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Impact of COVID-19 on port terminal performance in the United States of America

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IMPACT OF COVID-19 ON PORT TERMINAL PERFORMANCE IN THE UNITED STATES OF AMERICA

*A Case Study of the
Port of Los Angeles, California*

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A dissertation submitted to the World Maritime University in partial fulfilment of the requirements for the award of the degree of

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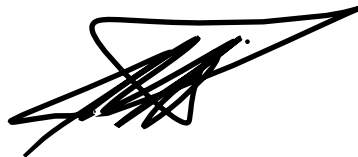
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Declaration

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

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

Signature:

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Date: **21 September 2021**

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Acknowledgements

Abstract

Title of Dissertation: **Impact of COVID-19 on Port Terminal Performance in the United States of America: A Case Study of the Port of Los Angeles, CA**

Degree: **Master of Science – Maritime Affairs (Port Management)**

With the emergence of the Coronavirus Disease (i.e., COVID-19, SARS-CoV-2) and its ascension to global pandemic, created significant disruptions with catastrophic impacts to global-trade, seafarer welfare, economies, travel, demand and supply, supply chains and logistics. With uncertainty as to when the virus will abate, it has become more critical than ever for Port Authorities, Marine Terminal Operators, and Supply Chains to collaborate and utilize resiliency measures to reign in chaos. In this study, we will focus on defining resilience, recognizing the sociological, technological, and economical theories that contribute to disruption growth, construct resiliency framework to counteract these changes, and measure the impacts of Port Performance to the largest seaport in the United States, the Port of Los Angeles. Utilizing key performance indicators (KPIs) from UNCTAD and IMO Publications, we will draw an analysis, focusing on pinpointing supply chain bottlenecks that were witnessed. Several of these findings include overcapacity of vessels at anchor and berths, terminal volume capacity and throughput, truck and rail statistics (e.g., turnaround, queue and dwell times), and warehousing (e.g., net absorption of goods, percent vacancy and real-estate availability). To compliment this statistical data, we will utilize various sources such as Google Scholar, Elsevier, JSTOR, Academia, Port Authority databases, and a questionnaire, to support findings to the research problems of how Port Terminal Performance has been impacted by COVID-19, why it's been considered as one of the worst disruptors of Global Maritime Trade, and what strategies and decisions Port Executives can take to mitigate future chaotic disruptions.

KEYWORDS: COVID-19 (SAR-CoV-2), Port Terminal Resilience, Port Terminal Performance, Resilience, Global Disruption, Multi-Criteria Decision Making

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Abbreviations

ABS	American Bureau of Shipping
AHP	Analytic Hierarchy Process
APMT	A. P. Møller Terminal
BNSF	Burlington North Santa Fe Railroad
CA	California
CAAP	Clean Air Action Plan
CAS	Complex Adaptive Systems
CAST	Complex Adaptive Systems Theory
CBP	Customs and Border Patrol
CDC	Centers for Disease Control
CISCO	San Francisco Systems
CMTA	California Manufacturing and Technology Association
CN	China
CO_2	Carbon Dioxide
COVID-19	Coronavirus 2019
DOT	Department of Transportation
ETS	Everport Terminals
FBI	Federal Bureau of Investigation
FDA	Food and Drug Administration
FEU	Forty-Foot Equivalent Unit
FMS	Fenix Marine Services
GDP	Gross Domestic Product
H1N1	Influenza A
HK	Hong Kong
IBT	International Brotherhood of Teamsters
ILU	International Longshoremen's Union
ILWU	International Longshoremen and Warehouse Union
IMCO	Inter-Governmental Maritime Consultative Organization
IMO	International Maritime Organization
ITC	Intermodal Transfer Centers
IXD	Intermodal Cross Dock
JP	Japan
LAFD	Los Angeles Fire Department
LAPD	Los Angeles Police Department
LCC	Limited Liability Company
LoV-LA	Logistics Victory Los Angeles
LPI	Logistics Performance Index
MARAD	Maritime Administration
MCDM	Multi Decision Criteria Making
MOU	Memorandum of Understanding
MSC[1]	Military Sealift Command
MSC[2]	Mediterranean Shipping Company
MTO	Marine Terminal Operator

NO$_2$	Nitrogen dioxide
PIP	Performance Improvement Plan
PM	Particulate Matter
PMA	Pacific Maritime Association
POC	Port of Call
POLA	Port of Los Angeles
POLB	Port of Long Beach
PPE	Personal Protective Equipment
PPP	Public Private Partnership
RTT	Rail Turnaround Times
SARS-CoV-2	Severe Acute Respiratory Syndrome, Coronavirus Variant 2
SC	Supply Chain
SCM	Supply Chain Management
SCRM	Supply Chain Risk Management
SK	South Korea
SO$_2$	Sulphur Dioxide
SOCAL	Southern California
TEU	Twenty-Foot Equivalent Unit
TRAPAC	TraPac Terminals
TTT	Truck Turnaround Times
TW	Taiwan
TWIC	Transportation Worker Identification Credential
UK	United Kingdom
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UP	Union Pacific Railroad
USA	United States of America
USCG	United States Coast Guard
USMM	United States Merchant Marine
USNS	United States Naval Ship
WBCT	West Basin Container Terminal
WHO	World Health Organization
YTI	Yusen Terminals

CHAPTER 1 – Introduction

This chapter summarizes the origins and development of the Port of Los Angeles and Containerization within the United States. Understanding their unique connections to one another has led to innovation, development and standardization of Port Terminal Systems along the southern coastline of California. These three characteristics, have helped to demonstrate how events in time have forced change, and prioritized the urgency for systems to become adaptive to defend from future chaos and disruptions.

System Innovation, Development, and Standardization can cohesively be seen as positive and negative contributions to both the Port of Los Angeles/Long Beach and Supply Chain Resilience within the San Pedro Bay Port Complex. In Chapter 1, we will define Disruption, what it means for Port Terminals and Supply Chain Systems, and how disruptions have significantly impacted the Port of Los Angeles.

After successfully defining Port Terminal disruption, we will connect the case study of the Port of Los Angeles, to answer the follow-on research questions throughout the preceding Chapters.

Chapter 1.1 The Foundations of "America's Port"

On December 9th, 1907, strategically located south of the San Gabriel's Mountains in the State of California of the United States, the Port of Los Angeles was opened to world commerce and bridged the link between states within the developing young nation.

Figure 1: Port of Los Angeles Terminals (Source: Port of Los Angeles Official Website, 2021)

Prior to this grandeur achievement, the history of the Port of Los Angeles and Southern California spans deeply to centuries prior, through several accounts from settlers, including the Portuguese explorer Juan Rodriquez Cabrillo (Palmer, 2007). As a seafarer and servant commissioned by the Spanish Government, he set sail to discover the Gulf of Mexico and Western Coastline of the United States in the 16th Century. Originally named Bahia de Los Fumas or "Bay of Smokes," was due to the initial Indian Settlement and continuous smoke of their villages seen from the distant Pacific Ocean. When the 13 Colonies of the Eastern Seaboard seceded and declared independence from British Rule in 1776, most of the territories continued to be owned by other countries, including Spain and France. Trade, was greatly impacted by this command and domineering proxy control. Through time, multiple treaties,

purchase agreements, annexations, revolts and cessions would arise to change and alter these territories, with the 1822 exodus of the Mexican Government as one key component towards a free state of California. As a result, this led to surges of settlement and commercial trade and the formation of the 50 now known states within the United States. Following flourishing business, influenced many important delegates, entrepreneurs and businessmen to establish San Pedro Bay as a gateway for West Coast Trade. The most important of these tradesmen, Phineas Banning, would be responsible for founding the county of Wilmington from which the Los Angeles Harbor resides. Senator Stephen White, another key delegate, supported the port's development, and pushed policy for the new seaport to be designated as the official port for Los Angeles in 1897.

The Port of Los Angeles accounts with a rich history of immigrant workers at the original Sunkist Oranges and Starfish Tuna procession warehouses (White, 2008), breakbulk and timber trade, rail expansion from the Union Pacific Railroad and essential wartime efforts for Ship building in World War II. Despite these achievements, the Port suffered from lack of uniformity and security due to no standardization of loading cargo, and the increased frequencies of lost, damaged cargo, and pilferage until introduction of Containerization, which would change the way we consider the term of Globalization.

Chapter 1.2 The Revolutionary Container and the "Ideal X"

For hundreds of years, globalization has been a key driver to connect continents across oceans, deliver commerce and trade to the people and help enhance our capabilities and opportunities for expansion to the modern era we live in today. Cargo was loaded as separate pieces, better known as break-bulk, which was both labour intensive and time consuming. A major achievement to evolve break-bulk cargo operations, was the development of the standardized container in 1956 by Malcolm McLean. With developing the container, came the very first containership

"the Ideal X", a converted World War II T-2 Oil Tanker, to make its maiden voyage from Newark, NJ to Houston, TX USA. At the time, the vessel could only hold 58, 33-foot containers. As of 2021, the largest class of container vessels from HMM Inc, have a maximum holding capacity of 23,964 TEU's. Throughout these past 65 years, the ability to transport larger amounts of cargoes over greater distances, at faster speeds, has allowed world economies to grow substantially faster, further expanding technology, innovation, and "just in time" logistics to meet the demands of consumers. But with this growth and expansion, also develops new dimensions of chaos and disruptions. Both can be impacted significantly due to geo-political events at home or abroad, environmental disasters, economic shifts or Acts of God. Containers therefore, have had a profound and enhancing effect on port operations, terminals and structures (Hayut, 1981).

Chapter 1.3 Disruptions in the History of the Port of Los Angeles

With the Twenty Equivalent Unit (TEU) and Forty Equivalent Unit (FEU) containers formally standardized in the Customs Convention of Containers in 1972 under the United Nations, Inter-Governmental Maritime Consultative Organization (renamed to IMO), and under the International Standards Organization (ISO), allowed global commerce to become standardized and uniformed. Despite the promising features that these modern containers provided, it was considered an unwelcoming guise for the ILWU workers, as this would mean the potential loss of jobs, and less money to make for simplified work. However, despite the inevitable change, work proved to be safer, efficient and easier to load and offload cargo. In addition, with expansions of trade and demand, commanded more labour force to work in the Port Terminals, which provided ample growth for the economy.

But through the evolutions of seaports and the services that feed into them, disruptions always were prevalent, whether directly impacting the port, dormant for a period of time, or affecting other parts of the world.

A Disruption, can be defined as an interruption of a process, system or industry through instigations of chaotic events, such as war, terrorism, natural disasters, political, economic instability, supply unavailability, transport delays and Labor conflicts (Figliozzi & Zhang, 2009). With the expansion of Globalization, has led to decreases of supply chain resilience and increases of disruptive events.

There have been many instances where disruptions have occurred at Ports in the United States as well as at the Port of Los Angeles within the past 20 years. First, the Al-Qaeda terrorist attacks on September 11th 2001 in New York City, had devastating ripple effects and consequences, which would forever change security protocols, starting with the United Nation Convention of the International Ship and Port Facility Security Code (ISPS) in 2002 and enforced within SOLAS Chapter XI-2 in 2004 (IMO, 2021). In the same year that the ISPS Code was introduced, the 2002 West Coast Port Lockout occurred, a dispute against the PMA by the ILWU in order to support new contract demands in negotiations. The ILWU was accused of deliberately engaging in slowing down work within the Port Terminals of Los Angeles, as an alternative to striking (Park et. al, 2008). This caused the employers responding to this slowdown of productivity to a complete lockout, preventing workers to do their jobs. With the Ports (Los Angeles and Long Beach) shutdown for 12 days, estimated total economic losses of $1.67 billion USD (Anderson & Geckil, 2002; Cohen, 2002). Labor strikes would be a common occurrence over the next 10 – 15 years in 2012, 2015, 2018 and 2021 which would add to the Los Angeles Port Terminals turmoil to control cargo flows (Monaco & Olsson, 2004; Gong & Liu, 2019; POLA, 2021). In addition, the Financial Crisis of 2008, coined the worst since the Great Depression of 1929 (Hemmelgarn & Nicodeme, 2010), disrupted cargo flows of greater than 20% in the first quarter of 2009 container throughput forecasting (Keenan, 2009), which imitates the same trends and disruptions currently caused by COVID-19. With bottlenecking at the Ports of Los Angeles and Port of Long Beach during the events of 2008-2009 Financial Crisis and the ongoing COVID-19 Pandemic, the West Coast has lost market share to Gulf and East Coast

Ports due to higher costs of operations and businesses in the States of California and Washington, widening of the Panama Canal, which include Houston, TX and a new APM Terminal at the Port of Norfolk, VA (Plunkett, 2009; O'Connell, 2020; Nacht et. al, 2021).

Chapter 1.4 Problem Statement

Understanding that disruptions are interruptions of a systems process due to uncontrollable cataclysmic events, can help us develop new methods of strategy to enhance elasticity and adaptability in maintaining uninterrupted performance at Port Terminals. One assumption, is to believe that all disruptions have a repetitive commonality and follow similar paths in the ripple effects they create through history. Though disruptions with COVID-19 can have similar trends as the Financial Crisis of 2008, this is not fully the case as demonstrated earlier by Notteboom, Pallis and Rodrigue (2021). The famous aphorism of "history doesn't repeat itself but it often rhymes" (Mark Twain) being one thing, another is failing to realize the vast differences of technology, science, medicine and status of the world during each chaotic event. For example, comparing the Spanish Influenza (A/H1N1) to the Novel Coronavirus (SARS-CoV-2) and Black Death (Bubonic Plaque) against Port Terminal Performance and Resilience, is not rational nor effective. Even though all share similarities as global pandemics, originated from mutated natural occurring strands in the environment, and deaths of millions (Aassve et. al, 2021), there are no preserved performance measures or statistics, as technology was archaic. With this argument, we can say that Resiliency Modelling is a very young, underdeveloped and misunderstood concept which provides foundations for the Marine Terminals that operate within Port Authorities. Despite automation, digitization, larger portainers, larger transport volumes by ship, rail and by truck, we continue to repeat and make the same critical mistakes. To understand why we make the same mistakes, we need to identify key objectives to answer the current problem with how COVID-19 has impacted Port Terminal Performance, which will be identified in the next section.

Chapter 1.5 Objectives of the Study

With the Port of Los Angeles contributing to 40% Market Share of West Coast Trade and 17% Overall in the United States, and its cargo value estimated at $259 billion USD (Chu, 2020), it is considered a critical and essential asset to the stability and economies of both the economies of the State of California and the United States as a whole (POLA, 2021). Combined with its neighbouring Port of Long Beach, together provide a controlling market share of 74% for the entire West-Coast. These statistics alone prove the worth and value of how important Port Terminals and Authorities are for the economy. Between providing jobs, security to waterways, peaceful expressions of world trade and the link to markets for commodities and consumables, Ports provide an endless wealth of opportunities. But to understand the past issues of disruptions that had affected the Port of Los Angeles, the Port Terminals within it, and connected Supply Chains, will allow us to better develop a concrete foundation of understanding and key objectives. The objectives for this study, is to define what Resilience means for Port Terminals in the years of Pre-COVID (2019) Global Pandemic (2020) and Futures (2021+), how an abnormality that occurred from outside the country, eventually spread, entered the United States and disrupted the entire scope of transportation systems, unbalancing import and export of containerized goods, forced ebbs and flows of demand which exploited the failures of proper utilization of Artificial Intelligence, vacancy and storage in warehousing, and how learning from the collapse of the Supply Chain can teach us to build resilience measures and procedures to enact when future disruptions begin to display themselves.

Chapter 1.6 Research Questions

Based on the objectives of the thesis, we can determine three critical questions to research through the study

1. How do you measure resilience?

2. What is the impact of COVID-19 on the Port of Los Angeles, CA?

3. How can Ports implement changes in order to build and restructure its resilience?

Chapter 1.7 Methodology

Through conducting this research, information was obtained through official web sources (MARAD, USDOT, Port of Los Angeles, Pacific Maritime Association, Pool of Pools, Wabtec Tower - Port Optimizer), databases, academic literature (Elsevier, JSTOR, ScienceDirect), and peer-reviewed journals (University of Southern California, California State University).

In order to fully identify how to define resilience, and how they apply through the impacts of the Port of Los Angeles, we will sample and deconstruct 25 definitions from various authors and utilize frequent terms to develop a new definition for the study.

Once we have established and fabricated "resilience", we will compare it against qualitative from interviews and surveys from essential personnel working in Port Terminals, Freight Forwarding, Warehousing, Rail, and Senior Staff of Logistics Companies; and quantitative data from the Wabtec Port Optimizer to compare Port of Los Angeles against the UNCTADs Port Performance Handbook. We then will develop a lean discipline model through interviews, survey and performance data, to construct an Analytic Hierarchy Process Model following the recommendations of Teknomo (2006) and Loh, Zhou, Thai, Wong and Yuen (2017). In doing so, will allow us to determine the weights of scenarios, and which decisions Senior

Executives and Stakeholders can make in order to restore or maintain resilient through current day disruptions and validate the answers of how COVID-19 impacted Port Terminal Performance in the United States.

Chapter 1.8 Limitations of Study

The limitations within this study, is the availability of specific information within the Port of Los Angeles, regarding individual container terminal throughputs, total discharge of individual shipping liners within them, average gang ton hours, average TEU's per hour / per terminal, crane hours and shipping liner total port times in daily format. This information would be deemed extremely sensitive, confidential, and unavailable for open public research. Also, with the limited time available, and requirements of the AHP Survey, surveyors were opened to Supply Chains that operate within Major Transportation hubs along the West and East Coasts of the United States.

Chapter 1.9 Research Structure

The study has been organized and structured as follows:

- Chapter One will briefly introduce the Port of Los Angeles' foundation in the late 1800's, and how through expansion of trade, war and time, developed into and earned the slogan of "Americas Port". We will also cover the historical significance to the invention of standardized containers by Malcolm McClean and the Ideal X T-2 Tanker and also demonstrate how expansions to Globalization has led to Supply Chains becoming less resilient and more susceptible to disruptions.

- Chapter Two is Literature Review focusing on what is Resilience, with a constructed table of 25 definitions, and how we can reduce these to properly define Port Terminal Resilience for the Study. We then identify Supply Chain

Resilience, Port Performance and how these are linked to Supply Chain
Performance, Logistics Performance and the importance of Foreland and
Hinterland Connectivity.

- Chapter Three will focus on developing a Resilience Framework in order to
  properly address how to measure resilience, and the different segments of
  complex adaptive systems theory

- Chapter Four will build the Case Study of the Port of Los Angeles by
  studying statistical data on Anchor Time, Days at Berth, Container
  Throughput by Shipping Company, Container Throughput at the Port of Los
  Angeles, Truck Transactions, Truck Turn Times, Dwell Times for Rail,
  Truck and Total as well as Intermodal Cross Deck Yard and Warehousing
  Congestion issues.

- Chapter Five will compose of data collection through Interviews and a AHP
  Questionnaire for a blend of qualitative and quantitative data. We will
  compare and contrast the Qualitative AHP Data to the Quantitative Port of
  Los Angeles data to finally pinpoint the issues of how COVID-19 impacts
  Port Terminal Performance

- Chapter Six will conclude and summarize all the information within the
  study.

CHAPTER 2 – Literature Review

Chapter 2.1 Resilience

The word "Resilience" shares multiple connotations when applied to various conditions through physiological, sociological or industrial psychology. Since most supply chain networks are composed of cluster nodes through various means of intermodal services, there is no singular definition (one size fits all) of resiliency for maritime, aviation, rail and roads. One example in terms of roadway resiliency, would be The Federal Aid Highway Act of 1956. In the United States, this Highway Act would be the largest public works project in the nation's entire history (GovInfo, 2018). This would provide the essential link of roads and highways between the opposite coasts, and overall, would bolster essential economic growth and strategic development of the interstate system through transcontinental trade. Investment in intrastate infrastructure was due largely with rising geo-political conflicts in rising nations of power, and the United States need to expand security and homeland defence (Weingroff, 1996). Approximately 90% of the funding utilized was paid for through the US Government. In short, roadway resiliency could be defined as a transporter's ability to maintain undisrupted methods of transport during routine and unexpected deteriorations of interstate services. But how can we effectively define the key principles of resiliency through capable abilities, adaptability, recovery and elasticity in vicissitudes of events at Maritime Ports and Port Terminals? The main functions of Maritime Ports are to provide supply service for freight and ships. However, these factors alone do not fully define the scope of activities and essential functions.

According to Rodrigue, Notteboom and Pallis (2021), the term of resilience allows the transportation infrastructure to cope and recover from disruptions while maintaining operations. This is due to the transportation sector being able to view internal and external disruptions through physical sciences, ecological sciences and complex adaptive system theory. The Ports overall objective achieved through

observant behaviour, is to reduce the probability of disruption, and if not successful, mitigate potential economic impacts it will have on the maritime port and hinterland supply chains it feeds into. Maritime Port resiliency can also vary due to the port's overall purpose and functionality. Ports can be segregated through two methods by Monofunctional and Polyfunctional services. Monofunctional harbours focus on limited arrays of commodities, in which the developed infrastructure in place is strategically designed strictly for only raw commodities or a singular product. The Port of Los Angeles, can be viewed as a Polyfunctional Port due to its ability to service container ships, roll on roll off (ro-ro) vessels, passenger, multi-use, maritime support services, break-bulk and wet-dry bulk commodities. In understanding which ports operational functions could lead to higher resiliency and mitigated disruption over the other remains unseen. This argument can be made due to unforeseen future events through geopolitical and geographical events. In this paper however, we will focus on container terminals of the Port of Los Angeles.

With the introduction of the Novel Coronavirus (COVID-19, SARS-CoV-2) in the latter of December 2019, this introduced a new level of disruption that was not familiar to the shipping industry since the turn of the 20th century with the 1918 Pandemic of the Spanish Flu (H1N1). Comparing the contingency factors for Maritime Ports through both pandemics, is impossible. This is due to significant variances of technology, economic development, existing transport infrastructure, social sciences of medicine, methods of communication, and absence of critical data. These factors also varied due to seaports' nationality, whether a country is fully developed or is in development. In argument with Rodrigue, Notteboom and Pallis,

how can we truly establish a solidified definition of Port Resiliency for the number of constants and variables available?

Table 1

Illustrative Definitions of Resilience

Publication (Author and Year)	Definition
Adger (2000)	The ability of communities to withstand external shocks to their social infrastructure. The ability of groups or communities to cope with external stresses and disturbances as a result of social, political and environmental change
Adger et al. (2005)	The capacity of linked social-ecological systems to absorb recurrent disturbances such as hurricanes and floods so as to retain essential structures, functions, and feedback. Resilience reflects the degree to which a complex adaptive system is capable of self-organization and the degree to which the system can build capacity for learning and adaptation
American Psychological Association (2021)	The process of adapting well in the face of adversity, trauma, tragedy, threats, or significant sources of stress
Brown and Kulig (1996)	The ability to recover from or adjust easily to misfortune or sustained life stress
Bruneau et al. (2003)	The ability of social units (e.g. organizations, communities) to mitigate hazards, contain the effects of disasters when they occur, and carry out recovery activities in ways that minimize social disruption and mitigate the effects of future earthquakes
Chenoweth and Stehlik (2001)	Communities can be considered as being resilient when they respond to crises in ways that strengthen community bonds, resources and the community's capacity to cope
Cambridge Dictionary (2021)	The ability of a substance to return to its usual shape after being bent, stretched, or pressed
Comfort (1999)	The capacity to adapt existing resources and skills to new systems and operating conditions
Egeland et al. (1993)	The capacity for successful adaptation, positive functioning, or competence, despite high-risk status, chronic stress, or following prolonged or severe trauma

Table 1 (Conti)

Publication (Author and Year)	Definition
Gunderson and Folke (2005), cited in Moser (2008)	The return or recovery time of a social-ecological system, determined by (1) that system's capacity for renewal in a dynamic environment and (2) people's ability to learn and change (which, in turn, is partially determined by the institutional context for knowledge sharing, learning, and management, and partially by the social capital among people)
Handmer and Dovers (1996)	From the three types of resilience defined by these authors, resilience as "openness and adaptability" is understood as an approach that has a high degree of flexibility. Preparedness is key in order to adopt new operating assumptions and institutional structures, and to adapt to the consequences of change and uncertainty rather than resist them
Holling (1973)	The persistence of relationships within a system and as a measure of the ability of systems to absorb changes of state variables, driving variables, and parameters, and still persist
Holling et al. (1995)	It is the buffer capacity or the ability of a system to absorb perturbation, or the magnitude of disturbance that can be absorbed before a system changes its structure by changing the variables
IPCC (2012)	The ability of a system and its component parts to anticipate, absorb, accommodate or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the reservation, restoration, or improvement of its essential basic structures and functions
Klein et al. (2003)	Facilitates and contributes to the process of recovery [y] describes specific system attributes concerning the amount of disturbance a system can absorb and still remain within the same state or domain of attraction and the degree to which the system is capable of self-organization
Krimsky (1992)	Individuals' sense of the ability of their own community to deal successfully with ongoing political violence

Table 1 (Conti)

Publication (Author and Year)	Definition
Liu et al. (2007)	The capability to retain similar structures and functioning after disturbances for continuous development
Merriam-Webster Dictionary (2021)	The capability of a strained body to recover its size and shape after deformation caused especially by compressive stress
Mileti (1999)	Local resilience with regard to disasters means that a locale is able to withstand an extreme natural event without suffering devastating losses, damage, diminished productivity, or quality of life without a large amount of assistance from outside the community
Paton (2006)	The measure of how well people and societies can adapt to a changed reality and capitalize on the new possibilities offered
Paton et al. (2000)	Resilience describes an active process of self – learned, resourcefulness and growth – the ability to function psychologically at a level far greater than expected given the individual's capabilities and previous experiences
Pfefferbaum et al. (2005)	The ability of community members to take meaningful, deliberate, collective action to remedy the effect of a problem, including the ability to interpret the environment, intervene, and move on
Resilience Alliance (2012)	The ability to absorb disturbances, to be changed and then to re-organize and still have the same identity (retain the same basic structure and ways of functioning). It includes the ability to learn from the disturbance. A resilient system is forgiving of external shocks
Rodrique et. al (2021)	the mechanism that allows a transportation infrastructure to cope and recover from disruptions while maintaining operations.
Timmerman (1981)	The capacity of a system to absorb and recover from the occurrence of a hazardous event

Table 1 (Conti)

Publication (Author and Year)	Definition
UN/ISDR (2007)	The capacity of a system, community or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organizing itself, to increase this capacity for learning from past disasters for better future protection and to improve risk reduction measures
Wildavsky (1991)	Resilience is the capacity to cope with unanticipated dangers after they have become manifest, learning to bounce back

Notes: Modification from "Framing Disaster Resilience: The implications of the diverse conceptualisations of "bouncing back" by Aldunce, Handmer, Beilin and Howden, 2014
(Source: Aldunce et. al, 2014)

Chapter 2.2 Port Resilience

Notteboom, Pallis and Rodrigue (2015), discussed that despite the effects on Logistics Supply Chains that haven't adapted and decentralized their clusters to compensate for disruption, COVID-19 on ports in general has had a short-lasting shock, and of shorter scale and duration than initially expected. The shorter shocks of disruption were due to proactive adaptation capabilities demonstrated by both shipping alliances and the container ports in collaboration. In order for both the shipping liners/alliances as well as the container ports to be effective, a multidimensional approach had to be taken. First, restructuring and reorganization within the Port Authorities to address sanitary protocols which include cleaning equipment and operating vehicles, longer shift changeovers, rotation schemes, and lowering the number of dock workers per shift. Also, collaboration amongst stakeholders through integration of newer technologies, such as automation of robotics at Port Terminals and methods of business being conducted through fully digitized means such as wayfarer bills and automated queuing gates. Port Authorities also adopted compensatory financial measures which include early payment to providers due to constrained demand and suppressed by lockdowns. Delaying

payments for users in the Port, also contributed to mitigate adverse effects of the crisis.

To further expand this multi-dimensional approach, multi-level port resiliency planning could be an amicable approach when involving stakeholders, operators, agencies, firms and multiple levels of government.

Shaw, Grainger and Achuthan (2016), expressed the necessity of multi-dimensional approaches as well with the United Kingdom's strong dependence on imported goods as an island nation. Specifically, the UK relies not only on strongly developed ports, but the significance they provide whilst serving as the gateway for 97% of overall trade for the entire country. Furthermore, these Ports are highly specialized by commodity, with Felixstowe handling 40% of all container traffic, and it would be quite difficult to properly replace the capabilities they provide if these services were lost (Grainger and Achuthan, 2014).

Chapter 2.3 Supply Chain Resilience

Kamalahmadi and Parast (2015), focused on the vulnerabilities and risks of disruptions in supply chains with the resulting growth of globalization and higher rates of innovation. Some of the challenges focus on increased demands of variability, shorter lifespan of products, and varied expectations from customers and consumers. As a result of these negative consequences, businesses essential to the economy such as Port Authorities and the terminals that operate within them to deliver these amenities, must address the rejuvenation and adaptable structure required to build new supply chain clusters that are resilient to disruptions. Many more companies now find themselves at increasing risk of supply chain disruption. A recent study by Aon Risk Solutions found that, on average, the percentage of global companies reporting a loss of income due to a supply chain disruption increased from 28% in 2011 to 42% in 2013 (Saenz and Revilla, 2014). Jüttner (as cited in

Kamalahmadi and Parast, 2015, pg.1) explained that supply chain risk management (SCRM) 'identifies potential sources of risk and implementations of appropriate strategies throughout coordinated approaches among risk members to reduce overall supply chain vulnerability'. The inability for businesses to anticipate unpredictable and unknowable events such as COVID-19, has caused irreversible damage, bankrupted many, and left millions without jobs. Supply Chains are a viable link in resiliency for Ports. Viability is the ability of a supply chain (SC) to maintain itself and survive in a changing environment through a redesign of structures and replanning of performance with long-term impacts (Ivanov, 2020). In order for the Port of Los Angeles to properly manage their Supply Chains through COVID-19, there needs to be a developed framework in order to guide them through deploying risk management practices. Reconfiguring these systems will help to develop Supply Chain Resiliency Programs.

Saenz and Revilla (2014) discuss in thorough detail the required systematic components in order to develop a successful resiliency program. The example used was CISCO Systems in comparison to two different periods of disruption. One was during the events of Hurricane Katrina and the other being the Tohoku Tsunami and Earthquake of 2011. Both were 'Acts of God' and uncontrollable, which could be similarly compared to COVID-19. The only substantial differences were the affected audience of people vs. damage to physical infrastructure. Through reconfiguring the company's supply chains, there were 6 strategies that CISCO took in order to prioritize maintaining undisrupted service to all clients. Foremost, CISCO identified strategic priorities. This was comparing competitor's particular products against the supply chains capabilities. Decision makers within the company had to weigh the priorities over cost or response time for particular products and services. The same could be applied to Port Terminals, as to what cargo being imported and exported is deemed 'essential'. A good example of essential supplies would be Personal Protective Equipment (PPE) from manufacturers in Central Asia and the Far East. Though these would be considered priority equipment, vaccines which have

significantly more constraints (size of container, required temperature for storage with uninterrupted power supply, efficacy and life-span of the medicine in days and weeks). So, the cost in order to overnight shipments of vaccines vice, having a 16,000 TEU container ship full of essential masks, clothes, coveralls and additional PPE arrive three weeks later, is stipulated in decision making in the strategic strategy of supply chain design.

Mapping Vulnerabilities can be inclusive to geo-political, economic, regulatory compliance mandates, expansions of technology, spikes of demand and supply as well as natural disasters. Resiliency Programs for COVID-19 in comparison to various Ports and Port Terminals in the United States can include the local state governance and policies. In the State of California, workers who maintained a Transportation Worker Identification Card (TWIC), who worked through maritime, aviation, rail, truck and local city transport, were deemed essential personnel, and had priority to receive the developed COVID-19 vaccines of Pfizer-BioTech and Moderna (POLA, 2021).

Another example of vulnerabilities, was the requirements of ventilators for hospitals all over the United States. To weight the consequences of time-delay from manufacturing of ventilators from China or other Far East distributors, to method of transportation due to high cost of aviation expenses or low cost but slow by surface, United States car manufacturers such as TESLA and Ford Motor Co, utilized their own supply chains to use car parts to manufacture ventilators for hospitals who were at maximum capacity.

With this understanding of what the United States needed in 2020 through 2021, this instability allowed critical supply chains to properly access the capabilities and weaknesses of connectivity, digitization and communication with alternative suppliers for various tiered customers. It also allowed the seaports on both East and West coast to understand the differences in Port Congestion, Increased Turn-around

times, increased anchor and delay times, and inputs, throughput and output dilemmas due to international, states and national guidelines to COVID-19 and prevention. Furthermore, understanding the Integrating Risk Awareness into the Product and Value Chain, monitor resiliency, and watching for events all effectively feeds into Resiliency Planning.

Chapter 2.4 Port Performance

As a strategic asset for local and regional economies in countries around the world, seaports must undergo constant routine self-assessments in order to know where their strengths and weaknesses lie both in competition and in improvement during the operating year. According to the UNCTAD Report of Port Performance Indicators (1976), there are various methods to appropriately determine port performance through the seaport's own operational and financial capabilities. The importance of these capabilities, provides collected information for planning and control by senior level management of Port Terminals. This information can be segregated into a functional transport chain graph, defined by maritime transport, port navigational services, cargo handling services, cargo transit storage services and hinterland support. For this paper, we will focus on the Cargo-handling services, as this portion delineates with significant detail how Port Terminal Performance can be greatly impacted by COVID-19 and other external factors.

Within Cargo-Handling Services, the 1976 report heavily focuses on financial indicators due to when cargo handling is lower or higher due to economic and yearly predicated trends. Some contingency options include increased market promotion to attract new customers, raising tariffs to increase revenue, measures to raise productivity and readjustments of deferrable budgeted expenditures. For the operational aspect of Port Performance, UNCTAD defines Arrival Rate, Waiting Time, Service Time, Turn-round Time, Tonnage per Ship, Fraction Time, Number of Gangs employed per ship per shift, Tons Per Gang-hour and Fraction of Time gangs idle as measurements of performance. While these are considerable measures for

beginning to map performance evaluation, the report is missing critical information which involves the utilization of capital equipment times. This information can be further segregated and richly delineated through crane hours, containers offloaded per hour, truck pulls and turnaround times, que times for trucks, gate transactions, and railing information. These can be measured up to the point of departure, where additional performance measures will need to be factored specifically for rail, warehouse storage capacity and processing, with further importing into the country's economy.

In 1987 under the UNCTAD Monographs on Port Management, the previous Port Performance Indicators report was further updated. First, Port Performance Measures were further expanded upon to include quality of cargo-handling equipment and the service to inland transport vehicles during passage through ports (De Monie, 1987). This solves the issue with major world ports publishing their reports on 'productivity in ports' without mentioning a single factual performance or productivity measure or figure.

Chapter 2.5 Definition of Resilience for the Study

In understanding definitions of Resilience, the most common descriptions of the word span from positive attributes of ability, capability, mechanism, systems and synonyms of action and optimism; with negative connections to hazards, dangers, disasters and stress. To define Port resilience in terms of this study, we can identify 4 key definitions of the original 25 selected aspects of Resilience.

The most influential definitions of the word resilience, effectively capture a synopsis of physical, psychological, sociological and environmental affluences. In summarizing these four key definitions, we can form a new definition for Resilience in application to the Case Study.

Table 2

Resilience: Key Definitions for Port Terminals

Publication (Author and Year)	Dimension	Definition
Rodrique et. al (2021)	a	The mechanism that allows a transportation infrastructure to cope and recover from disruptions while maintaining operations.
Intergovernmental Panel of Climate Change (2012)	b	The ability of a system and its component parts to anticipate, absorb, accommodate or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the reservation, restoration, or improvement of its essential basic structures and functions
Paton et al. (2000)	c	The active process of self – learned, resourcefulness and growth – the ability to function psychologically at a level far greater than expected given the individual's capabilities and previous experiences
Mileti (1999)	c	The ability to withstand an extreme natural event without suffering devastating losses, damage, diminished productivity, or quality of life without a large amount of assistance from outside the community
Sulzer (2021)	a,b,c	The effective coordination and communication of Port and Supply Chain systems to maintain optimal services through disruptive shocks, by implementing lessons learned from adaptible intermodal transportation systems, warehousing, capital equipment, all while eliminating sacrifices to overall security and system(s) integrity.

Notes: a, physical infrastructure; b, psychological; and c, sociological and environmental
(Source: Aldunce et. al, 2014; Author, 2021)

The most influential definitions of the word resilience, effectively capture a synopsis of physical, psychological, sociological and environmental affluences. In summarizing these four key definitions, we can form a new definition for Resilience in application to the Case Study. Resilience can be defined as effective coordination and communication of Port and Supply Chain Systems, to maintain optimal services through disruptive shocks. In addition, by implementing lessons learned from previous periods of disruption, we can effectively utilize adaptable intermodal transport systems, warehousing vacancy, capital equipment, all while eliminating sacrifices to overall security and system(s) integrity.

CHAPTER 3 – Resilience Framework

Chapter 3.1 How to Measure Resilience

When measuring Resilience, in all cases through physiological, sociological or industrial aspects, resilience shares a common flow of decline, sustainability and recovery from a disturbance or disruption, to either return from previous levels or surpass and rise to better numbers. To deeply interpret these four phases, Rodrique et. all (2021), identified a set of observative sciences which can fully construct analysis data through physical, ecological sciences and complex adaptive systems theories. Out of the three choices for observative sciences, Complex Adaptive Systems Theory (CAST) is the most appropriate approach to develop a cognisant, highly detailed and specialized focus system for the Port of Los Angeles. In doing so, we can determine the links of resilience, and the weak points where disruptions can regularly occur and thrive if not corrected.
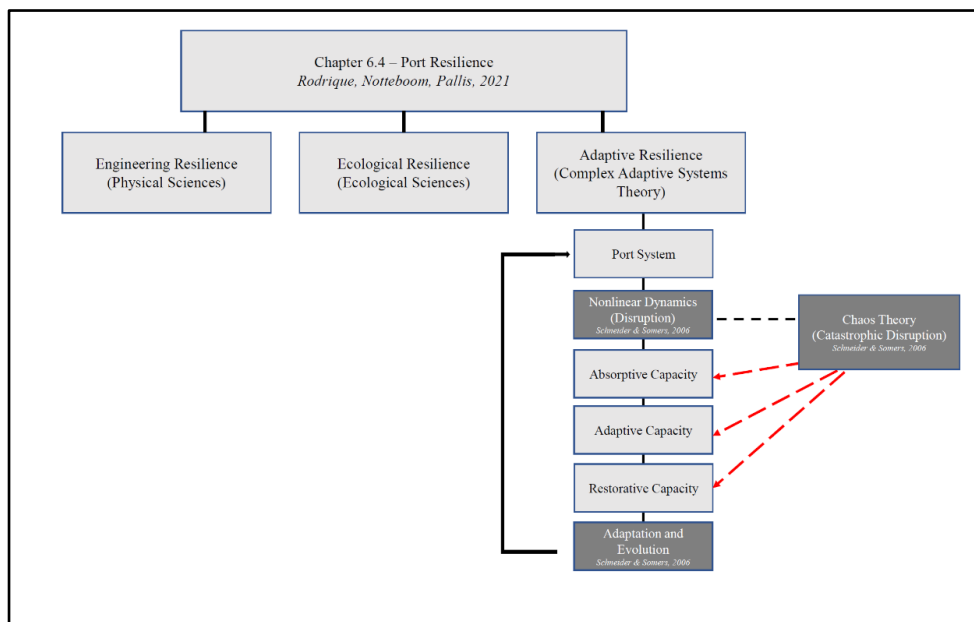
Figure 2: Resilience Framework (Source: Rodrique et. al, 2021; Schneider & Somers, 2006)

Through CAST, we can model the recirculated critical systems of the six Port Terminals, which control daily flows of commerce and exports of goods. These key

attributes, are always subject to feedback and regularity influences of disruption, which can be explained through CASTs three essential parts of Nonlinear Dynamics, Chaos Theory and Adaptation and Evolutions (Schneider & Somers, 2006).

Finally, in understanding these components and the system model of Port Terminals, will allow us to properly apply these theories to visualize three dimensions of resilient systems. These are Absorptive, Adaptive and Restorative Capacities. Merging the findings from Rodrique et al. (2021) with Schneider & Somers (2006), we can develop an effective Resiliency Framework.

Chapter 3.2 Complex Adaptive Systems Theory

When we define the word "Complex" or "Complexity", we are referring to the inter-relationship and inter-connectivity of elements within a system and the surrounding environment (Chan, 2001). In this phase of complexity in terms of both inter-relationships and interconnectivity, CAST suggests that the most productive state for this system lies at the 'edge of chaos', where there is maximum variety and creativity available (Health Foundation, 2010). Within a Ports Infrastructure System, lie the Agents, which includes Labor Forces, Marine Terminal Operators, Port Authority Executives, Rail Operating Companies, Warehousing and 3PL Services. These are all interconnected sub-components to various echelons of government, regardless of geographic location. Through this hierarchy, the interconnected networks are designed to rely on one another, and through applying adaptable resilience strategies to each of these sub-components, allows the freedom and flexibility to orchestrate solutions and controls when disruptions start to overwhelm branched connections in the model. These disruptions, can be generated internally and externally from their surrounding environments (Oughton et. al, 2018). However, the edge of chaos depends on the Operational Decisions, Interventions and choices each sub-component makes. If one makes an incorrect decision on how to manage and control

disruptions, the entire linkage of the supply chain will fail, and a new strategy must be implemented to regain lost control.

Figure 3: Complex Adaptive System Model (Source: Oughton et. al, 2018)
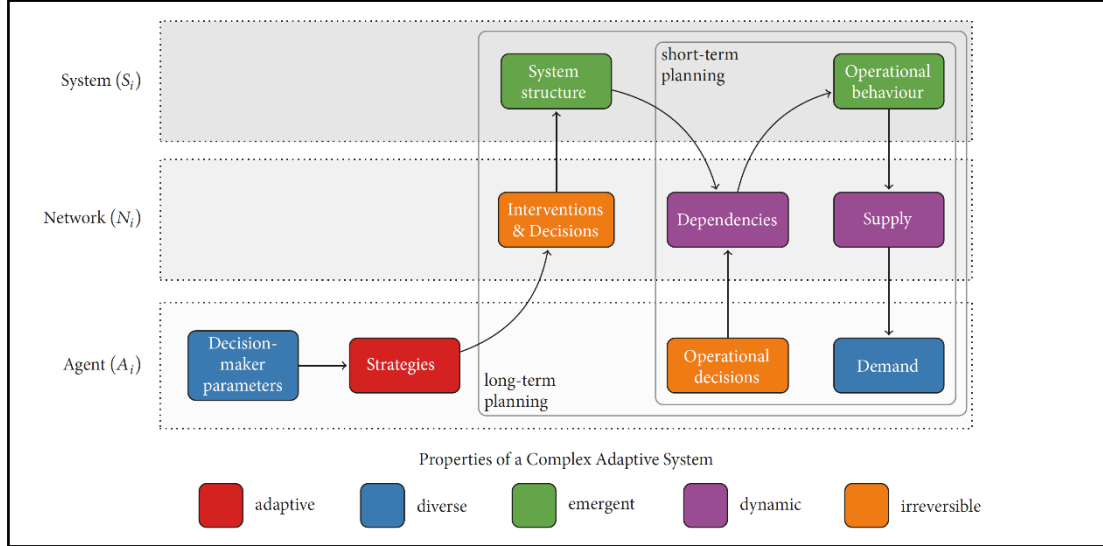
This demonstration of CAST (Figure 3), allows the Port Terminals to maintain a constant flow of energy to maintain the performance of a system, in which this case, how to continuously move containers forward and reverse rapidly and direct to and from ship to markets, with eliminating rail and highway congestion, and warehousing which can provide the ample space required for storage and movement of goods. If Container Terminal capacity becomes significantly reduced at a Port Facility due to congestion, the Port Authority may look to temporarily rent allocated surplus space within close vicinity, to move excess containers away, and eventually recirculate back into the supply chain. Another strategy for utilizing multiple rail lines in synchronized directions to optimize cargo flows, vice only using one or two dedicated channels. This is considered inter-communication and coordination through established connections of the CAST to be elastic and flexible in order to adapt for short periods of time before returning to normal cargo configurations.

Chapter 3.2.1 Nonlinear Dynamics

Another component of CAST, is understanding the variables of nonlinear dynamics in contrast to developments which could escalate to chaos theory. Nonlinear Dynamics can be described as multidimensional vectors within an information feed-back system (Wilding, 1998). All series of logistics and supply chain systems, including Port Terminals, are made up of these series of feedback control loops. These systems exist, when the environment, such as market demand and supply, develop into decision making processes, which results in actions directed by businesses, which impact the same environments and influence future decision making. This is a continuous, renewable process with re-emerging positives and consequences. Though this theory appears chaotic, unpredictable and counterintuitive, the behaviour in which feedback loops work, isn't random and can become recurrent overtime if not fully understood (Thompson & Steward, 2002). On one hand, examples include the number of containers loaded from multiple shipping liners through shipping alliances to cover blank sailings, as well as on the other hand, the relationship between available inventory which impacts shipment rates from warehousing.
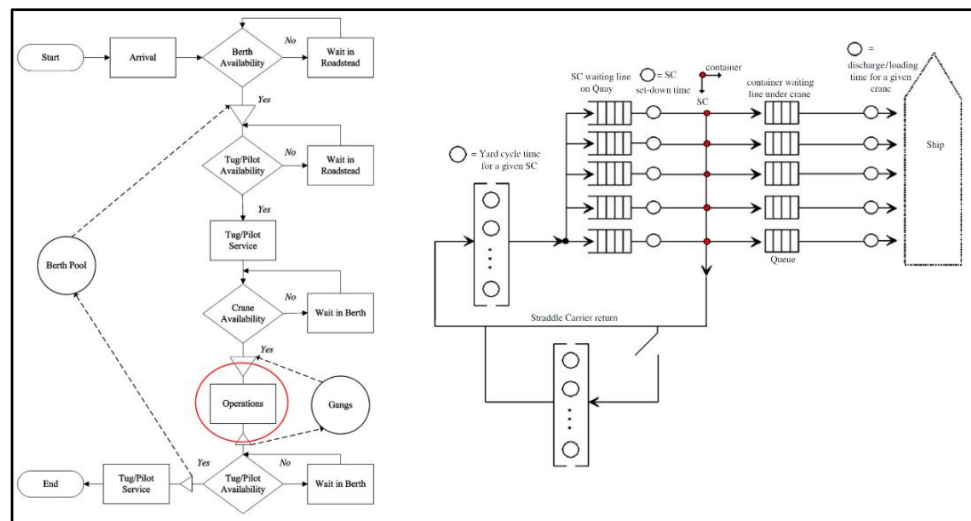
Figure 4: Example of a Container Terminal Queueing Model (Source: Canonaco et. al, 2007)

It is also, necessary to devise models to evaluate performances of container terminals through nonlinear programming and dynamic modelling. According to Aleesandri, Cervellera Cueno, Gaggero and Soncin (2009), with considerable growth of container shipping, it become crucial to maintain efficient management within container terminals. There are methods such as queuing theory, which was developed by Agner Krarup Erlang in order to address delays of telephone wait times through phone switchboards in the early 1900's (Heyde, 2001). In modern times, Queueing Theory has been used to evaluate port terminal performance measures (e.g., Figure 4), by determining the optimal number of berths based on occupational times, rates at which how often the berth is vacant or utilized, expected wait times for vessels, as well as truck gate times with the number of truck lanes to teller booths available to complete transactions (de la Peña-Zarzuelo et. al, 2020). In summary, nonlinear systems admit multiple solutions through multiple scenarios of behaviours, which when aggregated beyond controllable levels, can develop into Chaos Theory.

Chapter 3.2.2 Chaos Theory and the Butterfly Effect

CAST Modelling also factors into account the consequences of Chaos Theory. As a directional flow of nonlinear systems at extremes, Chaos Theory can be defined as a dynamic state of confusion or disorder, which erratically evolves over the two fundamental subjects of change and time, through processes of mathematical dynamic systems (Williams, 1997). Chaos Theory carries multiple characteristics, which have serious implications to Supply Chain Management. According to Wilding (1998), the three which are most relevant to supply chain disruptions are sensitivity to conditions, aperiodic behaviour, and pattern generations.

Sensitivity can be seen as a centralized concept of Chaos Theory, though this doesn't automatically imply chaos. Small errors are amplified exponentially to a point until there is no distinct means to differentiate between disruptions. The only way to detect chaos, is through Lyapunov exponents. Through calculations of propagation, a system can be determined chaotic if one positive Lyapunov exponent is present, while a negative would return as a stable system. This has been demonstrated through various linkages of the Supply Chain for the Port of Los Angeles, particularly warehousing, rail and chassis dwell times (Martin, 2021).

Aperiodic Behaviour can be described as irregular oscillations that do not exponentially grow, retract or move within a steady state of motion. Such examples could be compared and contrasting information from various global markets and analytics, such as NYSE, NASDAQ, Dow Jones Industrial Averages. Maritime Analytics can also be applied through freight indexes, stocks, new build and scrap prices and orderbooks, which can be observed through research information systems such as Clarksons, Shipnet ONE, and Spire Analytics.

When we forecast Chaos Theory in computer simulation, we can see that despite chaos' irregular behaviours of randomized data, it produces similar patterns within its data. Though these never repeat as exact same copies of one another, but carry distinct characteristic properties. Snowflakes are perfect examples of this replication of irregular behaviour through its interactions with the environment during formation, also known as attractors. These represent microscopic tears and disturbances, which are amplified until the full pattern is formed.

COVID-19 being classified as a Global Pandemic by the World Health Organization in March of 2020 (WHO, 2020), can be seen as a Chaotic

System. Strong evidence supporting this through random disorders of customer demands for products, inability to rapidly manufacture these same products, and inability to restock these items at the same rates at which they are being depleted. Commodities such as Personal Protective Equipment, Toilet Paper and Sanitizing Products were rapidly depleted from grocery and convenience stores. These small ripple effects within the timeframe of the beginning of COVID in November 2019 to April 2021, have evolved into multiple butterfly effects. These effects, though initially small, transpire to significant uncontrollable events. With Amazon Warehouses being depleted from consumers staying at home, lack of laborers at warehousing, and restrictions of social gatherings and activities, forced the logistics company to hire 100,000 additional workers in order to compensate for uncontrollable demand flows (Barrero et. al, 2020).

Chaos Theory can also be influenced by Geo-Political Events, such as disruptions with major trade partners of the United States. These could include engaging in acts of war, invading and annexing adjacent countries, and completely blocking and embargoing trade. These few factors alone, could put significant strains on the relationships between the United States, the United Nations, inter-governmental and non-governmental organizations, and host nations that feed into them.

In summarizing Complex Systems Theory, through Nonlinear Dynamics and Chaos Theory, there are four simplified methods that can be implemented, for management operating through and to remove chaos, as demonstrated in the following examples (Wilding, 1997):

- Long term planning is very difficult, focus on short term forecasts. It is better to allocate resources for developments of short-term effective decision making, rather than long term. For Port Terminals, focus on

how to correct short fall deficiencies, whether gate congestion, dwell times and rail, if capacity and containers per hour are not immediate threats.

- Focus on the market, by communicating information as far upstream through the supply chain as possible and adopt leaner approaches to make operations streamline and fit.

- Treat the supply chain as one complete system, and not segments. Port Terminals and Authorities are connected to endless branches of logistics. Small changes to optimize one component may result in massive changes to other parts.

- Realize that supply chains never achieve stable equilibrium, small perturbations will always be present in demand and supply markets, as well as influences from global events.

Understanding these elements, we can complete our resiliency framework by implementing absorptive and remaining capacity, adaptive capacity, adaptive resilience, and restorative capacity measures within our terminals.

Chapter 3.3 Absorptive and Remaining Capacity

Absorptive Capacity is the ability of a mode or terminal to absorb disruptions or stall chaos while maintaining levels of service. Some examples of this, is supply within warehousing that is meeting the current demand cycle of the consumers, but is not actively or rapidly being replenished at a rate which could equalize or add surplus to the demand cycle. The remaining capacity, is the amount or level remaining that a Port Terminal or Supply Chain System can manage on its own before complete failure

Chapter 3.3.1 Adaptive Capacity

Adaptive Capacity, is when a Port Terminal can route and reroute cargo through different nodes and segments during a disruption in order to maintain a level of service (Rodrique et. al, 2021). As reflected in our AHP Model in Chapter 6, we will analyse Infrastructure, Planning and Port Labor, which contain criteria relevant to expanding our adaptive capacity. These include, Road & Rail, Communications, Coordination and a Flexible Workforce. This could mean that if on-dock railing would become severely congested due to bottlenecks at Intermodal Cross Deck Stations, or scarcity of rail chassis by increased dwell times a container, that the port would utilize more trucks in order to appropriately move more container flows outside the port and to either warehousing or directly to market. It could also mean, if the congestion was significant enough to disrupt both truck and rail, and if in extreme cases were to cause weeks of delays, traffic could be rerouted to other ports or transhipment on smaller ships or barges could be utilized. Adaptive Capacity is a reaction to remaining capacity, in order to keep the system sustainable and functional.

Chapter 3.3.2 Adaptive Resilience

Adaptability in general, is the ability to adjust to new conditions (Oxford, 2021). These abilities to adjust and necessary, in order to interact dynamically between Port and Supply Chain Systems, is critical to control and prevent disruptions. Utilizing the 4 tiers of Port Terminal Resilience, we can modify our operational methods, including the working relationships between Marine Terminal Operators, Longshoremen, Warehousemen, Rail Companies and Drayman. One of the largest priorities that we have learned through the COVID-19 Pandemic, is the ability to maintain a sustainable workforce. Whether demand is scarce or heightened due to surges in demand, laborers such as highly skilled and qualified operators for heavy capital

equipment, efficient gang teams, and other labour systems within a port are irreplaceable, even with the introduction of automation.

For terminals with automation, well-trained and qualified personnel are still required, all whom are expected to know each component, system, control and how to react when this fails.

Chapter 3.3.3 Restorative Capacity

A ports Restorative Capacity, is its ability to return to a service level similar to or better than previous evaluated performance measures recorded prior to disruptions or chaotic events. This can be effectively modelled through trends of seasonality, annual changes in GDP growth and decline, globalized index's, inflation, and market share of import/export by country. Restorative Capacity is a critical part of Maritime Transportation Systems (MTS) (Figure 5), because it symbolizes time, returned and/or gained capacity. With utilizing market modelling and aggregating a ports restorative capacity, will allow decision makers the insight to see the strength of their resiliency frameworks.
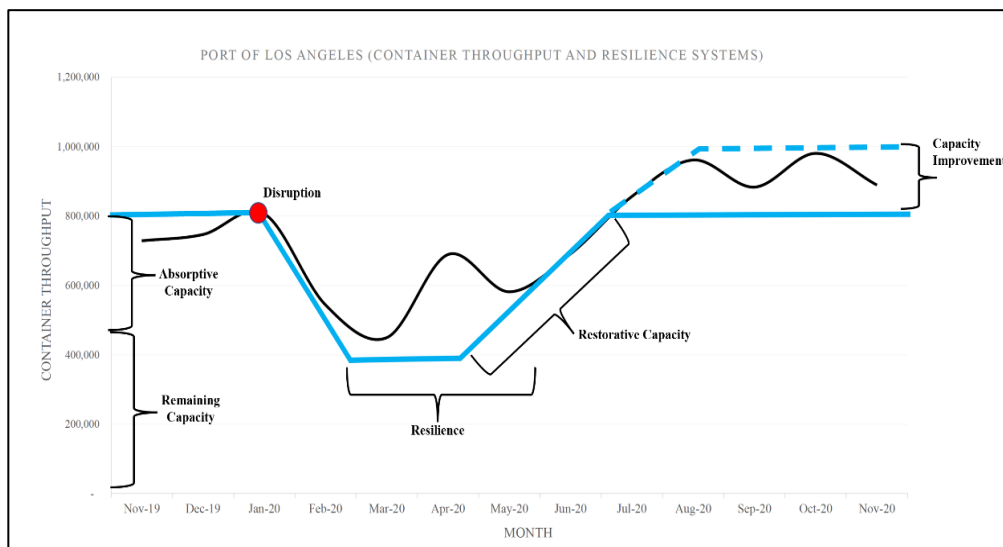
Figure 5: Modification Resilience of Maritime Transportation Systems (Source: Rodrique et. al, 2021)

CHAPTER 4 – Modelling the Case Study: The Port of Los Angeles, CA

To understand how disruptions, such as COVID-19 have impacted the Port of Los Angeles, we need to analyse series of events which occurred from January 2019 to April 2021. With almost three years of data, we can thoroughly map out events that caused disruptions through Labor Disputes, Geo-Political Strains, shutdowns and lockouts of manufacturing facilities, COVID-19, and the aggressive measures the United States introduced through stimulus packages, unemployment assistance, pay check protection programs, loan forgiveness, bail-out loans for major corporations and funding to state and local governments. The culmination of all these events, contributed to the initial disruption of Port Terminal Performance at the Port of Los Angeles, to April 2021's record setting cargo volumes in the Ports entire history.

Chapter 4.1 Declining Affairs and Premonition of Global Disruption

With the state of affairs in the United States in 2018, the 45th elected President of the United States, Donald J. Trump, initiated several aggregated raises of tariffs specifically on steel and aluminium on top exporting countries and specifically with China, in order to correct the $330 billion USD trade gap (Kapustina et. al, 2020). The United States also raised its tariffs on Chinese imports of textiles, machinery imports and apparel. In response to be competitive, China initiated lower tariffs for other countries within geographical range, and increased tariffs on the United States, strategically targeting critical exports of Agricultural Goods (wheat, soybeans, corn, cotton, dairy, nuts, prepared food products, pork and beef products). On May 10, 2019, before the G20 Summit, the Trump administration initiated a 25% tariff increase towards China, which would take full effect at the end of the year in December (Itakura, 2019). Escalation

of this war, has contributed to the largest welfare loss of Gross Domestic Product (GDP) for China by -1.41% and -1.35% for the US respectively.

 With many businesses and fashion industries relying on cheaper manufacturing of production through China, and with the predicted demands of seasonality's of summer, back to school, fall, and American holiday's, businesses ordered surplus of products in order to guarantee supply, and to receive these orders before the increased tariffs were placed into effect as well before the Chinese New Year. In a Report 'By the Numbers' issued by the Port of Los Angeles (2019), is a full comprehensive study on how the US-China Trade War tariffs will impact the Port of Los Angeles as well as the entire economy of the United States. At the time, Executive Director for the Port of Los Angeles, Gene Seroka, went to Washington D.C. during a news conference with stakeholders to discuss these findings and proceedings (Port of Los Angeles, 2019, 9:28). Simultaneously, with no response politically from all levels of US Government to urge lowering the tariffs, the first recorded case of COVID-19 in December occurred in Wuhan, China (WHO, 2020). This would begin the emergence of the world-wide pandemic.

Chapter 4.2 Emergence and Rise of COVID-19 to Global Pandemic

As mentioned earlier, Chaos Theory derives from a series of unchecked disruptions that leads to severely impacting nonlinear systems. These three terms are Sensitivity to Conditions, Aperiodic Behaviour and Pattern Generation. With the combination of the Port of Los Angeles being subjected to the US Governments implemented tariff policies, accelerated declining of west-coast market share of China manufactured imports to the east-coast ports of the United States (Johnson, 2020; O'Connell, 2020), holiday season both in the United States and in China, and the Federal Maritime Commission's investigation against shipping carriers rejecting US

Agricultural export containers at the Port of Los Angeles, which further extended the US-China Trade Gap (LaRocco, 2021). All of these small ripple effect disruptions introduced onto the Port System, would amplify through the introduction of COVID-19. This invisible adversary would become the catalyst for logistics hardships and transport uncertainties from 2020 onwards, as nations struggled to regain control and improvise resilient strategies.

In 2020, the Chinese New Year (Lunar New Year) started on the evening of January 24th, and typically lasts for 2-3 weeks until the rise of the full moon (*Chinese New Year | Summary, History, Traditions, & Facts*, n.d.). In addition to the New Year, the travel season known as *Chunyun*, occurs two weeks prior to the New Year and extends for a period of 40 days, with limited to no manufacturing plants being operational. With an estimated 440 million passengers expected to travel through China by all intermodal modes, controlling and containing the spread of the coronavirus outbreak would be difficult (Lee, 2020).

With the first case of COVID-19 emerging in Washington State on the West-Coast of the United States and several days later, the Chinese Government imposed quarantines and strict lockdowns on Hubei, Zhejiang, Liaoning and Jiangxi provinces in order to isolate the epicentre of the coronavirus (AJMC, 2021); which posed a serious threat to global trade and transportation. Social Distancing was practiced by cancelling many events, gatherings, closing of public places, schools and universities, and people forced to stay at home, which meant shut down of manufacturing plants and facilities for exports (Lau et. al, 2020). Eventually, many countries including the United States, issued travel bans. With lockdowns imposed, shifts in demand of consumer goods increased.

While China continued to increase the scope of its lockdowns in adjacent providences, the Labor force for the Port of Los Angeles would be returning to work near the end of January, despite the growing spread of the COVID-19, only to be welcomed to follow on disruptions.

As a guest speaker on CNBC's regularly broadcasted morning show "Squawk Box", Executive Director of POLA Gene Seroka, explained that 40 vessel sailings were cancelled from February 11th to April 1st of 2020, which represents 25% of normal vessel call during that period of time. In addition, strong uncertainties that cargo volumes will resume at regular volumes for March (*CNBC: Pain at the Ports; Virus Fallout for Shippers*, 2020, 1:16). In a follow-on Los Angeles City Council Meeting on March 4th 2020, the Executive Director explained the various economic disruptions occurring at the Port of Los Angeles. This includes reiterating the large cancelled sailings, and record declining cargo throughput from October to December 2020 (Q4) of 16% and January 1st to March 1st 2021 (QI) at 15-17% down from the previous year due to the US-China Tariffs in place. In addition, with the Port conducting half of all the trade business to and from China, the impact felt is significant, with manufacturing production throughout China operating at 40% of normal levels. This takes into account energy consumption, pollution measurements and traffic patterns. Adjacent South East Asia trading partners, such as Japan, South Korea and Vietnam, are trading at irregular heightened levels in order to compensate for the decline of business from China. (*Port of Los Angeles Executive Director City Council Presentation*, 2019, 1:11). The effects of the cancelled sailings, would impact dockworkers (ILWU), as with their coastwide contracts with the Pacific Maritime Association (PMA), would receive their salaries through the paid guarantee program, meaning that they were being paid to stay at home during COVID-19.

One week later from the Los Angeles City Council Meeting, the World Health Organization declared COVID-19 a global pandemic (WHO, 2020). At the end of March, the Chinese Government began to allow reopening and production of manufactured goods for export to resume, which in turn, caused increased sailings in order to compensate for several months of losses. This rebounded the Chinas Manufacturing Purchasing Managers Index (PMI) to 52.0pts, a measurement of economic activities in the Chinese Manufacturing Sector, from a -17.0pt. (35.0pt) drop in February statistics (see Appendix A) (McMorrow, 2020; (Purchasing Managers Index for March 2021, 2021). However, the slow accumulation of workers returning to work sites led to large manufacturing and logistics Labor shortages

At the same time, the Port of Los Angeles was having issues with accumulated capacity of empty containers, backlogs of aggregated US agricultural exports, perishable commodities meant for South East Asia due to lack of dock workers, truck drivers and cancelled sailings (Smith, 2020).

These series of events induced by COVID-19, exposed and exploited globalized trades sensitivity, by pinpointing weaknesses in the entire supply chain and inducing irregular bullwhip effects. With no quick way to cure and contain the spread of COVID, the Port of Los Angeles from March 2020, would experience many disruptions and challenges to their Port Operations and overall logistics resilience. These will be covered in the follow-on sub-chapter.

Chapter 4.3 Foreland Disruption

The Foreland, refers to the area where ocean-wise linkage occurs between Ports and International Markets by Shipping Services. As the world is covered by 71% water, transport by surface is significantly cheaper, more economical, transport capacity of ships is easier to manage and substantial potential for revenue through freight transport. Disruptions which occur in this section of the Supply Chain are usually caused by over-capacity of anchorages, storms and environmental abnormalities, limited and reduced port access, and cancelled sailings.

Utilizing statistical figures from Appendices B, C, and F, we can reference how Foreland Disruptions have contributed to degraded Port Terminal Performance, and link the study to the Port of Los Angeles.

During the months of February and March of 2019 (see Appendix B), Vessels at anchor exceeded the number of departures and vessels at berth. This was due to the ILWU strikes against APM Terminals and PMA's motion to have a necessary coastal development permit which would help implement zero and near-zero emissions automated equipment as well as reduction of emissions associated with drayage hauling at AMPT Pier 400. In a report issued by the Vice President & General Council of APM Terminals Pacific LLC, Peter Jabbour (2019), raises arguments that this not only follows the Port Master Plan, Coastal Act, and numerous state and local environmental plans, policies and requirements, but has the support and approval from the Executive Director of the Port of Los Angeles and the Pacific Maritime Association. It is also noted that cargo volumes dropped significantly, along with truck throughput times and gate transactions due to the strikes. Despite opposition from the ILWU, the permit was still issued. Five months later, APM and the ILWU came to an agreement after six-month long negotiations to establish a program to educate and train longshoremen, in order to maintain and repair the new automated cargo-handling equipment, ensuring the workers keep their jobs, while contributing to cleaner air management (Mongelluzzo, 2019).

The following year, with COVID-19 introduced, similar statistics on the West-Coast in early February of 2020, demonstrated the impacts of the Governors issued state-wide lockdowns and shutdowns in March, accumulated 40 cancelled sailings, scaled back workforce, and in all eliminated vessels at anchor. With no vessels to work on, laborers were forced to stay at home, and under their coast-wide contract, along with the Coronavirus Aid, Relief and Economic Security (CARES) Act, a $2.2 Trillion USD relief package, provided additional immediate direct payments to eligible US Citizens (116th Congress, 2020).
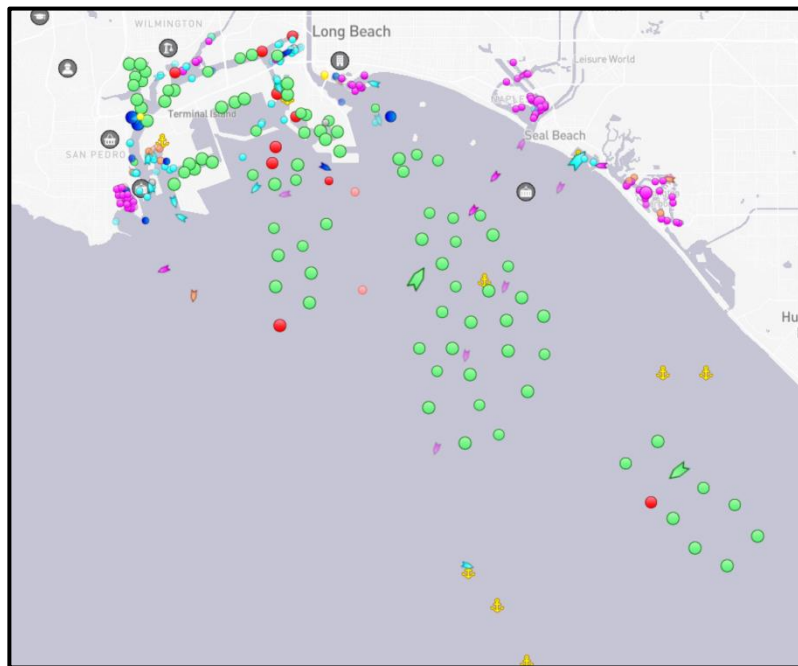
Figure 6: Vessels at Anchor or Drifting outside the Port of Los Angeles (Source: Marine Traffic, 2021)

Until manufacturing was restored, and more ships were sent from South West Asia Ports, anchorage wait times would sharply increase from two days, to weeks, while the number of ships at anchor became stagnate at 20 to 25 vessels on average for the Port of Los Angeles and Long Beach (Executive T.M, 2021), from December of 2020 to March 2021. This was due not only for COVID-19 quarantine measures enforced by the United States Coast Guard, but shifts of irregular disruptions from

within the cargo terminals and bottlenecking through failures of rail, truck and warehousing, as well as surges of positive cases for COVID-19, climaxing during the Christmas season in Los Angeles County, reaching a record of 74,000 new cases in one day (Lin, 2021).

Chapter 4.4 Port Terminal Disruption

With anchored vessels accumulating to the point of gridlock outside the Ports of Los Angeles and Long Beach, and shipping companies having to drift or reroute their vessels to ports farther north to offload containerized cargo, this posed a significant threat of sustainability and longevity for the Southern California Port Terminals.

The same chaotic effect, was occurring in the Port of Shanghai, with the port heavily congested with shipping containers and metal imports, warehouses overflowing with newly manufactured goods due to lack of trucks and chassis, as well as factories not operating at full capacity due to lack of critical components to maintain essential machinery (Bradsher & Chokshi, 2020).

Table 3

Port of Los Angeles Container Terminal Statistics

Factor	APM Terminals	Fenix Marine	TraPac	Yang Ming	China Shipping	Yusen LLC	Everport
Capacity (Ac.)	507	292	202	186	132	185	205
Berth Length (Ft.)	7300	4000	4630	2500	2500	5800	5800
# of Berths	6	3	4	2	2	3	3
Throughput Capacity (mm/y)	4.4	2.8	1.7	1.6	1.1	1.7	1.8
Automated	1	0	2	0	0	0	0
Water Depth (Ft.)	55	50	45-53	45	53	47-53	47
Portainers (Cranes)	19	16*	10	5	10	11**	6

Notes. *8 Super Post Panamax Cranes. **6 Super Post Panamax Portainers.

(Source: POLA Official Website*, 2021)

The Port of Los Angeles is comprised of six container terminals, with two operating companies (Yang Ming and China Shipping) jointly occupying the same water space known as the West Basin Container Terminal (WBCT). The seaport operates as a landlord port with more than 200 leaseholders, and generates revenue from leasing

and shipping services. The capabilities and limitations of each terminal, are listed in (Table 3).

In a research analysis completed by Martin Associates (2021) for the Pacific Maritime Association, the key constraints identified for the overall decline of Port Terminal Performance within the Port of Los Angeles, was pinpointed to hyper-inflated cargo volumes, amount of Labor hours worked by terminal per month, number of Labor gangs cancelled or not ordered, container dwell times by month (truck and rail) and truck turn times by terminal. Supporting data is also available from the Wabtec Port Optimizer, Los Angeles Harbourmasters Office, Pacific Merchant Shipping Association, Pacific Maritime Association, Pool of Pools, Harbor Trucking Association and several other Maritime Analytic Firms.

Statistics for additional Port Performance Measures defined in the UNCTAD Port Management Series Vol. 4, UNCTAD Monographs on Port Management 1987, and UNCTAD Port Performance Indicators 1976; were limited for this case study due to information confidentiality with the Port of Los Angeles, and limited availability of data through state and local records of California as defined in the Freedom of Information Act (EPA, 2021).
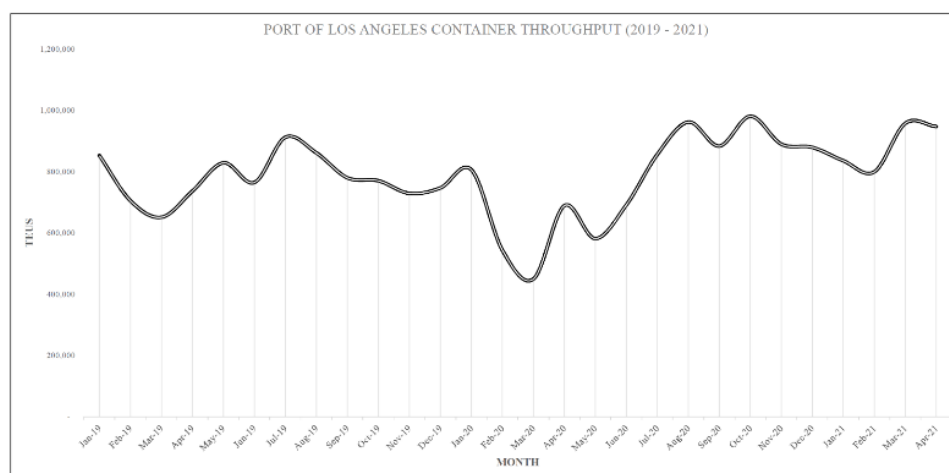
Figure 7: Container Throughput for the Port of Los Angeles (Source: Wabtec Port Optimizer for POLA, 2021)

Hyper-Inflated Cargo Volumes at the Port of Los Angeles (Figure 7), were caused by the backlogs of South East Asia Exports destined for the local economy of California, as well for Distribution Facilities which would forward this freight through the Union Pacific and Burlington North Santa Fe Rail Lines, through Chicago, Illinois and the rest of the United States. With the additional income received through various programs by the CARES Act, such as stimulus spending and payment protection programs (PPP) (116th Congress, 2020), shifted demands for manufactured goods for entertainment, home items, sanitation, as well as goods provided through E-Commerce Websites.

In conjunction with increases of demand from consumers, ILWU hours increased in response to this volume growth. However, reflected in (Figure 8), production per ILWU hour worked began to decline while TEU levels rose, which strongly reflects terminal congestion during the initial surge of April 2020 to September 2020, as well as lack of Labor Force available due to qualifications and status within the Union.
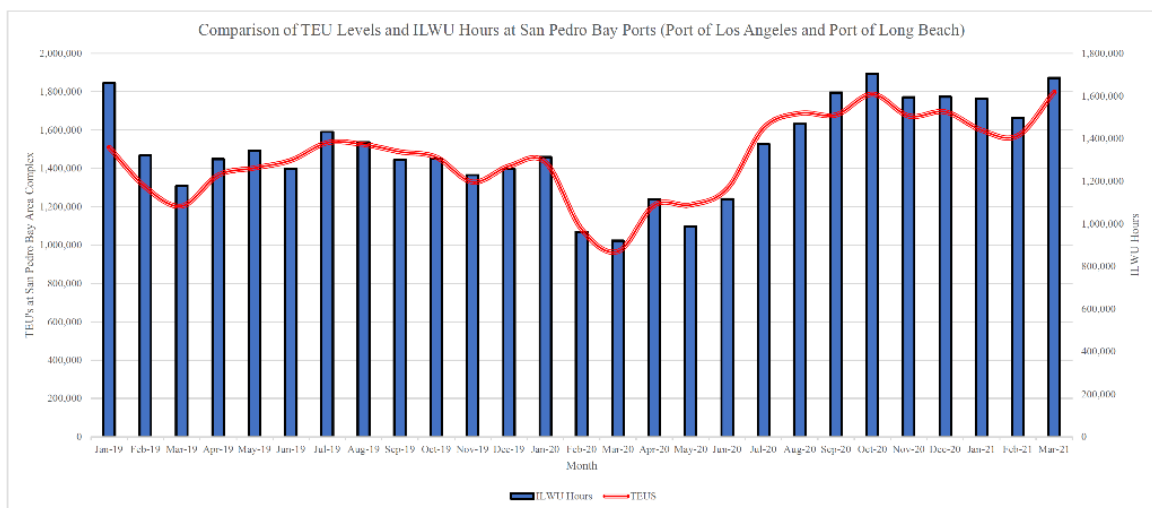
Figure 8: Comparison of TEU Levels and ILWU Hours at San Pedro Bay Ports (Port of Los Angeles and Port of Long Beach) (Source: Pacific Maritime Association, 2021)

On-Terminal Congestion, is a reflection of the growth of on-street dwell times of trucks. This number is measured by chassis turns, which is the movement to and from

transload facilities. Eventually with congestion and reduced vacancy of space at these transload facilities, led to less truck turns per day. Cargo being offloaded from ships, and not being pulled from the terminals, which congest and reduce the reserve container capacity of the Port, forcing extended dwell times inside the Terminals.

In (Figure 9), note that dwell times within all Port Terminals, exceed the Labor Hours, which strongly supports heightened on-street dwell times, and congestion at regional transload and distribution Centers. The significantly reduced number of rail-moves per day through the Alameda Corridor, also greatly impacted Port Terminal Performance. Capital Equipment issues, were not raised as a factor contributing to the decline, but rather the lack of capacity and reduced Labor in general to efficiently move the cargo.

Labor was able to respond to terminal volume demands, however the breakdown of the efficiency and stability of the supply chain through off-terminal logistics, contributed to terminal and vessel congestion.
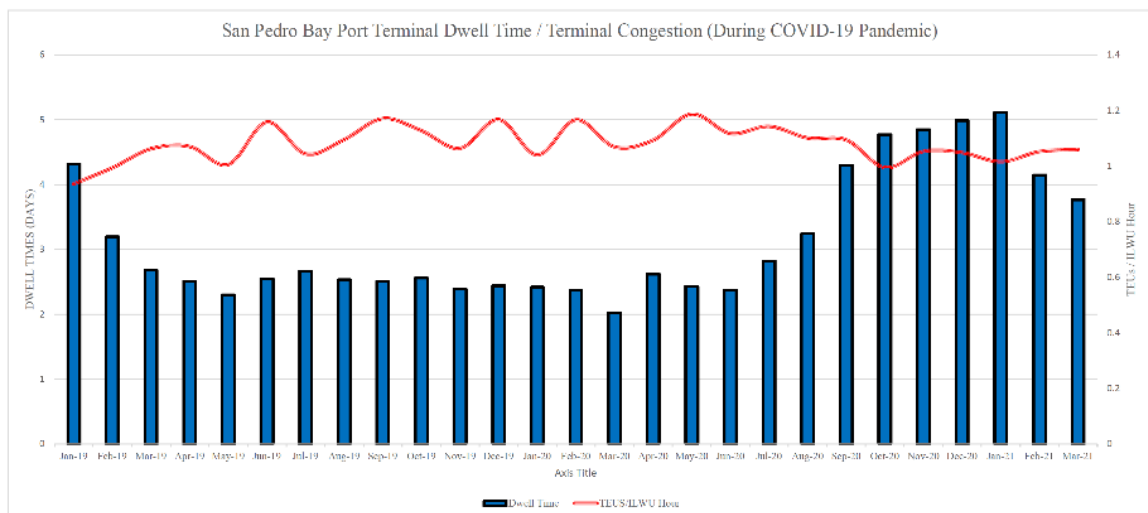
Figure 9: San Pedro Bay Port Terminal Dwell Time / Terminal Congestion (During COVID-19 Pandemic)
(Source: Pacific Maritime Association, 2021)

Reflected in (Figure 10) as for the number of container ships at the Port of Los Angeles, on average the number of cancelled or non-order Labor gangs ranged between 10% to 35% between fall and winter seasonality periods in 2020. This also coincides with the highest infection rates of COVID-19 (Appendix, X), and disruptions from rail pulls. These cancelled Labor gangs was due to overcapacity of container yards at the Port Terminals, and the lack of trucks to properly distribute them further up the supply chain.
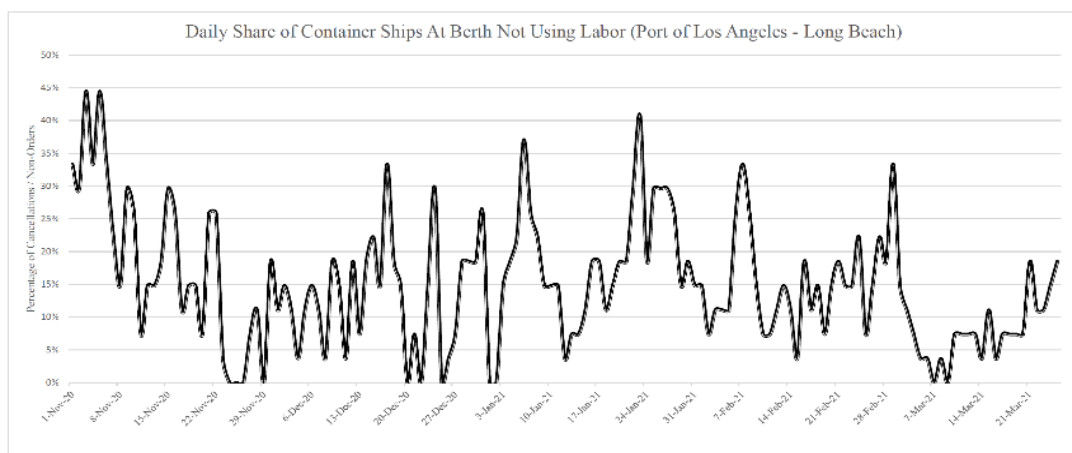
Figure 10: Daily Share of Container Ships at Berth Not Using Labor (Port of Los Angeles-Long Beach) (Source: Pacific Maritime Association, 2021)

Automated Terminals at the Port of Los Angeles, which include the TraPac Terminal (Fully), and Pier 100 of APM Terminals (Partial), have shown significant advantages over traditionally manned terminals during the past two years (Figure 11) (PMA, 2021). TEU's moved per hour had nearly doubled in comparison between May 2019 to July 2019, and tripled during heightened container volumes through the COVID-19 Pandemic (June 2020 to September 2020) despite ongoing disruptions in the terminals. Supportive reasoning for improved performance is due to programmed precision accuracy and efficiency, which drives TEU productivity and reduced degrees of error during cargo operations. Other factors include improved safety, and reduced berthing times for vessels.
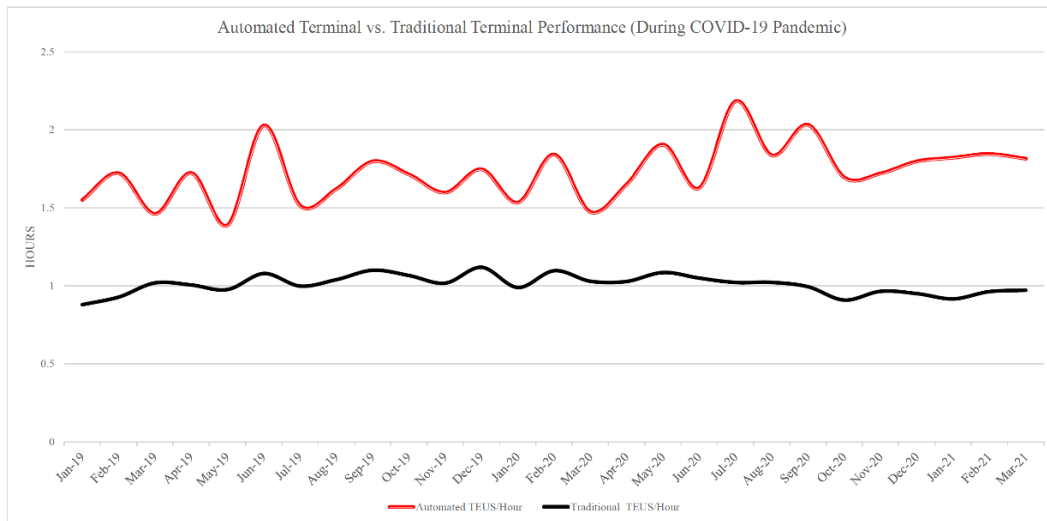
Figure 11: Automated Terminal vs. Traditional Terminal Performance (During COVID-19 Pandemic) (Source: Pacific Maritime Association, 2021)

Chapter 4.5 Truck Disruption

As Port Terminals became overwhelmed with container capacity issues due to supply chain congestion, it became critical to assess how to alleviate Truck Turn-times within the Port Terminals in Los Angeles. With nowhere to offload and transfer containerized goods to transload domestic containers, container street dwell-times exceeded standards defined by the Pool of Pools (POP), a multi-pool agreement between three major marine container chassis pools. These pools are Direct ChassisLink Pools (DCLP), Flexi-Van Central Chassis Pool (FCCP), and TRAC Intermodal (TPSP).

The services these three pools provide for the Ports of Los Angeles and Long Beach, is interoperability of their chassis across start/stop locations in the Los Angeles County Area. Under the POP, authorized truck drivers of any pool, can utilize any of the combined chassis from within the fleet. These were the findings observed and

concluded from POP, PMSA, Harbor Trucking Association and the Wabtec Port Optimizer.

From a study within the Port Terminals, Truck Turn Times at the start of the COVID-19 Pandemic, averaged 35 to 75 minutes during Shift 1 (0700 – 1600) and 35 to 100 minutes during Shift 2 (1800 – 0200). APM Terminals, the largest terminal complex at the Port of Los Angeles, consistently carried the highest Truck Throughput Times, at one point reaching over 160 minutes during the climax of port congestion in Fall of 2020. This impact, is reflected earlier in (Figure 8) and (Figure, 9), due to Dwell Times exceeding TEU/ILWU Hours, Cancelled Labor Gangs for offloading ships (Figure 10), lack of chassis, and accelerating on-street dwell times for truck and rail chassis. TraPac Terminal, outperformed all five other terminals consistently with their automated terminal, averaging 35 to 50 minutes during peak summer congestion periods.

However, several terminals took immediate action to offset disruptions and improve performance, through semi-automated operation. Fenix Marine Services (FMS) developed and launched a new Auto In-Gate (AIG) program in mid-April, reducing trucker queueing by 84% and aggressively lowering overall truck turn times at the terminal (Mongelluzzo, 2020). This is reflected strongly in (Figure 12). At the same time, Everport (ETS), underwent capital equipment, gate and terminal upgrades for performance improvements, which is also accounted for in (Figure 12) and (Figure 13) (Smith, 2020).
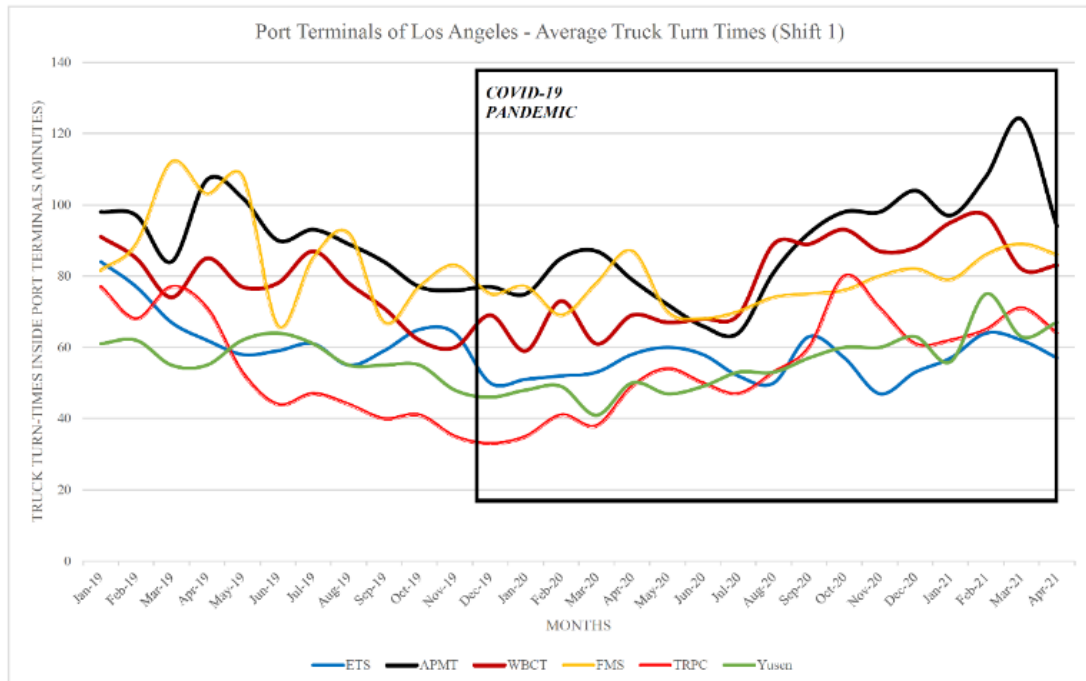
Figure 12: Port Terminals of Los Angeles - Average Truck Turn Times (Shift 1) (Source: Wabtec Optimizer, 2021)
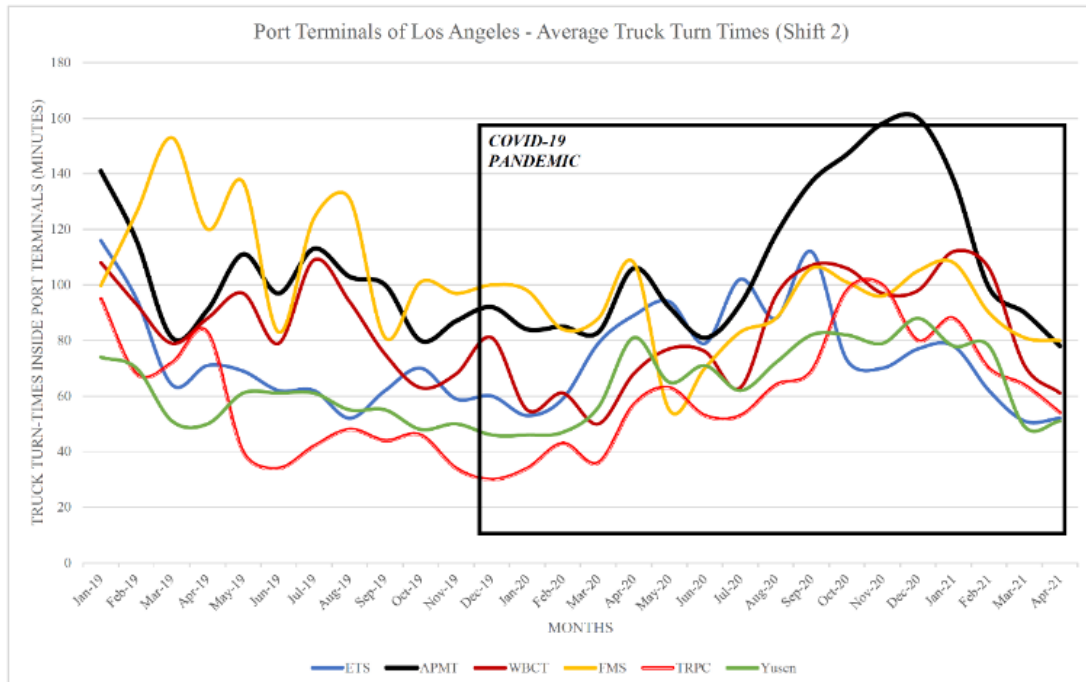
Figure 13: Port Terminals of Los Angeles - Average Truck Turn Times (Shift 2) (Source: Wabtec Optimizer, 2021)

When Warehousing vacancy within Los Angeles reached an all-time low of less than 1.5%, on-street container times exceeded 8 to 10 days (Figure 14). This meant that truck chassis could not properly discharge cargo within containers to swap for transload containers (53 ft. Standard Intermodal) therefore preventing the chassis from being better utilized. This applied to both TEU and FEU chassis within the POP. In addition to under-utilized container chassis, remaining chassis within the POP became exceedingly scarce. This was due to peak surge demands at the terminals, having not only overwhelmed reserve capacity of equipment at the start/stop points, but adding significant stress to equipment, ultimately putting many chassis out of service (Appendix F.13). With less chassis available for trucks, meant less trucks available to move containers. Dislocated chassis moves (chassis picked up from one POP and returned to another) and containers, have also added additional strain to load cargo for export (Appendix F.12). To respond to the disruption of chassis scarcity, POP developed a temporary start/stop yard for returns of bare chassis and empty containers, closer to the Port of Los Angeles. The goal to reduce the scope and distances of chassis from the terminals, assisting in increased timeliness and efficiency (Mongelluzzo, 2020, Tuthill, 2020). At its implementation in December 2020, Truck Turn-Times at all terminals began to improve.
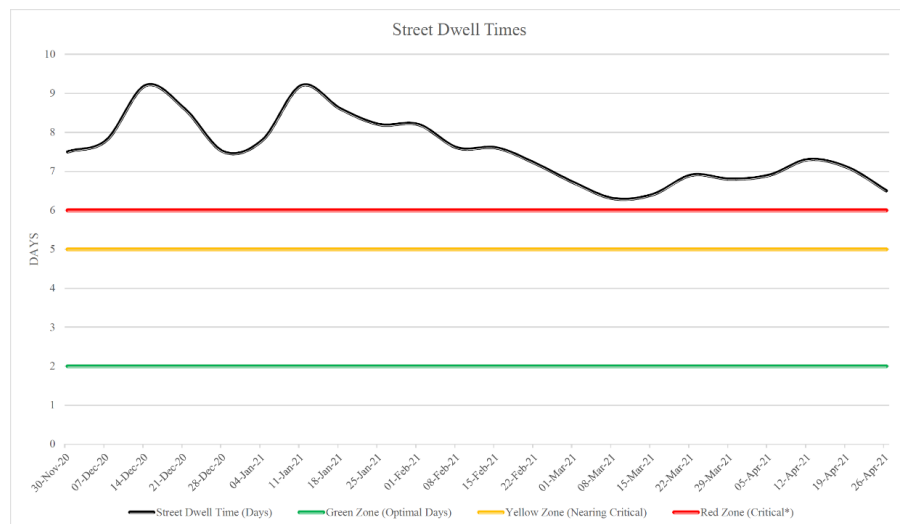
Figure 14: Street Dwell Times for Truck Chassis and Containers (Source: Pool of Pools, 2021)

Chapter 4.6 Rail Disruption

In the San Pedro Bay Port Complex (Port of Los Angeles and Long Beach), there are three major rail-lines that feed into the Ports and provide intermodal rail service through Los Angeles County and the rest of the United States. These rail lines include Burlington North Santa Fe (BNSF), Union Pacific (UP) and the Alameda Corridor which run directly to transient container yards. For the case-study, we will focus and analyse the disruptions within the Alameda Corridor, as data is not available for BNSF and UP. Following the data from PMSA and the Alameda Corridor Transportation Authority, we came to the following conclusions.
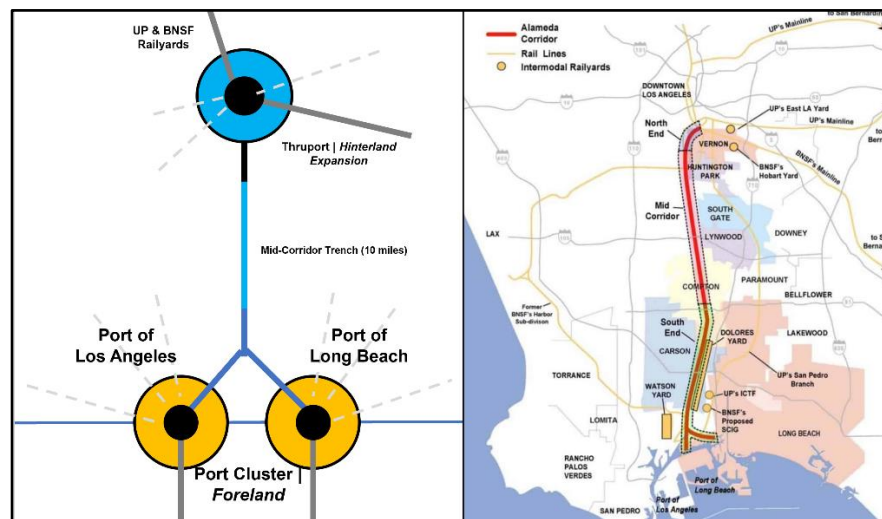
Figure 15: Port Cluster and Alameda Corridor (Source: Rodrique, 2006; Railway Age, 2019)

In (Figure 16,17), the average number of trains per day on the Alameda Corridor, was at its historical lowest in 20 years during the COVID-19 Pandemic. Data for dwell times for Intermodal Containers waiting for Rail Chassis, was only recently collected by PMSA, but captures an alarming rate of increase wait times from 8 days in January 2021, to 12 days in April. This is due to declines of warehousing vacancy, and processing, which under-performs the chassis to hold queued cargo for discharge, as well as builds the que for new containers to be replaced on the chassis at transient yards and within Port Terminals. The threshold for optimal chassis recycling, was surpassed from September 2020 to February 2021, as reflected in (Figure 18) on the following page.
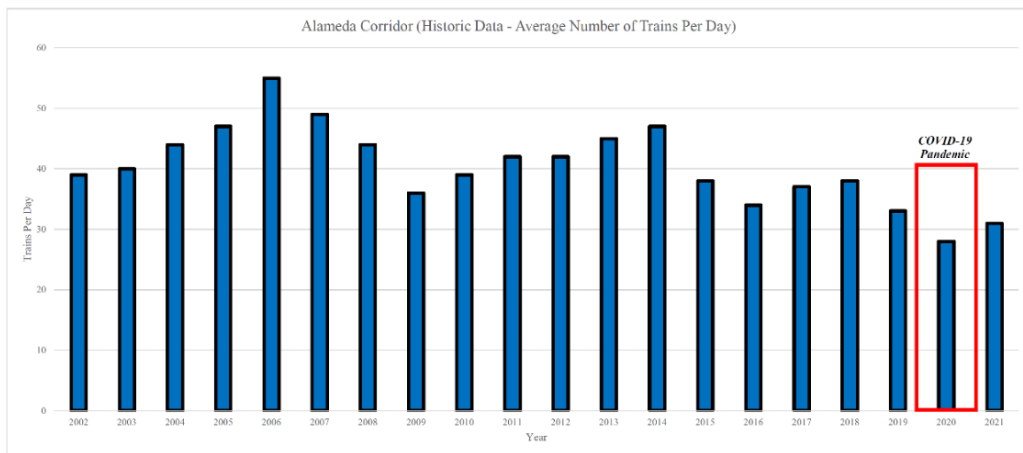
Figure 16: Alameda Corridor (Historic Data – Average Number of Trains Per Day) (Source: ACTA, 2021)
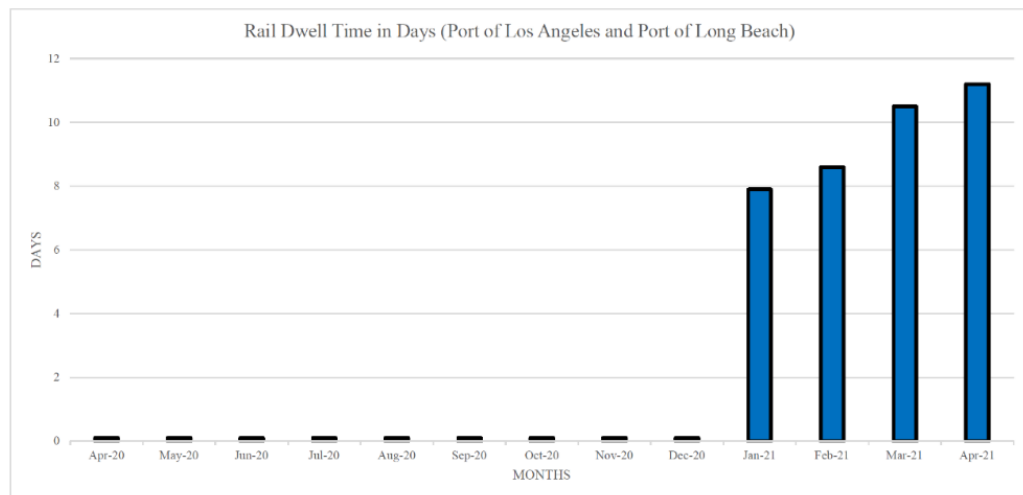
Figure 17: Rail Dwell Time in Days (Port of Los Angeles and Port of Long Beach) (Source: PMSA, 2021)
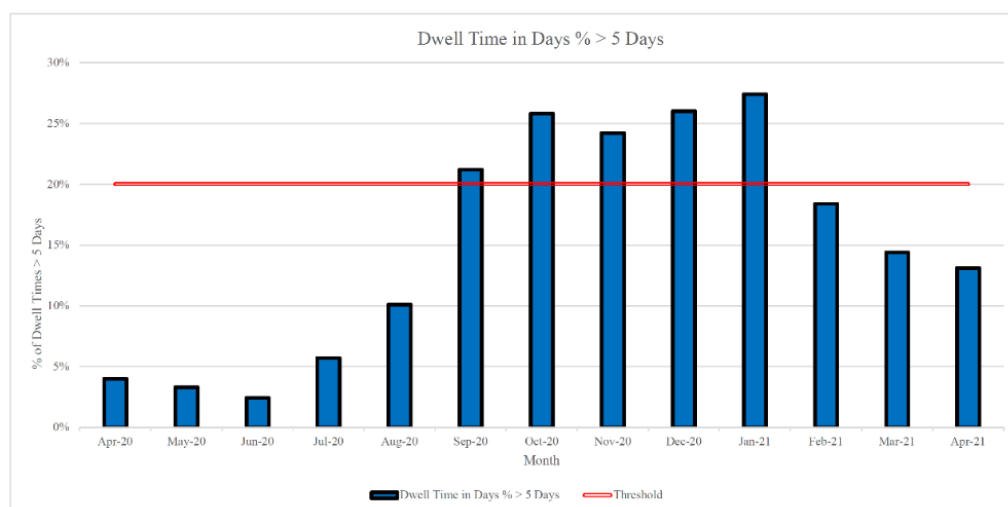
Figure 18: Dwell Times in Day % > 5 Days (Source: PMSA, 2021)

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To alleviate and correct the imbalance of rail chassis, Intermodal Equipment Providers (IEPs) have been authorized overtime to repair out-of-service (OOC) chassis, and reposition these along with truck chassis closer to the Port of Los Angeles. In September, OOC Chassis were at 4,593, which was down from 8,800 in July 2020 (Angell, 2020). Until Rail chassis have been properly repaired, service or massively produced, disruptions will continue to fall on the Alameda Corridor and the Transfer Centers they feed into. The Trade corridor Enhancement Program through the California Transportation Commission (CTC), will distribute $392.4 million USD to assist in rail programs to improve the East Basin Rail Gateway, and Fenix Marine Intermodal Rail-Yard Expansion feeding of the Alameda Corridor (Luczak, 2020).

Chapter 4.7 Transfer Centers and Warehousing Disruption

In research completed by Kang (2018), it was determined that the Port of Los Angeles feeds into 5,364 Warehouses in the Southern California Area as of 2016 (Figure 19). The concerns and basis of this report, addresses how and why warehousing locations have changed overtime and decentralized due to expansions of residential areas and re-zoning, which increases time and distance travelled for trucks and rail. It was also determined that the location of warehouses is dependent on flexibility of stringent land use regulations, high land prices, and congestion.
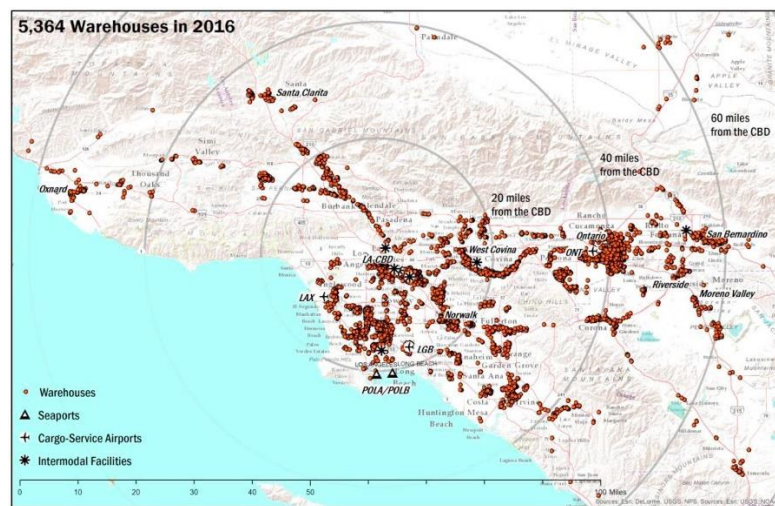
Figure 19: Warehousing Locations in Southern California (Source: Kang, 2018)

Through several reports completed by Avison Young, Lee & Associates, and DAUM Commercial, we analysed statistics for Los Angeles South Bay, Inland Empire East and West, and Los Angeles North Industrial Complexes. Criteria used to evaluate Warehousing Performance included Net Absorption, Net Deliveries, % Vacancy, Cost Per Square Foot in USD, and % Vacancy Rate by US Market. We make the following findings and concluded with the issues Warehousing faced during the COVID-19 Pandemic, and how its Ripple Effect eventually reached Port Terminal Performance at Port of Los Angeles.
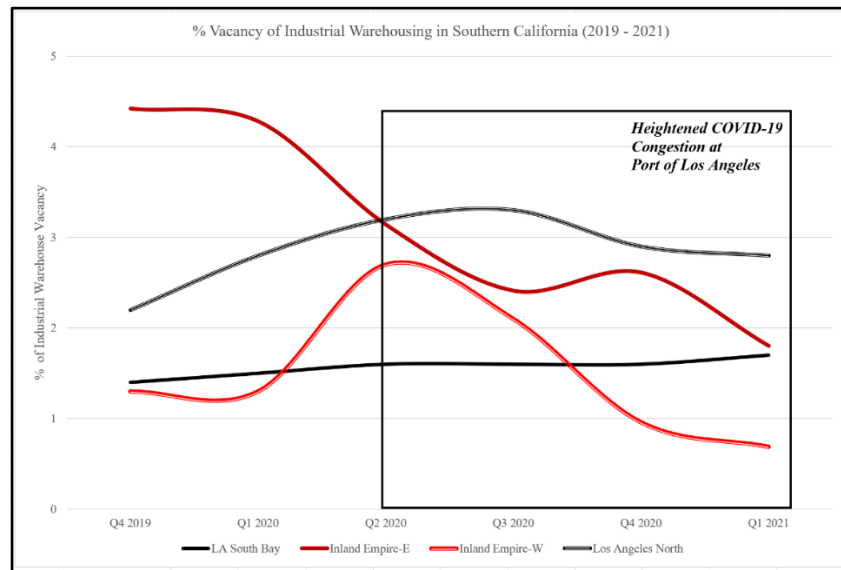
Figure 20: % Vacancy of Industrial Warehousing in Southern California (Source: Lee & Associates, 2021)

Overall Warehousing Vacancy sustained rapid declines during Q4 of 2020 due to Holiday Seasonality. This was also due to surpluses of manufactured goods in stock to avoid the 25% US-China Tariffs on goods. It's noted that Pandemic induced E-Commerce was on the rise, and was not just limited to goods, but many services such as groceries and pharmaceuticals. This increased a demand for cold-storage facilities, which to facilitate this surge would require conversion of warehousing (Avison Young Research, 2020).
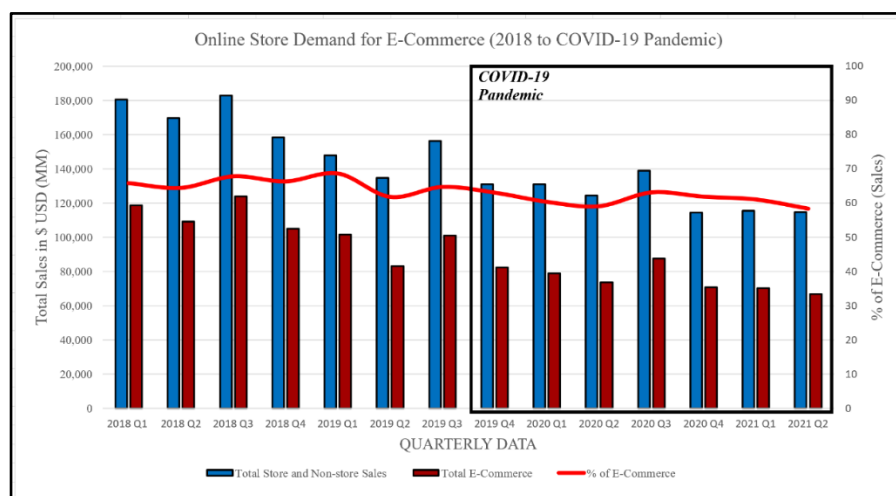
Figure 21: E-Commerce during COVID-19 (Source: US Census Bureau of Monthly Trade and Retail, 2021)

At one point, according to the US Census Bureau of Monthly Trade and Retail (2021), E-Commerce accounted for 15% overall total retail trade sales nationwide. This included Motor Vehicles and Parts, Furniture, Building Materials, Electronics, Clothing and General Merchandise (Figure 21). As for Non-Store Retailers, E-Commerce was utilized 60 – 68% during the Pandemic.
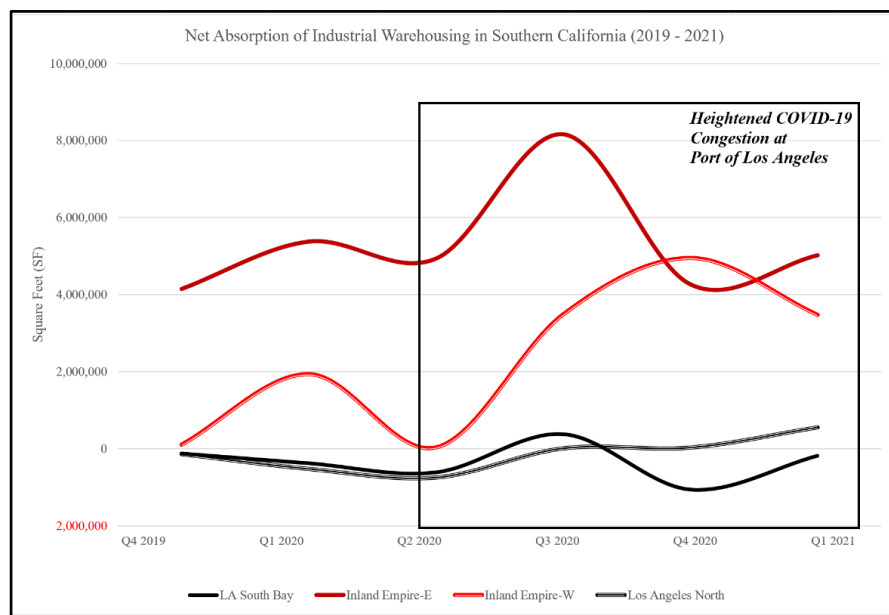
Figure 22: Net Absorption of Industrial Warehousing (Source: Lee & Associates, 2021)

It is noted (Figure 22), that out of all the warehousing areas near Los Angeles, both Inland Empire East (IEE) and West (IEW) account for > 70-75% of warehousing storage and processing, with both facilities having the highest Net Absorption of Cargo Volumes for both the Port of Los Angeles and Port of Long Beach. They also, have the lowest vacancy of warehousing space, with IEE at 1.8% and IEW at 0.69% reserve capacity for Q1 of 2021 (Figure 20). Project Statistics shared between DAUM, Lee & Associates and Avison Young, suggest that warehousing development is on the rise for IEE and IEW, but on the decline for LA South Bay (LASB) and Los Angeles North (LAN). The reasoning for both declines, is due to land availability and pricing per square foot. LAN, is the highest cost per square foot for warehousing, due to its centralized location. It is also the most difficult to

manage, due to inability to expand roads and rail. Its 2.8% vacancy rate is consistent and unchanged from the previous year, due to low vacancy rates and positive absorption, with low new inventory, makes it unfavourable for leasing. LASB, is the cheapest per square foot, but vacancy is scarce within the vicinity of the Port of Los Angeles and Long Beach, as this is prime space for container capacity, accommodation for rail and truck chassis, as well as expansions of on-dock rail, and rail that feeds into intermodal transfer yards.
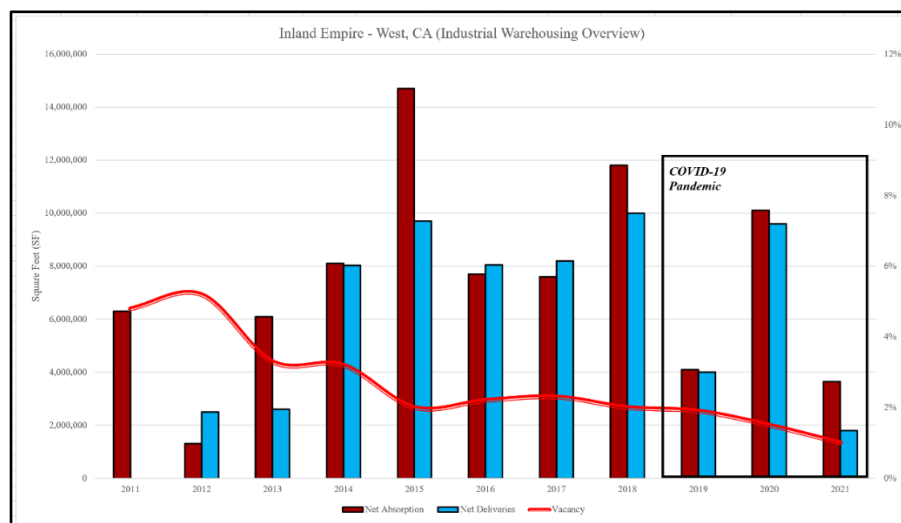
Figure 23: Inland Empire - West, CA Industrial Warehousing (Source: Lee & Associates, 2021)
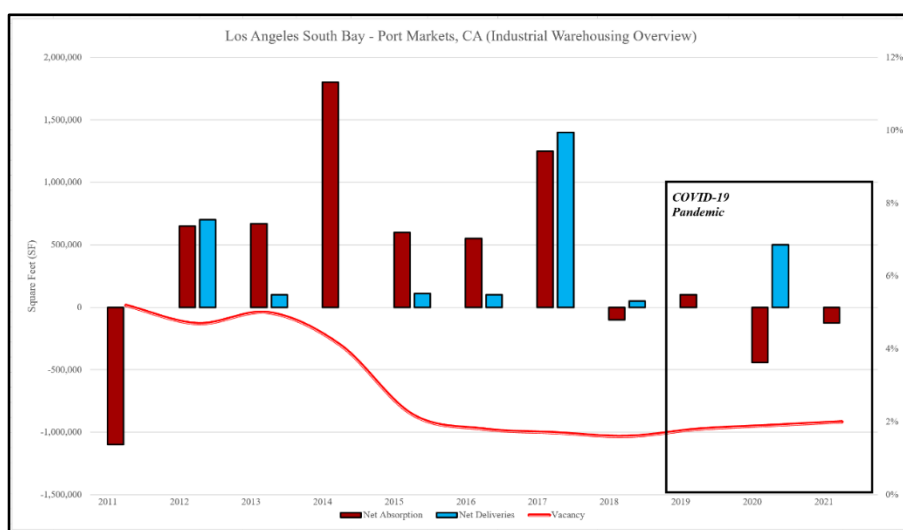
Figure 24: LA South Bay / Port Markets, CA Industrial Warehousing (Source: Lee & Associates, 2021)
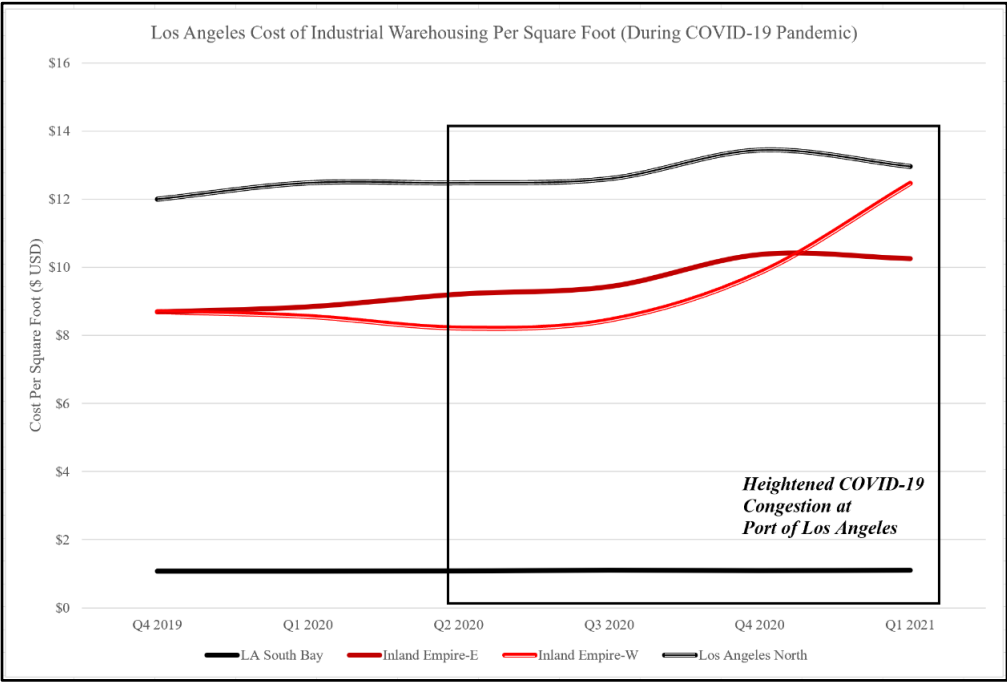
Figure 25: Los Angeles Cost of Indust. Warehousing Per Square Foot (Source: Lee & Associates, 2021)

Figure 26: Industrial Real Estate Vacancy Rate by Market 2020 (Source: Avison Young, 2021)

CHAPTER 5 – Implementing Resilient Futures

After gathering extensive data analysing the entire Supply Chain that feeds the Port of Los Angeles, we quantified it into many graphs and charts, and compared each data set against one another. We determined significant disruptions not only from within the Terminals, but all aspects of the chain were in catastrophic despair. But to truly understand the data we obtaining digitally, we must extend to sociological methods of questioning, reasoning, debating and articulating the facts and figures to present day reality. After interviews from two senior members of Port Terminal Operations in the United States, and a key Marine Economist with expertise in data driven figures, we identified the key issues and needed to draft a solution.

Table 4

Multi-Criteria Decision Making Systems

Name	Year	Author(s)	Used for Survey
Aggregated Indices Randomization Method (AIRM)	1908	Aleksey Krylov	
Analytic Hierarchy Process (AHP)	1980	Thomas Saaty	X
Analytic Network Process (ANP)	1996	Thomas Saaty	
Brown-Gibson Model (BGM)	1972	P. Brown, D. Gibson	
Data Envelopment Analysis (DEA)	1957	Michael Farrell	
Measuring Attractiveness by a Categorical-Based Evaluation Technique (MACBETH)	1997	Jean-Claude Vansnick, Jean-Marie De Corte, Carlos António Bana e Costa	
Superiority and Inferiority Ranking Method (SIR)	2001	Xiaozhan Xu	
Cased Based Reasoning (CBR)	1981	Roger Schank	
Preference Ranking Organization Method for Enrichment of Evaluations (PROMETHEE)	1982*	Jean-Pierre Brans*, Bertrand Mareschal	
Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS)	1981*, 1993	Ching-Lai Hwang*, Kwangsun Yoon*, Young-Jou Lai, Ting-Yun Liu	

Notes:
(Source: Author, 2021)

In Table 4, we referenced several decision-making processes, and determined that the Analytic Hierarchical Process, is the best way to engage senior leadership in the Port Management Sector of US Commerce. Through the process, like Chaos, we can pinpoint each segment of Port Terminals, and what criteria falls between each hierarchy which are subjected to disruptions. The AHP Port Terminal Performance Questionnaire was made available early September of 2021, and was utilized for two-weeks and sent to 50 surveyors, ranging in all aspects and skill-sets required for the full functionality of Port and Supply Chain Operations. 30 Questions were utilized, and optional comment sections were available to fully capture the surveyors reasoning and analytical understanding of problem solving for disruptions and chaos.

Utilizing the Analytical Hierarchical Process (AHP) as a method for organizing and analysing complex decisions, can help Port Executives, Governments, and Stakeholders make strategic decisions which can seem unclear when all criteria available can seem beneficial to growth and recovery of Port Systems. Through the case study survey conducted through various Port Authorities, Terminals, and components of Supply Chains, with their relation to the COVID-19 Pandemic, we can determine a general consensus for the best choices to foster Port Terminal Resilience. Another determining factor for criteria in AHP modelling, is dependent on the strengths and weaknesses of the economy, whether referring to a developed country(s) such as the United States, Europe or Asia, verse a developing country or one with poor infrastructure. Certain criteria, such as cyber-security, which involves internet of things, artificial intelligence, smart technologies, firewalls and dedicated servers, incurs heavy upfront costs, and required regular maintenance for it to maintain its ability to protect port systems. This alone, could be a deferring factor, which may be replaced with other traditional methods of security, which may help certain Port Terminals over others.

With strong constraints of time, COVID-19 protocols for the State of California and the United States, as well as available personnel to take the AHP survey at the Port of Los Angeles, the survey was extended to all major Port Authorities and Supply Chain Operators on the East and West Coasts of the United States. In doing so, allows us to fully understand the psychological aspect of how each individual surveyor reacted to multiple simultaneous disruptions within their linkage of the global supply chain to the United States. Furthermore, the survey data, paired with Port Performance data observed at the Port of Los Angeles, can encapsulate a collaborative strategy, as to the choices Port Authorities must make to better manage disruptions, including recently with COVID-19.

Chapter 5.1 Analytical Hierarchical Process (AHP) Introduction

The Analytical Hierarchical Process, or better known as AHP, is a multi-criteria decision-making technique, that helps people organize and analyse complex decisions. It was developed by Thomas Saaty in 1980, in order to address government agencies, businesses, healthcare and education processes for essential decisions for the national economy of the United States. One of the greatest challenges today that organizations face, is the ability to choose the most correct and consistent alternatives in a way that maintains the systems strategic framework, which in this case the goal in preserving Port Terminal Resilience (Triantaphyllou, 2002). The concept of a AHP structure, is to make pair-wise comparisons of criteria, in which we describe in the follow-on sub-chapters.
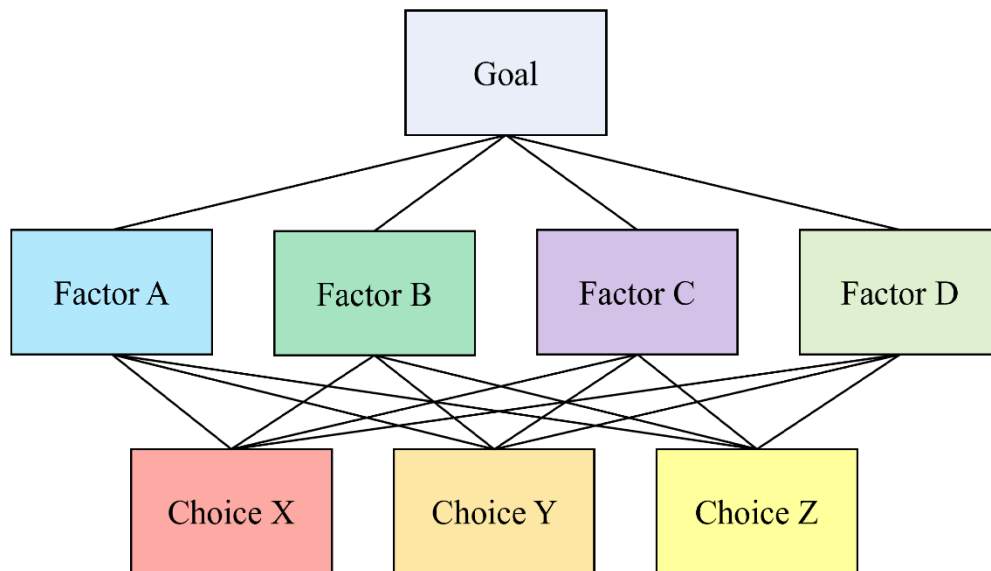
Figure 27: AHP Basic Structure with Two Levels (Source: Teknomo, 2006)

The importance of each data pair, is to establish which one takes precedence over the other through weighted averages. Following Shan, Zhou, Thai, Wong and Yuen (2017) port-centric supply chain disruption threat study, we utilize four distinct pillars of Infrastructure, Planning, Port Labor and Security. With comparing these

four distinct sets against each other in a Criteria Comparison Matrix (CCM), and determine their weighted averages through a Normalized Criteria Comparison Matrix (NCCM), we process the four additional sub-categories, which emphasis attributes to each foundational pillar. These additional pairs, will be crossed examined in their own Criteria Comparison Matrix's, like the previous sets, to determine weighted averages. These new averages will determine which subsets will provide the best alternative outcomes, or final choices that the Port Authority, Marine Terminal Operator, or the State Government can utilize for their resilience framework, as defined in Chapter 3. Before making final decisions within the AHP Process, we will conduct a Consistency Check, which will verify that the choices made are closely related to the transitive choice, which is the logic of preference. For example, If Infrastructure (I) is preferred over Planning (P), we would write this as I > P. Following on with the comparisons, Planning (P) would be compared to Port Labor (PL) which can be written as P > PL. Since I > P, and P > PL, we can assume that I > PL, which establishes that the dataset is consistent. If the answer chosen, is I < PL, this demonstrates inconsistency, which will be elaborated further on in the sub-chapters. Once the Consistency Index is established, we compare it with the original CCM to solve for the Consistency Ratio (CR), which will verify that all criteria chosen through the evaluation is consistent.

Chapter 5.1.1 AHP: Model Sequence
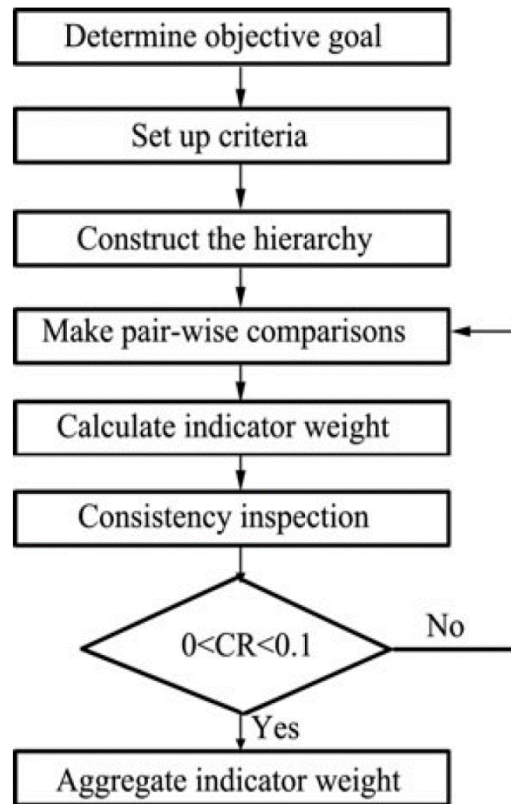
Figure 28: AHP Steps (Source: Liu et. al, 2013)

Figure 28, describes the step-by-step process for completing the AHP Model. First, we establish an overall goal with criteria, and alternatives as the final decisions and model these into a multi-tiered hierarchical structure. We evaluate these elements by pair-wise comparisons of each criteria level to obtain weights of elements. These weights will dictate which choices are more significant, and eliminating choices which are insignificant. After calculating weights for all elements through normalizing our preliminary Criteria Comparison Matrix, we conduct a consistency check. If all tiers of our Port Terminal Resilience structures do not demonstrate complete consistency (Value < 0.1), then we must re-evaluate the criteria choices and their weights again to complete the consistency check. Following this, we will rank and select the best alternatives.

Chapter 5.1.2 AHP: Model Structure

To answering the question "How can Ports implement changes in order to build and restructure its resilience?" we develop our AHP Model (Figure 29) with the four pillars from Shan et. al (2017), which include Infrastructure, Planning, Port Labor and Security and their sub criteria, which are important elements within Port Terminal Planning and Performance.
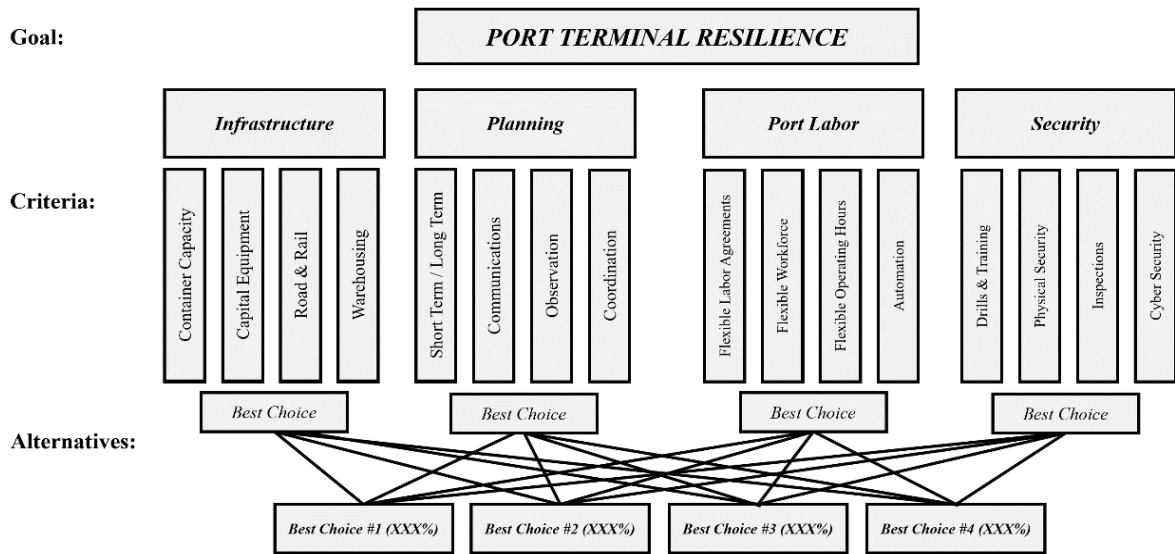
Figure 29: AHP Model for Port Terminal Resilience (Source: Loh et. al, 2017; Author, 2021)

Underneath the Infrastructure Criteria, we established Container Capacity, Capital Equipment, Roads & Rail, and Warehousing. All of these are essential physical systems and structures of a Port Terminal.

With Planning, we decided to utilized Short-Term & Long-Term Goals, Communications, Observation and Coordination. This focuses on the sociological aspects that drive human interaction through verbal, visual and cognitive activity.

Port Labor focuses on the essential workers who operate heavy machinery, capital equipment, gang teams, and work at Intermodal Cross Deck Facilities and Warehousing. These specifically include Longshoremen (Dockers), Warehousemen,

Crane Operators, Top Handler Drivers, Side Pick Drivers, Craftsman, and Draymen (Truck Drivers). Though sociological aspects are similar to pillars within the Planning Criteria, these focus on job-oriented, highly specialized physical components that drive the movement and work of the Labor Force and Operations within Terminals and Facilities. These include the Labor Agreements, Flexible Workforce Roles and Operating Hours that occurs through contract agreements and arbitrations with the Pacific Maritime Association (PMA) and the International Longshoremen and Warehouse Union (ILWU), which are specific to the case study. On the East Coast of the United States however, are different Union Labor Pools such as the International Longshoremen Association (ILA), International Brotherhood of Teamsters, and the International Brotherhood of Boilermakers, Iron Ship Builders, Blacksmiths, Forgers and Helpers. These are important, due to established work, rest, pay and vacation rules, which are agreed upon.

Finally, Security Criteria focuses on the physical and digital aspects of protecting Port Terminals. Cyber Security includes port terminal programs and software for Finance, Automation (Gates, Vehicles, Capital Equipment), Firewall Protection (against phishing, malware, extortion, hacktivism, ransomware) (Senarak, 2020), and IT Services. Inspections within Security criteria involve human health assessments and analysing declaration of cargos for contraband and dangerous substances and goods, which could impact the local and national economy at the port of entry to the country. Physical Security involves the structural integrity of barriers, gates, ease of access and contingencies taken when threats are elevates from minimal to severe at Port Authorities, Terminals and adjacent facilities. Finally, Drills and Training focuses on social interaction and communications between government agencies to be proactive and reactive to threats that could impact the port and local economy.

Chapter 5.1.3 AHP: Criteria Matrix and Pair-Wise Comparisons

After developing our base Criteria Comparison Matrix and developing our Survey Questions (Annex L), we must evaluate each criteria's levels of importance through pairwise comparisons. This will determine their precedence in order to obtain Criteria Weights.

Following the guidelines from Saaty (1980), Teknomo (2006), and (Table 5) each pair is evaluated by their Intensity of Importance. For this survey, we utilized scale numbers between 1 and 9, eliminated intermediate values between two adjacent judgements. An entry of 1, would mean that both categories being compared are equally important. Whereas a rating between 3 to 9 in either direction, would demonstrate elevating importance of the first element over the second in the pair (i.e., A > B, or B > A).

Table 5

Intensity of importance	Definition
1	Equal importance
3	Moderate importance of the first element over the second element in the pair
5	Strong or essential importance of the first element over the second element in the pair
7	Very strong importance of the first element over the second element in the pair
9	Extreme importance of the first element over the second element in the pair
2,4,6,8	Intermediate value between two adjacent judgements
Reciprocals of the above non-zero numbers	The inverse of the importance (e.g. a value of $\frac{1}{5}$ means that the second element has a very strong importance over the first element in the pair)

(Source: Saaty, 1980)

Upon completion of the Port Terminal Performance survey, each category of criteria was examined to determine their intensity of importance, which can be examined in the AHP Criteria Evaluation Table (Appendix, Table K.1).

In this table, we take all the results from pair-wise comparison questions, and formulate separate columns with corresponding rows for each surveyor.

Choices which strongly in favour Selection A, would have a positive integer, while negatives represent Section B.

$$\text{For a matrix of pair-wise elements:} \begin{bmatrix} C_{11} & C_{12} & C_{13} \\ C_{21} & C_{22} & C_{23} \\ C_{31} & C_{32} & C_{33} \end{bmatrix}$$

Figure 30: Pair-wise Element Table (Source: Bunruamkaew, 2012)

Table 6

AHP Process: Main Tier (STEP 1)

	Criteria Comparison Matrix (C)			
	Infrastructure	Planning	Port Labor	Security
Infrastructure	1.000	3.000	2.000	2.000
Planning	0.333	1.000	1.000	0.500
Port Labor	0.500	1.000	1.000	2.000
Security	0.500	2.000	0.500	1.000
Sum Columns	2.333	7.000	4.500	5.500

(Source: Author, 2021)

Once these rows and columns are formed, we take the averages of each column, to determine which will be the overall graded criteria to enter in our first Criteria Comparison Matrix Table.

Chapter 5.1.4 AHP: Normalized Principal Eigen Vectors and Weights

After establishing our Criteria Comparison Matrix (CCM), the next step is to compute our priority vectors by normalizing them, also known as normalized eigen vectors. The term Eigen, is as a German term which means "belong to" or "unique to" in relation to the original CCM Table created. The goal of these vectors, is to take the data from the preliminary data set (Table 6), and transform these numbers into more manageable sets, which will help us determine each criteria's weight and

precedence. For example, to calculate an Eigen Vector, we would utilize (Table 6) by entering into Row 1 (A) Column 1 (B) and take the first value (X). After computing the sum of each individual column, we would divide the first value against the sum (X / X). In doing so, with each Row and Column, we develop our Normalized Criteria Comparison Matrix (Table 7). At the bottom of the new table, and computing the calculations correctly, the sum of all elements within these columns of priority vectors equal to 1. After adding each individual rows entries across the table, will determine the weighted value for that criterion.

1) sum the values in each column of the pair-wise matrix

$$C_{ij} = \sum_{i=1}^{n} C_{ij}$$

2) divide each element in the matrix by its column total to generate a normalized pair-wise matrix

$$X_{ij} = \frac{C_{ij}}{\sum_{i=1}^{n} C_{ij}} \qquad \begin{bmatrix} X_{11} & X_{12} & X_{13} \\ X_{21} & X_{22} & X_{23} \\ X_{31} & X_{32} & X_{33} \end{bmatrix}$$

3) divide the sum of the normalized column of matrix by the number of criteria used (n) to generate weighted matrix

$$W_{ij} = \frac{\sum_{j=1}^{n} X_{ij}}{n} \qquad \begin{bmatrix} W_{11} \\ W_{12} \\ W_{13} \end{bmatrix}$$

Figure 31: Normalizing Pair-wise Element Table (Source: Bunruamkaew, 2012)

Table 7

AHP Process: Main Tier (STEP 2)

	Normalized Criteria Comparison Matrix (C)			
	Infrastructure	Planning	Port Labor	Security
Infrastructure	0.429	0.429	0.444	0.364
Planning	0.143	0.143	0.222	0.091
Port Labor	0.214	0.143	0.222	0.364
Security	0.214	0.286	0.111	0.182
Sum Columns	1.000	1.000	1.000	1.000

(Source: Author, 2021)

Chapter 5.1.5 AHP: Consistency Index

We can define Consistent as acting, completing or choosing decisions in the same way over time (Oxford, 2021). This is critical when making decisions which could impact a Shipping Company, a privately owned or inter-governmental agency Port Terminal, or a Port Authority in contrast to connecting systems. These systems, are the follow-on links to the Supply Chain (Forward and Reverse) as well as the overall economy. When Thomas Saaty developed AHP, he realized that as humans, we are susceptible to error, which is designated as inconsistencies. When we compare the data sets through the Consistency Index (CI), we are evaluating that inconsistency will not exceed 10%. However, if the ratio is more than 10%, we would need to go back and improve the CR of pair-wise comparisons in order for it to be acceptable. If the CI measure perfect zero, it means that the data set would be 100% accurate, which is not scientifically accurate.

Chapter 5.1.5.1 AHP: Lambda (λ) and Lambda Max (λ_{MAX})

In order to calculate consistency, we must calculate lambda (λ) and average the sums to achieve lambda max (λ_{max}). We do this by collecting data entries from the initial CCM table, and compare the weighted averages from the NCCM table for each row entry. Since we have four rows, we require four entries in order to achieve a proper average to find lambda max (Figure 32, Table 8).

$$\begin{bmatrix} C_{11} & C_{12} & C_{13} \\ C_{21} & C_{22} & C_{23} \\ C_{31} & C_{32} & C_{33} \end{bmatrix} * \begin{bmatrix} W_{11} \\ W_{21} \\ W_{31} \end{bmatrix} = \begin{bmatrix} Cv_{11} \\ Cv_{21} \\ Cv_{31} \end{bmatrix}$$

$$Cv_{11} = \frac{1}{W_{11}} \begin{bmatrix} C_{11}W_{11} + & C_{12}W_{21} & C_{13}W_{31} \end{bmatrix}$$

$$Cv_{21} = \frac{1}{W_{21}} \begin{bmatrix} C_{21}W_{11} + & C_{22}W_{21} & C_{23}W_{31} \end{bmatrix}$$

$$Cv_{31} = \frac{1}{W_{31}} \begin{bmatrix} C_{31}W_{11} + & C_{32}W_{21} & C_{33}W_{31} \end{bmatrix}$$

$$\lambda = \sum_{i=1}^{n} Cv_{ij}$$

Figure 32: Solving for Lambda Max (Source: Bunruamkaew, 2012)

Table 8

AHP Process: Main Tier (STEP 3)

	Infrastructure	Planning	Port Labor	Security	Sum (X)	Weight (W)	λ
			Consistency Calculations				
Infrastructure	0.416	0.449	0.472	0.396	1.733	0.416	4.164
Planning	0.139	0.150	0.236	0.099	0.623	0.150	4.163
Port Labor	0.208	0.150	0.236	0.396	0.990	0.236	4.200
Security	0.208	0.299	0.118	0.198	0.824	0.198	4.155
							λ MAX
Sum Columns	0.971	1.048	1.061	1.090			4.170

(Source: Author, 2021)

After completing this process, we have obtained λ_max for each criterion in (Table 8).

Chapter 5.1.5.2 AHP: Lambda Max (λ_{MAX}) and Comparison Matrix (N)

After determining each categories of Lambda Max (λ_{max}), we can complete a Consistency Index, which is comparing λ_{max} against the number of entries per row. In this case, N = 4, as each criterion has four entries.

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

Chapter 5.1.6 AHP: Consistency Ratio

Following completing our Consistency Index (CI), we can complete the final part of the AHP process and determine which factors can be utilized as our alternatives. In order to complete this final step, we must refer to Saaty (1980) Random Index Table. After calculating the Consistency Ratio (CR), we verifying that all five fields yield a ratio of less than 10% Consistency Error (0.10). Once verified, we took the weighted averages of all the main criteria and sub criteria, multiplied the sub-criteria to their foundation criteria's weight (Infrastructure, Planning, Port Labor and Security) in order to determine best alternatives.

$$CR = \frac{CI}{RI} = < \textbf{\textit{0.10}}$$

Table 9

Random Index (RI)														
n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.58

(Source: Saaty, 1980)

Table 10

AHP Process: Main Tier (STEP 3)

CI	RI	CR	Consistent (CR ≤ 0.1)?
0.05678	0.9	**0.063**	Yes

(Source: Author, 2021)

Chapter 5.2 AHP: Findings and Decision Making

The Port Terminal Performance Survey, was disseminated to 50 various Maritime Executive and professionals across the United States from September 3rd to September 14th, which asked 30 questions relevant to the study of "How COVID-19 has impacted Port Terminal Performance in the United States". Out of the initial 50, 25 were able to respond and provide essential feedback through individual remarks to justify their selections. This section provides an overview and summary of key analytical points of the survey and their remarks. As we determined through our analysis of survey data, the best four alternatives in each separate criterion selected for Port Terminal Resilience, were Capital Equipment (19.7%), Automation (11.3%), Cyber-Security (7.2%) and Coordination (5.53%).

Table 11

Decision Factors for AHP Alternatives

Final Alternatives	Sub-Criteria Weight	Main-Criteria Weight	Final Score	Rank
Capital Equipment	0.473	0.416	0.197	1
Automation	0.479	0.236	0.113	2
Cyber Security	0.368	0.198	0.073	3
Coordination	0.369	0.150	0.055	4
Road & Rail	0.275	0.416	0.114	5
Container Capacity	0.176	0.416	0.073	6
Physical Security	0.350	0.198	0.069	7
Communications	0.367	0.150	0.055	8
Flexible Workforce	0.217	0.236	0.051	9
Flexible Operating Hours	0.187	0.236	0.044	10
Inspections	0.211	0.198	0.042	11
Warehousing	0.076	0.416	0.032	12
Flexible Labor Agreements	0.118	0.236	0.028	13
Short Term / Long Term	0.179	0.150	0.027	14
Drills & Training	0.070	0.198	0.014	15
Observatiom	0.084	0.150	0.013	16
Sum of All Criteria			*1.000*	

Note: First four selections were ranked off of highest weighted average of each main critera, then remainder based off of final averages

(Source: Author, 2021)
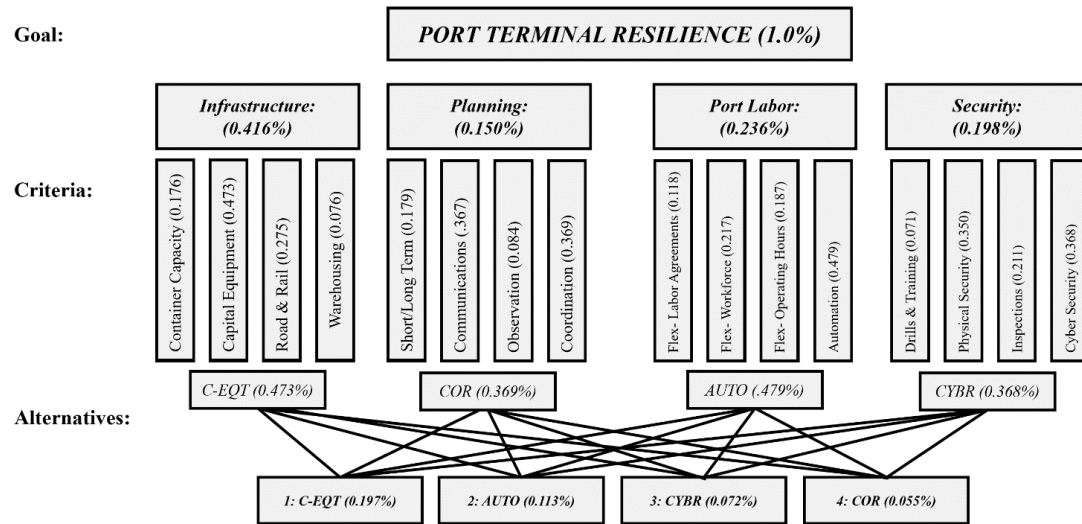
Figure 33: Finalized Model for Port Terminal Resilience (Source: Loh et. al, 2017; Author, 2021)

Other criteria that were deemed important but not critical, was Road & Rail (11.4%, Infrastructure), Container Capacity (7.3%, Infrastructure), Physical Security (6.9%, Security), and Communications (5.50%, Planning).

We were able to determine many findings and cases with supporting evidence as to why these four choices preceded slightly above high rated sub-criteria.

In the survey for Infrastructure, 16 of the 25 surveyors were involved as Terminal Operators and Port Authorities, as acting or former Executive Directors, CEOs, Senior Executive Staff as well as middle management for Port Terminals. The remaining (9) held roles involved within the Supply Chain that feeds major ports on both coasts of the United States. When asked what the most single important action to improve Infrastructural Performance at Port Terminals was, 64% (16) defended that Capital Equipment (Portainers, Front-End Loaders, Reach Stackers, Rail-Mounted Gantry's and Straddlers) was superior to Road & Rail Connectivity at 28% (7).

In terms of Capital Equipment and Automation for developing Port Terminal Resilience, this might predicate that Port stakeholders, if presented the opportunity, would want to expand and grow their port facilities and terminals while increasing available sub-services. These services, such as Cruise Terminals, can provide additional supplementary revenue for the Port Authority as well as the local economy (Santos et. al, 2019). In contrast, this would also force the improvements and developments of new Roads and Rail to feed the terminals. All this considered, would be included into required construction contracts, as state and federal governments own major highways and roadways. In addition to the expansion of Port Terminal footprints, would give opportunities to experiment in improved design, operations, and changes to nautical profiles (Rodrigue & Notteboom, 2021).

Though Roads & Rail are essential in terms of connectivity for Ports, as a demonstrated key disruptor for the Port of Los Angeles, it is difficult to develop new or repair roads, that are not privately owned by the Terminal or the Port Authority, as this is the responsibility of state and local governments (ARTBA, 2017). Also, maintenance and installation of new rail is dependent on the rail company that owns

it, such as the Alameda Corridor (AC), Union Pacific (UPR) and Burlington North Santa Fe (BNSF) rail operating companies for the Ports of Los Angeles / Long Beach (Heier, 2009).

With changes and adaptations of terminal growth, adding automated capital equipment, would help to alleviate Labor force strains, reduce accidents, pollution, and increase efficiency which would help with container throughput times (Dávid, 2019).

Automation however, has always been the source of controversy at the Ports of Los Angeles and Long Beach. According to Richardson (2021), Terminal Operators, who lease space within the Ports of LA/LB, plan to automate more of the port facilities, which do not coincide and agree with US Labor Unions (ILWU). On one hand, threats of Automation for Union Members, means loss of job security, wages, as well as reducing benefits of earnings for US and local economies, while maximizing extraction of foreign profit. On the other hand, upgrades of automation are essential for ports to remain efficient and competitive globally, especially for the Ports of Los Angeles and Long Beach (Pacific Maritime Association, 2020). In order to harmonize the partnership between Union Workers and Automated Robotics for Port Terminal Resilience Framework, negotiations between the Labor Force and the employment association should come to a general agreement that laborers will not only be guaranteed their jobs, but be further trained, specialized and certified to manage this equipment. In doing so, will prevent repeated attempted from the Los Angeles Board of Harbor Commissioners from issuing permits which block Terminal Operators and the Employment Association, such as the attempts of automation of Pier 400 of APM Terminals at the Port of Los Angeles.

With upgrades to Automation and all Port Terminal Systems, it is crucial that all glitches are thoroughly worked out before completely integrating newer technologies over older systems. The upgrades of NAVIS N4 Terminal Operating Systems (TOS)

at Maher Terminals in the Port of NY-NJ in 2013, caused significant delays, disruptions and ripple effects, which impacted drayage companies for losses to chassis rentals, per diem charges of equipment, and loss of productivity. In addition, the terminal was forced to waive free time and demurrage rates, as well as extend gate times to account for lost Port Performance (Bonney, 2013). This unifies the decisions within the AHP to choose Capital Equipment, Automation and enhancements of Cyber Security.

Cyber Security Awareness (7.2%) as mentioned earlier, is the practice of defending computer systems against malicious attacks and threats to supply chains. The maritime industry has increasingly become more digitalized, with most maritime operators adopting digital technologies to modify their business models, upgrade operations efficiency to create overall value for their customers (Shepherd, 2004, as cited in Senarak, 2020).

The link between systems for vessels at sea, and at shore-side facilities, are extremely vulnerable to external disruptions with the expansions of newer technology and software. However, one must understand that digitalization and cyber-risks are two sides of the same coin (Mallick, 2017).

With recent attacks in the past 10 years in the Maritime Industry, survey participants may have felt that with upgrading and expanding Port Capacity through Capital Equipment and Automation, comes an increased inherent risk that hackers will attempt to exploit and defeat Port Systems for monetary gain and spurring economic chaos. This was verified not only through the AHP choices, but reiterated as a question as to "what is the most single important action within Port Security to improve Resilience".

Most recently in the United States, a ransomware attack against Colonial Oil from Russian hacker group DarkSide, forced the shutdown of a strategic pipeline which

runs up the entire eastern seaboard, causing chaotic ripple effects of surging gas prices, demand, and public fear, while facilities were challenged to ration the amount of gas for consumers (Javers, 2021). Other attacks have occurred at the Port of San Diego, causing $30 million in IT damages and $6 million lost in ransom disbursements (Freeman, 2018), The NotPetya ransomware which attacked Maersk Line, disrupting operations in 76 ports and accumulated a loss of $300 million in 2017 (Gold, 2021), and cyberattacks against the International Maritime Organization (IMO) which occurred days after similar ones against shipping company CMA CGM (Konrad, 2020).

In defence for the importance of Cyber Security, the Port of Los Angeles in December of 2020 took initiatives to increase Cyber Security through a partnership with big-tech computer company, IBM. At $6.8 million USD, and with a three-year agreement between the seaport and the tech-business, the Port will design and operate a Port Cyber Resilience Centre (CRC). As a Maritime Security Intelligence and Operations Centre (SIOC), its objectives are to integrate complete supply chain security and resiliency between the port, terminal operators, shippers, suppliers, rail operators and telecommunications, analyse and predict threat activities. (Rundle, 2020). While allowing stakeholders control over their own information, the CRC will act as a "system of systems", which rapidly integrates and shares real-time data with each other to better coordinate defensive responses as needed (Sanfield & Campbell, 2020). This should set the example of the future directions for better overall supply chain security.

Coordination (5.5%) with all the previous best alternatives, was the final choice for Port Terminal Resilience. Through the vast networks of port and supply chain systems, their complexity and uncertainty for decision-making situations (e.g. COVID-19 disruptions), despite high level forecasting, can be managed through two basic categories by managing daily operational activities and improving processes. According to Huiskonen and Pirttilä (2001) coordination between supply chains and

overall logistics, is sharing a unified approach to tasks and objectives, unified working practices, and integration into vertical processes. All components of the system must fully integrate and have one generalized goal, and understand and accept the tasks, requirements and purpose for this goal.

In the case for the Ports of Los Angeles and Long Beach, CA (referred as the San Pedro Bay Port Complex), both are separate municipal authorities, occupying the same water space, fiercely competitive with one another, and utilize the same supply chain structure of roads, highways, and rail. As researched by Knatz (2018), there have been significant attempts to merge both ports, mostly from business groups, elected official and port users who have no real-time visibility, knowledge of port operations and limited stakeholder involvement; but these attempts have always been rejected. Cooperative efforts however, had increased in the 1980's to confront issues with both Port administrations.

More recently, in terms to protect and respond against rising competition from JAX Ports, Port of Savannah, and the Northwest Seaport Alliance of Port Seattle-Tacoma (Maritime Executive, 2020), Port LA/LB announced an alliance. Through coordination, the Port would work together to improve infrastructure, operational efficiency, connectivity, workforce development, cyber-security and additional metrics (Ports Strengthen Collaboration to Boost Competitiveness | Port of Los Angeles, 2020). This has been agreed and expanded on through the Federal Maritime Commission Agreement No. 201219 (Federal Maritime Commission, 2015; Burnson, 2020). In periods of disruption, through such coordination to address COVID-19, this is one direction that US Ports have pursued to control, and view the supply chain as one single harmonious system.

CHAPTER 6 – Summary and Conclusion

Resilience, has been a very powerful and important mechanism to give people the strength to overcome hardships and become stronger than before. Through history, World events such as wars, civil conflicts, coup d'état's, natural disasters, periods of economic decline and more recently, the COVID-19 pandemic, has taught us to revisit the lesson of "What is Resilience?" The definition we establish today, could very well mean something different tomorrow for the billions of other people we trade and share our oceans with.

In determining a definition of Resilience for the study, we were able to thoroughly analyse and examine a case-study of the United States largest seaport, the Port of Los Angeles. Through this case-study, were able to identify periods of disruption, such as the ILWU's attempt to block a permit that would provide partial-automation for APM Terminals in 2019, to the ongoing US-China Tariffs, their dreadful economic impacts to the United States economy, and how it has impacted foreign relations, suppliers and consumer demand.

We identified the pinpoints of supply chain bottlenecks through the study of COVID-19 infection within Los Angeles County and how it impacted the Port of Los Angeles Performance Measures. These measures included Truck Throughput Times, Container Volumes, Rail Times, Dwell Times for Containers, Labor Force Hours, Anchor Times and Berthing Times. In addition, we analysed data from Rail, Trade and Warehousing in the Southern California area. To support the data, we also completed a follow-on Port Terminal Performance Questionnaire, to further examine the choices that Senior Executive Management staff would take, in order to improve their Port Terminal Supply Chain Systems. Through a blend of Quantitative and Qualitative methods, we were able to identify, critique and draw a conclusion with the following key points.

Port Authorities want to expand their footprints, the priority in being able to support and host larger container vessels. These larger vessels guarantee growth through the local and national economy, which will expand overall development and growth for businesses. However, in expanding overall port capacity, requires the rest of the foreland and hinterland services that feed into it to follow suite. Without dredging, you cannot allow access for deeper draught vessels beyond the sea-buoy for most ports, or have anchorages deep and safe enough to protect these vessels from storms. Larger berths, with state-of-the-art capital equipment, automation, and a highly skilled Labor force, will allow discharge and loading of containers at record volumes, but is meaningless if the same cargo can't efficiently be moved through the terminals and recirculate in the remainder of the supply chain. Finally, you cannot effectively move containers with damaged, dislocated or scarcity of both truck and rail chassis.

The lesson to be learned from the COVID-19 Pandemic, is that entire Supply Chains must be treated as one system, not individual parts, to overcome disruptions. Chaos Theory thrives on the concept of pinpointing weaknesses in all components of non-linear systems. Coordination and communication with all key stakeholders, must be clear, concise and transparent, with unanimous understanding. Only then, will chaos and disruptions be better managed. In addition, Ports and Supply Chains must expand at the same scale together. More rail and roads to feed larger warehousing (whether in footprint volume or physical number), in order to house the increased cargo volumes from Intermodal Yards and Terminals, all delivered from the ever-growing container ship. Extension of Operating Hours per Shift for Truck-Drivers, would also allow more time to return chassis to prove performance. There is also a point to where Port Expansion is no longer possible due to the surrounding land, thus reaching the inability to meet storage requirements, which was answered through the questionnaire.

In the Questionnaire, Capital Equipment, Automation, Cyber-Security and Coordination, in that order, were identified as the most important factors for Port Terminals Resiliency. All four concepts, also strongly integrate and correlate with each other. When Port Expansion is no longer possible, a solution would be to increase container throughput of the port by minimizing loading times and upgrading Capital Equipment.

This Capital Equipment, can also be automated, and as a tool it needs to be programmed precisely in order to coordinate work at its highest efficiency. Utilizing partial-automation at terminals, while retaining a workforce specialized in operating and maintaining this equipment, would satisfy the ILWU, as well as relations between the operators and the PMA. Phases of Automation could temporarily be increased or scaled back, depending on the levels of demand or disruptions from within the Terminals, in order to correct throughput times and maximize efficiency. Automation for the future could be extended to Rail Operations, and Warehousing Efficiency, to allow around the clock operations.

With Automation, also comes the need to protection against rising cyber-threats through security measures. Port Directors greatest concerns for the future of port automation, are these cyber-threats, which have demonstrated repetitively the substantial vulnerabilities within critical business systems which feed global commerce. Without proper protection, the failure of these systems has catastrophic consequences, costing millions for damage recovery, repairs, and induce market bullwhip effects to economies, which last several weeks to months.

Some Ports, have taken appropriate steps to develop state-of-the-art security systems, as a solution. The Port of Los Angeles partnered with IBM, to develop their Cyber Resilience Center. The CRC, acts as an insurance policy and $6 million USD long-term investment. This demonstrates to operating companies and stakeholders, that their interests will be protected and safeguarded to the best of the Ports ability. In

return, this extended sense of security and trust, will allow stakeholders to invest more time, money, and capital while reciprocating their mutual respect to the Port Authorities leadership.

Finally, Coordination brings all the elements of this study together, and is necessary in order to collaborate many goals at various levels, whether strategic planning by essential stakeholders, or routine operations at different managerial levels.

Through identifying several issues through the study and questionnaire, the best recommendation and solution for the Port of Los Angeles, would be to update their current Port Master Plan (2018) with lessons learned from 2019 to April 2021.

Key areas of improvement for the Port Master Plan, are Section's 3.0 (Development Goals), 4.0 (Factors Affecting Demand for Port Development), 5.4 – 5.6 (Proposed Projects for Container Terminal Expansions), 5.7 (Dredging), with strong emphasis on 7.2.2. (Expansions of Rail).

In identifying the choke-points from inside all six container terminals, rail, truck, intermodal yards and warehousing, a COVID-19 Performance Analysis should be drafted, collaborated, (similar to the language of "By the Numbers" tariff report) and presented from the Executive Director to the Los Angeles Board of Harbor Commissioners. In this report, can identify and present performance data not covered in this study and protected from the Freedom of Information Act.

With these issues addressed to the Board of Commissioners, the Port Master Plan can be updated, sanitized, and elevated further up to the Mayor's Office, Los Angeles City Council and eventually addressed to the State Legislatures of the General Assembly and the Senate of California. Only then, can the issues from the state legislatures for expansion of warehousing leasing and land, development of roads and rail, be properly addressed and prepared to be presented to the Governor of

California, and further addressed to the US Department of Transportation. With coordination of all these political policies and plans to address the supply chain issues, will provide the necessary friction to move forward, redevelop the Port of Los Angeles better, and help to regain lost market share of foreign imports from the East Coast of the United States. All these implemented actions and strategies, would ensure the Port of Los Angeles to continue delivering its promise and slogan as "America's Port".

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Appendices

Appendix A. China and West Coast US Trade Index's (Graphs)

Appendix B. Port of Los Angeles Statistics - Number of Ships at Anchor, Berth, Departed (Graphs)

Appendix C. Port of Los Angeles Statistics - Days at Berth, Days at Anchor (Graphs)

Appendix D. COVID-19 Infection Statistics (Graph)

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Appendix I: Warehousing Statistics (Graph)

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Appendix L. Port Terminal Performance AHP Survey

Appendix A. China and West Coast US Trade Index's (Graphs)

Graph A.1 (SCFI Shanghai – WC America Freight Rate)
Source: Clarkson's Research
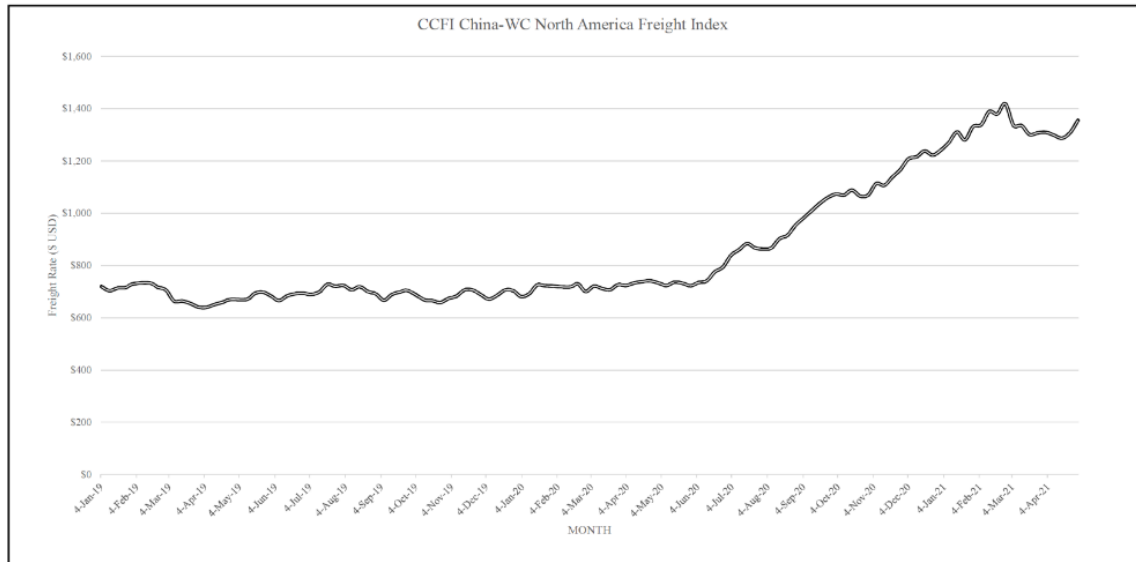
Graph A.2 (CCFI China – WC America Freight Rate)
Source: Clarkson's Research
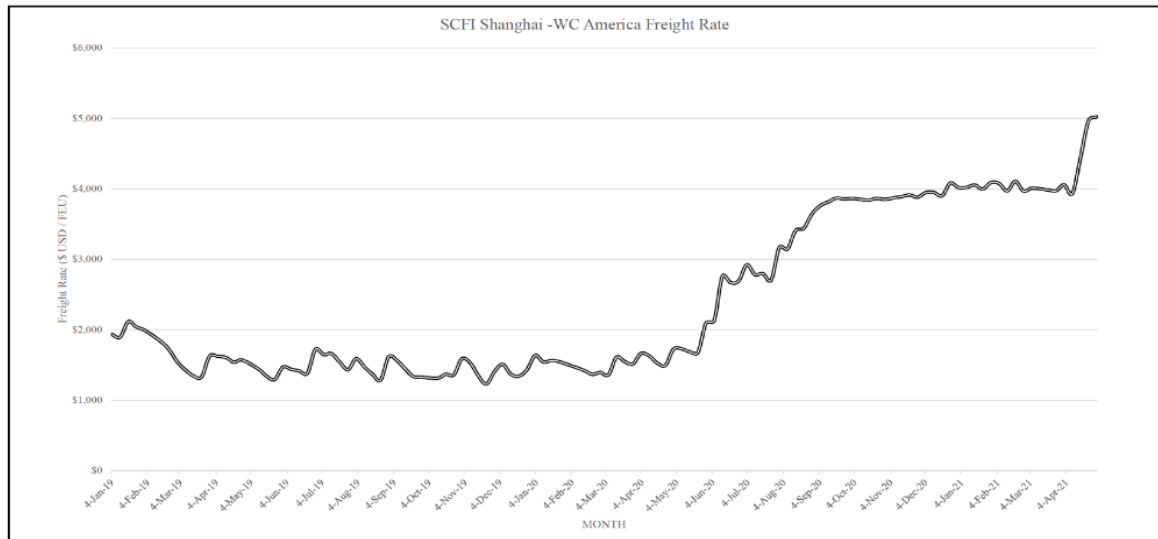
Graph A.3 (China Manufacturing Purchasing Managers Index)
Source: Clarkson's Research

China Manufacturing Purchasing Managers Index

Graph B.1 (Port of Los Angeles Anchor and Berthing Statistics 2019)
Source: Port of Los Angeles Harbourmaster Office
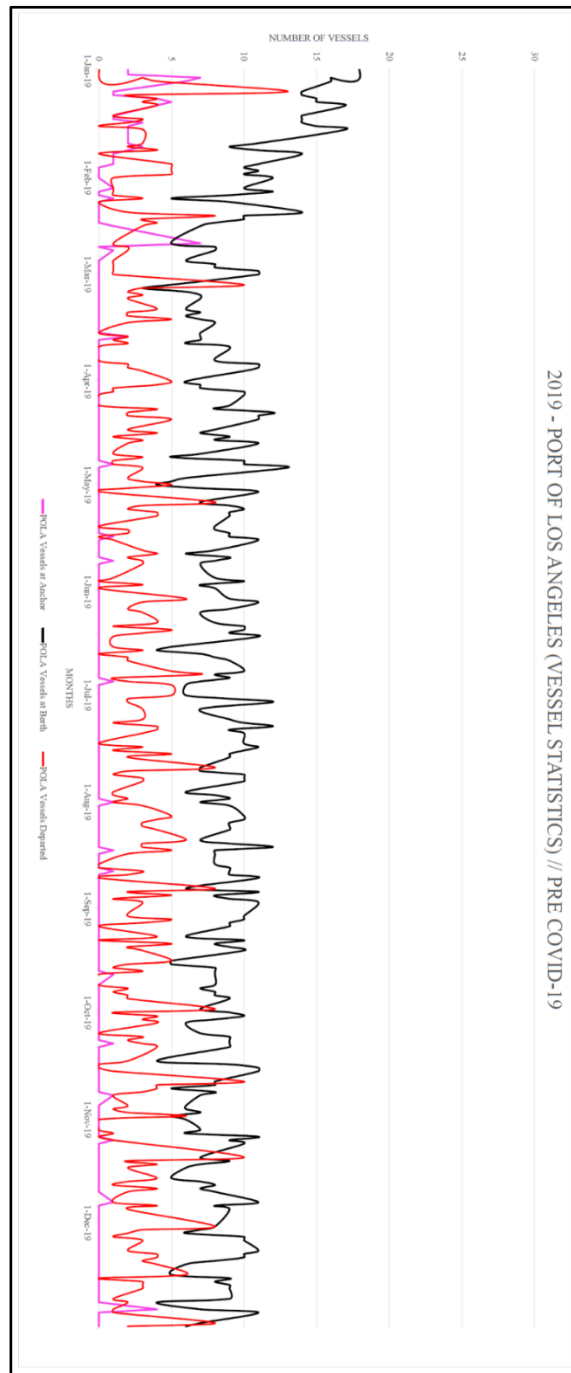
Graph B.2 (Port of Los Angeles Anchor and Berthing Statistics 2020)
Source: Port of Los Angeles Harbourmaster Office
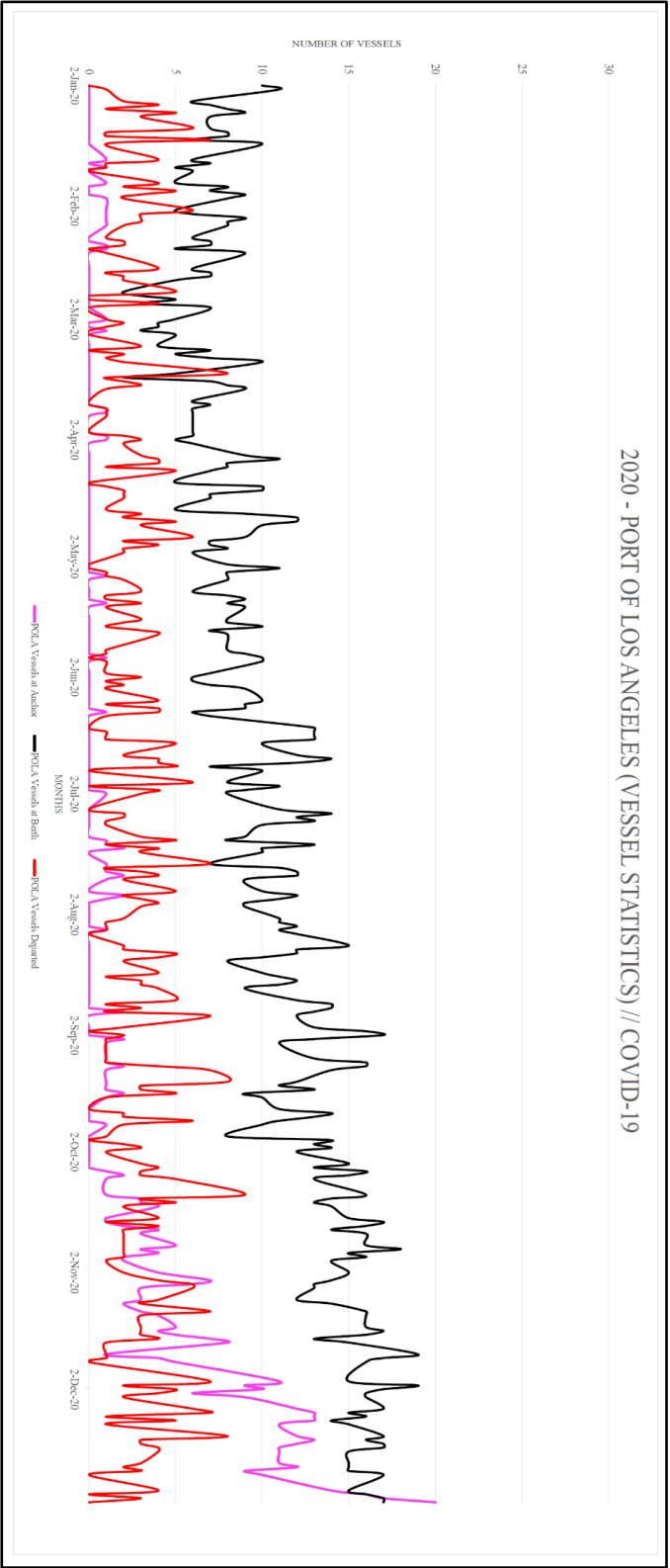
Graph B.3 (Port of Los Angeles Anchor and Berthing Statistics 2021)
Source: Port of Los Angeles Harbourmaster Office

Appendix C. Port of Los Angeles Statistics - Days at Berth, Days at Anchor (Graphs)

Graph C.1 (Port of Los Angeles Average Days at Anchor and Berth 2019)
Source: Port of Los Angeles Harbourmaster Office
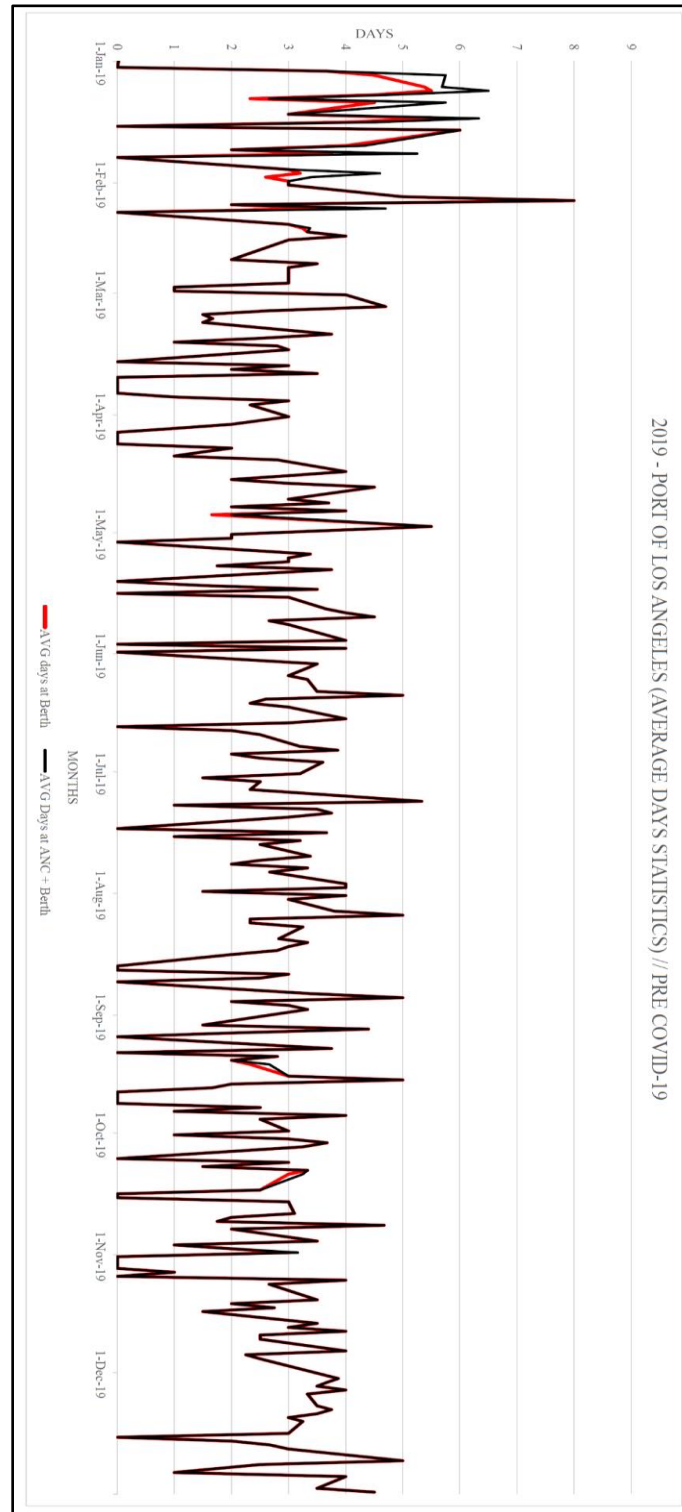
Graph C.2 (Port of Los Angeles Average Days at Anchor and Berth 2020)
Source: Port of Los Angeles Harbourmaster Office
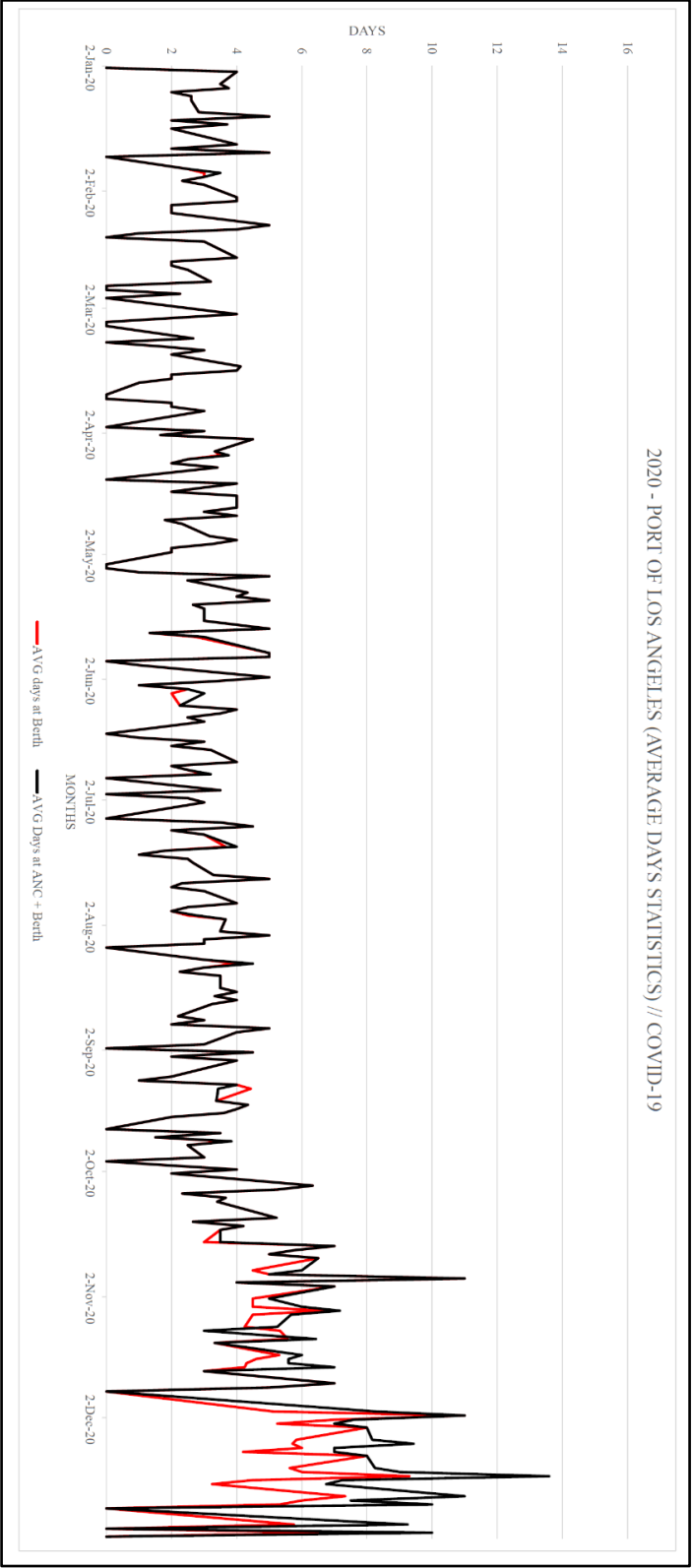
Graph C.3 (Port of Los Angeles Average Days at Anchor and Berth 2021)
Source: Port of Los Angeles Harbourmaster Office
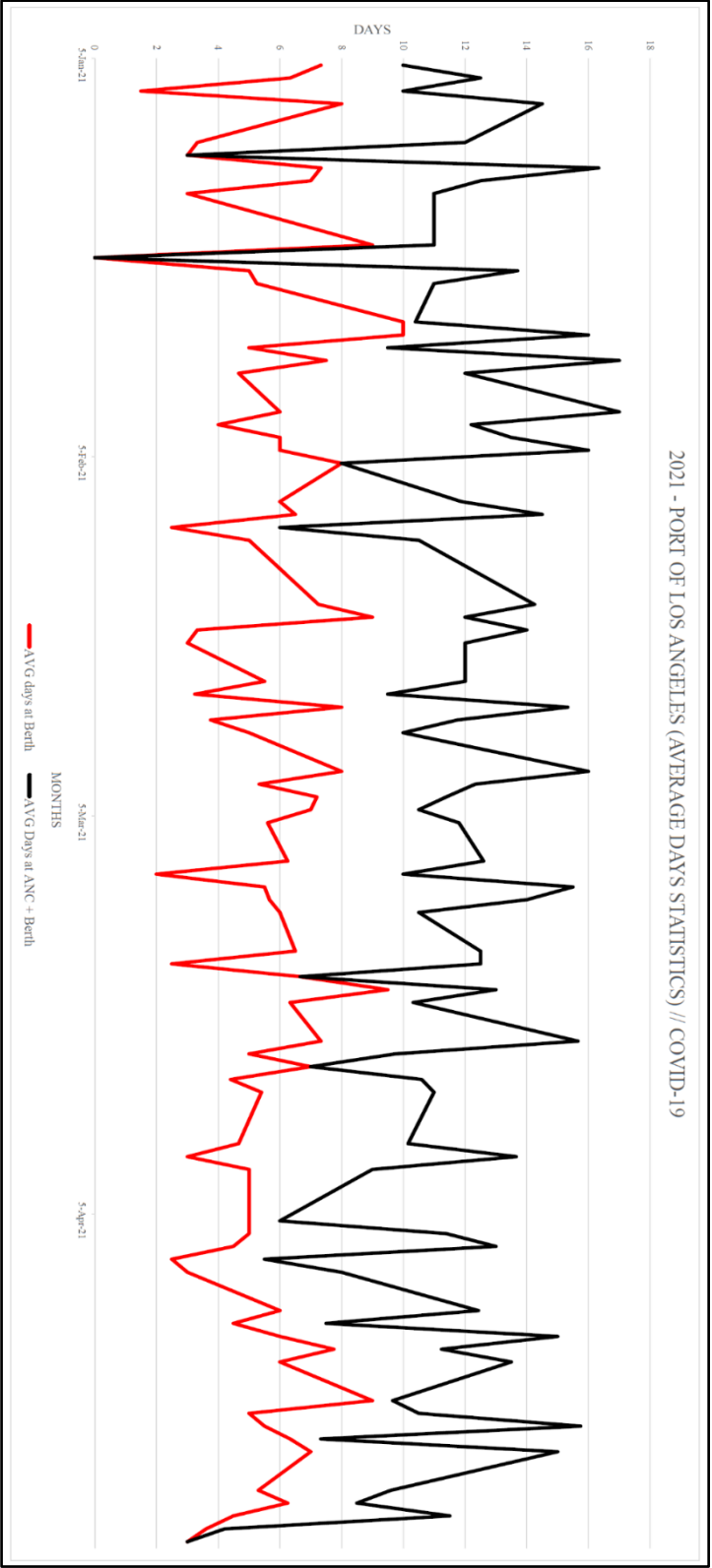
Appendix D. COVID-19 Infection Statistics (Graph)

Graph D.1 (COVID-19 Infection Rates of Trading Partners and Los Angeles County 2020 - 2021)
Source: Our World in Data (https://ourworldindata.org/coronavirus)
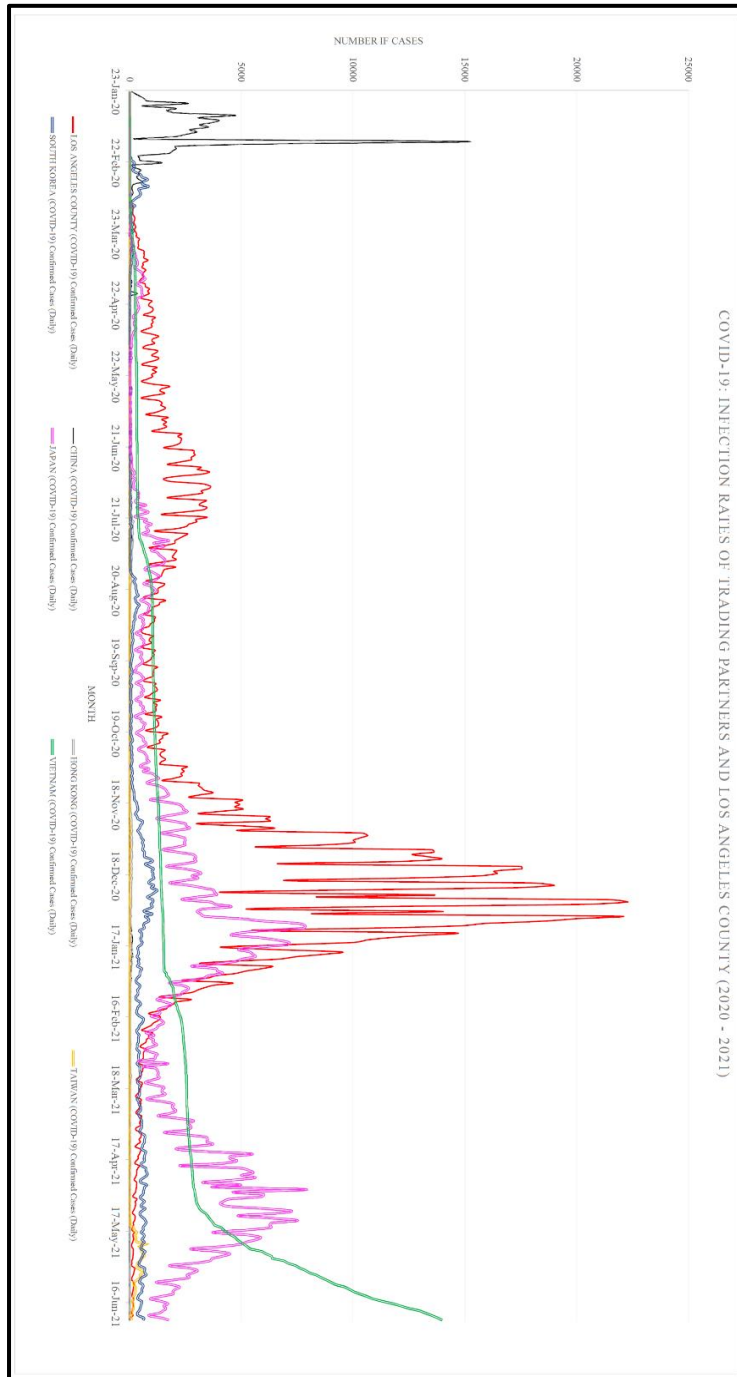
Appendix E. Shipping Liner Throughput at Port of Los Angeles (Graph)

Graph E.1 (TOP 10 Shipping Liners in the Port of Los Angeles 2019 – 2021)
Source: Wabtec Port Optimizer (https://tower.portoptimizer.com/)
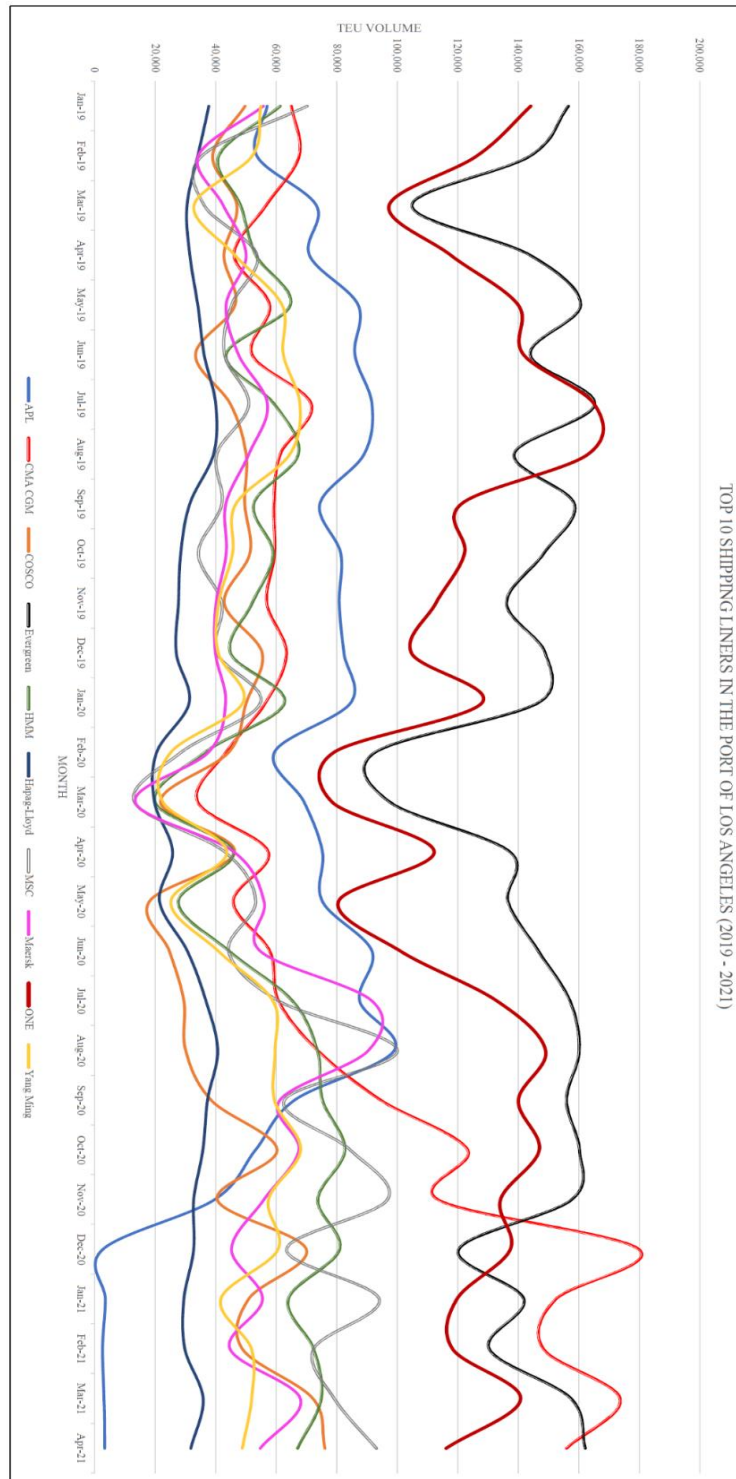
Graph E.2 (Port of Los Angeles Total Twenty Equivalent Unit Volume (2019-2021))
Source: Wabtec Port Optimizer (https://tower.portoptimizer.com/)
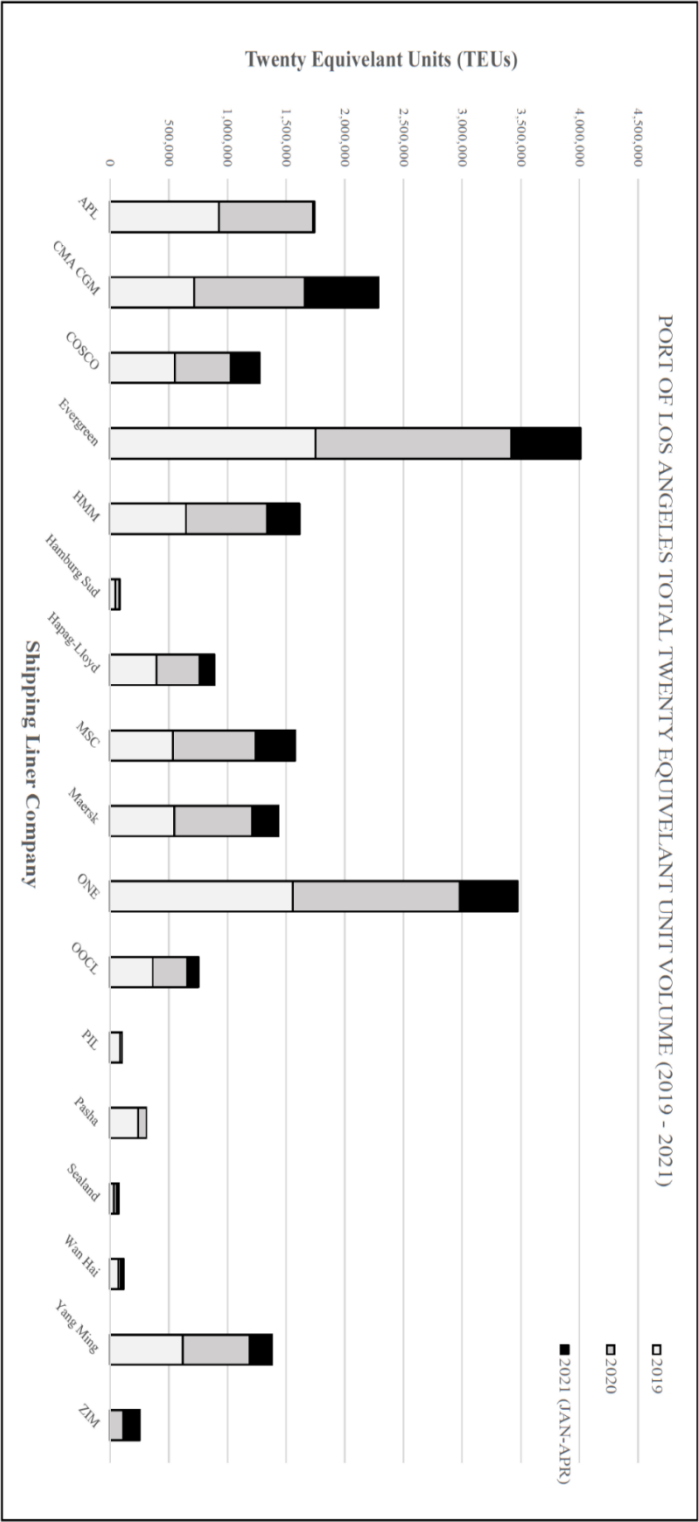
Appendix F. Truck Turn-Times and Gate Transactions (Graphs and Tables)

Graph F.1 (Port of Los Angeles Truck Turn-Times and Gate Transactions 2019 – 2021)
Source: Wabtec Port Optimizer (https://tower.portoptimizer.com/)
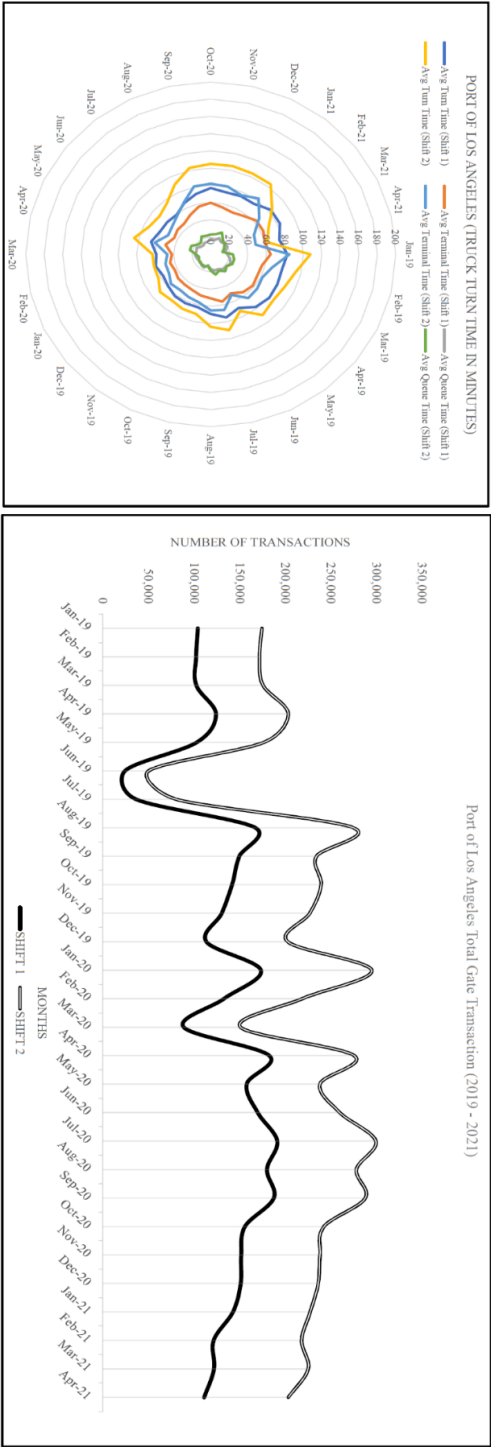
Graph F.2 (APM Terminals Truck Turn-Times and Gate Transactions 2019 – 2021)
Source: Wabtec Port Optimizer (https://tower.portoptimizer.com/)
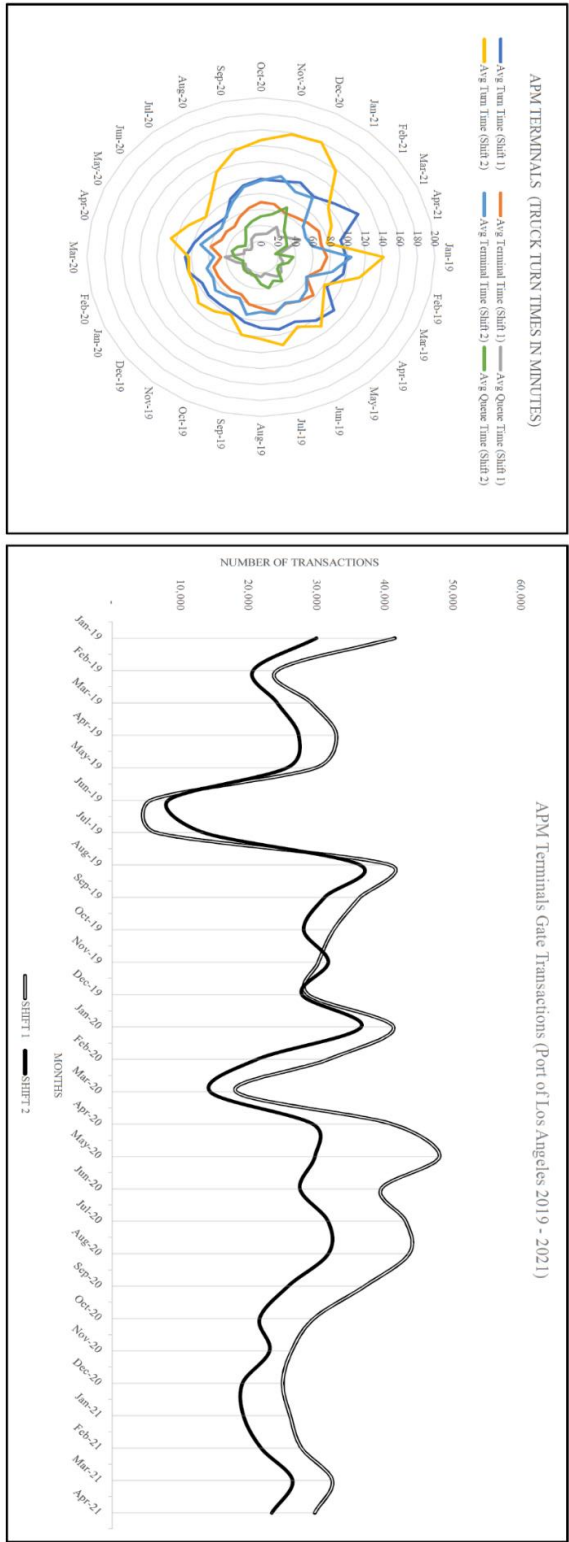
Graph F.3 (WBCT Truck Turn-Times and Gate Transactions 2019 – 2021)
Source: Wabtec Port Optimizer (https://tower.portoptimizer.com/)
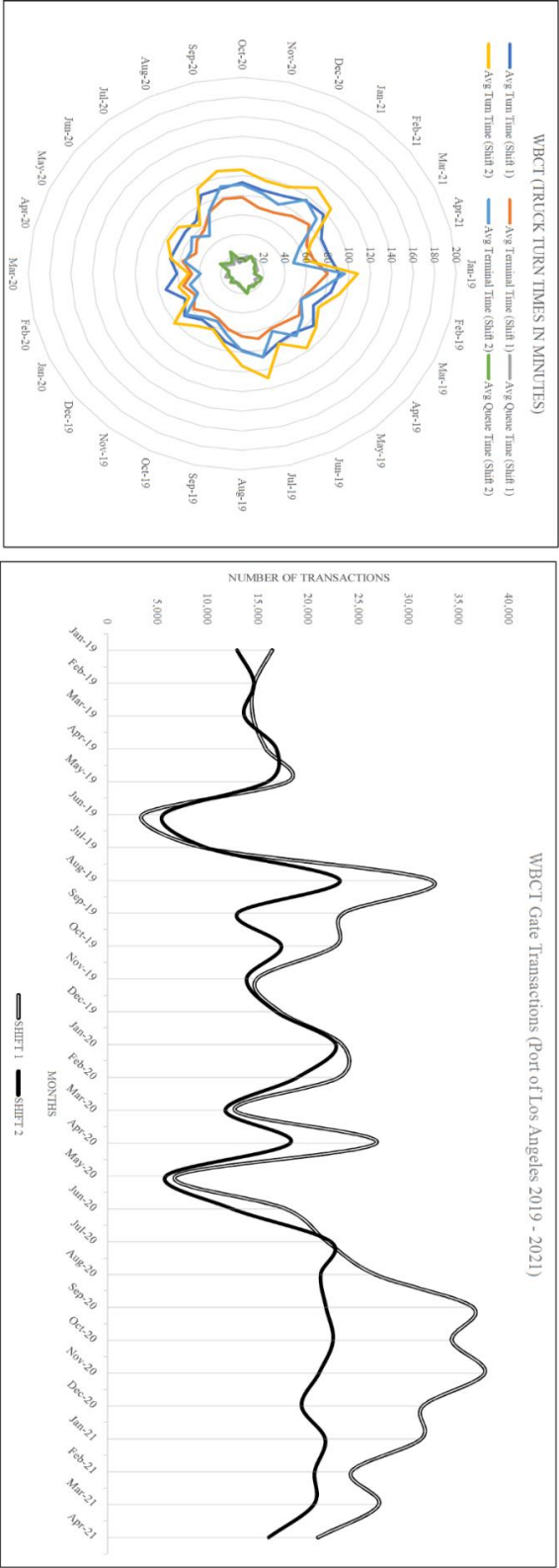
Graph F.4 (Fenix Marine Services Truck Turn-Times and Gate Transactions 2019 – 2021)
Source: Wabtec Port Optimizer (https://tower.portoptimizer.com/)
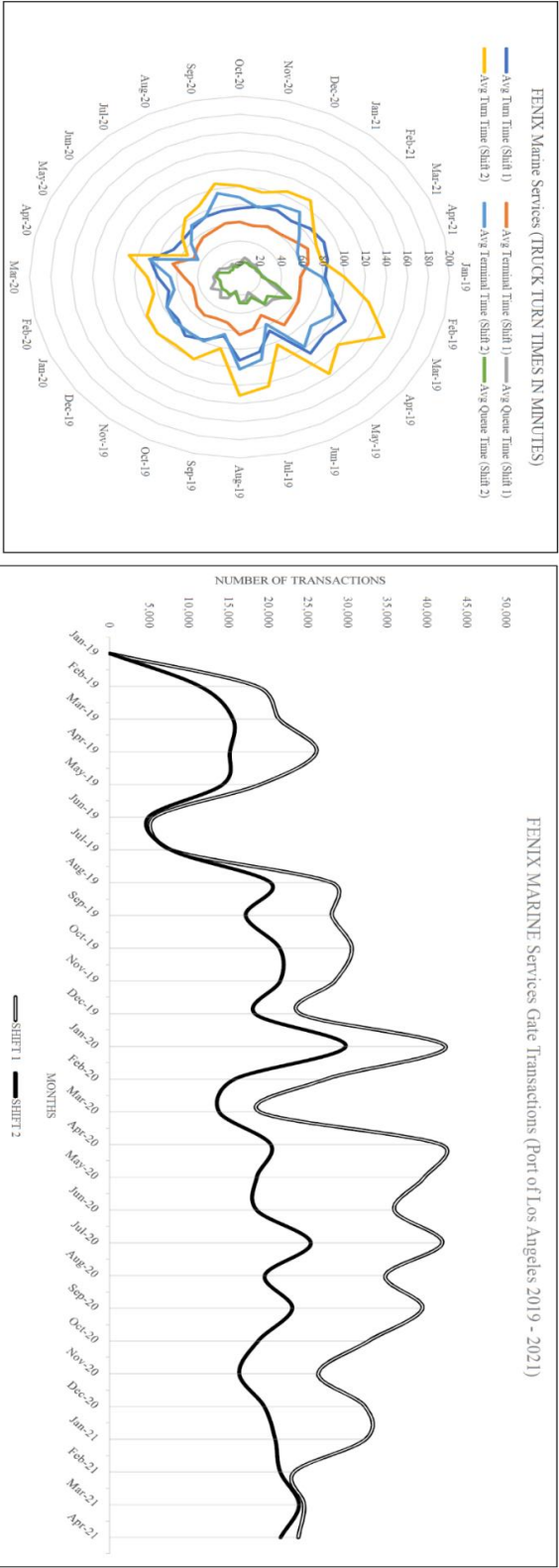
Graph F.5 (TraPac Terminal Truck Turn-Times and Gate Transactions 2019 – 2021)
Source: Wabtec Port Optimizer (https://tower.portoptimizer.com/)
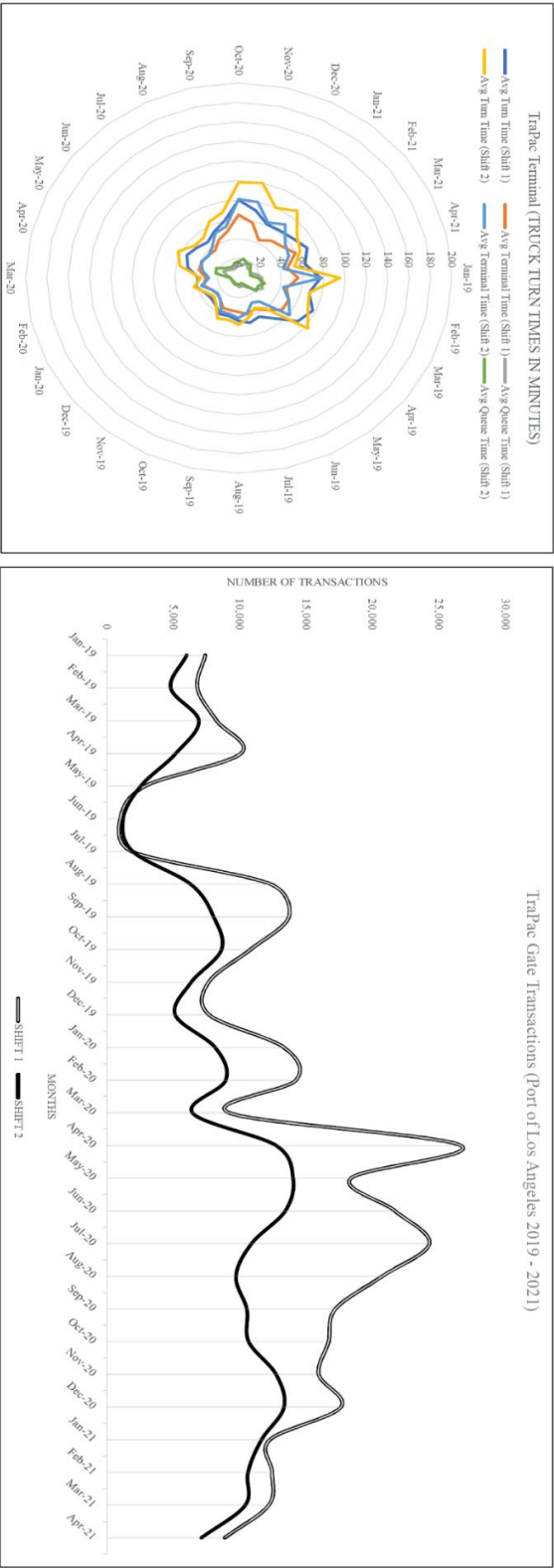
Graph F.6 (Yusen Terminals Truck Turn-Times and Gate Transactions 2019 – 2021)
Source: Wabtec Port Optimizer (https://tower.portoptimizer.com/)
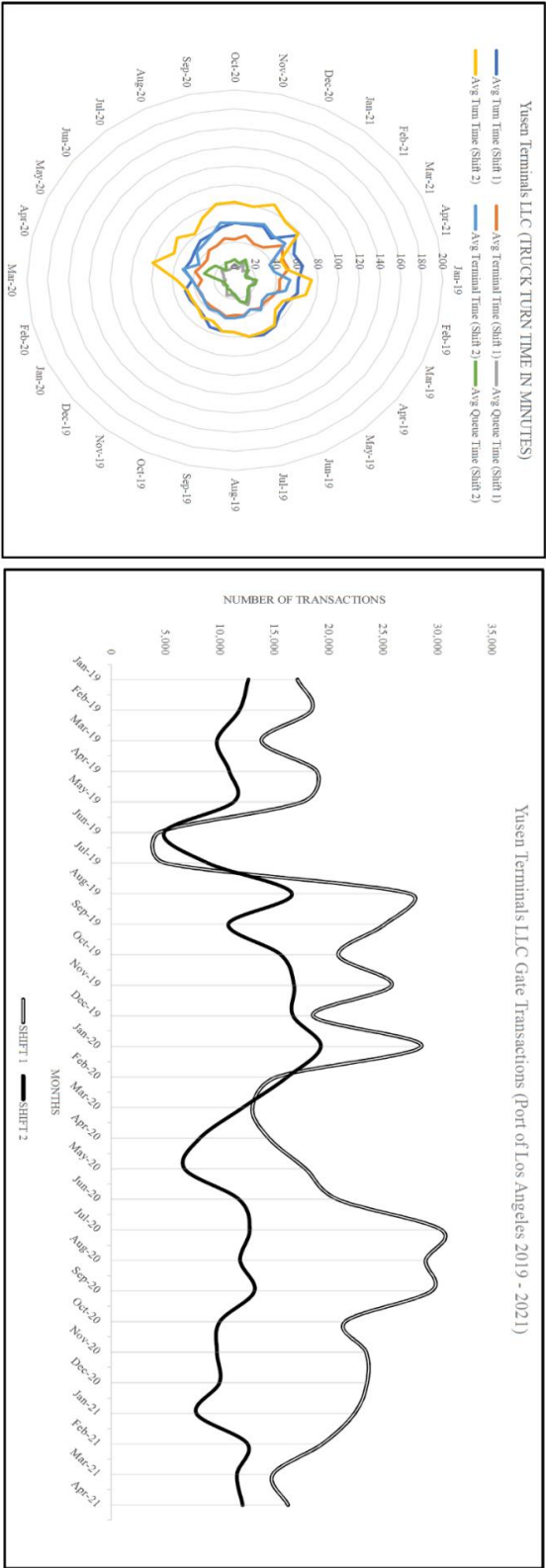
Graph F.7 (Everport Terminals Truck Turn-Times and Gate Transactions 2019 – 2021)
Source: Wabtec Port Optimizer (https://tower.portoptimizer.com/)
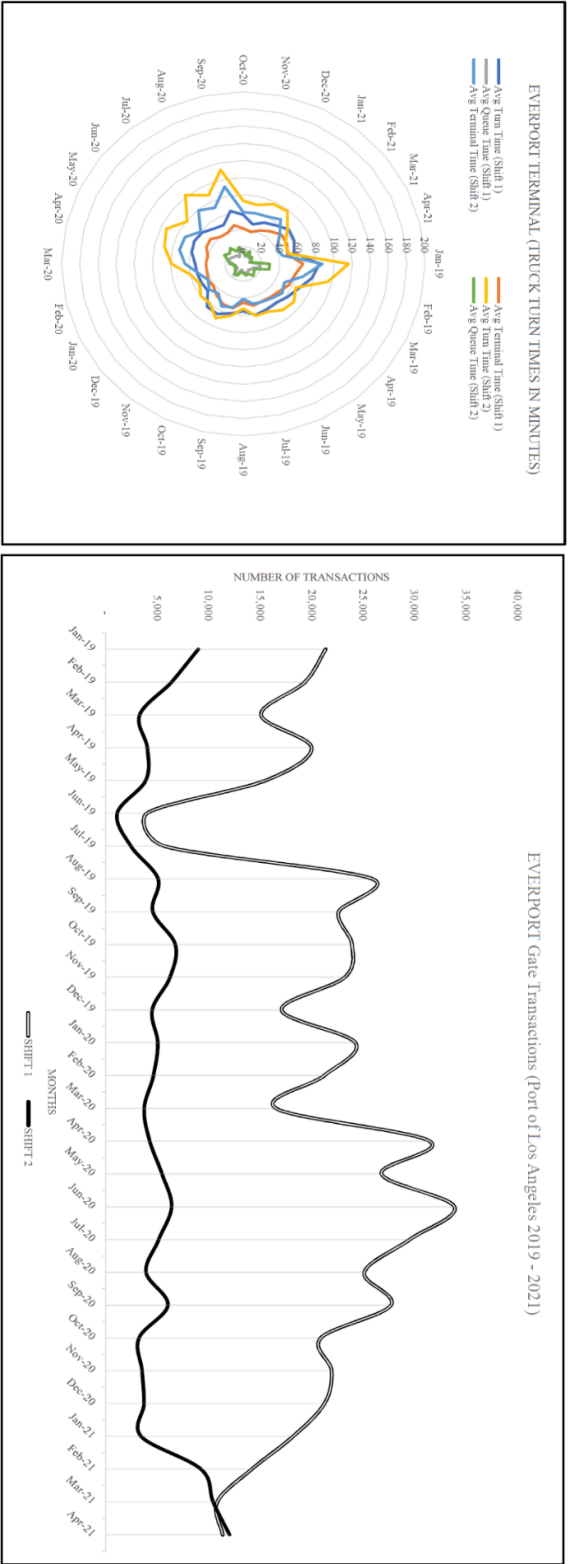
Graph F.8 & F9 (Port Terminals of Los Angeles – Average Truck Turn Times (Shift 1 & 2)
Source: Wabtec Port Optimizer (https://tower.portoptimizer.com/)
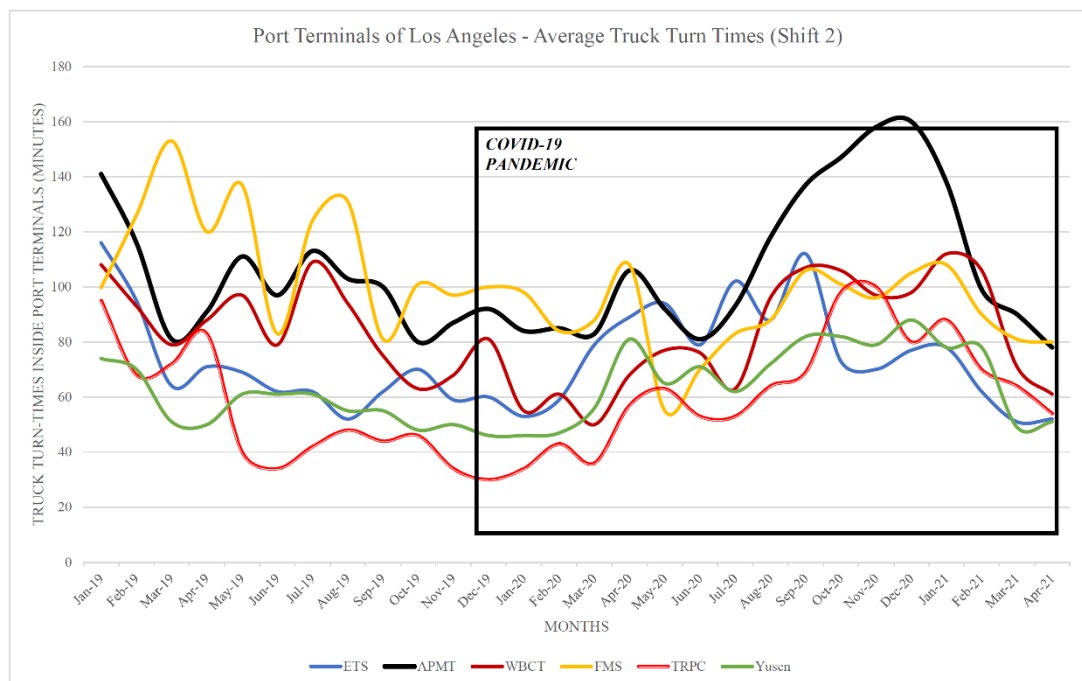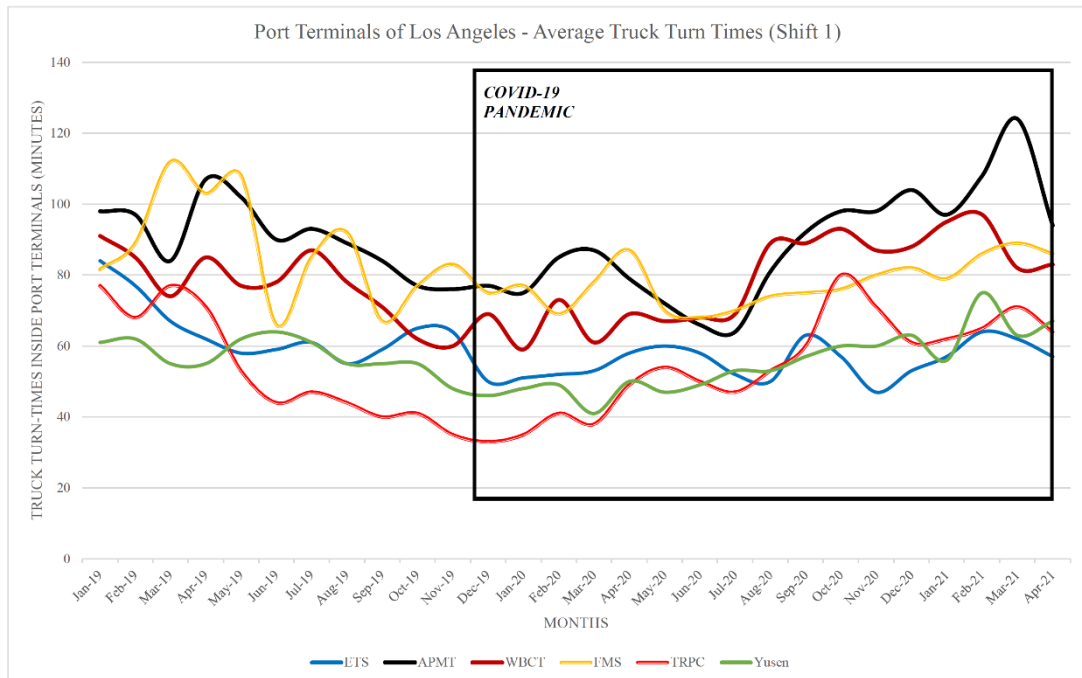
Graph F.10 (Street Dwell Times of Truck Containers and Chassis)
Source: Pool of Pools Official* (http://www.pop-lalb.com/reports/Net_Imbalance.pdf)

Table F.1 & F.2 (Port of Los Angeles Terminal Times and Gate Transactions (Shift 1)
Source: Wabtec Port Optimizer (https://tower.portoptimizer.com/)

Port of Los Angeles : Terminal Times in Minutes (Shift 1)

Month / Year	APM Terminals	Fenix Marine	TraPac	WBCT	Yusen LLC	Everport
Jan-19	76	58	56	80	43	66
Feb-19	71	59	46	68	44	58
Mar-19	58	62	52	61	40	56
Apr-19	77	64	52	68	37	51
May-19	71	68	42	63	38	49
Jun-19	65	47	35	62	34	48
Jul-19	71	59	38	68	38	50
Aug-19	64	64	35	64	37	45
Sep-19	61	52	34	58	39	53
Oct-19	52	51	34	51	36	52
Nov-19	54	54	28	50	36	47
Dec-19	54	52	26	58	36	42
Jan-20	55	47	28	49	36	43
Feb-20	56	46	34	56	37	41
Mar-20	46	53	31	47	32	41
Apr-20	59	65	38	57	39	40
May-20	50	48	38	48	35	45
Jun-20	51	52	37	54	34	46
Jul-20	49	56	36	57	40	40
Aug-20	56	57	43	70	40	40
Sep-20	63	61	49	78	45	46
Oct-20	69	61	65	78	43	41
Nov-20	68	58	58	69	48	38
Dec-20	62	62	43	69	42	43
Jan-21	64	61	49	75	44	48
Feb-21	69	65	52	80	58	54
Mar-21	74	72	59	67	51	53
Apr-21	71	67	47	68	53	50

Notes: Port of Los Angeles, Wabtec Corp. Tower Control 2021

Port of Los Angeles : Gate Transactions (Shift 1)

Month / Year	APM Terminals	Fenix Marine	TraPac	WBCT	Yusen LLC	Everport
Jan-19	41,483	0*	7410	16430	17135	21,376
Feb-19	24,158	18516	6819	14656	18438	19,356
Mar-19	29,219	21348	8275	14494	13820	15,094
Apr-19	32,910	26060	10094	15802	18916	20,005
May-19	29,892	18959	2882	17997	17608	15,543
Jun-19	5,669	5586	1011	3516	4393	4,007
Jul-19	6,416	7769	1879	9468	4932	5,680
Aug-19	40,761	28018	12344	32272	27455	25,883
Sep-19	36,358	28008	13713	23534	25190	22,640
Oct-19	32,490	30517	10821	22743	20894	23,931
Nov-19	30,269	28395	7668	14901	25815	23,236
Dec-19	28,739	23994	7712	17216	18575	17,088
Jan-20	41,285	42346	13345	23396	28534	24,267
Feb-20	31,730	27260	14240	23093	15242	21,237
Mar-20	18,165	18910	9250	12710	12989	16,558
Apr-20	41,114	41771	26654	26801	14506	31,481
May-20	48,047	39639	18375	6828	17881	26,794
Jun-20	39,475	35874	21702	17782	20824	33,887
Jul-20	43,092	41928	24284	21897	30379	29,543
Aug-20	43,588	34752	20730	26723	28941	25,126
Sep-20	37,084	39412	17210	36453	29461	27,722
Oct-20	29,603	32625	16698	34338	21545	20,906
Nov-20	26,341	26278	15958	37602	23458	21,950
Dec-20	25,024	32179	17624	31452	23541	21,261
Jan-21	26,100	32247	12272	31277	22395	18,228
Feb-21	27,789	23245	12438	24314	19430	14,199
Mar-21	32,313	24503	12201	27060	14866	10,838
Apr-21	29,716	23769	8872	20975	16276	11,362

Note: * Data Not Available; Port of Los Angeles, Wabtec Corp. Tower Control 2021

Table F.3 & F.4 (Port of Los Angeles Truck Turn-Times and Queue Times (Shift 1)
Source: Wabtec Port Optimizer (https://tower.portoptimizer.com/)

Port of Los Angeles : Truck Turn Times in Minutes (Shift 1)

Month / Year	APM Terminals	Fenix Marine	TraPac	WBCT	Yusen LLC	Everport
Jan-19	98	82	77	91	61	84
Feb-19	97	89	68	85	62	77
Mar-19	84	112	77	74	55	67
Apr-19	107	103	71	85	55	62
May-19	102	108	53	77	62	58
Jun-19	90	66	44	78	64	59
Jul-19	93	85	47	87	61	61
Aug-19	89	92	44	78	55	55
Sep-19	84	67	40	71	55	59
Oct-19	77	77	41	62	55	65
Nov-19	76	83	35	60	48	64
Dec-19	77	75	33	69	46	50
Jan-20	75	77	35	59	48	51
Feb-20	85	69	41	73	49	52
Mar-20	87	78	38	61	41	53
Apr-20	79	87	49	69	50	58
May-20	72	70	54	67	47	60
Jun-20	66	68	50	68	49	58
Jul-20	64	70	47	69	53	52
Aug-20	81	74	53	89	53	50
Sep-20	92	75	60	89	57	63
Oct-20	98	76	80	93	60	57
Nov-20	98	80	71	87	60	47
Dec-20	104	82	61	88	63	53
Jan-21	97	79	62	95	56	57
Feb-21	108	86	65	97	75	64
Mar-21	124	89	71	82	63	62
Apr-21	94	86	64	83	67	57

Notes: Port of Los Angeles, Wabtec Corp. Tower Control 2021

Port of Los Angeles : Queue Times in Minutes (Shift 1)

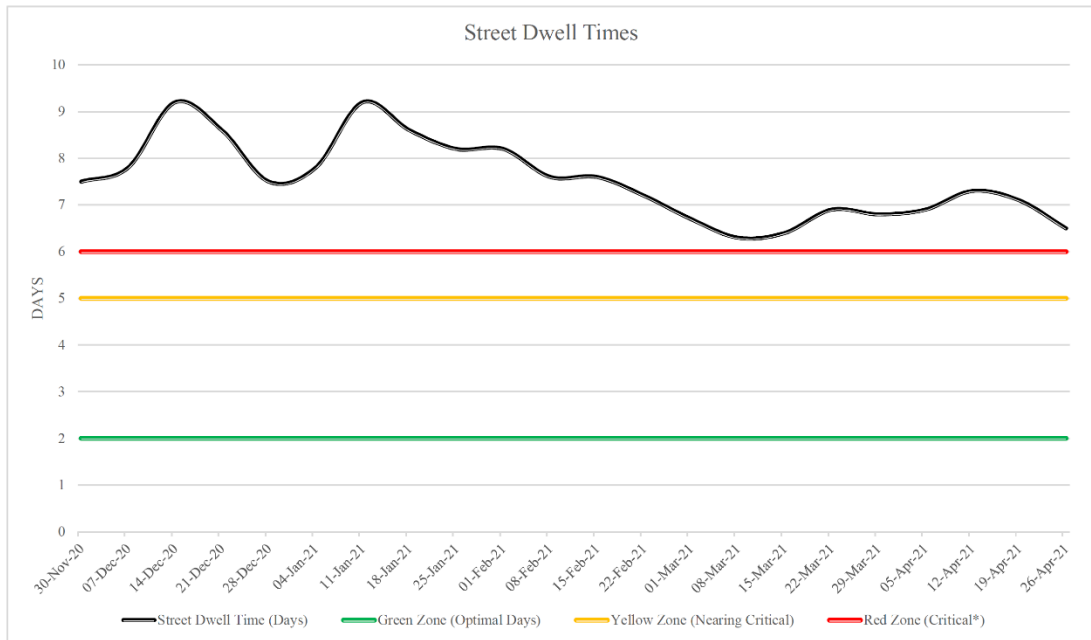| Month / Year	APM Terminals	Fenix Marine	TraPac	WBCT	Yusen LLC	Everport
Jan-19	22	24	22	11	18	18
Feb-19	26	30	22	17	18	19
Mar-19	25	51	25	13	15	11
Apr-19	30	40	19	17	18	11
May-19	31	40	12	14	23	9
Jun-19	25	19	9	16	29	11
Jul-19	21	26	9	19	23	11
Aug-19	25	29	9	14	17	10
Sep-19	23	16	7	13	16	7
Oct-19	25	26	7	11	18	13
Nov-19	21	29	7	10	12	17
Dec-19	23	23	7	11	10	8
Jan-20	20	30	7	10	12	8
Feb-20	29	24	7	16	12	11
Mar-20	41	25	7	14	9	11
Apr-20	20	22	11	12	11	18
May-20	21	21	16	19	12	15
Jun-20	15	15	13	14	16	13
Jul-20	16	14	11	12	13	12
Aug-20	25	16	10	19	12	9
Sep-20	29	13	11	11	13	17
Oct-20	29	15	15	15	17	16
Nov-20	30	22	13	18	12	9
Dec-20	42	20	18	19	20	10
Jan-21	33	18	13	19	12	9
Feb-21	39	21	13	16	17	10
Mar-21	50	17	12	15	12	9
Apr-21	23	19	17	15	14	7

Notes: Port of Los Angeles, Wabtec Corp. Tower Control 2021

Table F.5 & F.6 (Port of Los Angeles Terminal Times and Gate Transactions (Shift 2)
Source: Wabtec Port Optimizer (https://tower.portoptimizer.com/)

Port of Los Angeles : Terminal Times in Minutes (Shift 2)

Month / Year	APM Terminals	Fenix Marine	TraPac	WBCT	Yusen LLC	Everport
Jan-19	104	78	78	96	53	87
Feb-19	84	91	43	74	50	67
Mar-19	58	98	52	61	35	50
Apr-19	67	87	61	72	34	55
May-19	71	99	31	81	40	51
Jun-19	64	58	28	65	34	49
Jul-19	73	94	36	87	39	48
Aug-19	69	102	41	79	40	41
Sep-19	74	65	38	64	41	52
Oct-19	57	79	38	54	37	55
Nov-19	62	78	28	57	39	44
Dec-19	67	79	25	67	37	48
Jan-20	61	77	28	46	35	43
Feb-20	64	64	36	50	37	50
Mar-20	54	66	28	39	41	64
Apr-20	71	88	35	55	51	72
May-20	62	44	39	53	38	71
Jun-20	58	59	36	60	47	60
Jul-20	65	73	40	49	48	79
Aug-20	76	74	51	71	52	72
Sep-20	90	95	54	91	62	92
Oct-20	96	88	81	91	60	60
Nov-20	104	79	80	84	61	60
Dec-20	91	88	63	78	65	61
Jan-21	95	92	70	96	59	66
Feb-21	62	73	56	89	62	51
Mar-21	57	61	52	59	37	41
Apr-21	61	60	43	49	39	44

Notes: Port of Los Angeles, Wabtec Corp. Tower Control 2021

Port of Los Angeles : Gate Transactions (Shift 2)

Month / Year	APM Terminals	Fenix Marine	TraPac	WBCT	Yusen LLC	Everport
Jan-19	29,974	0*	6014	12919	12619	8,986
Feb-19	20,684	11387	4806	14611	11810	6,380
Mar-19	24,232	15517	6920	13642	9732	3,287
Apr-19	27,356	15154	5203	16832	10864	4,035
May-19	25,708	14223	2554	15973	11291	3,894
Jun-19	8,259	4870	1225	5583	4880	1,121
Jul-19	13,360	7720	1951	9787	8847	2,434
Aug-19	36,385	20242	6314	23166	16632	5,077
Sep-19	31,149	17130	8043	13006	10777	4,568
Oct-19	28,111	21383	8635	17342	15605	6,757
Nov-19	31,694	21501	6363	13877	16816	6,257
Dec-19	27,815	18295	5151	16816	16729	4,505
Jan-20	36,543	29747	8164	22762	19293	5,051
Feb-20	21,267	15774	8958	18946	16217	4,635
Mar-20	14,383	13783	6448	11744	12087	3,734
Apr-20	29,485	20282	12741	18243	8156	4,270
May-20	29,769	18532	14022	5819	6748	5,477
Jun-20	27,570	18513	13436	12460	11754	6,388
Jul-20	31,688	25333	10896	22260	12752	5,154
Aug-20	31,720	19551	9730	21251	11872	3,917
Sep-20	25,804	22993	10540	21795	13184	6,039
Oct-20	21,612	18682	10690	22499	9988	3,222
Nov-20	23,077	16316	12737	21086	9729	3,518
Dec-20	19,139	19454	13347	19349	9970	3,716
Jan-21	19,269	20863	11642	21689	7830	3,455
Feb-21	21,838	21487	10628	20656	12537	9,268
Mar-21	26,449	23839	10430	20559	11569	10,434
Apr-21	23,385	21537	7130	16085	12104	12,034

Note: * Data Not Available; Port of Los Angeles, Wabtec Corp. Tower Control 2021

Table F.7 & F.8 (Port of Los Angeles Truck Turn-Times and Queue Times (Shift 2)
Source: Wabtec Port Optimizer (https://tower.portoptimizer.com/)

Port of Los Angeles : Truck Turn Times in Minutes (Shift 2)

Month / Year	APM Terminals	Fenix Marine	TraPac	WBCT	Yusen LLC	Everport
Jan-19	141	100	95	108	74	116
Feb-19	116	126	68	93	70	95
Mar-19	81	153	72	79	51	64
Apr-19	91	120	83	88	50	71
May-19	111	137	40	97	61	69
Jun-19	97	83	34	79	61	62
Jul-19	113	124	42	109	61	62
Aug-19	103	131	48	94	55	52
Sep-19	100	81	44	75	55	62
Oct-19	80	101	46	63	48	70
Nov-19	87	97	34	68	50	59
Dec-19	92	100	30	81	46	60
Jan-20	84	98	34	55	46	53
Feb-20	85	84	43	61	47	59
Mar-20	83	88	36	50	56	79
Apr-20	106	108	57	68	81	89
May-20	92	55	63	77	65	94
Jun-20	81	70	53	76	71	79
Jul-20	93	83	53	63	62	102
Aug-20	118	88	64	96	72	88
Sep-20	137	106	69	107	82	112
Oct-20	147	101	98	106	82	73
Nov-20	158	96	100	97	79	70
Dec-20	160	105	80	98	88	77
Jan-21	138	108	88	112	78	78
Feb-21	99	90	70	106	78	62
Mar-21	90	81	64	71	49	51
Apr-21	78	80	54	61	51	52

Notes: Port of Los Angeles, Wabtec Corp. Tower Control 2021

Port of Los Angeles : Queue Times in Minutes (Shift 2)

Month / Year	APM Terminals	Fenix Marine	TraPac	WBCT	Yusen LLC	Everport
Jan-19	37	22	18	12	21	29
Feb-19	32	35	25	19	20	29
Mar-19	23	54	20	18	15	14
Apr-19	24	34	21	16	16	15
May-19	39	38	9	17	20	18
Jun-19	33	25	6	14	26	13
Jul-19	40	30	6	21	23	14
Aug-19	34	29	7	15	15	11
Sep-19	26	17	6	11	13	10
Oct-19	23	22	8	10	11	15
Nov-19	25	20	6	12	12	15
Dec-19	25	21	6	14	9	11
Jan-20	23	20	6	10	10	10
Feb-20	21	19	7	12	10	9
Mar-20	30	22	8	12	15	15
Apr-20	34	21	22	14	30	17
May-20	30	11	23	23	27	23
Jun-20	23	11	16	17	24	19
Jul-20	28	10	14	15	13	23
Aug-20	41	13	13	25	20	16
Sep-20	46	11	16	16	20	20
Oct-20	51	13	17	16	22	13
Nov-20	55	17	20	13	18	10
Dec-20	69	17	17	20	24	16
Jan-21	43	16	18	16	19	11
Feb-21	37	17	14	16	16	12
Mar-21	33	19	12	12	11	10
Apr-21	17	20	11	12	11	8

Notes: Port of Los Angeles, Wabtec Corp. Tower Control 2021

Table F.9 (Port of Los Angeles Days After Discharge Containers (LOCAL)
Source: Wabtec Port Optimizer (https://tower.portoptimizer.com/)

Port of Los Angeles : Days After Discharge (Containers) LOCAL

Month / Year	0 - 4 Days	5 - 8 Days	9 - 12 Days	13+ Days
Jan-19	51%	40%	6%	3%
Feb-19	54%	37%	5%	4%
Mar-19	72%	25%	2%	1%
Apr-19	67%	29%	2%	2%
May-19	61%	33%	2%	3%
Jun-19	68%	29%	3%	1%
Jul-19	60%	36%	2%	1%
Aug-19	62%	34%	2%	2%
Sep-19	64%	32%	2%	2%
Oct-19	68%	30%	2%	1%
Nov-19	64%	32%	2%	1%
Dec-19	57%	34%	7%	2%
Jan-20	65%	32%	2%	1%
Feb-20	57%	37%	4%	2%
Mar-20	65%	30%	4%	1%
Apr-20	71%	27%	1%	1%
May-20	68%	30%	2%	0%
Jun-20	70%	28%	2%	1%
Jul-20	60%	35%	3%	2%
Aug-20	58%	33%	5%	4%
Sep-20	42%	42%	9%	8%
Oct-20	44%	38%	9%	9%
Nov-20	46%	38%	9%	8%
Dec-20	43%	37%	10%	10%
Jan-21	56%	32%	6%	5%
Feb-21	57%	34%	4%	4%
Mar-21	59%	32%	4%	5%
Apr-21	61%	32%	4%	4%

Note: Port of Los Angeles, Wabtec Corp. Tower Control 2021

Table F.10 (Port of Los Angeles Days After Discharge Containers (RAIL)
Source: Wabtec Port Optimizer (https://tower.portoptimizer.com/)

Port of Los Angeles : Days After Discharge (Containers) RAIL

Month / Year	0 - 2 Days	3 - 4 Days	5 - 7 Days	8+ Days
Jan-19	40%	23%	23%	15%
Feb-19	31%	26%	28%	15%
Mar-19	57%	23%	16%	4%
Apr-19	63%	19%	15%	3%
May-19	60%	21%	11%	8%
Jun-19	55%	20%	17%	8%
Jul-19	57%	26%	12%	5%
Aug-19	60%	23%	13%	4%
Sep-19	63%	24%	11%	2%
Oct-19	60%	26%	12%	2%
Nov-19	58%	25%	14%	2%
Dec-19	55%	26%	16%	3%
Jan-20	52%	28%	17%	2%
Feb-20	60%	28%	10%	2%
Mar-20	68%	24%	6%	2%
Apr-20	51%	24%	18%	7%
May-20	59%	25%	13%	3%
Jun-20	70%	21%	8%	1%
Jul-20	57%	28%	12%	3%
Aug-20	49%	29%	17%	5%
Sep-20	43%	27%	20%	11%
Oct-20	29%	24%	24%	22%
Nov-20	25%	17%	23%	35%
Dec-20	20%	15%	18%	47%
Jan-21	26%	19%	18%	37%
Feb-21	15%	12%	16%	57%
Mar-21	12%	11%	16%	61%
Apr-21	11%	13%	16%	60%

Note: Port of Los Angeles, Wabtec Corp. Tower Control 2021

Table F.11 (Port of Los Angeles Days After Discharge Containers (TOTAL)
Source: Wabtec Port Optimizer (https://tower.portoptimizer.com/)

Port of Los Angeles : Days After Discharge (Containers) TOTAL

Month / Year	0 - 4 Days	5 - 8 Days	9 - 12 Days	13+ Days
Jan-19	54%	37%	6%	2%
Feb-19	55%	36%	6%	3%
Mar-19	74%	23%	2%	1%
Apr-19	71%	26%	2%	1%
May-19	67%	28%	3%	2%
Jun-19	69%	27%	3%	1%
Jul-19	68%	29%	3%	1%
Aug-19	69%	28%	2%	2%
Sep-19	70%	26%	2%	2%
Oct-19	73%	25%	2%	1%
Nov-19	69%	27%	2%	1%
Dec-19	64%	29%	5%	1%
Jan-20	70%	28%	2%	1%
Feb-20	66%	29%	3%	1%
Mar-20	73%	23%	3%	1%
Apr-20	72%	25%	2%	1%
May-20	72%	26%	2%	0%
Jun-20	75%	23%	2%	0%
Jul-20	67%	29%	2%	2%
Aug-20	63%	29%	4%	3%
Sep-20	49%	37%	8%	7%
Oct-20	46%	36%	10%	8%
Nov-20	45%	35%	10%	10%
Dec-20	41%	33%	12%	13%
Jan-21	53%	30%	9%	8%
Feb-21	50%	31%	8%	12%
Mar-21	50%	29%	8%	13%
Apr-21	52%	29%	8%	10%

Note: Port of Los Angeles, Wabtec Corp. Tower Control 2021

Table F.12 (Pool of Pools Chassis Statistics)
Source: Pool of Pools Official* (http://www.pop-lalb.com/reports/Net_Imbalance.pdf)

Pool of Pools Chassis Statistics

SIZE	LOCATION	Nov 2020	Dec 2020	Jan 2021	Feb 2021	Mar 2021	Apr 2021
20 FT	BNRR	704	774	850	(35)	67	45
	TTI	(390)	(207)	(592)	(676)	(360)	(624)
	UPRR	224	349	1030	769	1148	1583
	ITS	72	(204)	(136)	(217)	(194)	151
	APMT	(158)	(226)	(269)	253	(49)	(634)
	GGS	(98)	(201)	(45)	(161)	(548)	(209)
	LBCT	(27)	(82)	(10)	(2)	116	(189)
	ETS	(176)	(155)	(187)	(128)	(44)	(266)
	YTI	(173)	(254)	(250)	(62)	(369)	(246)
	PCT	7	(90)	(88)	(254)	(259)	(180)
	PIERA	168	151	(189)	5	(206)	7
	TRAPC	(281)	(81)	(220)	(310)	(260)	(156)
	WBCT	139	238	104	194	(105)	(388)
	Minimum Repo Moves	1314	1512	1984	1221	1331	1786
40/45 FT	BNRR	(50)	196	1161	(97)	142	(82)
	TTI	(178)	(930)	(2043)	(3575)	861	(2743)
	UPRR	(66)	(359)	2202	2803	3343	4988
	ITS	(600)	(743)	129	(356)	(749)	(914)
	APMT	(947)	(582)	(1321)	1493	(611)	(1370)
	GGS	(467)	16	(271)	(399)	(1248)	(298)
	LBCT	2200	1851	636	343	1406	191
	ETS	(690)	(579)	(229)	(501)	(25)	(1141)
	YTI	(1298)	22	(712)	343	(1367)	254
	PCT	435	273	(352)	(914)	(1464)	(1376)
	PIERA	1484	1081	1020	621	497	1617
	TRAPC	(480)	(33)	(1101)	(1104)	(1954)	(1078)
	WBCT	768	(104)	897	98	(1294)	(1316)
	Minimum Repo Moves	4887	3439	6045	5701	6249	7050
Total Minimum Repo Moves		6201	4951	8029	6922	7580	8836

Notes: **NET IMBALANCE** refers to the net result of all dislocated moves by location and by equipment size. Surplus flows are expressed as a positive number, deficit flows as a negative number (in brackets).

MINIMUM REPO MOVES represent the theoretical number of repositioning moves that would be required to correct the Net Imblance. Please note that this is the minimum number, additional moves are often required depending on actual situations (variations in volume or individual alternating between surplus/deficit within the monthly time period are two expamples of such situations).

Table F.13 (Pool of Pools Chassis Out of Service Chassis)
Source: Pool of Pools Official* (http://www.pop-lalb.com/reports/OOS.pdf)

Pool of Pools - Out of Service Chassis as of 15-09-2021

| Location	20'	40'	45'	Total
ITS	30	76	15	121
Trapac	60	26	27	113
ICTF	6	2	0	8
UPELA	0	0	1	1
LATC	0	0	0	0
BNSF	6	9	1	16
PCMC/HP	33	82	9	124
PIER B	19	123	25	167
FMS	18	52	0	70
ETS	136	266	52	454
APMT	163	396	36	595
PCT	49	65	26	140
Pier A	21	147	51	219
TTI	28	207	0	235
WBCT	8	29	43	80
YTI	55	107	40	202
Total	632	1587	326	2545

Appendix G. Port Terminal Disruptions (Graph)

Graph G.1 (Comparison of TEU Levels and ILWU Hours at San Pedro Bay Ports (Port of Los Angeles and Port of Long Beach)

Source: Pacific Maritime Association (https://www.pmanet.org/wp-content/uploads/2021/07/John_Martin_Research-July_2021.pdf)
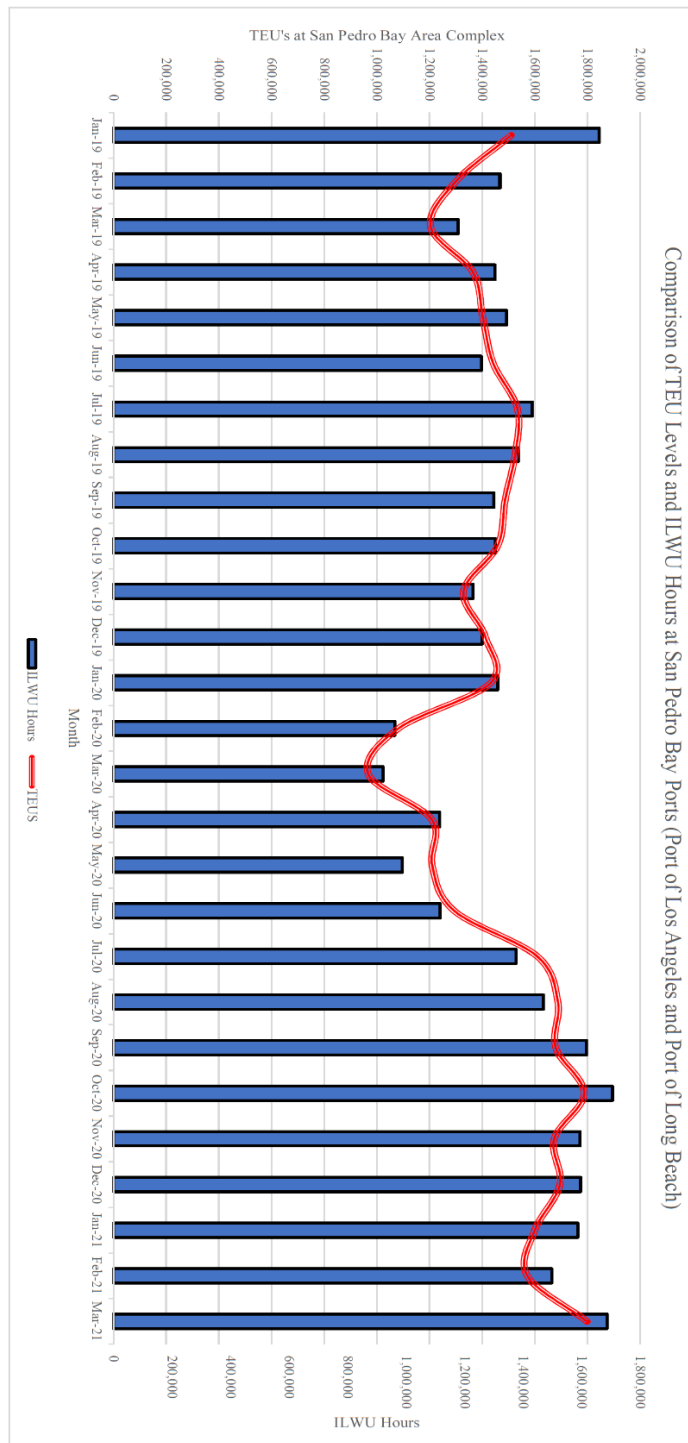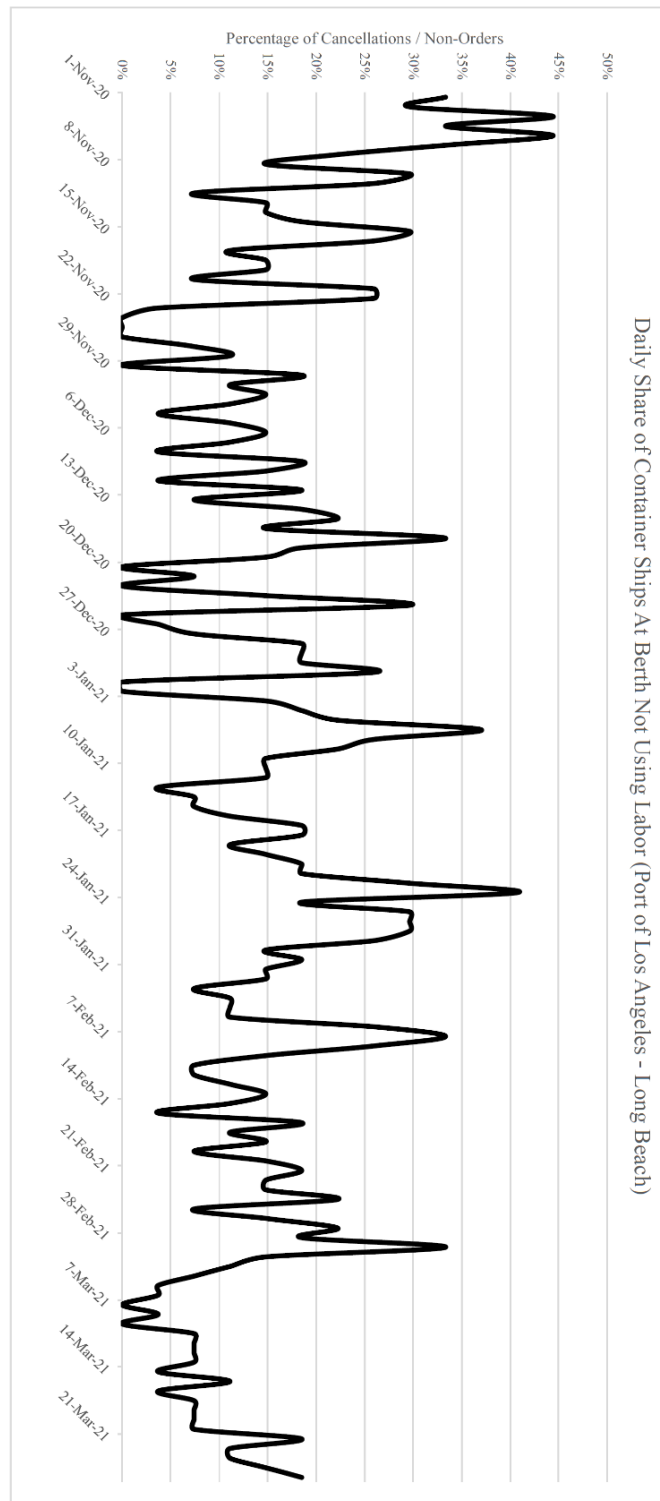
Graph G.2 San Pedro Bay Port Terminal Dwell Time / Terminal Congestion (During COVID-19 Pandemic)

Source: Pacific Maritime Association (https://www.pmanet.org/wp-content/uploads/2021/07/John_Martin_Research-July_2021.pdf)
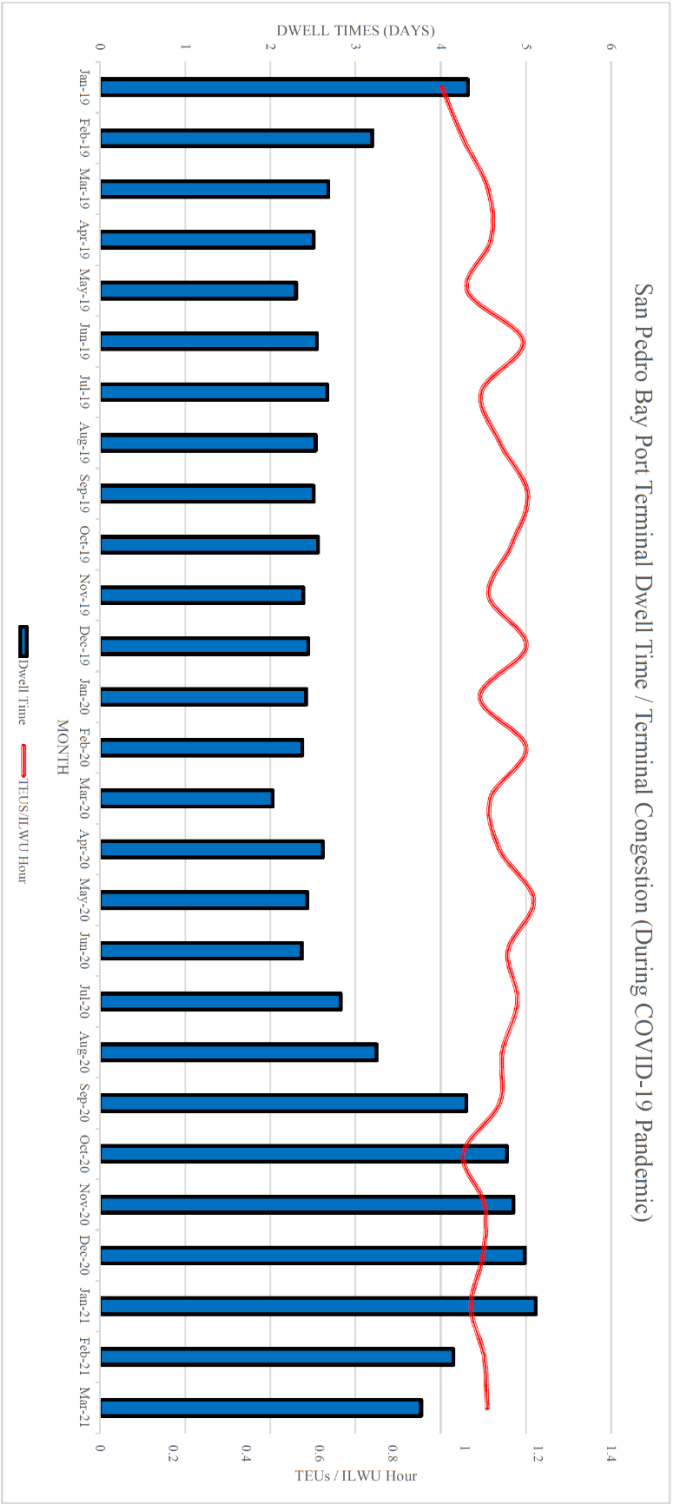
Graph G.3 Daily Share of Container Ships at Berth Not Using Labor (Port of Los Angeles-Long Beach)

Source: Pacific Maritime Association (https://www.pmanet.org/wp-content/uploads/2021/07/John_Martin_Research-July_2021.pdf)

Graph G.4 Automated Terminal vs. Traditional Terminal Performance (During COVID-19 Pandemic)

Source: Pacific Maritime Association (https://www.pmanet.org/wp-content/uploads/2021/07/John_Martin_Research-July_2021.pdf)
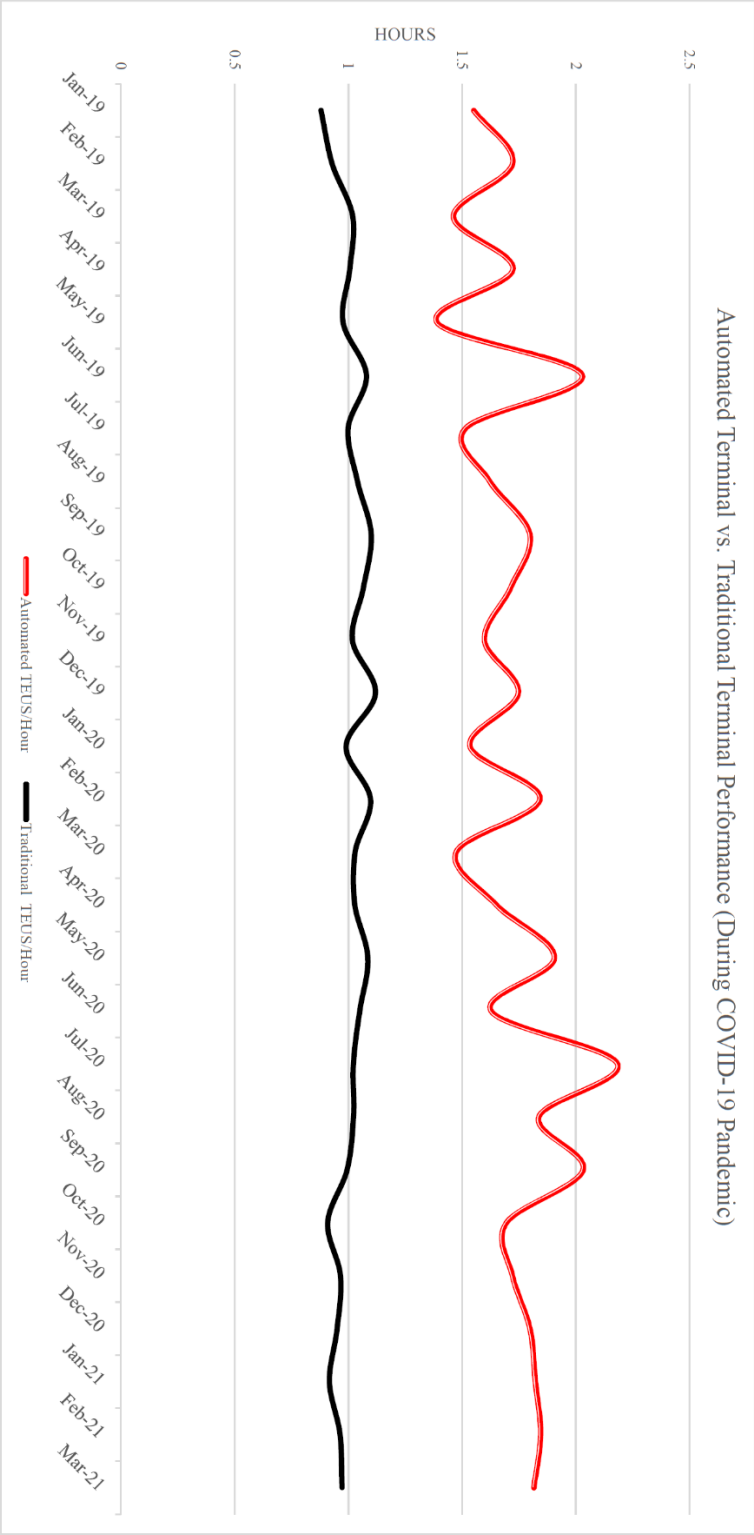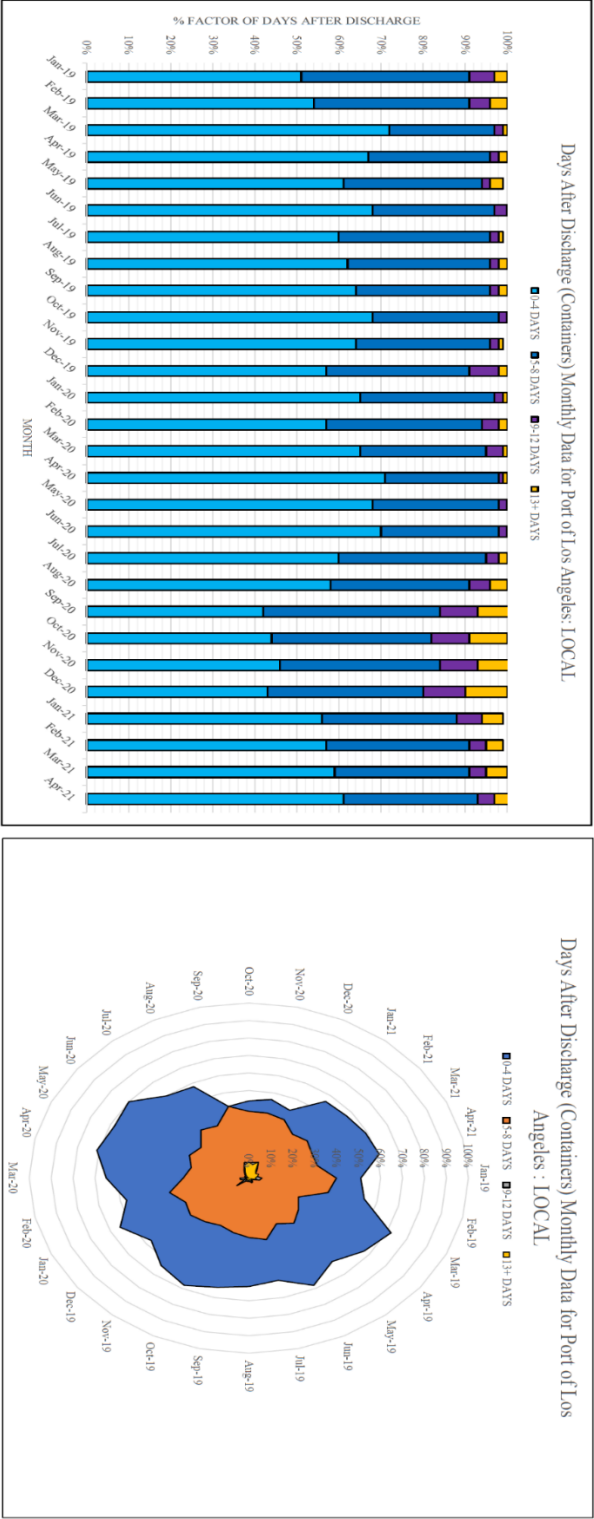
Appendix H. Rail, On-Street Dwell Times (Graph)

Graph H.1 Days after Discharge (Containers) for Port of Los Angeles (TOTAL)
Source: Wabtec Port Optimizer (https://tower.portoptimizer.com/)
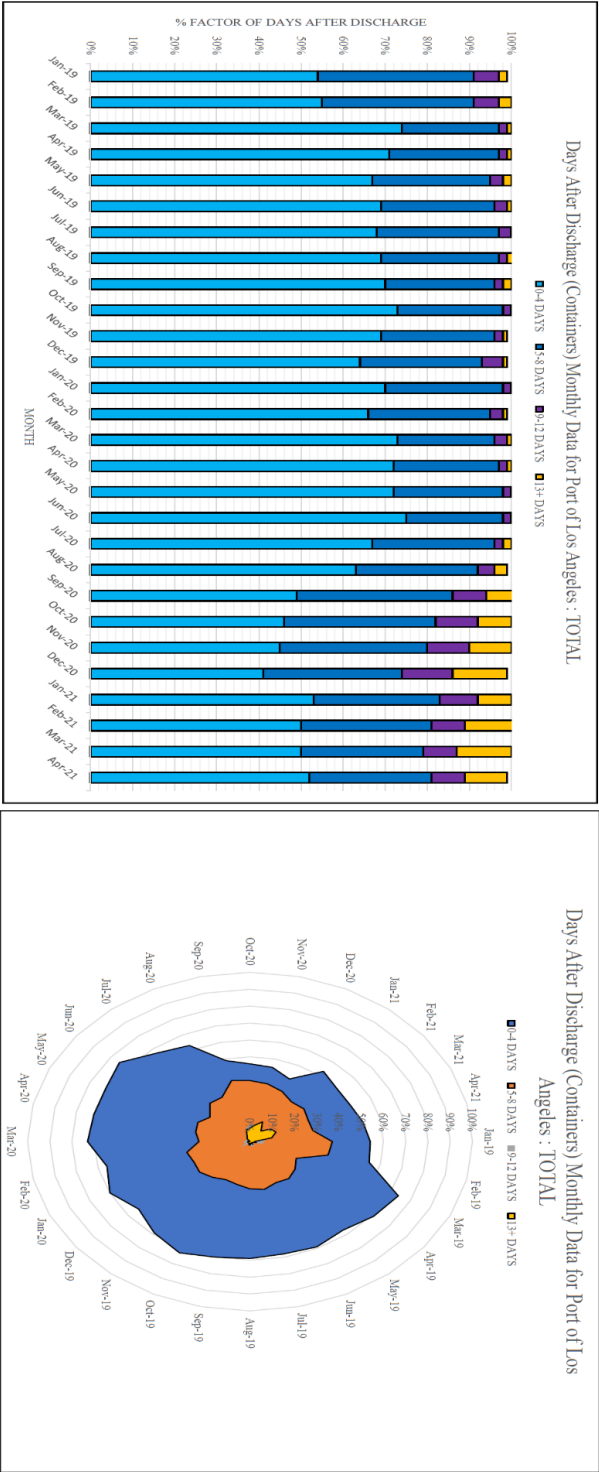
Graph H.2 Days after Discharge (Containers) for Port of Los Angeles (LOCAL)
Source: Wabtec Port Optimizer (https://tower.portoptimizer.com/)

Graph H.3 Days after Discharge (Containers) for Port of Los Angeles (RAIL)
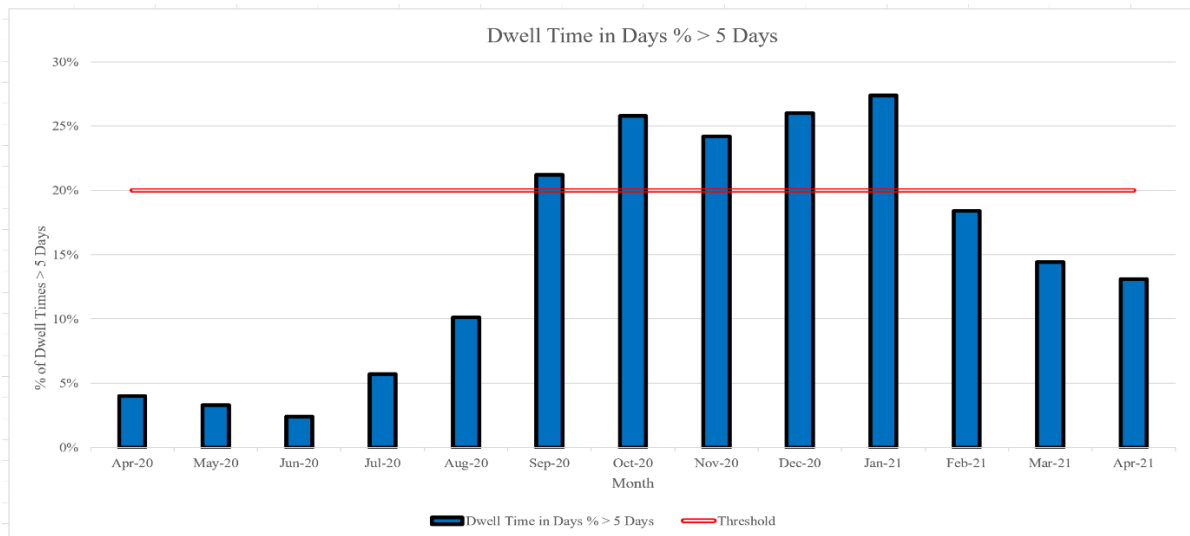Source: Wabtec Port Optimizer (https://tower.portoptimizer.com/)

Graph H.4, H.5 and H.6
Rail Dwell Time in Days (Port of Los Angeles and Port of Long Beach)
Dwell Times in Day % > 5 Days
Source: PMSA (https://www.pmsaship.com/wp-content/uploads/2021/05/West-Coast-Trade-Report-May-2021.pdf)

Rail Dwell Time in Days (Port of Los Angeles and Port of Long Beach)

Dwell Time in Days % > 5 Days
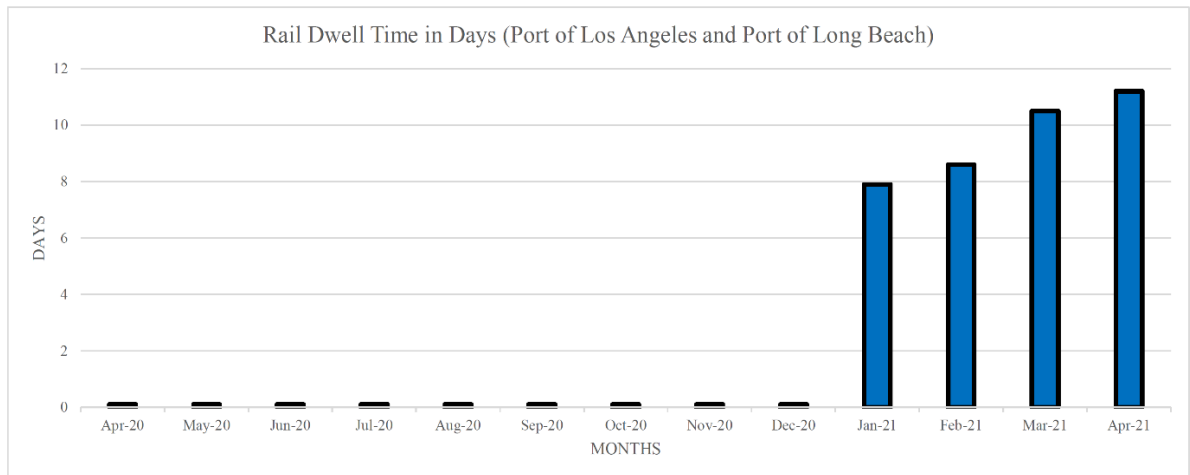
Graph H.6 Alameda Corridor (Historic Data – Average Number of Trains Per Day)
Source: Alameda Corridor Transit Authority (https://1popqd1sgf8034z1s33q7dj6-wpengine.netdna-ssl.com/wp-content/uploads/2021/01/CorridorTrainCounts.pdf)
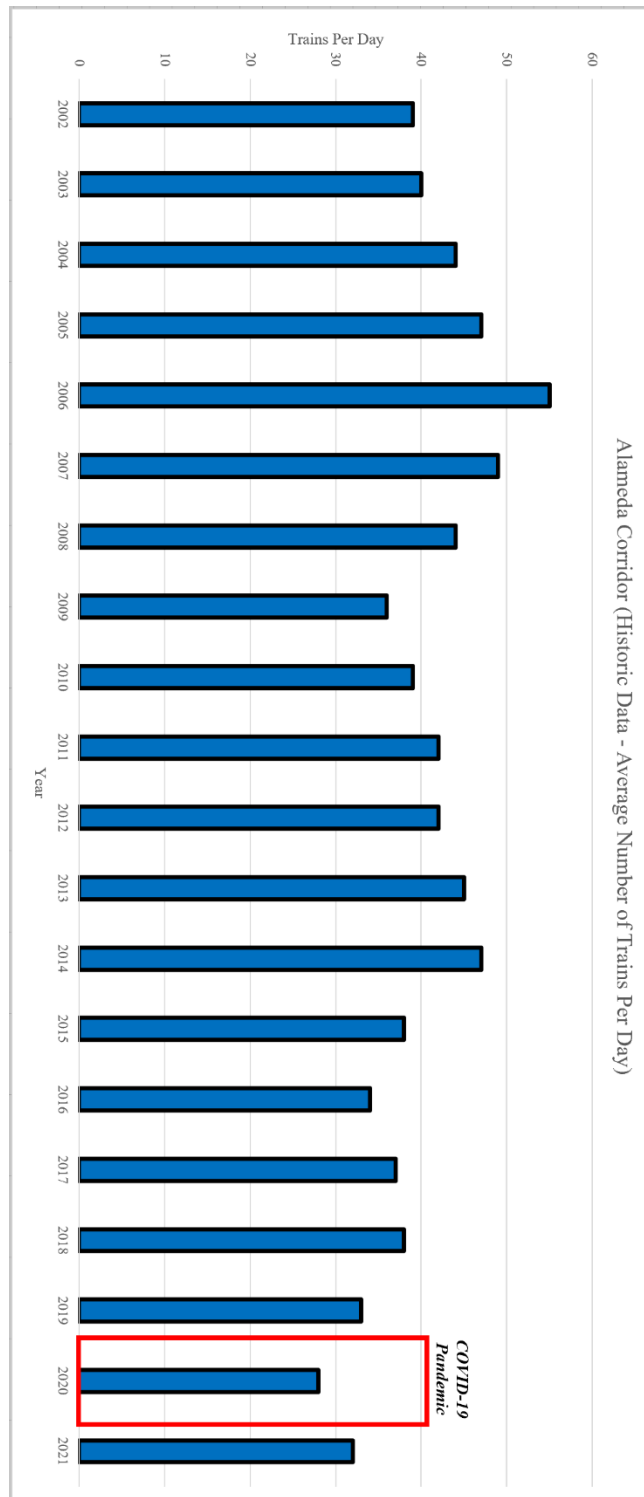
Appendix I. Warehousing Statistics (Graph)

Graph I.1 & I.2

Net Absorption of Industrial Warehousing in Southern California (2019 - 2021)

% Vacancy of Industrial Warehousing in Southern California (2019 – 2021)

Source: https://www.lee-associates.com/research/page/3/?research-property-type=-1&research-location=3838&research-year=-1

Net Absorption of Industrial Warehousing in Southern California (2019 - 2021)

% Vacancy of Industrial Warehousing in Southern California (2019 - 2021)
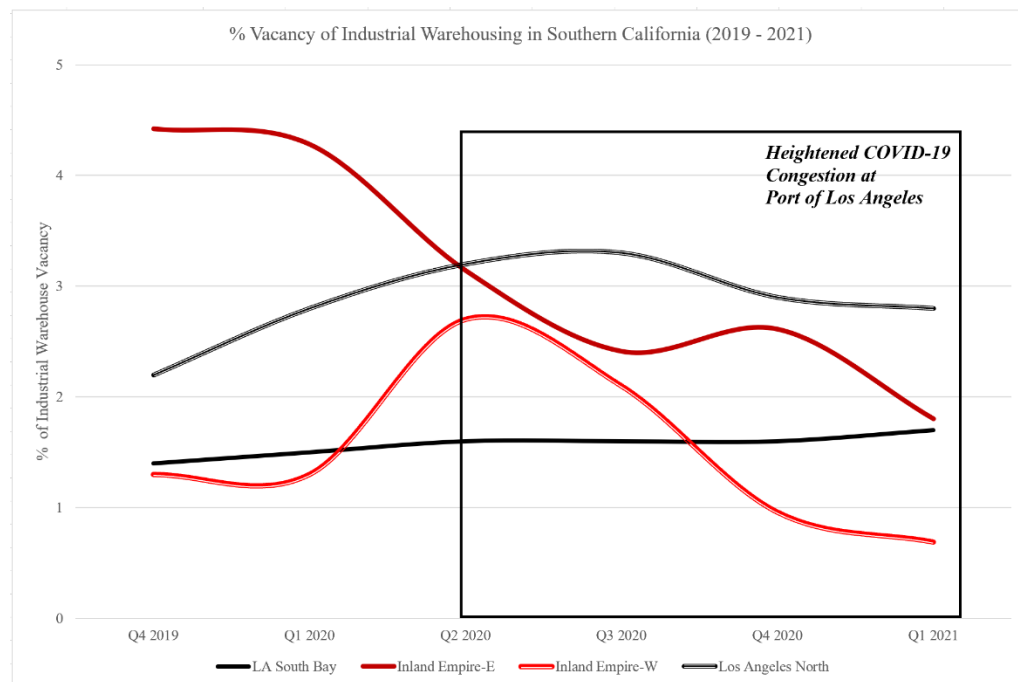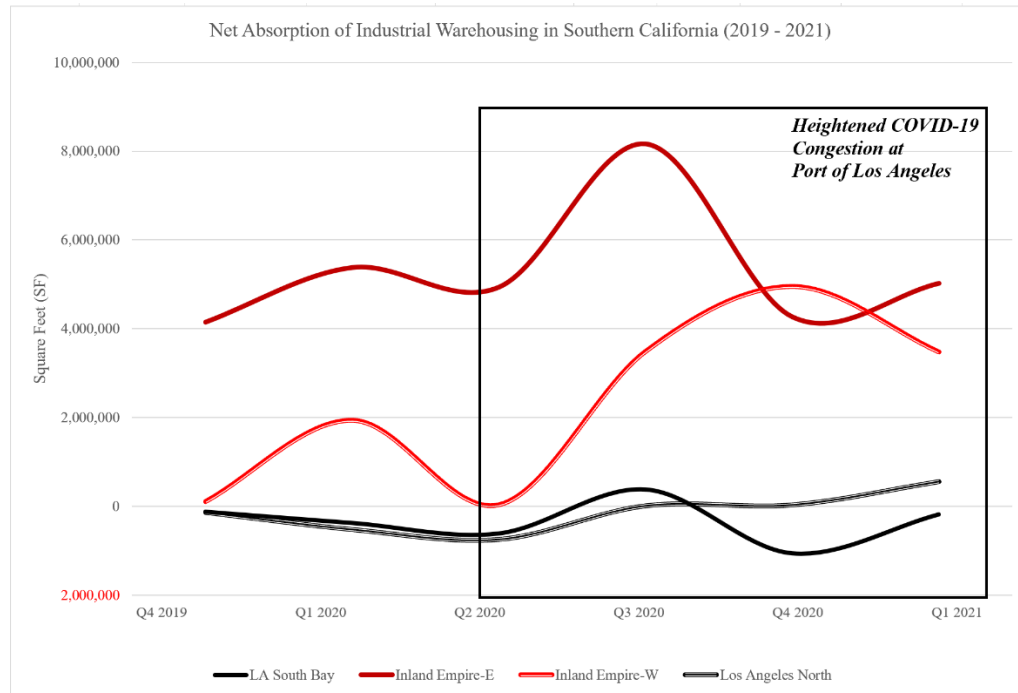
Graph I.3 & I.4
Los Angeles Cost of Industrial Warehousing Per Square Foot (During COVID-19 Pandemic)
Los Angeles South Bay – Pork Markets, CA (Industrial Warehousing Overview)
Source: https://www.lee-associates.com/research/page/3/?research-property-type=-1&research-location=3838&research-year=-1

Los Angeles Cost of Industrial Warehousing Per Square Foot (During COVID-19 Pandemic)

Los Angeles South Bay - Port Markets, CA (Industrial Warehousing Overview)
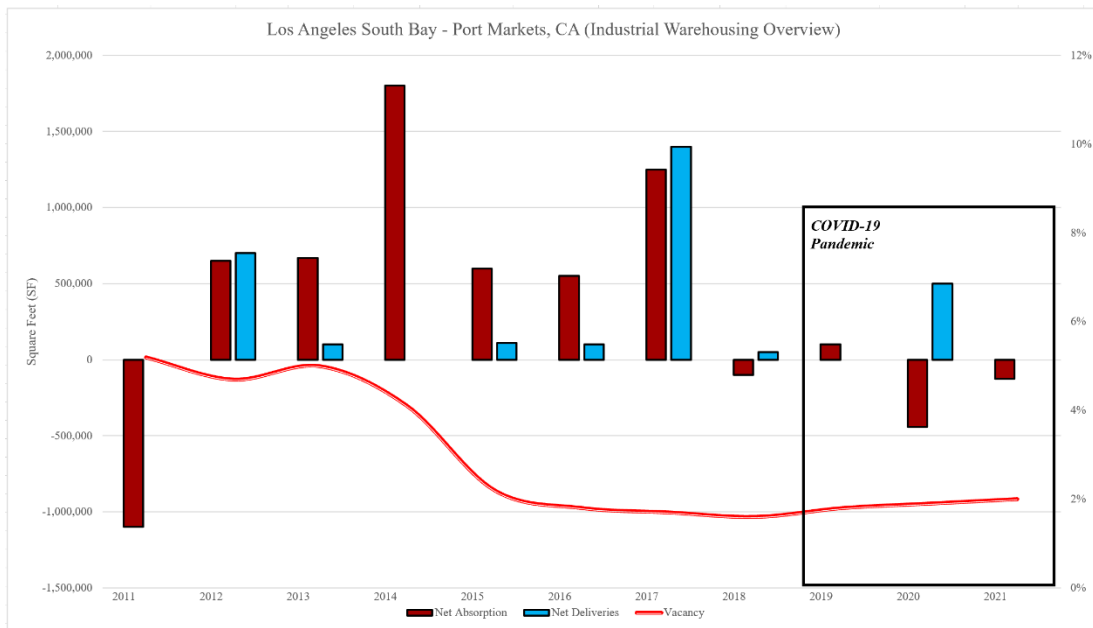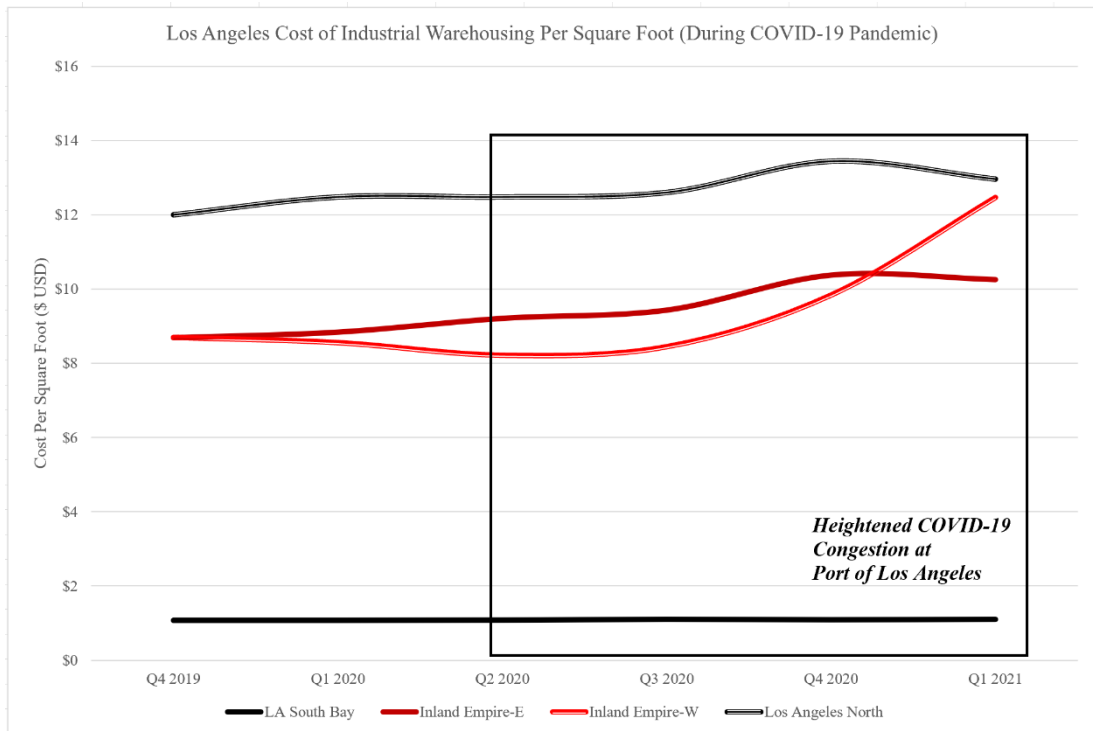
Graph I.5 & I.6
Inland Empire - West, CA (Industrial Warehousing Overview)
Inland Empire – East, CA (Industrial Warehousing Overview)
Source: https://www.lee-associates.com/research/page/3/?research-property-type=-1&research-location=3838&research-year=-1
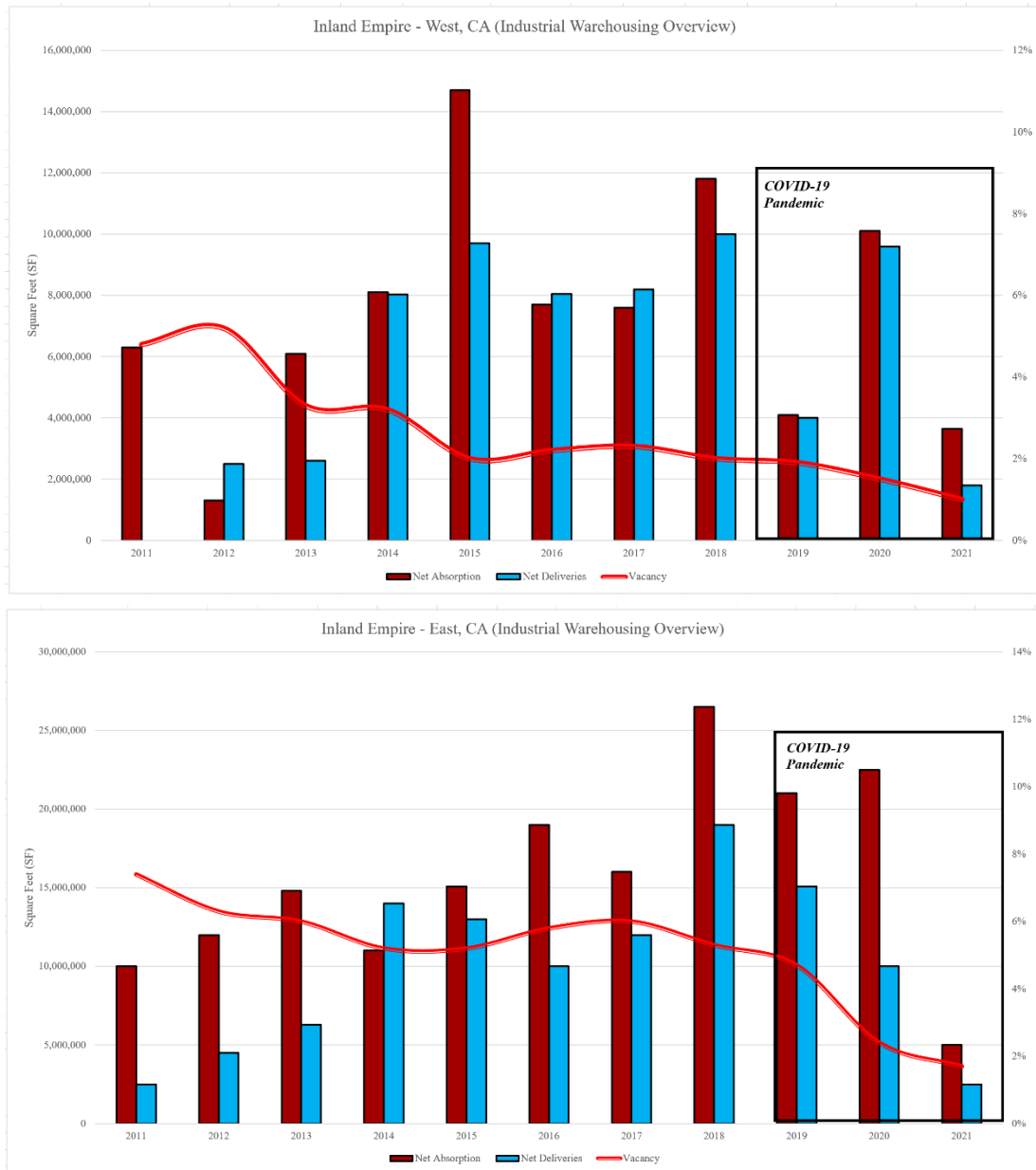
Graph I.7 & I.8
Los Angeles North, CA (Industrial Warehousing Overview)
Industrial Real Estate Vacancy Rate by Market 2020 (Year Average)
Source: (https://www.lee-associates.com/research/page/3/?research-property-type=-1&research-location=3838&research-year=-1) (https://avison-young.foleon.com/2021-forecast/us-real-estate-trends/industrial/)
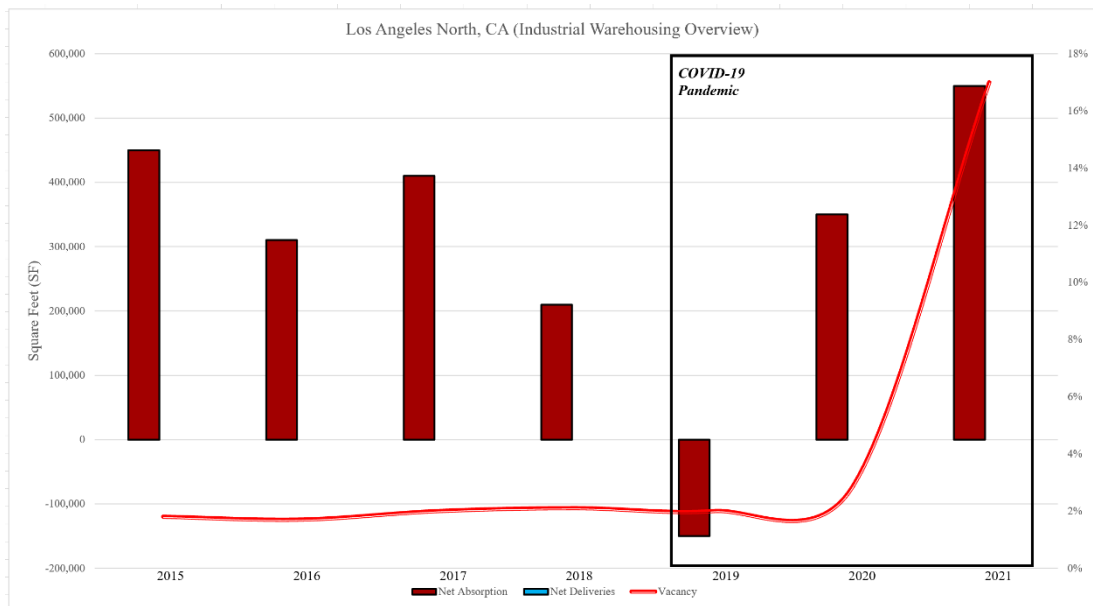
Graph J.1 & J.2
Changes in Demand for E-Commerce (2018 to COVID-19 Pandemic)
Online Store Demand for E-Commerce (2018 to COVID-19 Pandemic)
Source: (https://www.census.gov/retail/index.html#ecommerce)

Changes in Demand for E-Commerce (2018 to COVID-19 Pandemic)

Online Store Demand for E-Commerce (2018 to COVID-19 Pandemic)
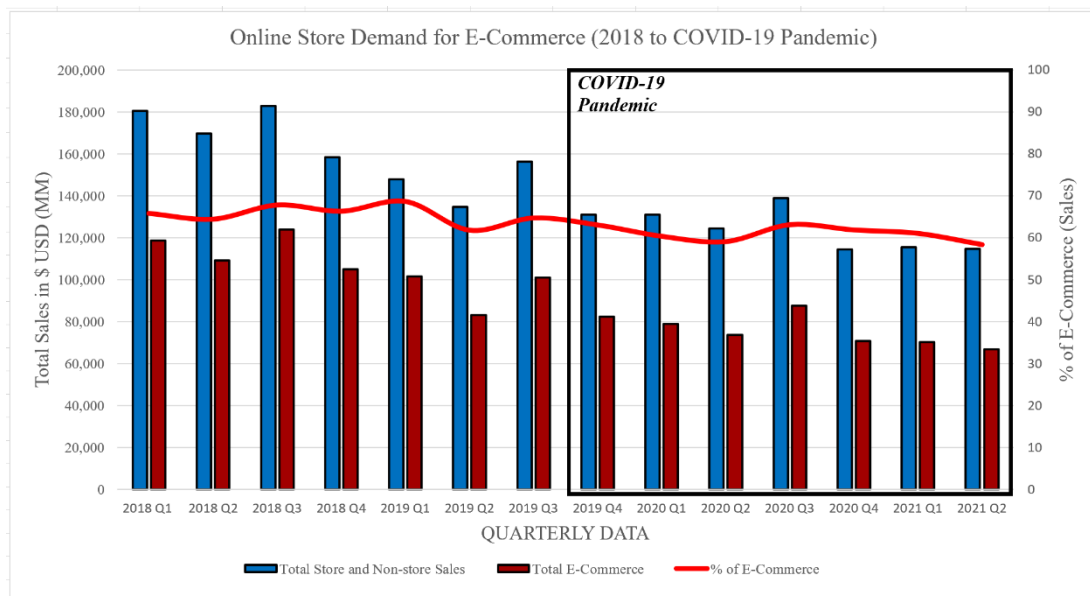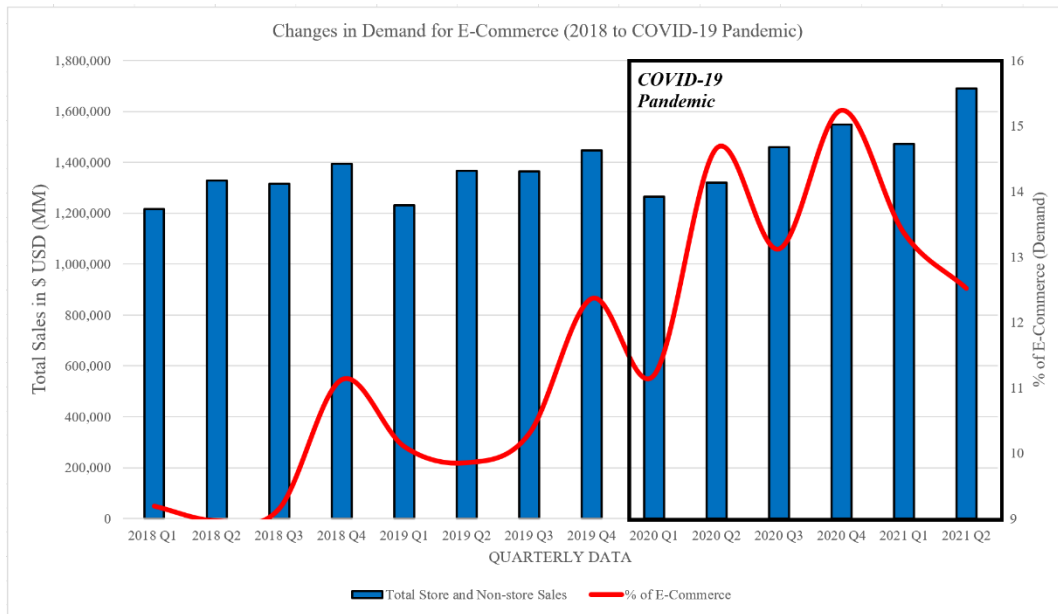
Appendix K. Analytic Hierarchical Process Data (Tables)

Table K.1 AHP Criteria Evaluation Table

Source: Author

AHP Criteria Evaluation Table

Surveyor (Confidential*)	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24	Q25	Q26	Q27	Q28	Q29	Q30	SUM	AVG
S1	7	1	7	1	1	1	1	1	1	-5	1	1	1	1	1	1	1	7	1	1	1	1	1	1	1	1	-9	1	-9	-9	12	0.40
S2	9	9	9	1	1	9	1	9	9	3	-5	1	1	1	7	1	-9	1	1	1	1	1	1	-7	-7	-7	-7	1	7	7	50	1.67
S3	5	-3	1	9	7	-3	9	-5	7	-9	1	-9	1	-7	1	-5	-5	7	5	3	9	-3	9	-9	7	3	5	3	7	3	44	1.47
S4	-5	3	1	-9	-9	9	1	9	9	5	3	1	9	1	9	1	-9	1	9	1	-5	1	-5	1	1	1	-5	5	-5	-5	24	0.80
S5	5	-3	-3	-9	-5	7	5	3	5	-5	1	-5	7	-3	1	-3	1	-5	-5	1	-7	-3	-7	-7	1	-5	-9	1	-5	-5	-54	1.80
S6	-3	3	-3	-5	1	1	3	-7	1	-3	-5	-3	5	-5	1	1	1	7	-5	-7	1	1	3	1	-7	-7	1	1	-3	-3	-34	1.13
S7	7	3	1	-5	-9	5	-5	5	5	5	-3	1	1	-7	-5	3	-5	-3	3	5	-7	-3	-5	-5	-9	-5	1	1	1	-7	-36	1.20
S8	5	-3	1	-7	-3	3	7	5	5	7	-3	-3	1	-5	-5	-3	-5	5	-7	-3	-3	-7	1	-5	-7	-5	-9	5	-7	-7	-52	1.73
S9	5	-3	-7	-5	1	7	1	5	5	5	-3	-3	1	-7	-5	1	-5	7	-5	1	-5	1	-5	-5	-7	-5	-9	1	7	3	-28	0.93
S10	5	-3	-5	-5	1	-5	1	-5	1	-5	1	1	1	-3	-5	1	-5	7	-5	1	-5	-3	-5	-5	-7	-5	-7	1	-3	7	-58	1.93
S11	5	1	3	-5	1	5	5	1	3	-3	-3	-3	3	1	7	1	-7	5	-5	1	-5	1	-5	-5	-3	-5	-7	-3	-5	-5	-26	0.87
S12	3	1	3	-5	1	7	7	7	7	5	-5	-3	3	1	5	-3	-3	5	3	-5	-5	-3	-3	-5	1	1	-9	1	-3	-3	6	0.20
S13	5	1	1	-7	3	3	7	5	5	1	1	-3	5	-3	5	1	-5	7	-3	-3	-3	-3	-5	-3	-3	-5	-9	1	1	-5	-8	0.27
S14	5	1	1	-7	-5	3	7	5	5	1	1	1	5	1	9	1	-5	3	1	-3	-7	1	-5	-5	-3	-3	-5	1	-5	-5	-6	0.20
S15	-5	1	1	-5	-3	1	3	7	5	5	5	-3	-3	-3	1	1	-3	3	-3	-3	-5	-3	-3	-3	-3	-3	-5	3	-5	-5	-30	1.00
S16	7	1	1	-3	-3	3	5	5	3	-5	1	-5	3	-5	5	-5	-5	1	-3	-5	-5	1	-3	-5	-5	-5	-7	1	1	-5	-36	1.20
S17	5	3	1	-7	-3	5	5	3	3	-5	-7	-5	3	-5	1	1	-5	-5	-5	-5	1	5	-3	-3	-3	5	1	5	1	-18	0.60
S18	5	3	5	-3	-3	7	-5	7	7	1	1	1	5	1	-5	-3	-7	3	1	-3	-3	1	3	-5	-5	1	-7	1	-7	-7	0	0.00
S19	5	3	1	-5	-5	7	1	9	5	3	1	-5	5	-5	7	-3	-9	-5	-5	-3	-5	1	-5	-5	-7	-5	-3	1	3	3	-20	0.67
S20	5	3	3	-7	-5	7	3	5	7	-5	-5	-5	3	-3	5	1	-5	1	-3	-3	-3	3	-5	-9	-5	-3	-5	1	1	-5	-28	0.93
S21	-3	-3	3	-3	3	3	3	5	3	3	-3	-5	3	1	7	1	-5	1	-5	-3	-7	3	-5	-5	-7	-7	-3	1	7	1	-16	0.53
S22	5	1	1	-3	-5	5	-5	7	3	3	-5	-5	3	1	5	1	-5	3	-3	-3	-5	3	-3	-5	-5	-5	-5	1	5	5	-10	0.33
S23	7	1	1	-5	-7	-5	-5	-5	-5	1	-3	-3	3	-3	5	1	-5	5	7	3	3	7	7	5	-7	-7	1	1	3	3	4	0.13
S24	5	3	1	-5	1	7	1	5	5	-5	1	-3	3	1	5	1	-5	7	-5	-3	-5	-3	-3	-5	-7	-3	-3	3	1	-3	-8	0.27
S25	3	3	3	-7	1	3	1	7	5	1	-3	-3	3	-3	5	-5	-5	3	1	-3	-3	-3	-5	-3	-7	-5	-3	1	-5	-5	-28	0.93
AVG of Questions	3.88	1.08	1.24	-4.44	-1.72	3.80	2.28	3.72	4.36	-0.04	-1.40	-2.68	3.00	-2.28	3.16	-0.44	-4.76	2.84	-1.40	-1.48	-3.32	-0.28	-1.88	-4.04	-4.12	-3.64	-4.52	1.40	-0.52	-2.04		
AHP Entries / Pair-Wise Comparison	4A	2A	2A	4B	2B	4A	2A	4A	4A	1	2B	3B	3A	2B	3A	1	5B	3A	2B	2B	3B	1	2B	4B	4B	4B	5B	2A	1	2B		
Pair-Wise Corrections	3A																	2A														

Notes — *Anything that is 0 (or between +1 and -1), must be converted to 1, as this means that both are significant and follows SAATY, 1980 AHP Guide. Anything Slightly above +1 or -1, must be rounded up to the next number (+2, -2). There cannot be zeros in the table*

Table K.2 AHP Criteria Comparison Matrix (All Sets for Step 1)
Source: Author

AHP Process: Main Tier (STEP 1)

	Criteria Comparison Matrix (C)			
	Infrastructure	Planning	Port Labor	Security
Infrastructure	1.000	3.000	2.000	2.000
Planning	0.333	1.000	1.000	0.500
Port Labor	0.500	1.000	1.000	2.000
Security	0.500	2.000	0.500	1.000
Sum Columns	2.333	7.000	4.500	5.500

AHP Process: Infrastructure Tier (STEP 1)

	Criteria Comparison Matrix (C)			
	Container Capacity	Capital Equipment	Road & Rail	Warehousing
Container Capacity	1.000	0.250	0.500	4.000
Capital Equipment	4.000	1.000	2.000	4.000
Road & Rail	2.000	0.500	1.000	4.000
Warehousing	0.250	0.250	0.250	1.000
Sum Columns	7.250	2.000	3.750	13.000

AHP Process: Planning Tier (STEP 1)

	Criteria Comparison Matrix (C)			
	Short Term / Long Term	Communications	Observation	Coordination
Short Term / Long Term	1.000	0.333	3.000	0.500
Communications	3.000	1.000	3.000	1.000
Observation	0.333	0.333	1.000	0.200
Coordination	2.000	1.000	5.000	1.000
Sum Columns	6.333	2.666	12.000	2.700

AHP Process: Port Labor (STEP 1)

	Criteria Comparison Matrix (C)			
	Flexible Labor Agreements	Flexible Workforce	Flexible Operating Hours	Automation
Flexible Labor Agreements	1.000	0.500	0.500	0.333
Flexible Workforce	2.000	1.000	1.000	0.500
Flexible Operating Hours	2.000	1.000	1.000	0.250
Automation	3.000	2.000	4.000	1.000
Sum Columns	8.000	4.500	6.500	2.083

AHP Process: Security Tier (STEP 1)

	Criteria Comparison Matrix (C)			
	Drills & Training	Physical Security	Inspections	Cyber Security
Drills & Training	1.000	0.250	0.250	0.200
Physical Security	4.000	1.000	2.000	1.000
Inspections	4.000	0.500	1.000	0.500
Cyber Security	5.000	1.000	2.000	1.000
Sum Columns	14.000	2.750	5.250	2.700

Notes:

Table K.3 AHP Criteria Comparison Matrix (All Sets for Step 2)
Source: Author

AHP Process: Main Tier (STEP 2)

	Normalized Criteria Comparison Matrix (C)				
	Infrastructure	Planning	Port Labor	Security	Criteria Weights (W)
Infrastructure	0.429	0.429	0.444	0.364	0.416
Planning	0.143	0.143	0.222	0.091	0.150
Port Labor	0.214	0.143	0.222	0.364	0.236
Security	0.214	0.286	0.111	0.182	0.198
Sum Columns	1.000	1.000	1.000	1.000	1.000

AHP Process: Infrastructure Tier (STEP 2)

	Normalized Criteria Comparison Matrix (C)				
	Container Capacity	Capital Equipment	Road & Rail	Warehousing	Criteria Weights (W)
Container Capacity	0.138	0.125	0.133	0.308	0.176
Capital Equipment	0.552	0.500	0.533	0.308	0.473
Road & Rail	0.276	0.250	0.267	0.308	0.275
Warehousing	0.034	0.125	0.067	0.077	0.076
Sum Columns	1.000	1.000	1.000	1.000	1.000

AHP Process: Planning Tier (STEP 2)

	Normalized Criteria Comparison Matrix (C)				
	Short Term / Long Term	Communications	Observation	Coordination	Criteria Weights (W)
Short Term / Long Term	0.158	0.125	0.250	0.185	0.179
Communications	0.474	0.375	0.250	0.370	0.367
Observation	0.053	0.125	0.083	0.074	0.084
Coordination	0.316	0.375	0.417	0.370	0.369
Sum Columns	1.000	1.000	1.000	1.000	1.000

AHP Process: Port Labor (STEP 2)

	Normalized Criteria Comparison Matrix (C)				
	Flexible Labor Agreements	Flexible Workforce	Flexible Operating Hours	Automation	Criteria Weights (W)
Flexible Labor Agreements	0.125	0.111	0.077	0.160	0.118
Flexible Workforce	0.250	0.222	0.154	0.240	0.217
Flexible Operating Hours	0.250	0.222	0.154	0.120	0.187
Automation	0.375	0.444	0.615	0.480	0.479
Sum Columns	1.000	1.000	1.000	1.000	1.000

AHP Process: Security Tier (STEP 2)

	Normalized Criteria Comparison Matrix (C)				
	Drills & Training	Physical Security	Inspections	Cyber Security	Criteria Weights (W)
Drills & Training	0.071	0.091	0.048	0.074	0.071
Physical Security	0.286	0.364	0.381	0.370	0.350
Inspections	0.286	0.182	0.190	0.185	0.211
Cyber Security	0.357	0.364	0.381	0.370	0.368
Sum Columns	1.000	1.000	1.000	1.000	1.000

Notes:

Table K.4 AHP Criteria Comparison Matrix (All Sets for Step 3)
Source: Author

AHP Process: Main Tier (STEP 3)

				Consistency Calculations								
	Infrastructure	Planning	Port Labor	Security	Sum (X)	Weight (W)	λ	CI	RI	CR	Sufficient (CR ≤ 0.1)?	
Infrastructure	0.416	0.449	0.472	0.396	1.733	0.416	4.164	0.05678	0.9	0.063	Yes	
Planning	0.139	0.150	0.236	0.099	0.623	0.150	4.163					
Port Labor	0.208	0.150	0.236	0.396	0.990	0.236	4.200					
Security	0.208	0.299	0.118	0.198	0.824	0.198	4.155					
							λ MAX					
Sum Columns	0.971	1.048	1.061	1.090			4.170					

AHP Process: Infrastructure Tier (STEP 3)

				Consistency Calculations								
	Container Capacity	Capital Equipment	Road & Rail	Warehousing	Sum (X)	Weight (W)	λ	CI	RI	CR	Sufficient (CR ≤ 0.1)?	
Container Capacity	0.176	0.118	0.138	0.303	0.735	0.176	4.176	0.06314	0.9	0.0702	Yes	
Capital Equipment	0.704	0.473	0.550	0.303	2.030	0.473	4.291					
Road & Rail	0.352	0.237	0.275	0.303	1.167	0.275	4.242					
Warehousing	0.044	0.118	0.069	0.076	0.307	0.076	4.050					
							λ MAX					
Sum Columns	1.276	0.946	1.031	0.985			4.189					

AHP Process: Planning Tier (STEP 3)

				Consistency Calculations								
	Short Term / Long Term	Communications	Observation	Coordination	Sum (X)	Weight (W)	λ	CI	RI	CR	Sufficient (CR ≤ 0.1)?	
Short Term / Long Term	0.179	0.122	0.251	0.185	0.738	0.179	4.110	0.03516	0.9	0.039	Yes	
Communications	0.538	0.367	0.251	0.369	1.526	0.367	4.156					
Observation	0.060	0.122	0.084	0.074	0.340	0.084	4.057					
Coordination	0.359	0.367	0.419	0.369	1.514	0.369	4.099					
							λ MAX					
Sum Columns	1.137	0.979	1.005	0.998			4.105					

AHP Process: Port Labor (STEP 3)

				Consistency Calculations								
	Flexible Labor Agreements	Flexible Workforce	Flexible Operating Hours	Automation	Sum (X)	Weight (W)	λ	CI	RI	CR	Sufficient (CR ≤ 0.1)?	
Flexible Labor Agreements	0.118	0.108	0.093	0.159	0.479	0.118	4.053	0.03217	0.9	0.036	Yes	
Flexible Workforce	0.236	0.217	0.187	0.239	0.879	0.217	4.059					
Flexible Operating Hours	0.236	0.217	0.187	0.120	0.759	0.187	4.070					
Automation	0.355	0.433	0.746	0.479	2.013	0.479	4.204					
							λ MAX					
Sum Columns	0.946	0.974	1.212	0.997			4.097					

AHP Process: Security Tier (STEP 3)

				Consistency Calculations								
	Drills & Training	Physical Security	Inspections	Cyber Security	Sum (X)	Weight (W)	λ	CI	RI	CR	Sufficient (CR ≤ 0.1)?	
Drills & Training	0.071	0.088	0.053	0.074	0.285	0.071	4.012	0.01586	0.9	0.018	Yes	
Physical Security	0.284	0.350	0.422	0.368	1.424	0.350	4.066					
Inspections	0.284	0.175	0.211	0.184	0.854	0.211	4.051					
Cyber Security	0.355	0.350	0.422	0.368	1.495	0.368	4.062					
							λ MAX					
Sum Columns	0.994	0.963	1.107	0.994			4.048					

Notes:

Random Index (RI)

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.58

Appendix L. Port Terminal Performance AHP Survey

WORLD MARITIME UNIVERSITY

WMU Research Ethics Committee Protocol

Name of principal researcher:	Ian M Sulzer
Name(s) of any co-researcher(s):	
If applicable, for which degree is each researcher registered?	MSc. Maritime Affairs (Port Management)
Name of supervisor, if any:	Prof. Gang Chen
Title of project:	How COVID-19 has impacted Port Terminal Performance in the United States: A Case Study of the Port of Los Angeles
Is the research funded externally?	No
If so, by which agency?	
Where will the research be carried out?	Malmo, SE. Through Networked Email and Online Survey
How will the participants be recruited?	Have identified 50 participants for survey, through network
How many participants will take part?	30-50 Participants
Will they be paid?	No
If so, please supply details:	
How will the research data be collected (by interview, by questionnaires, etc.)?	Interview and Questionnaire
How will the research data be stored?	Personal Laptop, Hard-disk with Strong Password
How and when will the research data be disposed of?	Data will be deleted from Laptop upon completion of MSC Studies and Degree scheduled to be awarded 31 OCT 2021
Is a risk assessment necessary? If so, please attach	No

Signature(s) of Researcher(s):   Date: 31st August, 2021

Ian M Sulzer

Signature of Supervisor: Date: 31st August, 2021

Please attach:
- A copy of the research proposal
- A copy of any risk assessment
- A copy of the consent form to be given to participants
- A copy of the information sheet to be given to participants
- A copy of any item used to recruit participants

Port Terminal Performance – AHP

Welcome!

Thank you for agreeing to participate in this research survey, which is carried out in connection with a Dissertation which will be written by the interviewer, in partial fulfilment of the requirements for the degree of Master of Science in Maritime at the World Maritime University in Malmo, Sweden.

The topic of the Dissertation is "HOW COVID-19 HAS IMPACTED PORT TERMINAL PERFORMANCE: A Case Study of the Port of Los Angeles "

The information provided by you in this interview will be used for research purposes and the results will form part of a dissertation, which will later be published online in WMU's digital repository (maritime commons) subject to final approval of the University and made available to the public. Your personal information will not be published. You may withdraw from the research at any time, and your personal data will be immediately deleted.

Anonymized research data will be archived on a secure virtual drive linked to a World Maritime University email address. All the data will be deleted as soon as the degree is awarded.

The key objectives of this survey is to better analyze and understand the potential disruptions that can degrade Port Terminal Performance, and how to implementing resilience measures through 4 distinct pillars.

Definitions:

- Infrastructure:
  " The basic physical and organizational structures and facilities (e.g. buildings, roads, equipment, power supplies) needed for the operation of a society or enterprise."

- Planning :
"The process of thinking about and organizing the activities required to achieve a desired goal and is also a management process, concerned with defining goals for a Port Authorities /Terminals future direction and determining the missions and resources to achieve those targets with Supply Chain Partners"

- Port Labor:
" Employed Work Forces which involves Longshoremen and Warehousemen (e.g. ILWU, ILA, Teamster, Boilermakers) who can operate heavy capital equipment (e.g. Portainers, Front-End Loaders, Reach Stacker, Rail-Mounted Gantry, Rubber-tired Gantry, Straddle Carrier)"

- Security:
"The safeguarding of vessels, harbors, ports, waterfront facilities, and cargo from internal threats such as destruction, loss, or injury from sabotage or other subversive acts; accidents; thefts; or other causes of similar nature"

** There are 30 Questions in this Survey **

Your participation in the interview is highly appreciated.

Thank you for your time,

Ian M Sulzer
Port Management Student Representative

1. What is your Role in the Maritime Transportation System?

    Check all that apply.

    ☐ Terminal Operator
    ☐ Port Authority
    ☐ Shipping Company
    ☐ Truck Carrier
    ☐ Rail Carrier
    ☐ Distribution Center
    ☐ Freight Forwarder
    ☐ Shipper
    ☐ Customs Broker

    Other: ☐ _____

2. Optional* Please provide your position in your organization

    _____

Infrastructure	" The basic physical and organizational structures and facilities (e.g. buildings, roads, equipment, power supplies) needed for the operation of a society or enterprise."

3. In reference to the image below, the Four Main Pillars of Port Terminal Resilience are included. How much more important is A = INFRASTRUCTURE compared to _____? (Evaluate the Pairs on each line, with 9(A) making Infrastructure the Most important, whereas 9(B) make the alternative for each line the most important.)

B (Line 1)= | *Planning*

A = | *Infrastructure*   B (Line 2)= | *Port Labor*

B (Line 3)= | *Security*

- Infrastructure:
  " The basic physical and organizational structures and facilities (e.g. buildings, roads, equipment, power supplies) needed for the operation of a society or enterprise."

- Planning :
  "The process of thinking about and organizing the activities required to achieve a desired goal and is also a management process, concerned with defining goals for a Port Authorities future direction and determining the missions and resources to achieve those targets with Supply Chain Partners"

- Port Labor:
  " Employed Work Force which involves Longshoremen and Warehousemen (e.g. ILWU, ILA, Teamster, Boilermakers) who can operate heavy capital equipment (e.g. Portainers, Front-End Loaders, Reach Stacker, Rail-Mounted Gantry, Rubber-tired Gantry, Straddle Carrier)"

- Security:
  "The safeguarding of vessels, harbors, ports, waterfront facilities, and cargo from internal threats such as destruction, loss, or injury from sabotage or other subversive acts; accidents; thefts; or other causes of similar nature"

Mark only one oval per row.

	9 (A)	7 (A)	5 (A)	3 (A)	1 Equal	3 (B)	5 (B)	7 (B)	9 (B)
Infrastructure vs. Planning	◯	◯	◯	◯	◯	◯	◯	◯	◯
Infrastructure vs. Port Labor	◯	◯	◯	◯	◯	◯	◯	◯	◯
Infrastructure vs. Security	◯	◯	◯	◯	◯	◯	◯	◯	◯

4. In Infrastructure Development, what would be the most important actions for Port improvements to reduce the impact of disruption? (Evaluate the Pairs on each line, with 9(A) making Container Capacity the Most important, whereas 9(B) make the alternative for each line the most important.)

| Infrastructure | Which is Better to Focus on for Improvement of Performance in Infrastructure? |

Container Capacity | Capital Equipment | Road and Rail | Warehousing

A = Container Capacity

9 7 5 3 1 3 5 7 9

B1 = Capital Equipment
B2 = Road / Rail
B3 = Warehousing

Container Capacity (Allocate more space within the Terminal to house Containers)

Capital Equipment (Portainers, Front-End Loaders, Reach Stacker, Rail-Mounted Gantry, Rubber-tired Gantry, Straddle Carrier)

Road and Rail Connectivity (Upgrade and/or add new roads, highways and rail within Terminals to increase cargo flows to off terminal facilities (Intermodal Cross Decks and Warehousing)

Warehousing (Only Upgrade and Increase the Number of Warehouses available for storage)

Mark only one oval per row.

	9 (A)	7 (A)	5 (A)	3 (A)	1 Equal	3 (B)	5 (B)	7 (B)	9 (B)
A vs. B1 = Capital Equipment	○	○	○	○	○	○	○	○	○
A vs. B2 = Road / Rail	○	○	○	○	○	○	○	○	○
A vs. B3 = Warehousing	○	○	○	○	○	○	○	○	○

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5. In Infrastructure Development, what would be the most important actions for Port improvements to reduce the impact of disruption? (Evaluate the Pairs on each line, with 9(A) making Capital Equipment the Most important, whereas 9(B) make the alternative for each line the most important.)

Infrastructure	Which is Better to Focus on for Improvement of Performance in Infrastructure?

Container Capacity | Capital Equipment | Road and Rail | Warehousing

A = Capital Equipment

B1 = Road / Rail
B2 = Warehousing

9 7 5 3 1 3 5 7 9

Capital Equipment (Portainers, Front-End Loaders, Reach Stacker, Rail-Mounted Gantry, Rubber-tired Gantry, Straddle Carrier)

Road and Rail Connectivity (Upgrade and/or add new roads, highways and rail within Terminals to increase cargo flows to off terminal facilities (Intermodal Cross Decks and Warehousing)

Warehousing (Only Upgrade and Increase the Number of Warehouses available for storage)

Mark only one oval per row.

	9 (A)	7 (A)	5 (A)	3 (A)	1 Equal	3 (B)	5 (B)	7 (B)	9 (B)
A vs. B1 = Road / Rail	◯	◯	◯	◯	◯	◯	◯	◯	◯
A vs. B2 = Warehousing	◯	◯	◯	◯	◯	◯	◯	◯	◯

6. In Infrastructure Development, what would be the most important actions for Port improvements to reduce the impact of disruption? (Evaluate the Pairs on each line, with 9(A) making Road/ Rail the Most important, whereas 9(B) make the alternative for each line the most important.)

Infrastructure	Which is Better to Focus on for Improvement of Performance in Infrastructure?

Container Capacity | Capital Equipment | Road and Rail | Warehousing

A = Road / Rail

B = Warehousing

9 7 5 3 1 3 5 7 9

Road and Rail Connectivity (Upgrade and/or add new roads, highways and rail within Terminals to increase cargo flows to off terminal facilities (Intermodal Cross Decks and Warehousing)

Warehousing (Only Upgrade and Increase the Number of Warehouses available for storage)

Mark only one oval per row.

	9 (A)	7 (A)	5 (A)	3 (A)	1 Equal	3 (B)	5 (B)	7 (B)	9 (B)
A vs. B = Warehousing	◯	◯	◯	◯	◯	◯	◯	◯	◯

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7. What is the most single important action to improve Infrastructural Performance at Port Terminals?

   Mark only one oval.

   ◯ Container Capacity (Allocate more space within the Terminal to house Containers)

   ◯ Capital Equipment (Portainers, Front-End Loaders, Reach Stacker, Rail-Mounted Gantry, Rubber-tired Gantry, Straddle Carrier)

   ◯ Road and Rail Connectivity (Upgrade and/or add new roads, highways and rail within Terminals to increase cargo flows to off terminal facilities (Intermodal Cross Decks and Warehousing)

   ◯ Warehousing (Only Upgrade and Increase the Number of Warehouses available for storage)

8. In your opinion, how strongly did COVID-19 Impact your Port Terminal Performance OVERALL (Terminal Capacity, Throughput Times for Trucks, On-dock Rail Times, Cancelled Sailings)?

   Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Little to No Effect	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	Catastrophic

9. Explain why you chose your answer to the previous question.

   _____

   _____

   _____

   _____

   _____

Planning	"The process of thinking about and organizing the activities required to achieve a desired goal and is also a management process, concerned with defining goals for a Port Authorities future direction and determining the missions and resources to achieve those targets with Supply Chain Partners"

10. In reference to the image below, how much more important is A = PLANNING compared to _____?
(Evaluate the Pairs on each line, with 9(A) making PLANNING the Most important, whereas 9(B) make the alternative for each line the most important.)

A = | **Planning** | B (Line 1)= | **Port Labor** |

B (Line 2)= | **Security** |

- Planning :
"The process of thinking about and organizing the activities required to achieve a desired goal and is also a management process, concerned with defining goals for a Port Authorities future direction and determining the missions and resources to achieve those targets with Supply Chain Partners"

- Port Labor:
" Employed Work Force which involves Longshoremen and Warehousemen (e.g. ILWU, ILA, Teamster, Boilermakers) who can operate heavy capital equipment (e.g. Portainers, Front-End Loaders, Reach Stacker, Rail-Mounted Gantry, Rubber-tired Gantry, Straddle Carrier)"

- Security:
"The safeguarding of vessels, harbors, ports, waterfront facilities, and cargo from internal threats such as destruction, loss, or injury from sabotage or other subversive acts; accidents; thefts; or other causes of similar nature"

Mark only one oval per row.

	9 (A)	7 (A)	5 (A)	3 (A)	1 Equal	3 (B)	5 (B)	7 (B)	9 (B)
Planning vs. Port Labor	⭕	⭕	⭕	⭕	⭕	⭕	⭕	⭕	⭕
Planning vs. Security	⭕	⭕	⭕	⭕	⭕	⭕	⭕	⭕	⭕

11. In Port Planning, what are the most important actions to reduce the impact of disruptions (Evaluate the Pairs on each line, with 9(A) making Short Term/ Long Term Scope the Most important, whereas 9(B) make the alternative for each line the most important.)

Planning	Which is Better to Focus on for Improvement of Performance with Planning?

Short Term / Long Term | Communications | Observation | Coordination

A =
Short Term / Long Term
9 7 5 3 1 3 5 7 9

B1 = Communications
B2 = Observation
B3 = Coordination

Short Term / Long Term (Short Term Planning = Weekly to Monthly / Long Term = Yearly to 5 years | Development of Master Plan for Port)

Communications (The Link of Executive Staff, Intermediate Management and Laborers through telecommunications, internet, or other efficient means)

Observation (Studying Competitors Actions, Market Analysis for Container Freight Indexes, Local and International Economies)

Coordination (Port Authority Executives utilizing and working closely with all aspects of the Supply Chain (e.g. Shipping Companies, Rail Operators, Unions and Maritime Authorities and Warehousing)

Mark only one oval per row.

	9 (A)	7 (A)	5 (A)	3 (A)	1 Equal	3 (B)	5 (B)	7 (B)	9 (B)
A vs. B1 = Communications	◯	◯	◯	◯	◯	◯	◯	◯	◯
A vs. B2 = Observation	◯	◯	◯	◯	◯	◯	◯	◯	◯
A vs. B3 = Coordination	◯	◯	◯	◯	◯	◯	◯	◯	◯

12. In Port Planning, what are the most important actions to reduce the impact of disruptions (Evaluate the Pairs on each line, with 9(A) making Communications the Most important, whereas 9(B) make the alternative for each line the most important.)

Planning	Which is Better to Focus on for Improvement of Performance with Planning?

Short Term / Long Term · Communications · Observation · Coordination

A = Communications

B1 = Observation
B2 = Coordination

9 7 5 3 1 3 5 7 9

Communications (The Link of Executive Staff, Intermediate Management and Laborers through telecommunications, internet, or other efficient means)

Observation (Studying Competitors Actions, Market Analysis for Container Freight Indexes, Local and International Economies)

Coordination (Port Authority Executives utilizing and working closely with all aspects of the Supply Chain (e.g. Shipping Companies, Rail Operators, Unions and Maritime Authorities and Warehousing)

Mark only one oval per row.

	9 (A)	7 (A)	5 (A)	3 (A)	1 Equal	3 (B)	5 (B)	7 (B)	9 (B)
A vs. B1 = Observation	◯	◯	◯	◯	◯	◯	◯	◯	◯
A vs. B2 = Coordination	◯	◯	◯	◯	◯	◯	◯	◯	◯

13. In Port Planning, what are the most important actions to reduce the impact of disruptions (Evaluate the Pairs on each line, with 9(A) making Observation the Most important, whereas 9(B) make the alternative for each line the most important.)

Planning	Which is Better to Focus on for Improvement of Performance with Planning?

Short Term / Long Term · Communications · Observation · Coordination

A = Observation

B = Coordination

9 7 5 3 1 3 5 7 9

Observation (Studying Competitors Actions, Market Analysis for Container Freight Indexes, Local and International Economies)

Coordination (Port Authority Executives utilizing and working closely with all aspects of the Supply Chain (e.g. Shipping Companies, Rail Operators, Unions and Maritime Authorities and Warehousing)

Mark only one oval per row.

	9 (A)	7 (A)	5 (A)	3 (A)	1 Equal	3 (B)	5 (B)	7 (B)	9 (B)
A vs. B = Coordination	◯	◯	◯	◯	◯	◯	◯	◯	◯

14. What is the most single important action within Planning which is critical to enhance resilience?

Mark only one oval.

◯ Short Term / Long Term (Short Term Planning = Weekly to Monthly / Long Term = Yearly to 5 years | Development of Master Plan for Port)

◯ Communications (The Link of Executive Staff, Intermediate Management and Laborers through telecommunications, internet, or other efficient means)

◯ Observation (Studying Competitors Actions, Market Analysis for Container Freight Indexes, Local and International Economies)

◯ Coordination (Port Authority Executives utilizing and working closely with all aspects of the Supply Chain (e.g. Shipping Companies, Rail Operators, Unions and Maritime Authorities and Warehousing)

15. What systems, processes and operations within a Port need to be resilient in order to plan and react to disruptions?

Mark only one oval per row.

	Critical	Important but NOT Critical	Not Important	Not Applicable
Terminal Equipment	◯	◯	◯	◯
Intermodal Equipment	◯	◯	◯	◯
Road and Rail Connections	◯	◯	◯	◯
Yard/Storage Operations	◯	◯	◯	◯
Gate Operations and Port Entry	◯	◯	◯	◯
Truck Operations	◯	◯	◯	◯
Rail Operations	◯	◯	◯	◯

16. From the above list, what are the three most important supply chain disruption risks that is of greatest concerned to you?

_____

_____

_____

_____

_____

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17. Follow Up : Out of these three greatest concerns, Have you experienced a supply chain disruption that could have been better managed?

_____

_____

_____

_____

_____

Port Labor
" Employed Work Force which involves Longshoremen and Warehousemen (e.g. ILWU, ILA, Teamster, Boilermakers) who can operate heavy capital equipment (e.g. Portainers, Front-End Loaders, Reach Stacker, Rail-Mounted Gantry, Rubber-tired Gantry, Straddle Carrier)"

18. In reference to the image below, how much more important is A = PORT LABOR compared to _____? (Evaluate the Pairs on each line, with 9(A) making PORT LABOR the Most important, whereas 9(B) make the alternative for each line the most important.)

$A =$ | **Port Labor** | $B =$ | **Security** |

- Port Labor:
" Employed Work Force which involves Longshoremen and Warehousemen (e.g. ILWU, ILA, Teamster, Boilermakers) who can operate heavy capital equipment (e.g. Portainers, Front-End Loaders, Reach Stacker, Rail-Mounted Gantry, Rubber-tired Gantry, Straddle Carrier)"

- Security:
"The safeguarding of vessels, harbors, ports, waterfront facilities, and cargo from internal threats such as destruction, loss, or injury from sabotage or other subversive acts; accidents; thefts; or other causes of similar nature"

Mark only one oval per row.

	9 (A)	7 (A)	5 (A)	3 (A)	1 Equal	3 (B)	5 (B)	7 (B)	9 (B)
Port Labor vs. Security	○	○	○	○	○	○	○	○	○

19. In maintaining Port Labor, what would you think would make the labor force more effective during periods of disruption? (Evaluate the Pairs on each line, with 9(A) making Flexible Labor Agreements the Most important, whereas 9(B) make the alternative for each line the most important.)

Port Labor

| Flexible Labor Agreements | Flexible Workforce | Flexible Operating Hours | Automation |

Which is Better to Focus on for Improvement of Performance with Port Labor?

A =
Flexible Labor Agreements ◄————————► 9 7 5 3 1 3 5 7 9

B1 = Flexible Workforce
B2 = Flexible Operating Hours
B3 = Automation

Flexible Labor Agreements (Quick Negotiations of Contracts, Faster Rate of Hiring, Can work in several positions but not greater than two roles)

Flexible Workforce (Highly Skilled in Multiple Fields and can be utilized in more than two job roles)

Flexible Operating Hours (Shifts can be adjusted so more workers can maintain operations for 24/7 at Port Terminals and Warehouses)

Automation (Introduction to Hybrid Model of AI Robotics working with Humans, to allow 24/7 operations with reduced staff)

Mark only one oval per row.

	9 (A)	7 (A)	5 (A)	3 (A)	1 Equal	3 (B)	5 (B)	7 (B)	9 (B)
A vs. B1 = Flexible Workforce	◯	◯	◯	◯	◯	◯	◯	◯	◯
A vs. B2: Flexible Operating Hours	◯	◯	◯	◯	◯	◯	◯	◯	◯
A vs. B3 = Automation	◯	◯	◯	◯	◯	◯	◯	◯	◯

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20. In maintaining Port Labor, what would you think would make the labor force more effective during periods of disruption? (Evaluate the Pairs on each line, with 9(A) making Flexible Workforce the Most important, whereas 9(B) make the alternative for each line the most important.)

Port Labor

Flexible Labor Agreements | Flexible Workforce | Flexible Operating Hours | Automation

Which is Better to Focus on for Improvement of Performance with Port Labor?

A =
Flexible
Workforce

B1 = Flexible Operating Hours
B2 = Automation

9 7 5 3 1 3 5 7 9

Flexible Workforce (Highly Skilled in Multiple Fields and can be utilized in more than two job roles)

Flexible Operating Hours (Shifts can be adjusted so more workers can maintain operations for 24/7 at Port Terminals and Warehouses)

Automation (Introduction to Hybrid Model of AI Robotics working with Humans, to allow 24/7 operations with reduced staff)

Mark only one oval per row.

	9 (A)	7 (A)	5 (A)	3 (A)	1 Equal	3 (B)	5 (B)	7 (B)	9 (B)
A vs. B1: Flexible Operating Hours	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭
A vs. B2 = Automation	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭

21. In maintaining Port Labor, what would you think would make the labor force more effective during periods of disruption? (Evaluate the Pairs on each line, with 9(A) making Flexible Operating Hours the Most important, whereas 9(B) make the alternative for each line the most important.)

Port Labor

Flexible Labor Agreements | Flexible Workforce | Flexible Operating Hours | Automation

Which is Better to Focus on for Improvement of Performance with Port Labor?

A =
Flexible
Operating
Hours

B = Automation

9 7 5 3 1 3 5 7 9

Flexible Operating Hours (Shifts can be adjusted so more workers can maintain operations for 24/7 at Port Terminals and Warehouses)

Automation (Introduction to Hybrid Model of AI Robotics working with Humans, to allow 24/7 operations with reduced staff)

Mark only one oval per row.

	9 (A)	7 (A)	5 (A)	3 (A)	1 Equal	3 (B)	5 (B)	7 (B)	9 (B)
A vs. B = Automation	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭

22. What is the most single important action within Manpower to make in order to alleviate or eliminate disruptions in Port Terminals?

Mark only one oval.

◯ Flexible Labor Agreements (Quick Negotiations of Contracts, Faster Rate of Hiring, Can work in several positions but not greater than two roles)

◯ Flexible Workforce (Highly Skilled in Multiple Fields and can be utilized in more than two job roles)

◯ Flexible Operating Hours (Shifts can be adjusted so more workers can maintain operations for 24/7 at Port Terminals and Warehouses)

◯ Automation (Introduction to Hybrid Model of AI Robotics working with Humans, to allow 24/7 operations with reduced staff)

23. How Large of Scale would you say your Ports Labor Force is? (Direct Jobs within the Port Authority, each increment from 1-10 increases 50,000+)

Mark only one oval per row.

	1: 0 - 50,000	2: 50,000 - 100,000	3: 100,000 - 150,000	4: 150,000 - 200,000	5: 200,000 - 250,000	6: 250,000 - 300,000	7: 300,000 - 350,000	8: 350,000 - 400,000	9: 400,000 - 450,000	10: 450,000 - 500,000
Port Labor Size	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

24. In your opinion, how strongly did COVID-19 Impact your Port Terminal, Authority or Supply Chain LABOR FORCE

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Little to No Effect	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	Catastrophic

Security — "The safeguarding of vessels, harbors, ports, waterfront facilities, and cargo from internal threats such as destruction, loss, or injury from sabotage or other subversive acts; accidents; thefts; or other causes of similar nature"

25. In Port Security, what would you think would make the labor force more effective during periods of disruption? (Evaluate the Pairs on each line, with 9(A) making Drills and Training the Most important, whereas 9(B) make the alternative for each line the most important.)

Security

Drills and Training | Physical Security | Inspections | Cyber Security

Which Pair is Better to Focus on for Improvement of Performance with Port Security?

A =
Drills and
Training

9 7 5 3 1 3 5 7 9

B1 = Physical Security
B2 = Inspections
B3 = Cyber Security

Drills and Training (Conduct exercises with local and federal law enforcement agencies (USCG, CBP, FD, PD, FBI, ATF) and increase classroom education)

Physical Security (Increase Physical Security Measures such as Gate Control Access, Additional Security Barriers, Check-Points, Patrols (Water and Land) and Security Along Entire Supply Chain)

Inspections (Health Inspections (e.g. COVID-19 Screenings), Customs (CBP), and Vehicle (Truck, Trains and Capital Equipment for Explosive Devices))

Cyber Security (Biometric Scanning against World-Wide Databases (CIA/INTERPOL), Firewall Security for Port Systems and Internet of Things, Security for Artificial Intelligence (Robotics, Automated Gates))

Mark only one oval per row.

	9 (A)	7 (A)	5 (A)	3 (A)	1 Equal	3 (B)	5 (B)	7 (B)	9 (B)
A vs. B1 = Physical Security	◯	◯	◯	◯	◯	◯	◯	◯	◯
A vs. B2 = Inspections	◯	◯	◯	◯	◯	◯	◯	◯	◯
A vs. B3 = Cyber Security	◯	◯	◯	◯	◯	◯	◯	◯	◯

26. In Port Security, what would you think would make the labor force more effective during periods of disruption? (Evaluate the Pairs on each line, with 9(A) making Physical Security the Most important, whereas 9(B) make the alternative for each line the most important.)

Security

Drills and Training | Physical Security | Inspections | Cyber Security

Which Pair is Better to Focus on for Improvement of Performance with Port Security?

A = Physical Security

9 7 5 3 1 3 5 7 9

B1 = Inspections
B2 = Cyber Security

Physical Security (Increase Physical Security Measures such as Gate Control Access, Additional Security Barriers, Check-Points, Patrols (Water and Land) and Security Along Entire Supply Chain)

Inspections (Health Inspections (e.g. COVID-19 Screenings), Customs (CBP), and Vehicle (Truck, Trains and Capital Equipment for Explosive Devices))

Cyber Security (Biometric Scanning against World-Wide Databases (CIA/INTERPOL), Firewall Security for Port Systems and Internet of Things, Security for Artificial Intelligence (Robotics, Automated Gates))

Mark only one oval per row.

	9 (A)	7 (A)	5 (A)	3 (A)	1 Equal	3 (B)	5 (B)	7 (B)	9 (B)
A vs. B1 = Inspections	◯	◯	◯	◯	◯	◯	◯	◯	◯
A vs. B2 = Cyber Security	◯	◯	◯	◯	◯	◯	◯	◯	◯

27. In Port Security, what would you think would make the labor force more effective during periods of disruption? (Evaluate the Pairs on each line, with 9(A) making Inspections the Most important, whereas 9(B) make the alternative for each line the most important.)

Security

Drills and Training | Physical Security | Inspections | Cyber Security

Which Pair is Better to Focus on for Improvement of Performance with Port Security?

A = Inspections

9 7 5 3 1 3 5 7 9

B = Cyber Security

Inspections (Health Inspections (e.g. COVID-19 Screenings), Customs (CBP), and Vehicle (Truck, Trains and Capital Equipment for Explosive Devices))

Cyber Security (Biometric Scanning against World-Wide Databases (CIA/INTERPOL), Firewall Security for Port Systems and Internet of Things, Security for Artificial Intelligence (Robotics, Automated Gates))

Mark only one oval per row.

	9 (A)	7 (A)	5 (A)	3 (A)	1 Equal	3 (B)	5 (B)	7 (B)	9 (B)
A vs. B = Cyber Security	◯	◯	◯	◯	◯	◯	◯	◯	◯

28. What is the most single important action within Port Security to improve Resilience within Port Terminals

Mark only one oval.

◯ Drills and Training (Conduct exercises with local and federal law enforcement agencies (USCG, CBP, FD, PD, FBI, ATF) and increase classroom education)

◯ Physical Security (Increase Physical Security Measures such as Gate Control Access, Additional Security Barriers, Check-Points, Patrols (Water and Land) and Security Along Entire Supply Chain)

◯ Inspections (Health Inspections (e.g. COVID-19 Screenings), Customs (CBP), and Vehicle (Truck, Trains and Capital Equipment for Explosive Devices))

◯ Cyber Security (Biometric Scanning against World-Wide Databases (CIA/INTERPOL), Firewall Security for Port Systems and Internet of Things, Security for Artificial Intelligence (Robotics, Automated Gates))

29. What are some Security measures your Port participates or actively uses in order to promote Supply Chain Security? What importance do each of these bring?

Mark only one oval per row.

	Critical	Important but NOT Critical	Not Important	Not Applicable
C-TPAT (Customs Trade Partnership Against Terrorism) Program	◯	◯	◯	◯
Radiation Monitoring (Scanning of Containers, Trucks)	◯	◯	◯	◯
Devanning (Visual Inspection of Product Packaging)	◯	◯	◯	◯
K-9 Patrols	◯	◯	◯	◯
Vehicle Inspections (e.g. Under Chassis Sweeps, Engine Check)	◯	◯	◯	◯
Ship Inspections (Waterline and Underwater Inspections,	◯	◯	◯	◯
Port Access Control (TWIC, Port Badges)	◯	◯	◯	◯
Coastline Radar and Dedicated Vessel Traffic Service	◯	◯	◯	◯
Imaging and Surveillance Camera Systems (Thermal, Radiation, Infrared, Night Vision)	◯	◯	◯	◯
Waterborne Patrols (At Anchorages and within Terminals)	◯	◯	◯	◯
Elevations of MARSEC Level with no notice	◯	◯	◯	◯

30. In your opinion, how strongly did COVID-19 Impact your Port Terminal, Authority or Supply Chain SECURITY

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Little to No Effect	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	Catastrophic

Conclusion

Follow-up to the Port Terminal Performance Survey

31. In your opinion, what was the greatest unanticipated port consequence of COVID-19?

_____

_____

_____

_____

_____

32. Follow up from Previous Question, What was the single largest change in operations as a result of learned experiences?

_____

_____

_____

_____

_____

Thank You!!!!! Please Click SUBMIT at bottom of Page to Complete

I greatly appreciate your time