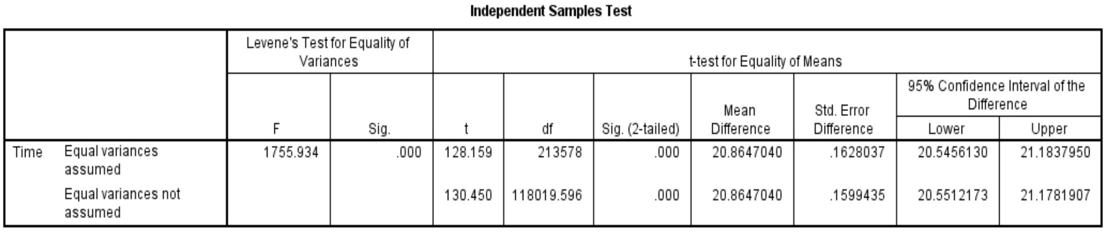
Cycle



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	35274.137	.000	-154.801	213610	.000	-23.1125729	.1493046	-23.4052062	-22.8199397
	Equal variances not assumed			-171.193	213364.558	.000	-23.1125729	.1350090	-23.3771871	-22.8479587

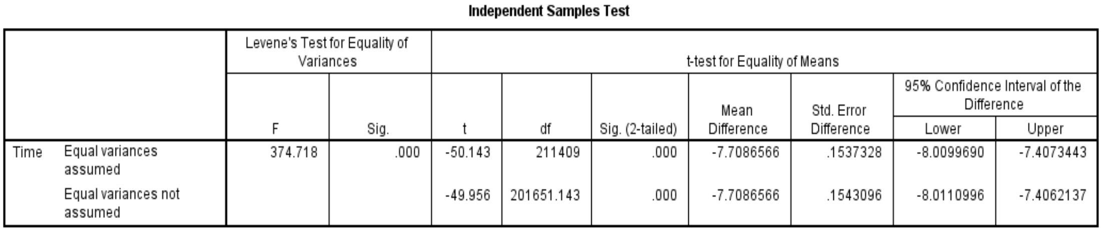
Mode



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	1755.934	.000	128.159	213578	.000	20.8647040	.1628037	20.5456130	21.1837950
	Equal variances not assumed			130.450	118019.596	.000	20.8647040	.1599435	20.5512173	21.1781907

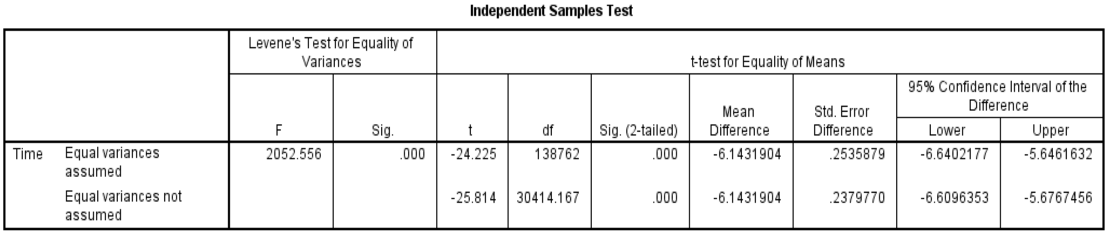
Size



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	374.718	.000	-50.143	211409	.000	-7.7086566	.1537328	-8.0099690	-7.4073443
	Equal variances not assumed			-49.956	201651.143	.000	-7.7086566	.1543096	-8.0110996	-7.4062137

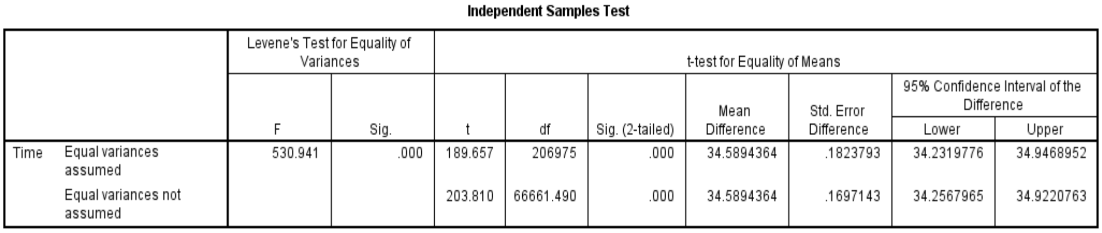
Status



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	2052.556	.000	-24.225	138762	.000	-6.1431904	.2535879	-6.6402177	-5.6461632
	Equal variances not assumed			-25.814	30414.167	.000	-6.1431904	.2379770	-6.6096353	-5.6767456

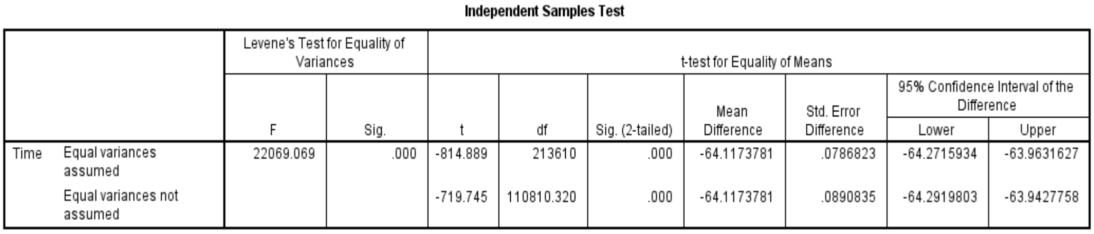
Delivery



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	530.941	.000	189.657	206975	.000	34.5894364	.1823793	34.2319776	34.9468952
	Equal variances not assumed			203.810	66661.490	.000	34.5894364	.1697143	34.2567965	34.9220763

Tracking



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	22069.069	.000	-814.889	213610	.000	-64.1173781	.0786823	-64.2715934	-63.9631627
	Equal variances not assumed			-719.745	110810.320	.000	-64.1173781	.0890835	-64.2919803	-63.9427758

T test for the independent variables for Port K

12.Port L OLS data analysis and Independent sample T test results

```
In [294]: data_lm.summary()
Out[294]:
```

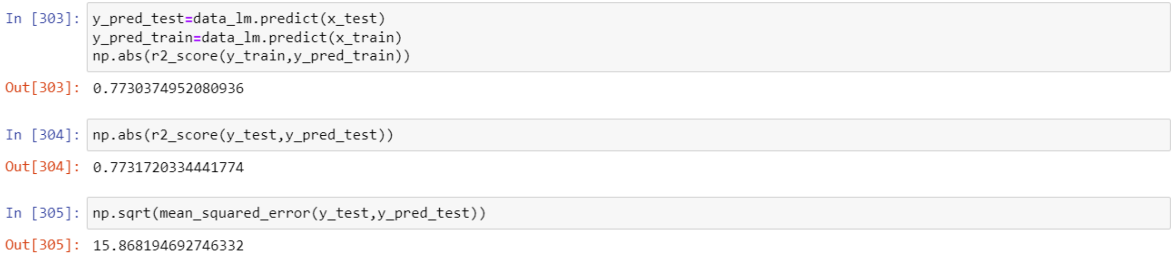
OLS Regression Results

Dep. Variable:	y	**R-squared:**	0.773
Model:	OLS	**Adj. R-squared:**	0.773
Method:	Least Squares	**F-statistic:**	1.768e+05
Date:	Tue, 13 Dec 2022	**Prob (F-statistic):**	0.00
Time:	14:59:41	**Log-Likelihood:**	-1.3019e+06
No. Observations:	311269	**AIC:**	2.604e+06
Df Residuals:	311262	**BIC:**	2.604e+06
Df Model:	6		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	29.0826	0.134	216.528	0.000	28.819	29.346
x1	12.8631	0.077	167.042	0.000	12.712	13.014
x2	12.4441	0.090	138.379	0.000	12.268	12.620
x3	0.3048	0.058	5.254	0.000	0.191	0.419
x4	-5.4661	0.107	-50.856	0.000	-5.677	-5.255
x5	-6.1047	0.080	-76.455	0.000	-6.261	-5.948
x6	49.2934	0.072	683.357	0.000	49.152	49.435

Omnibus:	18447.445	**Durbin-Watson:**	1.911
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	24178.356
Skew:	0.561	**Prob(JB):**	0.00
Kurtosis:	3.778	**Cond. No.**	10.4

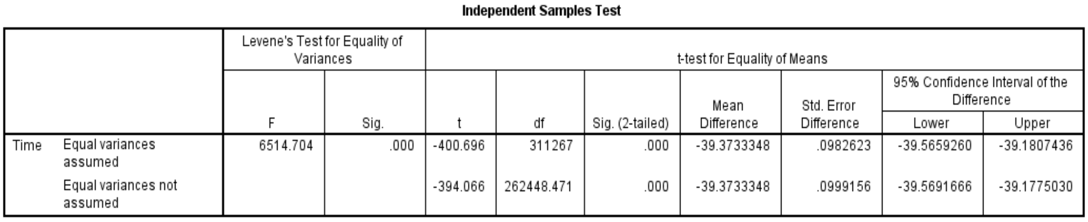
Summary of OLS Test of Port L



```
In [303]: y_pred_test=data_lm.predict(x_test)
          y_pred_train=data_lm.predict(x_train)
          np.abs(r2_score(y_train,y_pred_train))

Out[303]: 0.7730374952080936

In [304]: np.abs(r2_score(y_test,y_pred_test))

Out[304]: 0.7731720334441774

In [305]: np.sqrt(mean_squared_error(y_test,y_pred_test))

Out[305]: 15.868194692746332
```

RMSE and R^2 of test and train data of Port L

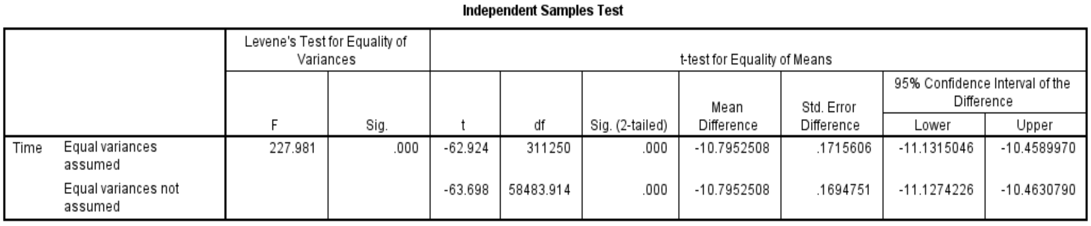
Cycle



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	6514.704	.000	-400.696	311267	.000	-39.3733348	.0982623	-39.5659260	-39.1807436
	Equal variances not assumed			-394.066	262448.471	.000	-39.3733348	.0999156	-39.5691666	-39.1775030

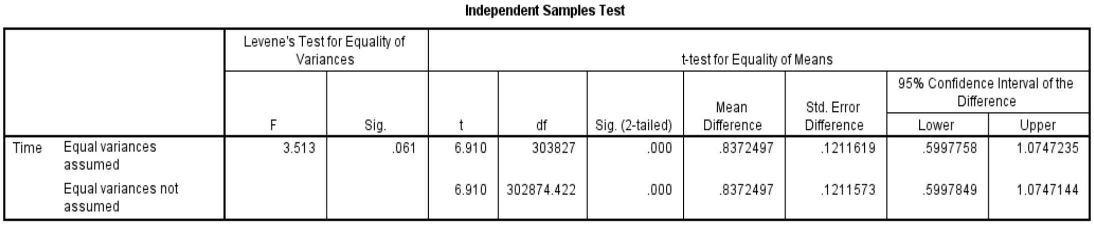
Mode



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	227.981	.000	-62.924	311250	.000	-10.7952508	.1715606	-11.1315046	-10.4589970
	Equal variances not assumed			-63.698	58483.914	.000	-10.7952508	.1694751	-11.1274226	-10.4630790

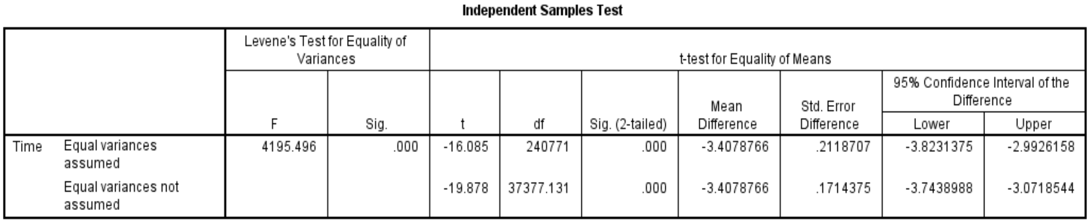
Size



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	3.513	.061	6.910	303827	.000	.8372497	.1211619	.5997758	1.0747235
	Equal variances not assumed			6.910	302874.422	.000	.8372497	.1211573	.5997849	1.0747144

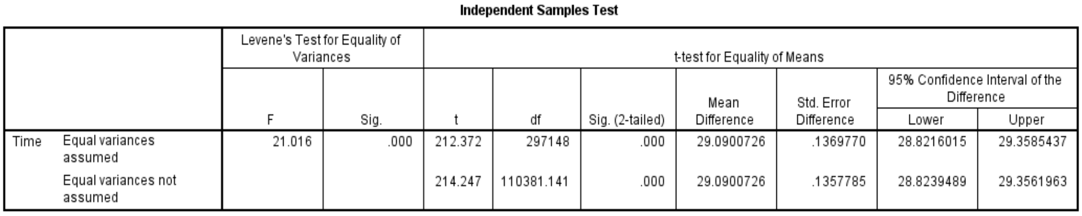
Status



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	4195.496	.000	-16.085	240771	.000	-3.4078766	.2118707	-3.8231375	-2.9926158
	Equal variances not assumed			-19.878	37377.131	.000	-3.4078766	.1714375	-3.7438988	-3.0718544

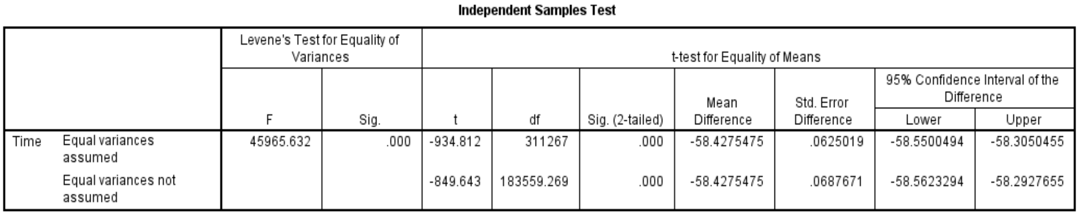
Delivery



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	21.016	.000	212.372	297148	.000	29.0900726	.1369770	28.8216015	29.3585437
	Equal variances not assumed			214.247	110381.141	.000	29.0900726	.1357785	28.8239489	29.3561963

Tracking



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	45965.632	.000	-934.812	311267	.000	-58.4275475	.0625019	-58.5500494	-58.3050455
	Equal variances not assumed			-849.643	183559.269	.000	-58.4275475	.0687671	-58.5623294	-58.2927655

T test for the independent variables for Port L

13.Port M OLS data analysis and Independent sample T test results

Out[316]:

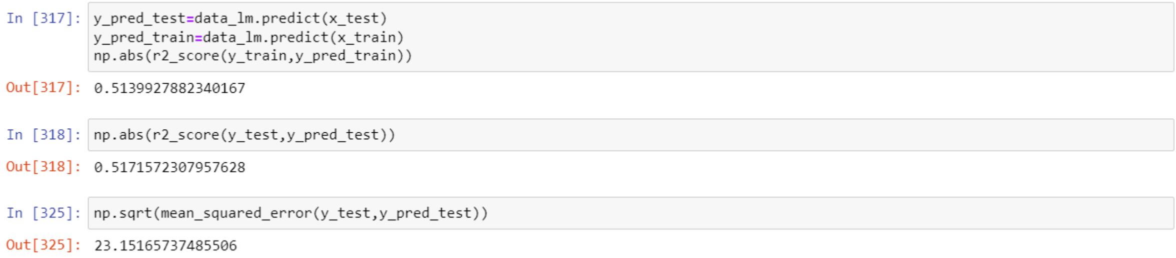
OLS Regression Results

Dep. Variable:	y	**R-squared:**	0.714
Model:	OLS	**Adj. R-squared:**	0.714
Method:	Least Squares	**F-statistic:**	2.498e+04
Date:	Tue, 13 Dec 2022	**Prob (F-statistic):**	0.00
Time:	16:25:36	**Log-Likelihood:**	-2.2657e+05
No. Observations:	50044	**AIC:**	4.531e+05
Df Residuals:	50038	**BIC:**	4.532e+05
Df Model:	5		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P>|t|**	**[0.025**	**0.975]**
const	30.0164	4.034	7.440	0.000	22.109	37.923
x1	10.3472	0.227	45.587	0.000	9.902	10.792
x2	1.551e-14	3.42e-16	45.362	0.000	1.48e-14	1.62e-14
x3	-1.6210	0.207	-7.833	0.000	-2.027	-1.215
x4	-5.9031	4.024	-1.467	0.142	-13.791	1.985
x5	6.8984	0.323	21.352	0.000	6.265	7.532
x6	68.0851	0.220	309.450	0.000	67.654	68.516

Omnibus:	3886.518	**Durbin-Watson:**	1.798
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	4853.443
Skew:	0.738	**Prob(JB):**	0.00
Kurtosis:	3.383	**Cond. No.**	inf

Summary of OLS Test of Port M

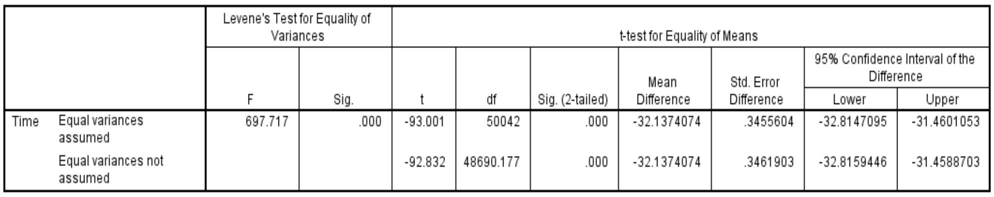


```
In [317]: y_pred_test=data_lm.predict(x_test)
          y_pred_train=data_lm.predict(x_train)
          np.abs(r2_score(y_train,y_pred_train))

Out[317]: 0.5139927882340167

In [318]: np.abs(r2_score(y_test,y_pred_test))

Out[318]: 0.5171572307957628

In [325]: np.sqrt(mean_squared_error(y_test,y_pred_test))

Out[325]: 23.15165737485506
```

RMSE and R^2 of test and train data of Port M

Cycle

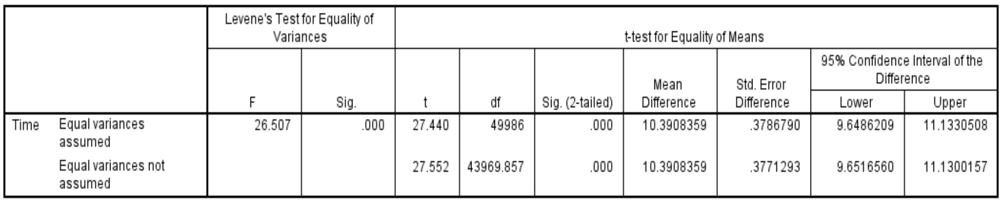
Independent Samples Test



		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	697.717	.000	-93.001	50042	.000	-32.1374074	.3455604	-32.8147095	-31.4601053
	Equal variances not assumed			-92.832	48690.177	.000	-32.1374074	.3461903	-32.8159446	-31.4588703

Size

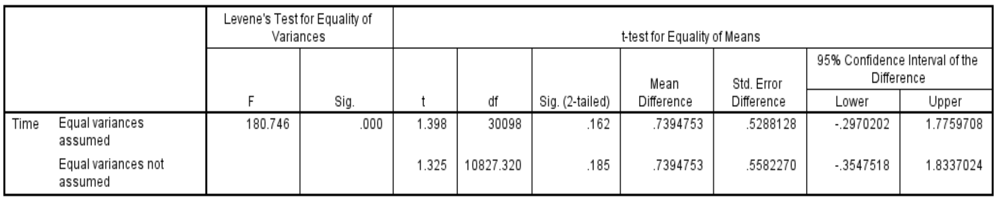
Independent Samples Test



		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	26.507	.000	27.440	49986	.000	10.3908359	.3786790	9.6486209	11.1330508
	Equal variances not assumed			27.552	43969.857	.000	10.3908359	.3771293	9.6516560	11.1300157

Status

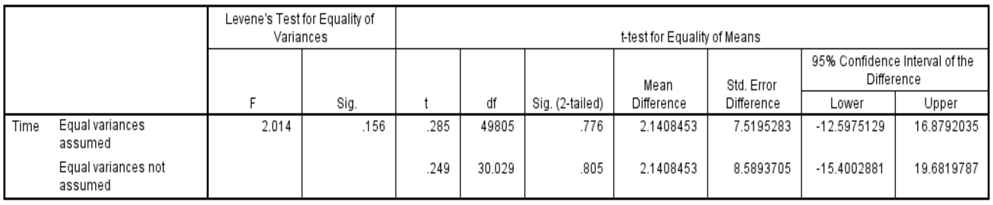
Independent Samples Test



		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	180.746	.000	1.398	30098	.162	.7394753	.5288128	-.2970202	1.7759708
	Equal variances not assumed			1.325	10827.320	.185	.7394753	.5582270	-.3547518	1.8337024

Delivery

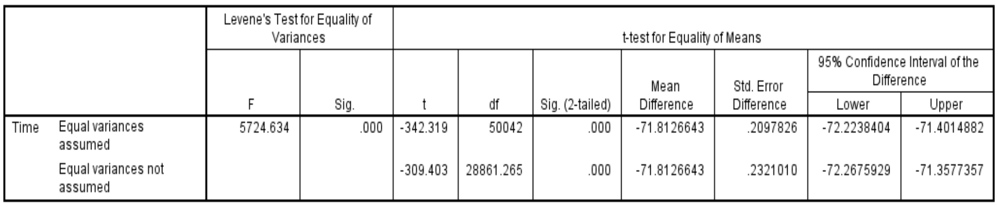
Independent Samples Test



		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	2.014	.156	.285	49805	.776	2.1408453	7.5195283	-12.5975129	16.8792035
	Equal variances not assumed			.249	30.029	.805	2.1408453	8.5893705	-15.4002881	19.6819787

Tracking

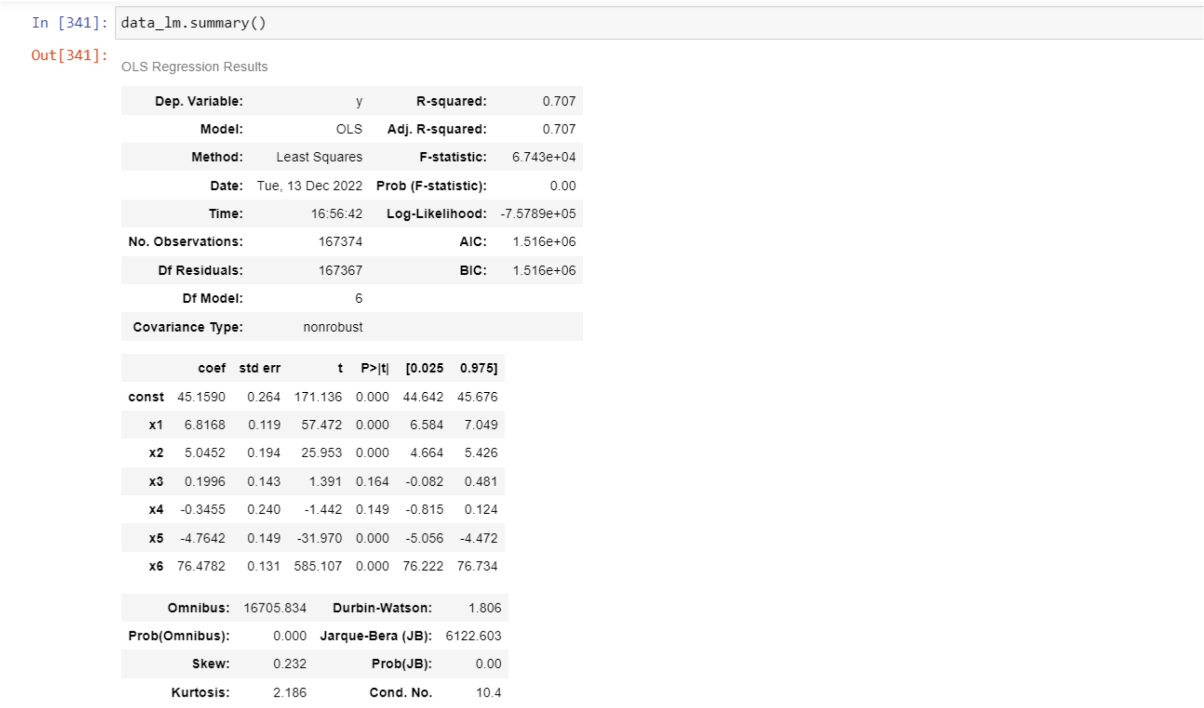
Independent Samples Test



		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	5724.634	.000	-342.319	50042	.000	-71.8126643	.2097826	-72.2238404	-71.4014882
	Equal variances not assumed			-309.403	28861.265	.000	-71.8126643	.2321010	-72.2675929	-71.3577357

T test for the independent variables for Port M

14.Port N OLS data analysis and Independent sample T test results



```
In [341]: data_lm.summary()
Out[341]:
```

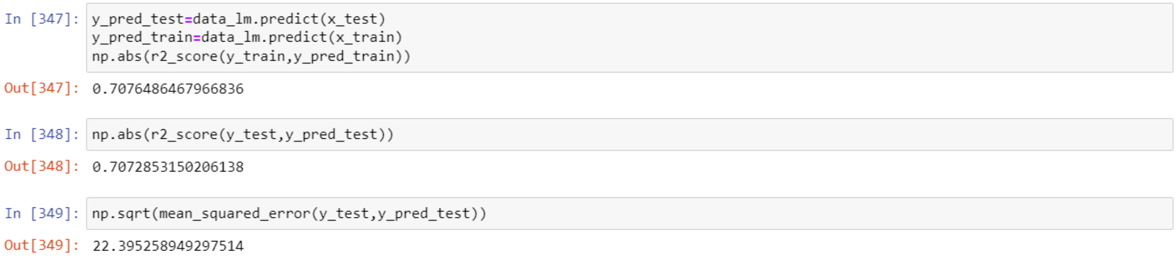
OLS Regression Results

Dep. Variable:	y	**R-squared:**	0.707
Model:	OLS	**Adj. R-squared:**	0.707
Method:	Least Squares	**F-statistic:**	6.743e+04
Date:	Tue, 13 Dec 2022	**Prob (F-statistic):**	0.00
Time:	16:56:42	**Log-Likelihood:**	-7.5789e+05
No. Observations:	167374	**AIC:**	1.516e+06
Df Residuals:	167367	**BIC:**	1.516e+06
Df Model:	6		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	45.1590	0.264	171.136	0.000	44.642	45.676
x1	6.8168	0.119	57.472	0.000	6.584	7.049
x2	5.0452	0.194	25.953	0.000	4.664	5.426
x3	0.1996	0.143	1.391	0.164	-0.082	0.481
x4	-0.3455	0.240	-1.442	0.149	-0.815	0.124
x5	-4.7642	0.149	-31.970	0.000	-5.056	-4.472
x6	76.4782	0.131	585.107	0.000	76.222	76.734

Omnibus:	16705.834	**Durbin-Watson:**	1.806
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	6122.603
Skew:	0.232	**Prob(JB):**	0.00
Kurtosis:	2.186	**Cond. No.**	10.4

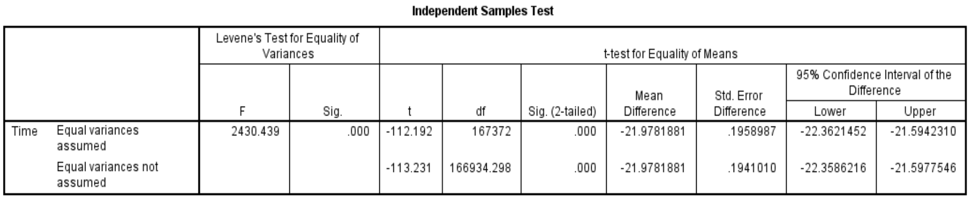
Summary of OLS Test of Port N



```
In [347]: y_pred_test=data_lm.predict(x_test)
          y_pred_train=data_lm.predict(x_train)
          np.abs(r2_score(y_train,y_pred_train))
Out[347]: 0.7076486467966836

In [348]: np.abs(r2_score(y_test,y_pred_test))
Out[348]: 0.7072853150206138

In [349]: np.sqrt(mean_squared_error(y_test,y_pred_test))
Out[349]: 22.395258949297514
```

RMSE and R^2 of test and train data of Port N

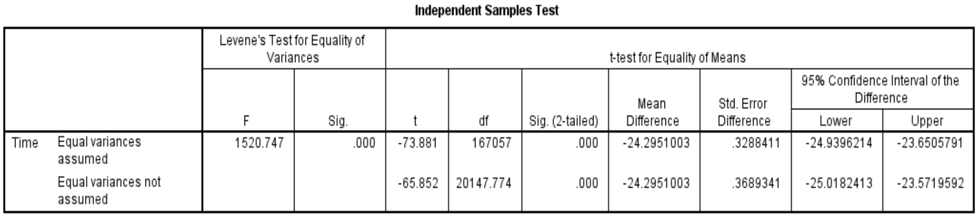
Cycle



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	2430.439	.000	-112.192	167372	.000	-21.9781881	.1958987	-22.3621452	-21.5942310
	Equal variances not assumed			-113.231	166934.298	.000	-21.9781881	.1941010	-22.3586216	-21.5977546

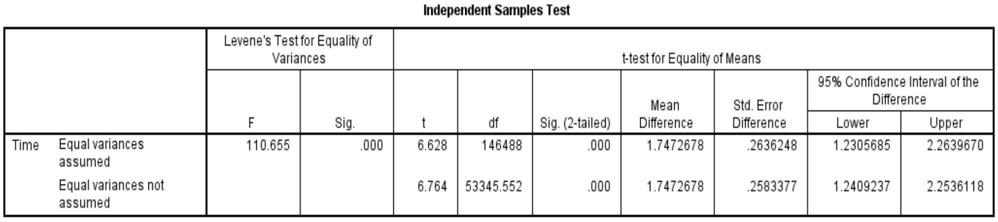
Mode



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	1520.747	.000	-73.881	167057	.000	-24.2951003	.3288411	-24.9396214	-23.6505791
	Equal variances not assumed			-65.852	20147.774	.000	-24.2951003	.3689341	-25.0182413	-23.5719592

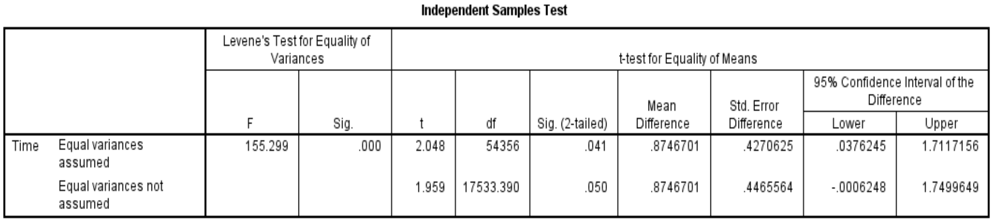
Size



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	110.655	.000	6.628	146488	.000	1.7472678	.2636248	1.2305685	2.2639670
	Equal variances not assumed			6.764	53345.552	.000	1.7472678	.2583377	1.2409237	2.2536118

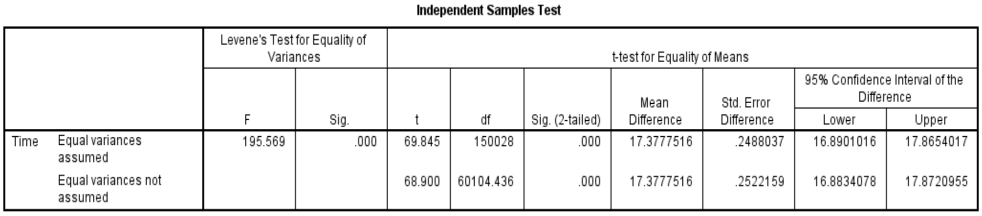
Status



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	155.299	.000	2.048	54356	.041	.8746701	.4270625	.0376245	1.7117156
	Equal variances not assumed			1.959	17533.390	.050	.8746701	.4465564	-.0006248	1.7499649

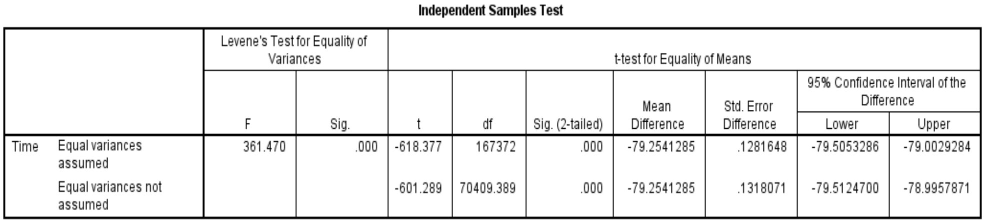
Delivery



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	195.569	.000	69.845	150028	.000	17.3777516	.2488037	16.8901016	17.8654017
	Equal variances not assumed			68.900	60104.436	.000	17.3777516	.2522159	16.8834078	17.8720955

Tracking



Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Time	Equal variances assumed	361.470	.000	-618.377	167372	.000	-79.2541285	.1281648	-79.5053286	-79.0029284
	Equal variances not assumed			-601.289	70409.389	.000	-79.2541285	.1318071	-79.5124700	-78.9957871

T test for the independent variables for Port N

PUBLICATION SUMMARY BY THE AUTHOR

Conference Publications

Saini. Mohan, Lerher. Tone (2020). Reshuffling & Rehandling of Containers during Storage and Retrieval: A Systematic Literature Review In DOKBAT 2020 - 16th Annual *International Bata Conference for Ph.D. Students and Young Researchers* (Vol. 16). Zlín: Tomas Bata University in Zlín, Faculty of Management and Economics. Retrieved from http://dokbat.utb.cz/conference-proceedings/. ISBN: 978-80-7454-935-9. DOI: 10.7441/dokbat.2020.10.

Saini, M., & Hrušecká, D (2020). Role of RFID in data exchange for efficient container logistics. *An international serial publication for theory and practice of Management Science*, 400. ISSN 2620-0597, Volume XVI, Issue (1), (2020)

Saini, M & Efimova, A. (2022) Data standardization in container management for process optimization | *IDS Conference* 2022 | **Winner of the first place in Industrial Engineering and Logistics**.

Nchena, L. **; Saini, M. ;** Khiev, V. ; Kalko MM. ; Mikeska, M; (2022). Labour economic aspect of Automation in Europe: A proposed study using advanced Machine Learning Algorithms. In DOKBAT 2022 - 18th Annual *International Bata Conference for Ph.D. Students and Young Researchers* (Vol. 16). Zlín: Tomas Bata University in Zlín, Faculty of Management and Economics.

Journal publications

Saini, M., & Hrušecká, D. (2021). Influence of Logistics Competitiveness and Logistics Cost on Economic Development: An FsQCA Qualitative Approach. *E&M Economics and Management*, 24(2), 51–65. https://doi.org/10.15240/tul/001/2021-2-004

Saini, M., & Hrušecká, D. (2021). Comparative impact of logistics performance index, ease of doing business and logistics cost on economic development: a fuzzy QCA analysis. *Journal of Business Economics and Management,* 22(6), 1577-1592. https://doi.org/10.3846/jbem.2021.15586

Saini, M., Efimova, A., & Chromjaková, F. (2021). Value stream mapping of ocean import containers: A process cycle efficiency perspective. *Acta Logistica*. DOI:10.22306/al. v8iX.245

Efimova, A., & **Saini, M.** (2023). Assessing carbon emissions reduction by incorporating automated monitoring system during transit: a case study. Acta Logistica, 10(1), 79-88.

Saini, M., Efimova, A., Lerher, T. & Chromjaková, F. Optimization in shipping container transportation management: A Bibliometric Review (Under review)

Saini, M & Lerher T. (2023) Assessing the factors impacting shipping container dwell time: A Multiport Optimization study (Under review)

4 Projects

IGA/FaME/2021/002 Performance analysis of container yard for the dwell time and reshuffle: A smart 4.0 perspective to monitor the hazard of logistics process

IGA/FaME/2022/005 Industry 4.0 and Circular Economy Adoption for Manufacturing and Logistics Processes

5 **Pedagogical activities:** Logistics Concept, Business Information System.

PROFESSIONAL C V

Mohan Saini

CZ : MSI, Zlin, CZ ✉ saini@utb.cz , mohan.saini123@gmail.com
IND: Flat No. 79-D, PKT 6, Mobile: CZ : +420-774154701
MIG Flats, Mayur Vihar - III IND: +91- 9958718775
Delhi, India.

EDUCATION

PhD Student September 2019 – Till date
Department of Industrial Engineering and Info. System
Tomas Bata University in Zlin, Czech Republic

Institute of Rail Transport August 2010 – July 2011
Diploma in Logistics and Multimodal management

Hindu College, Delhi University July 2003 to April 2006
BSc Chemistry (Hons)

ICFAI, ICFAI University May 2006 to April 2008
Master of Business Administration (MBA)

PROFESSIONAL EXPERIENCE

NEC Technologies India Pvt Ltd April 2017 – January 2020 Manager – Container Tracking Operations
Rivigo Services Pvt Ltd June 2016 – April 2017
Cluster Manager – Operations & Trainer
Delhivery Pvt Ltd May 2015 – June 2016
Sr Manager – Logistics Operations
Balmer Lawrie & Co Ltd April 2012 – April 2015
Assistant Manager – Logistics Services
JIL Information Technology, Jaypee Group August 2008 – April 2012
ICT Consultant

Date of Birth: 26th September 1985; Marital Status: Married
Languages Known: English, Hindi, and Punjabi.

Mohan Saini

Assessing the factors impacting the shipping container dwell time: A multiport research study

Posouzení různých faktorů ovlivňujících dobu zdržení přepravního kontejneru: Studie napříč několika námořními přístavy

Doctoral Thesis

Published by: Tomas Bata University in Zlín,

nám. T. G. Masaryka 5555, 760 01 Zlín

Edition: 5pcs

Typesetting by: Mohan Saini

This publication has not undergone any proofreading or editorial review.

Publication Year: 2023