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ENERGY EFFICIENCY IN PORTS WITH A GREEN PORT PERSPECTIVE: A CONCEPTUAL FRAMEWORK

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ABSTRACT
Ports can be defined as the main centers of maritime transportation and trade, which provide the continuity of international trade as well as provide loading and unloading services to ships. As a result of the globalizing world, the importance of ports has continued to increase day by day because trade can be made faster and more efficiently. The fact that the ports are located at such a critical point, the increasing transaction volume, and the development of environmentally sensitive systems bring along an inevitable process of change. At this point, with increasing awareness, the concept of a green port has been developed. Green port is an approach that aims to minimize the adverse effects on the environment and ecosystem. While the ports continue their activities to achieve this goal, it aims to use systems that use energy resources efficiently and effectively while meeting energy needs and having the most negligible impact on the ecosystem. The equipment that maintains port operations, port equipment, and ships berthing in the port are energy-consuming elements. This study aims to analyze the energy efficiency in ports from a green port perspective by using the literature review method. In this context, the energy efficiency practices of two of the leading ports in Europe were examined. As a result of the qualitative analysis, it has been determined that the studies of the ports for energy efficiency have reached a critical point, and an approach compatible with the green port principles has been exhibited.

Keywords: *Green port, Energy efficiency, Sustainable energy, Maritime transportation*

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1. INTRODUCTION

With the consequences of climate change and increasing awareness, the concepts of decarbonization and energy efficiency, which have become more prevalent in recent years, make green transformation a necessity in ports. The green port is a product of the long-term commitment to the sustainable and climate-friendly development of the port's infrastructure (Pavlic et al., 2014). Green transformation in ports is addressed to express the "green port" concept in the literature. It is a policy to include environmentally friendly methods in the port's activities and operations, thus increasing efficiency and minimizing the adverse effects on the environment and ecosystem (Demir, 2021). The term "green port" was first announced at the United Nations (UN) climate conference in 2009, in other words, at the Copenhagen summit (COP15). At the conference, the importance and necessity of reducing emissions originating from ports and ships were emphasized (Demir and Arslan, 2021). It is seen that energy efficiency and green port principles and policies are directly related. In short, it is possible to say what criteria a port with a green perspective should consider, such as waste management, sustainability, water, air, and energy management, and sustainable port activities (Satır and Doğan-Sağlamtimur, 2018). In the maritime sector, it is stated that the emission generation number of ports is approximately 3%. Although it can be considered low for the port sector in maritime, it is seen that it is significant when the greenhouse gas (GHG) emission rates are considered (Alamoush et al., 2020). If we need to list the motivation and importance of decarbonization studies in ports as follows (Alamoush et al., 2022):

1. Compliance with international regulations of the International Maritime Organization (IMO) and decarbonization regulations
2. Ensuring green port practices and contributing to sustainability in ports
3. Within the scope of harmonization with the UN sustainable development goals, target 13, climate change mitigation, and target 7, implementation of renewable energy use targets
4. Contributing to the expansion of the corporate social responsibility vision of the ports and achieving cooperation and harmony with the stakeholders
5. Reducing greenhouse gas emissions from port operations
6. Contributing to the corporate image of ports with the green port concept and reduction in energy costs

This paper evaluates the green port concept in the framework of alternative energies. The main distinction of this paper from the scarce literature on Green Ports and Ecoports is that it revolves around renewable technologies.

2. DECARBONIZATION AND ENERGY EFFICIENCY APPLICATIONS IN PORTS

2.1. Alternative Fuels and Use

It is possible to obtain the energy needs of the equipment used to maintain the activities in the ports from different fuel sources such as liquefied natural gas (LNG), hydrogen, biomethanol, and biofuel obtained by recycling wastes and biomass, which are expressed as alternative energy sources. Considering the use of LNG in ports, it is seen that it is used in port internal operations and activities as well as used to power the ships in the port. While the reduction in emissions of air pollutants compared to petroleum-based fuels is seen as a positive feature, the need for extensive infrastructure for storage and bunkering points is a disadvantage (Sifakis and Tsoutsos, 2021). With the use of LNG, a significant decrease in NOx and SO2 emissions can be achieved, and an almost one-fourth reduction in CO2 emissions can be achieved (Yun et al., 2018).

Hydrogen is not a natural energy source; other energy sources are needed to ensure production. It is essential to achieve hydrogen energy by choosing and utilizing renewable energy sources to produce it since it is possible and beneficial in terms of GHG reduction (Elüstün, 2021). Although the use of biomass and biofuels in ports is very new, special equipment and hardware are required to generate and use this kind of energy. High investment costs and the requirement for complex production tools are seen as other difficulties (Sifakis and Tsoutsos, 2021).

2.2. Renewable Energy Resources and Use in Ports

Renewable energy sources in ports are the general expression of preferred energy production sources due to their positive contribution to reducing greenhouse gas emissions (Figure 2.1). It is possible to express renewable energy sources as wind, solar, wave, and geothermal energy (Acciaro et al., 2014). Solar energy is described as the radiant energy that emerges from the fusion process in the solar core because of the conversion of hydrogen gas to helium. It is a clean and renewable energy source that can meet the amount of energy needed by the world with approximately 3.9x1026 W of power emitted by the sun. Photovoltaic (PV) solar modules are the technology used to convert the solar energy source into electrical energy (Ministry of Energy and Natural Resources, 2022a). Solar energy is proposed as an energy system used in ports to reduce carbon emissions (Lam et al., 2017). Radiation originating from the sun heats the earth at different rates. As a result of this warming difference, changes occur in the temperature, humidity balance, and pressure of the air. All these changes cause air movements, and these air movements create winds. Wind energy is the name given to the use of these changes in air movements as energy. Approximately 2% of the solar energy reaching the Earth's surface is converted into wind energy. The high initial investment cost of using wind energy as an energy source, the low-capacity factor, and the variability of energy production can be expressed as disadvantages. Despite all these disadvantages, the advantages of wind energy are:

• Being an environmentally friendly and renewable energy source,

• No possibility of extinction or increase in price over time,

• Low maintenance costs of the system,

• Its technology is relatively simple to implement and operate,

• The establishment of the facility in the short term (Ministry of Energy and Natural Resources, 2022b).

The oceans, which cover 71% of the world, provide opportunities for wave energy. Wave energy is recognized as one of the most promising methods among renewable energy sources. It is estimated to produce a maximum of 2000 terawatt-hours (TWh) and at least 1 TWh annually (Li et al., 2021). According to the intergovernmental Panel on Climate Change (IPCC) (2012), geothermal resources are thermal energy stored in trapped steam and water from the Earth's interior. In geothermal energy, the power of heat is used to generate electricity. Antwerp and Hamburg Ports, which are European Union (EU) ports, generate energy from geothermal sources located close to the surface (Alamoush et al., 2020). As GHG emissions cause concerns on a global scale, the interest in renewable energy sources for energy production and transportation sectors is increasing daily. Promoting and using renewable energy is vital in tackling climate change (Yorke et al., 2022). Also, Aregall et al. (2018) identified only 76 out of 365 ports that apply the green port concept to their hinterland dimension.

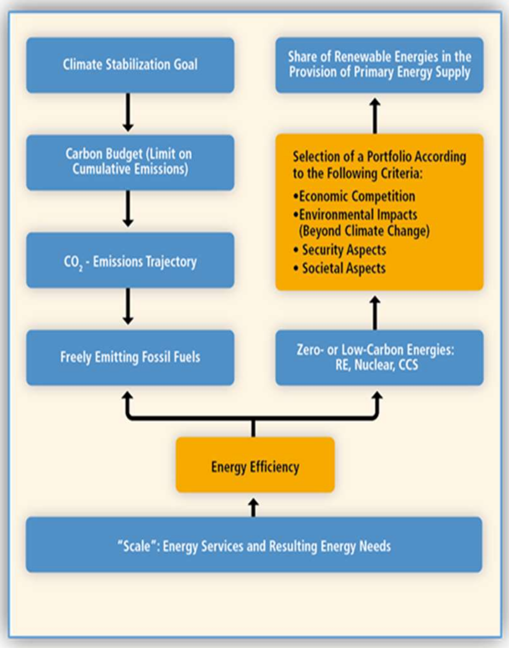

Figure 2.1: The role of renewable energies in a portfolio of zero or low carbon abatement options (IPCC, 2012).

2.3 Alternative Power Systems Used in Ports

2.3.1 Cold Ironing

Although the sources of pollution in the ports are very diverse, the ships in the ports are responsible for a large part of the air emissions in the ports. The new system that can be used instead of the fuel generators used by the ships for their energy needs during berthing and waiting at the port is expressed as "cold ironing." The definition is the transportation of energy to the vessels through the systems installed in the port rather than meeting the energy needs of the auxiliary engines of the ships waiting at berth (Ballini and Bozzo, 2015). The operation can be conveyed in different ways: land power supply, shore-to-ship power supply, and shore-to-shore power supply. Currently, it is seen as the most effective way to reduce emissions from ships waiting in berth. The cold ironing power system consists of three parts. These are the port power system, the port-ship power system, and the ship power system. The visual representation of the system is shown in Figure 2.2 (Chen et al., 2019).

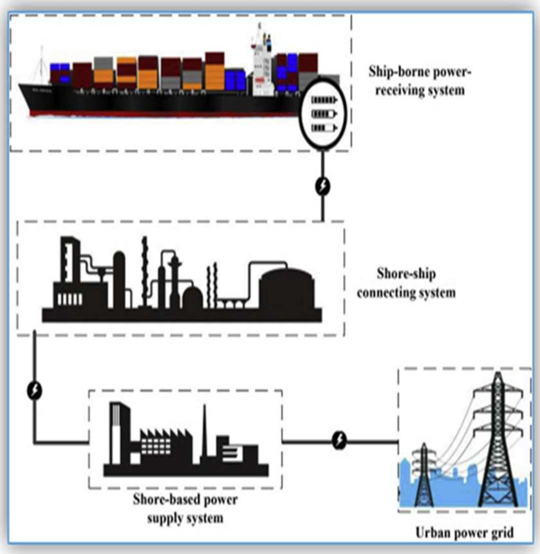

Figure 2.2: Cold ironing system (Chen et al., 2019).

It is possible to say as an advantage that the shore power supply system allows feasibility to be made in the short-term, and all the necessary components have been available for many years. The biggest obstacle to the system's applicability is the incompatibility between the port and ship connection points. While it does not pose a problem for ships that follow the same route all the time, it is not suitable for vessels operating between ports on different routes. This lack of standardization has been overcome with the standards developed by the Institute of Electrical and Electronics Engineers (IEEE). In addition, the low cost of adapting the system to newly built ships can be considered an advantage. However, the high initial investment cost of the system in ports is seen as a disadvantage (Daniel et al., 2022). 70% of the gases in the ship plume are emitted within 400 km of the shore. Besides greenhouse gas emissions, these pollutants are causing severe health and environmental problems (Eyring et al., 2010; Cullinane and Bergqvist, 2014). One of these pollutants, namely black carbon, even burns off the low marine clouds if it resides in the cloud layer, hence changing precipitation patterns (Johnson, 2004; IMO, 2022). The vast majority of oceangoing ships use fossil fuels for their auxiliary engines, which adds to maritime transportation's anthropogenic air pollution budget (Deniz and Zincir, 2016). Ships mostly use heavy fuel oil and marine distillate fuels to generate electricity for lighting, ventilation, cooling, heating, communication, and cargo operations (IMO, 2021; Seyhan et al., 2022). In Figure 2.3, on-shore power supply technologies, another name for cold ironing, whose purpose is to reduce the density of carbon-based consumption via offering electricity from the shoreside, are given.

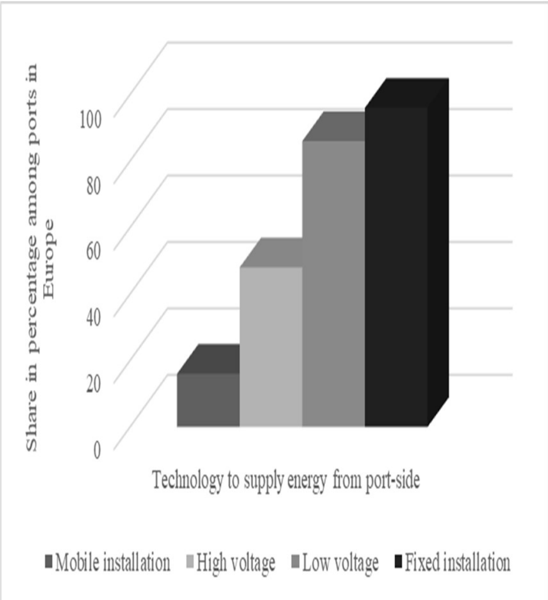

Figure 2.3 Share of ports with on-shore power supply availability in Europe by technology (ESPO, 2019).

3. USE OF RENEWABLE ENERGY IN EUROPEAN PORTS

Within the scope of the study, two ports operating in Europe were examined. These ports are the Port of Rotterdam, which is in the Netherlands and is the largest in Europe, and the Port of Antwerp, operating in Belgium.

3.1. 3.1 Port of Rotterdam

The Port of Rotterdam has a surface area of over 12,600 hectares and 70 kilometers of quayside without adding the dolphins and buoys to give a ship to ship or repair service (Port of Rotterdam, 2022a). Thanks to its hinterland connected to the Central European region, the Port of Rotterdam, which annually hosts approximately 30 thousand ships, is the busiest in Europe (Fransen and Davydenko, 2021). The findings of the review conducted within the scope of energy management for the Port of Rotterdam are as follows. It has been observed that the use of wind energy within the scope of renewable energy is done quite actively. The Port of Rotterdam can generate wind energy with a power capacity of approximately 200 MW.

Increasing the capacity by 150 MW is among the plans of the port. Another renewable energy usage area of the port is biomass. It is planned to provide hydrogen energy with biofuels, an essential step in reducing emissions. The port's most important renewable energy work is the generation of hydrogen energy, named "green hydrogen" from renewable energy sources that are also environmentally friendly. With this vision, the port continues its projects to execute its 2025 targets. It has also been seen that the port has been very successful in energy production using solar energy (Port of Rotterdam, 2022b).

3.2. Port of Antwerp

The Port of Antwerp is the second-largest port in Europe. It is idealized that emissions will be reduced by 2050, and the port will be sustainable with the energy management and vision of the port. In this context, it is seen that energy transition studies with a greener perspective gain importance, and action is taken in this direction. Using solar energy as an energy source in the port produces heat, expressed as green heat, and uses it for heat processes. Another renewable energy source used by the Antwerp port is biomass energy. In addition, more than 200 MW of energy can be produced annually with wind energy at the port. The port continues its new projects with its partnerships. One of the most important of these, the "power-to-methanol" project, aims to reduce CO2 emissions by at least eight thousand tons. In addition to all these activities, the port's work on generating energy with hydrogen continues (Port of Antwerp, 2022).

4. DISCUSSION

The main limitation of the cold ironing technology is delivering such high power to the shore. The improvements are needed by port authorities to further adapt their port to the greener approach. The incapability of powering cranes enough to carry two containers at a time with the provided electric technologies is holding back the further decarbonization process of maritime transportation.

The Port of Rotterdam is the largest seaport in Europe and the tenth-largest container port in the world. At the same time, this port is also one of the first smart and green ports in Europe. The port of Rotterdam uses environmentally friendly energy sources such as biomass, biofuel, green hydrogen, solar energy, etc. This port has especially smart applications at the container terminal. The Port of Antwerp is the second-largest port in Europe and the fourteenth container port in the world. The Port of Antwerp is using solar and biomass energy in the port area.

The European Sea Ports Organization (ESPO) established the EcoPort (Green Port) initiative in 1997. One hundred eight ports are members of this organization. If a member port has completed the requirements, ESPO also gives the Port Environmental Review System (PERS), which resembles green port certification. It is not compulsory, but 35 ports have this certification. This certificate and being a member of this organization has prestige and stands out in the competition. The Turkish Ministry of Transportation started a Green Port certification program in 2011. Twenty Turkish ports have received Green Port certificates since 2011.

Cold ironing technology is part of the Green Port but is not mandatory. For example, only one port in Turkey has this technology. Marport, a container port located North of Marmara, has a cold ironing system but is not frequently used by ships.

5. CONCLUSION

With the increasing awareness of climate change, it was seen that the use of renewable energy in ports and the transition to alternative fuels are more frequently adopted by the ports. It was found that ports are given importance in the transition from carbon-intensive sources to renewable sources, on which ports are dependent, both because of their targets of being more sustainable and because they are more efficient in terms of cost.

Operations of ports demand a relatively higher energy intake on a single move due to the many aspects of modern maritime transportation. The infancy of renewable fuels in such heavy duties critically sets drawbacks in this industry. Nonetheless, some visionary port authorities are setting examples. As seen in the ports of Rotterdam and Antwerp, which are the two ports given as examples in this study, it is seen that solar energy is utilized in the transition to renewable resources in the ports. In addition, it was seen that investments were made to meet the energy needs by using wind energy. It has been observed that replacing port equipment with electrical energy-operated equipment significantly reduces the number of emissions originating from the port. In this context, all the steps ports take to reduce fossil fuel emissions are considered necessary.

Another substantial issue is the air pollution caused by ports primarily located in dense areas. A lesser amount of fossil-based fuel used in the processes denotes minor respiratory issues. The ports should be held accountable to third parties. Therefore, aspects of a cleaner atmosphere can be ensured via renewable and alternative fuels. The technological readiness levels are vital for applying incentives or enforcements to the industry. The maritime transportation policy framework mostly limits the transportation network to a single dimension: vessels. However, if a holistic approach is adopted, market-based measurements may be applied to ports to promote electrification. Thus, such an act can be the catalyst for the much-needed link between the improvements of renewable energy and the port infrastructure.

Measurement of technological readiness of port's renewable energy investments is entitled to further discussion as well as its compatibleness to the existing situation. The debate about using alternative fuels in ports is another must-expand issue via in situ measurements. Satellite tracking of anomalies observed with and without renewable energies will most probably highlight the effectiveness as well.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Research Article

THE IMPACT OF COVID-19 ON MARITIME TRADE AND TRANSPORTATION: AN ESTIMATION OF THE MARITIME TRADE POST-COVID-19

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ABSTRACT

The coronavirus which emerged in December 2019 has affected the health of people and the whole world's social and working life. This pandemic has impressed not only people's health and life but also the world economy and especially maritime trade. International organizations and maritime authorities such as World Health Organization (WHO) and International Maritime Organization (IMO) have taken several measures and responses to mitigate the impact the Covid-19 on the maritime industry. Taking precautions, implementing protocols, and complying with guidelines at ships and ports which helps to protect the health of seafarers, passengers, port workers, and the general public have adversely affected the entire world economy and international trade. The study aims to identify the impacts of Covid-19 on maritime trade and transportation and to estimate world maritime trade for the years 2023, 2025, and 2030. In the study, a literature review was conducted, the impact of the Covid-19 on world maritime trade, maritime transportation, port calls, and shipping companies have been examined and the least squares method which is a form of regression analysis was used to estimate maritime trade and container throughput for these years. According to the result of the analysis, it is estimated that the world maritime trade will be 24,100.8 million tons in 2023, 25,163.2 million tons in 2025, and 27,819.2 million tons in 2030, and the estimated total container throughput at container ports in the world will be 906,104.1 thousand TEU in 2023, 959,701.5 thousand TEU in 2025 and 1,093,695 thousand TEU in 2030. It has been concluded that the total global maritime trade and amount of containers handled will increase gradually.

Keywords: *Maritime Trade, Maritime Transportation, Port Calls, Ports, Covid-19*

1. INTRODUCTION

Nearly 90% of world trade is transported by ships with the maritime transport sector acting as a considerable adjuvant to the international economy. Maritime transport is the backbone of the world economy and trade. The UNCTAD has estimated that international maritime trade will decrease by 3.8 percent in 2020 and increase by 4.3 percent in 2021. (UNCTAD, 2022).

Shipping has been vital in terms of assurance supply lines around the globe and moving crucial stocks of fuel, food, and medical supplies from one direction to another while the Covid-19 pandemic. The European Maritime Safety Agency (EMSA) has investigated the impact of the pandemic on marine traffic. According to the report, the maritime transport sector was also affected by the pandemic in 2020. The European Maritime Safety Agency (EMSA) has investigated the impact of the pandemic on marine traffic (EMSA, 2022).

International organizations and maritime authorities take several measures to cut down on the effects of Covid-19 on the maritime industry. The precautions have been implemented by the maritime sector and authorities such as the International World Health Organization (WHO), the International Chamber of Shipping (ICS), the International Maritime Organization (IMO), the Labour Organization (ILO), etc. Precautions, protocols, and guidelines regarding the Covid-19 have been enforced onboard and in ports to save the health of mariners, passengers, stevedores, dock laborers, and the community. WHO prepared guidance such as "Operational considerations for managing COVID - 19 cases or outbreaks on board ships: interim guidance, 25 March 2020". IMO has issued several guidelines and circulars "Covid-19 Related Guidelines for Ensuring A Safe Shipboard Interface Between Ship And Shore-Based Personnel and "Operational considerations for managing the Covid-19 cases and outbreaks on board ships". The information notes on maritime Labour issues and coronavirus were published by ILO on 7 April 2020. Most governments have implemented national and local restrictions to mitigate the effect of Covid-19. The main measures are cleaning/disinfection of vessels and prevention of crew changes, shore leave and embarking or disembarking of crew or passengers, a refutation of port entry in case of emergency prevention of handling of cargo, taking water on board, food, fuel, and supplies and quarantine of ships (ICS, 2021).

In the study, the literature review was conducted, the impact of the pandemic on global maritime commerce, shipping transport, port calls, and shipping companies have been examined and the least squares method which is a form of regression analysis was used to estimate maritime trade and container throughput in 2023, 2025 and 2030.

2. LITERATURE REVIEW

The Covid-19 affected the maritime industry. Some incidences include border restrictions for airlines and port closure, disputes in laytime arbitration, decreased demand for freight, disagreements between shipowners and charterers of such vessels due to lack of time and resources, bankruptcy due to decreased demand, and the failure to control the company's finances and reduced demand for shipping and freight. Covid-19 affected the shipping industry as follows: fall in ship supply, demand reduction of the container ship, reduction of dry bulk, lower fuel cost, reduce in demand tanker (Kumar and Jolly, 2021).

The number of liner transportation services, liner shipping operators, port calls on weekly, direct calls, and carrying capacity of ships deployed have decreased in the first half of 2020 at the regional level (Notteboom, 2021). There was a decrease in the amount of cargo handling at the container ports during the Covid-19 virus pandemic (İncaz and Karaköprü, 2021). İncaz performed a future forecast analysis for the container handling on a TEU basis in the Ambarlı port by using the Single Exponential Smoothing method. According to the result of the analysis, there will not be any significant change in the containers handled by Ambarlı Port in the coming years ((İncaz and Karaköprü, 2021).

The measurements taken to mitigate the effects of the pandemic have mostly negatively affected management/operation costs, disinfection costs, and crew changes due to 14 days quarantine requirement, the need to get a fit-to-travel certificate, negative test results for on/off signers, 14 days quarantine request for the vessels (Danışman and Akkartal 2021). The Covid-19 pandemic may require supplementary restrictions on ships such as stranger crew not being allowed onshore unless demands about sanitary elementary checks; the need for a medical emergency, and health documents of ship personnel before entry permit to most harbors, both personnel and passengers of cruise vessels are not permitted to step ashore and suspicious ships staying in 14 days quarantine. Precautions are carried out for suspicious vessels to remain in quarantine for 14 days and after these days tests are carried out (Notteboom and Pallis, 2020).

Dagestani has analyzed to measure the potential economic impacts of Covid-19 on trade volume between China and One Belt One Road countries by the Gravity Model. According to the findings of the study are that potential trade values between China and European Union will decrease by 11.5%, China and East Asia and Pacific (EAP) by 6,7%, China and the Middle East and North Africa (MENA) by 8.9%, China and South Asia (SAR) by15%, China and Europe and Central Asia (ECA) by 9% (Dagestani 2022).

The maritime sector and enhancing their resistance to future risks and disruptions adjusted their capacity. Harbor management took precautions to make sure that ports, transportation, and terminals, function well along the global supply chain and to sustain their management in response to the calls of the ship, arrangement the procedures and particular measures during the pandemic (Piñeiro 2021).

Verschuur et.al have mined the effects of Covid-19 by using Automatic Identification System (AIS) data for 1,153 ports including 166 countries worldwide by the geospatial position and features of marine vessels (from January 2019 - August 2020). They formed a novel high-frequency economic activity index using tentative vessel tracking data and utilized them to estimate the global maritime trade missing while the first eight months of the pandemic. They found that catholicly port-level commerce lacking, with the biggest missing found for harbors in China, the Middle East, and

Western Europe, related to the collapse of particular supply chains (e.g. crude oil, vessel producing). In all, they presumed that global marine commerce decreased by -7.0% to -9.6% through the first eight months of 2020, which is equal to 225–412 billion USD in value losses and around 206–286 million tons in volume losses. The Covid-19 affected manufacturing sectors most seriously, with deprivations up to 11.8%. Besides, it is found that public and school transport shutdowns on exports in all countries have a significant negative effect of the Covid-19. In all, they indicated how real-time indexes of economic activity could enlighten policymakers on the effects of separate economic policies. (Verschuur et. all, 2021)

Most viewpoints of social culture like human-to-human interactive relations and health care have been affected by the Covid-19 pandemic. Firstly, it is found that the Covid-19 has impacts on globalization. Secondly found that the "de-coupling" of the United States–China connection has consequences on present international systems and redirecting of the world economy. Thirdly is about the effects on global clarity impacts. The Covid-19 pandemic has an identical effect on the global economy with the maritime sector which is most wicked affected.

The pandemic has affected the international establishment's economic control and system of international and national precedencies. States and private sectors are concentrated on internal sources and mostly gentilic imminences (Permal, 2022). Yılmazkuday has researched the Covid-19 impacts on global economic activity using the pandemic's effects on the Baltic Exchange Dry Index (BDI) and crude oil prices (COP). He used a structural vector autoregression model for his research by wielding daily data between January 28th, 2020, and November 15th, 2021. Finally, it is found in the research rises in the Covid-19 incidences showing adverse request concussions in the worldwide economic movement (represented as decreases in COP) and adverse supply concussions in the worldwide carriage of commodities (represented as growth in BDI) (Yilmazkuday, 2022).

Koyuncu et. al, are conducted a study about modeling the Institute of Shipping Economics and Logistics (ISL) and the Leibniz-Institute für Wirtschaftsforschung (RWI) Container Throughput Index. They used the series of times, to find out the interaction across the short-term estimation results and the pandemic revealed in the beginning months of 2020. The study revealed that Covid-19 has a strong impression on marine commerce. With consideration of seasonal variations, RWI/ISL Container throughput Index is used in 89 main universal container ports. The decline will go on according to the three months' estimated results (Koyuncu et al., 2021).

Narasimha et al. investigated the impacts of the Covid-19 virus pandemic in India on marine supply-chain areas and seaway shipping with its associated topics. They consulted the expert's views on the effect, preparedness, response, and recovery way about the Indian maritime-associated sector. It is found that there is a decrease in traffic and a shortening vessel traffic density throughout the Covid-19. According to expert survey results, there is a need of improving future strategies (Narasimha et al., 2021).

Cengiz and Turan (2021) have determined the management impacts of the pandemic on the global maritime sector by Questionnaire Method. The questionnaires have been completed by 84 respondents in 21 countries around the world. Some findings of the study are that 34% of the companies emphasized that they were partly influenced, 31% of the companies were lightly influenced, 24% of the companies were heavily influenced and in contrast, 11% of the companies stated that they were not influenced by Covid-19. Other effects of the pandemic were lack of superintendents, difficulty in bringing onboard, reduced freight rates and servicemen due to the closure of the borders, canceled requests, modification of operating procedures, dividing employees into groups for time and location separation, reduction in the number of ship repair customers, more business, contract postponements/cancellations and clients not paying their bills (Cengiz and Turan 2021).

The Covid-19 virus has caused shockwaves and laid the world for a changing the global maritime sector and related supply-chain administration. The quarantine conditions and prohibitions, for workers crossing borders in certain countries that led to crew shifts and repatriations for mariners, especially those operating on cruise ships and yachts, are critical issues that harm the global maritime industry during the pandemic (Kumar and Jolly, 2021).

Zhang and Sun (2021) investigated how international organizations (IMO) member states, and associate members have embarked on maritime management (MM) measures to address dire situations in the context of the Covid-19 pandemic. According to the results of the analysis, the maritime transportation sector is damaged by an enormous organization because of the pandemic, triggering the export of four circular letters from IMO, which could impact the health of the crew, maintenance of the ship, and cargo transport. As a result of port isolation and traveling limitations, the crew shift crises raised and IMO invited its members to ease crew change, as required by maritime conventions. Through the period, IMO designated mariners as key workers, which promoted cooperation among member states and relieved the crew change crisis. After vaccination was developed marine transport sector entered the post-pandemic era (Zhang and Sun, 2021).

The throughput of container ports in Asia except China reduced by about 5.6% in 2020 during the Covid-19 pandemic. Many seafarers have suffered from Covid-19 due to a lack of availability of qualified nautical personnel and an increase in personnel costs (Yazır, et al., 2020). Xu et al. employ a panel linear regression model including panel data from 14 ports in China from January 2020 to October 2020 to study the key parameters influencing the cargo throughput in the Covid-19 pandemic content. One of the main results of the analysis is as follows: The severity of the epidemic has a significant adverse effect on both import and export commodity throughputs, further, the impact of the pandemic on import is greater than on export (Xu et.al, 2021).

Saral and Sanrı (2022) have conducted a bibliographic analyze the articles written on the the Covid-19 effects on marine logistics and harbors. Some of the analysis results areas are as follows; in the first quarter of the pandemic, the adverse effect of the Covid-19 on marine logistics was seen more. This effect may vary according to cruise ships, cargo ships, and the regions where the harbors are located. In port and ship operations digitalization and new technology use need has become more significant (Saral and Sanrı, 2022).

The Covid-19 pandemic has strongly decreased economic development activities with an accompanying reduction in the number of and/or cancellation of cruise voyages (Choquet and Sam-Lefebvre, 2021). Most of the port calls were aborted; frequency, connectedness, and service quality decreased; and the volume of laid tonnage also increased, reaching high levels in six months of 2020 due to the pandemic. Liner shipping quickly adjusted supply to meet requests in the second half of 2020. (Cullinane and Haralambides, 2021).

The Covid-19 lockdown led to a 4% reduction in global Gross domestic product (GDP) and resulted in over $5 trillion of output lost in 6 months. The Covid-19 expedites digitization and creates new digital opportunity structures which increase cyber risks (Kuhn et al., 2021). During the pandemic at the national level restrictions are adopted, which mariners could not disembark from ship to shore leave and carry out crew changes. These restrictions caused seafarers must stay onboard the ship for many months without disembarking, well beyond the specified limits. Such situations are unmaintainable for the safety and welfare of crewmembers and the safe operation of marine commerce (Doumbia-Henry, 2020).

Deb et al. investigate the economic effects of the Covid-19 repression precautions by using daily global data on repression measures, infections, and economic activity indicators. Some results of the study derive evidence that repression precautions have considerably reduced the amount of NO2 emissions. Cancellation of public events and school closures are the most effective in the pacification of the Covid-19 spread and are less costly in terms of their effect on economic activity (Deb et al., 2022).

Dirzka et al. (2022) have researched carriage geography and reverting management by network theory and investigated the precaution suggested to mitigate the reverting effects during the Covid-19. According to the analysis, the Covid-19 (at least in its beginning phases) has been a geographically constrained reverting: A single local source spreading to a limited number of additional clusters within the liner transportation network (Dirzka et al. 2022).

Secondary ports are the ports most influenced by blank sailings mostly, while the decrease in f calls to main hub ports was moderate. Most of the transportation enterprises have funded activities and substructures such as sea and midland terminals, and road transportation by vertical integration during the pandemic (Merk et. al. 2022).

The transport sector of maritime will come across many problems regarding the pandemic in forthcoming years, both directly through the effects of climate change on maritime operations and indirectly through demand changes that are affected by the geopolitical evolutions, and international health crises (Monios and Wilmsmeier, 2022).

The Covid-19 pandemic and economic shocks, such as the 2008–2009 financial-economic crisis, combined with rising international commerce controversies such as China–USA commerce interactions and stresses in present commencing blocks such as Brexit in Europe put into the sighted volatility in foreign commerce and commercial good volumes in harbors (Notteboom. and Haralambides, 2020). The UNCTAD impresses that China's maritime supply chains have come in sight to be tougher throughout the pandemic knowledge than other geographies (Tianming et. al., 2021). The personnel has been requested by port authorities in many countries to work from home. Technologies supported distant work such as virtual confidential networks, virtual meetings, work collaboration tools, voice-over-internet protocols, cloud technology, etc. (Keshta and Elmesmary, 2020).

The marine carriage sector recorded the highest missing, in TEU volume and finances (decrease in revenue and profits) in the first three quarters of 2020. It is estimated that maritime container companies may suffer a loss in the amount of 10 billion US dollars at the end of 2020. While the first months of 2020, the sector of global maritime transportation, especially container carriage was especially influenced by the impacts of the crisis due to the intensity of ports (lockdown) and the global supply chain's continuous disorganization (Grzelakowski, 2022). Polat and Bamyacı (2022) examined the causes of empty container movements and the effect of the economic crisis caused by the Covid-19 epidemic on empty container movements. According to the result of findings that the import/export gap for 2020 increased compared to previous years, and it was concluded that the increasing difference triggered the empty container movement by creating a trade imbalance (Polat and Bamyacı, 2022).

Peng and Chu (2009) applied container throughput data to six univariate forecasting models such as the seasonal dummy variables, the grey forecast, the hybrid grey forecast, and the SARIMA for the container throughput volumes in Taiwan's three major ports. They compared the predictive accuracy of the models by calculating the MAE, MAPE, and RMSE for each. The classical decomposition and SAR in the IMA model give the best results in estimating the container volume of Taichung Port (Peng, and Chu (2009).

3. THE IMPACT OF COVID-19 ON THE WORLD MARITIME TRADE

Global economic output collapsed by 3.5 percent (UNCTAD, 2021). In 2020, the global total trade raised 12.1 billion tons and the maritime trade raised 10.7 billion tons. Even though most nations have closed their borders, the share of the maritime transport sector in world commerce has reached 90% (IMEAK, 2021). UNCTAD projected international seaborne commerce has fallen by 5.4% in 2020 and merchandise commerce by 5.4 percent, while international maritime transportation fell by 3.8%, to 10.65 billion tons. (UNCTAD, 2021).

UNCTAD presumed that the volume of global maritime commerce decreased by 3.8% in 2020 and by 4.3 % in 2021. The Covid-19 virus pandemic has deduced new trends which will redesign marine carriage and commerce. Reducing the effect of self-enclosed manners on protectionism and commerce in the maritime sector, and ensuring sustainability and low carbon in maritime transportation will remain on the agenda (UNCTAD, 2020). The world maritime trade by cargo types is shown in Table 1.

In 2020, total goods handled decreased by 3.83%, total goods loaded declined by 3.82 and total goods discharged by 3.84% in 2020 compared with 2019 due to the Covid-19. The world maritime trade by years is given in Table 2.

World total trade was realized as 13.33 billion in 2020 and world maritime trade amounted to 13.33 billion in 2020. In 2020, the Covid-19 pandemic negatively affected logistics supply chains, and production activities and turned the world economy upside down. Global maritime trade is estimated to be close to 2019 levels and recovering in 2021. In 2020, after the effects of the Covid-19, maritime trade increased by 3.2% and reached around 12 billion tons. At the beginning of 2022, global maritime trade is expected to increase by 3.5% and reach approximately 12.4 billion tons. Expectation trends in China and the Omicron variant of the Covid-19 potential impacts perpetuate risks in global maritime trade (IMEAK, 2021).

The World maritime trade by years is given in Figure 1. World maritime trade by types of cargo is given in Table 3.

In 2020, the world maritime trade by all types of cargo decreased according to the previous year due to the pandemic. Expectation trends in China and the Omicron variant of the Covid-19 potential impacts perpetuate risks in global maritime trade.

4. THE IMPACT OF COVID-19 ON MARITIME TRANSPORTATION

In 2021, according to the Clarksons Research Company; approximately 1.524 million tons of iron ore, 1.239 million tons of coal, 530 million tons of grain, 2.086 million tons of small dry bulk cargo, 1.959 million tons of containers and 942 million tons of other dry cargo were transported by sea as shown in Table 4 (Clarksons Research February Seaborn; IMEAK, 2022).

Table 1.The world maritime trade by cargo types (Million tons)

Years/ Types of cargo	2013	2014	2015	2016	2017	2018	2019	2020
Crude oil loaded	1,738	1,712	1,761	1,832	1,875	1,881	1,860	1,716
Other tanker trade loaded	1,091	1,121	1,178	1,238	1,279	1,320	1,303	1,202
Dry cargo loaded	6,625	6,983	7,074	7,176	7,560	7,818	7,908	7,730
Total goods loaded	9,453	9,816	10,013	10,247	10 714	11,019	11,071	10,648
Crude oil discharged	1,882	1,850	1,910	1,985	2, 033	2,049	2,023	1,864
Other tanker trade discharged	1,091	1,088	1,175	1,235	1,288	1,339	1,320	1,222
Dry cargo discharged	6,511	6,782	6,879	7,083	7,366	7,629	7,712	7,545
Total goods discharged	9,483	9,720	9,965	10,303	10,687	11,017	11,055	10,631
Total goods handled	18,936	19,536	19,978	20,550	22,689	22,036	22,126	21,279

Source: UNCTADSTAT, 2022a

Table 2. The world maritime trade by years

Year	World total trade (Billion Tons)	World maritime trade (Billion Tons)	Maritime trade growth rate (%)
2011	11.50	9.50	82.0
2012	11.80	9.90	84.0
2013	12.20	10.20	83.0
2014	12.50	10.56	84.0
2015	12.7	10.79	85.0
2016	12.95	11.12	86.0
2017	13.56	11.57	86.0
2018	13.95	11.89	86.0
2019	14.07	11.95	85.0
2020	13.33	11.54	87.0
2021*	14.11	11.95	85.0
2022*	14.77	12.37	84.0

* Estimated figures
Source: Clarksons Research Feb.2022; IMEAK, 2021

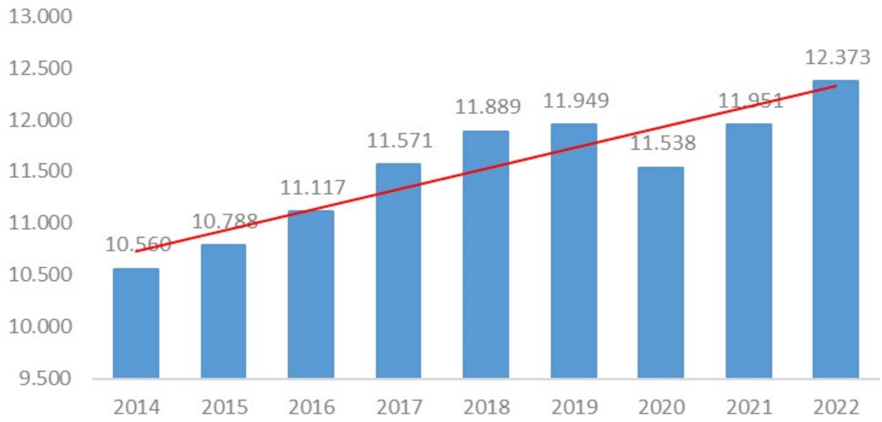

Figure 1. World maritime trade by years
Source: Clarksons Research Feb.2022; IMEAK, 2021

Table 3. World maritime trade by types of cargo (Metric tons in millions)

Years/	Loaded				Discharged			
Types of cargo	Crude Oil	Other tanker trade	Dry cargo	Total goods loaded	Crude oil	Other tanker trade	Dry cargo	Total goods discharged
2010	1,785	968	5,649	8,401	1,939	971	5,454	8,364
2011	1,751	1,028	5,959	8,739	1,897	1,039	5,766	8,702
2012	1,785	1,055	6,357	9,197	1,930	1,056	6,129	9,115
2013	1,738	1,091	6,625	9,453	1,882	1,091	6,511	9,483
2014	1,712	1,121	6,983	9,816	1,850	1,088	6,782	9,720
2015	1,761	1,178	7,074	10,013	1,910	1,175	6,879	9,965
2016	1,832	1,238	7,176	10,247	1,985	1,235	7,083	10,303
2017	1,875	1,279	7,560	10,714	2,033	1,288	7,366	10,687
2018	1,881	1,320	7,818	11,019	2,049	1,339	7,629	11,017
2019	1,860	1,303	7,908	11,071	2,023	1,320	7,712	11,055
2020	1,716	1,202	7,730	10,648	1,864	1,222	7,545	10,631

Source: UNCTADSTAT, 2022a

Table 4. The World maritime transport by cargo types (Million tons)

Million tons	2014	2015	2016	2017	2018	2019	2020	2021 (Nearly)	2022 (Est.)
Iron Ore	1,340	1,364	1,418	1,472	1,475	1,455	1,502	1,524	1,525
Coal	1,217	1,138	1,141	1,203	1,264	1,284	1,165	1,239	1,259
Grain	409	430	450	476	475	478	512	530	544
Minor dry bulk	1,847	1,891	1,880	1,936	2,012	2,036	1,990	2,086	2,135
Crude Oil	1,807	1,875	1,957	2,019	2,030	2,008	1,860	1,829	1,963
Petroleum Products	943	1,012	1,058	1,075	1,087	1,033	908	962	1,017
Gas	332	344	371	399	433	478	480	507	529
Chemical	298	314	321	342	362	371	365	371	389
Container	1,557	1,591	1,666	1,761	1,838	1,879	1,851	1,959	2,045
Other dry bulk	809	830	855	888	914	927	903	942	966
Total	10,560	10,788	11,117	11,571	11,889	11,949	11,538	11,951	12,373
Percentage change	3.4%	2.2%	3.0%	4.1%	2.7%	0.5%	-3.4%	3.6%	3.5%

Source: Clarksons Research February Seaborn; IMEAK, 2022.

Asian container line volume reached 41.5 million TEU in 2021. Trade flows from the Far East to North America and Europe reached 23.6 million TEUs and 14.7 million TEUs in 2021, respectively. The world container trade is estimated to grow by %3.9 in 2022-2025 (Statista, 2022). In 2020, international marine transportation was reduced by 3.6% on a per-ton basis due to the pandemic. Clarkson Research predicts world shipping will increase by 4.2% in 2021 and 3% in 2022. While the pandemic, access to fundamental cargoes and medical materials were secured through the maritime supply chain. Key stakeholders in the maritime supply chain carried out many responses and risk reduction precautions to overcome the disruption and maintain link supply chains and enable smooth cargo flows (UNCTAD, 2022).

Major responses and measures to mitigate the effects of the Covid-19 on maritime transport and logistic sectors are making use of international recommendations and directives, including safety and health protocols; preparing emergency and operational/business continuity plans; –improving organizational capacity, relevant know-how, and skills; enabling telecommuting arrangements; facilitating and prioritizing the flow of fundamental cargoes; enhancing collaboration between relevant stakeholders, service providers, and suppliers; to improve international cooperation between government authorities and actors of the maritime supply-chain and other relevant stakeholders; enabling effective communications and implementing technology and digital solutions that decrease physical transaction; expedite clearance procedures, and minimize paper-based processes; improving hinterland transport connectivity and struggling physical and management bottlenecks (UNCTAD, 2022).

5. THE IMPACT OF COVID-19 ON PORT CALLS

The number of port calls in the world decreased by 10% in 2020 compared to 2019 due to the Covid-19 and increased by 1% in 2021 compared to 2020 as given in Table 5. In 2020, the number of port calls in all regions decreased compared to 2019 and increased in 2021 except in Oceania (UNCTADSTAT, 2022b). The number of port calls by region and the median time spent by ships in port (days) are given in Table 5 and Table 6 respectively. (UNCTADSTAT, 2022b; UNCTADSTAT, 2022c).

The median time spent on all ships is 1.05 days in port in 2021. Container ships spent the least amount of time in port in 2021(0.80) as given in Table 6.

Table 5. Number of port calls by regions

Region/Year	2018	2019	2020	2021
Africa	93,340	101,788	83,888	88,743
America	535,288	568,631	495,696	525,937
Asia	1,274,527	1,402,937	1,292,554	1,401,454
Europe	2,120,489	2,193,392	1,950,851	2,190,815
Oceania	89,288	95,974	83,987	79,255
Developing Regions	1,273.926	1,406,876	1 269 362	1,377,924
Developed Regions	2,839,018	2,955,861	2,637,625	2,908,280
World Total	4,112,944	4,362,737	3,906,987	4,286,204

Source:UNCTADSTAT, 2022b; UNCSTAD, 2022c

Table 6. The median time spent by ships in port (days)

Type of Ships/Year	2018	2019	2020	2021
All ships	0.97	0.97	1.00	1.05
Liquid bulk carriers	0.94	0.93	0.97	0.98
Liquefied petroleum gas carriers	1.02	1.01	1.04	1.03
Liquefied natural gas carriers	1.11	1.11	1.12	1.13
Dry bulk carriers	2.05	2.01	2.07	2.11
Dry breakbulk carriers	1.11	1.10	1.15	1.17
Container ships	0.70	0.69	0.71	0.80

Source: UNCTADSTAT, 2022b

The Shanghai Port which is the largest container handling port in the world handled 47 million TEU in 2021 as given in Table 7.

Table 7. The top 10 world container ports (Million TEU)

Container Ports/Year	2015	2016	2017	2018	2019	2020	2021
Shanghai, China	36.54	37.13	40.23	42.01	43.30	43.50	47.00
Singapore	30.96	30.90	33.67	36.60	37.20	36.6	37.50
Ningbo-Zhoushan	20.59	21.56	24.61	26.35	27.49	28.72	31.1
Shenzhen, China	24.20	23.97	25.21	25.74	25.77	26.55	28.8
Guangzhou Harbor	17.46	18.90	20.37	21.87	23.23	23.19	24.2
Busan, South Korea	19.30	19.85	20.49	21.66	21.99	21.59	22.7
Qingdao, China	17.47	18.01	18.30	18.26	21.01	22.00	23.7
Hong Kong, S.A.R, China	20.11	17.95	18.30	19 60	20.76	19.81	17.8
Tianjin, China	14.11	14.49	15.07	16.00	17.30	18.35	20.3
Rotterdam	12.24	12.38	13.73	14.51	14.82	14.35	15.3

Source: WSC, 2021; Bansard, 2021; Ece, 2020

Limitations, such as port closures and reduced flights, have left many seafarers stranded on board. Many sailors had to extend their service on board. Some countries did not allow crew changes. In 2020, terminal operators and intermodal transport providers had to spend more time in ports due to the Covid-19 (UNCTAD, 2022).

6. THE IMPACT OF COVID-19 ON SHIPPING COMPANIES

The governments have taken strict precautions about against the Covid-19, which has negatively changed our lifestyles. These precautions affected most of the sectors such as the maritime transportation sector in which cruise companies were affected most. Carnival Corporation (CCL) a publicly traded cruise company listed on the New York Stock Exchange (NYSE) has been specifically investigated. Golden Ocean (GOGL), on the other hand, is a publicly held corporation operating in the maritime sector with 92 dry cargo ships listed on NASDAQ. These two types of shipping companies' stock prices and trading volumes have been investigated and it is found that the price of CCL and GOGL has dropped drastically and the trading volume has increased highly. After vaccine approval, it has been observed that the average value of the CCL stock has increased (Yazır and Yay, 2022).

Beyazgül et al. (2022) analyzed the impact of the Covid-19 outbreak on the liquidity and financial failure risk of the land, maritime, and air passenger transport sectors in Turkey. On the sector balance sheets published by the Central Bank of the Republic of Turkey, the liquidity risks of the Sea and Coastal Water Passenger Transport sectors for the years 2019-2020 were analyzed. As a result of the analysis, it has been seen that the maritime sectors examined have high liquidity and financial failure risks (Beyazgül et al., 2022).

The Covid-19 hit the global economy in the early months of 2020 and then has adversely affected the shipping companies' improvement such as shipping operators, passengers, port operators, government authorities, mariners, shippers, and supply chain operators. Dry bulk, tanker, container, and cruiser sector are chosen to find out the newest difficulties and asses potential solutions for the maritime industry. It has been found that shipping companies have encountered operational losses and incommodity because of health and safety precautions and potential operational risk could be decreased with effective Port State Inspections in the post-Covid 19 eras (Yazır et al., 2020).

The Covid-19 crisis has had a serious impact on the maritime transport sector. Cruise companies and ferry services had the most affected sectors due to the pandemic. Dry cargo and tanker transport also faced demand declines and challenges during the pandemic (Cullinane, and Haralambides, 2021).

7. METHODOLOGY

Basic forecasting techniques are separated into two parts qualitative methods and quantitive methods. The qualitative methods are Delphi Metod, Market Research, Panel Consensus, Visionary Forecast, Historical Analogy, etc. The quantitative methods are Time Serious Analyses and Projections such as Moving Average, Exponential Smooting, The Box-Jenkins Model, X-11 Procedure, Trend Projections, etc. The Causal Methods are Regression Model, Econometric Model, Input-Output Model, Diffusion Index, etc.).

In the study regression analysis with the least squares method which is the most reliable of the trend methods has been used to minimize the errors.

Regression analysis is the analysis of the relationship between the dependent and independent variable as it depicts how the dependent variable will change when one or more independent variable changes due to factors, the formula for calculating it is;

$Y = a + bx + e$, where Y is dependent variable, x is the independent variable.

The least squares method which is a form of regression analysis was used to determine the position of the trend, ~~T~~the least squares method was used to determine the line of best fit for a set of data, and estimate the value of y at a value of x.

Assuming the trend is linear, The equation of the least square line is given below (Akdeniz, 2016):

$$\hat{Y} = a + bx \quad (1)$$

where Y is the dependent variable, X is the independent variable.

Normal equations for "a" and "b" are given below, respectively:

$$\sum_{i=1}^{n} y_i = an + b \sum_{i=1}^{n} x_i \quad (2)$$

$$\sum_{i=1}^{n} x_i y_i = a \sum_{i=1}^{n} x_i + b \sum_{i=1}^{n} x_i^2 \quad (3)$$

Since the number of years is odd and $\sum_{i=1}^{n} x_i = 0$, the normal equations are given below:

$$na = \sum_{i=1}^{n} y_i \quad (4)$$

$$b \sum_{i=1}^{n} x_i^2 = \sum_{i=1}^{n} x_i y_i \quad (5)$$

The data used in the study were obtained from the UNCTADSTAT data center.

8. RESULTS

Maritime trade figures by cargo types between 2010-2020- and the values related to the least square equations are given in Table 8.

Since the number of years is odd, the year that coincides with the middle is taken as the starting year and shown with zero as given in Table 8.

The world maritime trade (million tons) and the least squares equation values are given in Table 8 (UNCTADSTAT, 2022a). The estimated values of global maritime trade assume that the Covid-19 pandemic does not continue severely.

Table 8. The world maritime trade (million tons) and the least squares equation values

Types of cargo/Year	Total cargo handled (Y)	Year code (X)	XY	X^2	Year code X	XY	X^2
2010	16,765	0	0	0	-5	-83,825	25
2011	17,441	1	17,441	1	-4	-69,764	16
2012	18,312	2	36,624	4	-3	-54,936	9
2013	18,936	3	56,808	9	-2	-37,872	4
2014	19,536	4	78,144	16	-1	-19,536	1
2015	19,978	5	99,890	25	0	0	0
2016	20,550	6	123,300	36	1	20,550	1
2017	21,401	7	149,807	49	2	42,802	4
2018	22,036	8	176,288	64	3	66,108	9
2019	22,126	9	199,134	81	4	88,504	16
2020	21,279	10	212,790	100	5	106,395	25

The calculations in million tons basis are given below:

$\sum_{i=1}^{11} Y_i = 218{,}360$ $\quad \sum_{i=1}^{11} X_i = 55$ $\quad \sum_{i=1}^{11} X^2 = 385$

$\sum_{i=1}^{11} X_i Y_i = 1{,}150{,}226$ $\quad \sum_{i=1}^{11} X = 0$

$\sum_{i=1}^{11} XiYi = 58{,}426$ $\quad \sum_{i=1}^{11} Xi^2 = 110$

The normal equations for "a" and "b" are given below by using formulas 2 and 3:

I. 218,360 = 11a + 55b
II. 1,150,226 = 55a + 385b

a = 17,195.2 b = 531.2

According to the values of a and b, the trend line has a value of 17,195.2. The estimated change in maritime trade on a million-ton basis is 531.2. Using the regression equation below, The estimated maritime trade in million tons for the years 2023, 2025, and 2030 is given below:

$\hat{Y}_i = a + bx = 17.195{,}2 + 531.2\ x$

$\hat{Y}_{2023} = 17{,}195.2 + 531.2\ (2023\text{-}2010) = 24{,}100.8$ million tons
$\hat{Y}_{2025} = 17{,}195.2 + 531.2\ (2025\text{-}2010) = 25{,}163.2$ million tons
$\hat{Y}_{2030} = 17{,}195.2 + 531.2\ (2030\text{-}2010) = 27{,}819.2$ million tons

According to the result of the analysis, it is estimated that the world maritime trade will be 24,100.8 million tons in 2023, 25,163.2 million tons in 2025, and 27,819.2 million tons in 2030.

Total container throughput at container ports in the world (million TEU) and least squares equation values are given in Table 9 (UNCTADSTAT, 2022d). The estimated values of global maritime trade and port cargo volumes on a TEU basis assume that the Covid-19 pandemic does not continue severely.

Table 9. Total container throughput at container ports in the world (thousand TEU) and the least squares equation values

Types of cargo/Year	Total container throughput (Y)	Year code (X)	XY	X^2	Year code X	XY	X^2
2010	541.759	0	0	0	-5	- 2.708.795	25
2011	582.988	1	582.988	1	-4	- 2.331.952	16
2012	616.566	2	1.233.132	4	-3	- 1.849.698	9
2013	647.306	3	1.941.918	9	-2	- 1.294.612	4
2014	677.551	4	2.710.204	16	-1	- 677.551	1
2015	688.838	5	3.444.190	25	0	0	0
2016	700.974	6	4.205.844	36	1	700.974	1
2017	754.208	7	5.279.456	49	2	1.508.416	4
2018	792.470	8	6.339.760	64	3	2.377.410	9
2019	807.330	9	7.265.970	81	4	3.229.320	16
2020	798.869	10	7.988.690	100	5	3.994.345	25

Source: UNCTADSTAT, 2022d

The calculations in million TEU are given below:

$\sum_{i=1}^{11} Y_i = 7,608,859$ $\sum_{i=1}^{11} X_i = 55$ $\sum_{i=1}^{11} X^2 = 385$

$\sum_{i=1}^{11} X_iY_i = 40,992,152$ $\sum_{i=1}^{11} X = 0$

$\sum_{i=1}^{11} XiYi = 2,947,857$ $\sum_{i=1}^{11} Xi^2 = 110$

The normal equations for "a" and "b" are given below by using formulas 2 and 3:

I. 7,608,859 = 11a + 55b
II. 40,992,152 = 55a + 385b

The estimated total container throughput at container ports in the world (TEU) for the years 2023, 2025, and 2030 are given below:

a = 557,720.955 b = 26,798.700

$\hat{Y}_i$= a+ bx = 557,721.955+ 26,798.700 X

$\hat{Y}_{2023}$ = 557,721.955 + 26,798.700 (2023-2010) = 906.104,1 thousand TEU

$\hat{Y}_{2025}$ = 557,721.955 + 26,798.700 (2025-2010) = 959,701,5 thousand TEU

$\hat{Y}_{2030}$ = 557,721.955 + 26,798.700 (2030-2010) =1,093,695 thousand TEU

According to the result of the analysis, it estimated that the total container throughput at container ports in the world will be 906.104,1 thousand TEU in 2023, 959,701,5 thousand TEU in 2025, and 1,093,695 thousand TEU in 2030.

As given in Figure 2, it is expected that the total amount of containers handled in the world will increase gradually.

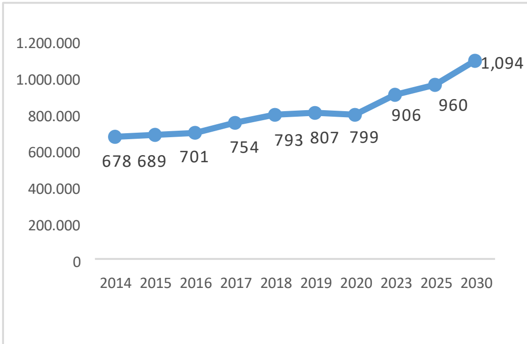

Figure 2. The total container throughput in 2014-2030
Source: UNCTADSTAT, 2022d

9. CONCLUSION

World total trade volume reached more than 12 billion tons and global maritime trade volume reached 10.7 billion tons in 2020. UNCTAD has estimated that international maritime trade will decrease by 3.8 percent in 2020 and increase by 4.3 percent in 2021. Many countries closed their borders during the the Covid-19 days. The Covid-19 adversely impressed maritime trade and transportation, ports, logistics supply chains, production activities, and the global economy.

During the Covid-19, major ports around the world have implemented a 14-day quarantine period for ships coming from or transiting through the impacted areas, and many ports have stopped cruise ship calls. Cargo vessels were exposed to increase maritime health declarations and monitoring needs. Strict restrictions were placed on crew landing, shore clearance, and substitution. Limitations, such as port closures and reduced flights, have left many seafarers stranded on board. Many sailors had to extend their service on board. Some countries did not allow crew changes. Terminal operators and intermodal transport providers had to spend more time in ports in 2020 due to the Covid-19.

The Covid-19 pandemic has revealed new trends which will reconfigure marine transportation and commerce. The Covid-19 has affected the use of technology in shipping. The maritime and logistics industries have invested in technologies such as digital solutions, artificial intelligence and automation in the Covid-19 period.

According to the result of the analysis, It is estimated that the world maritime trade will be 24,100.8 million tons in 2023, 25,163.2 million tons in 2025, and 27,819.2 million tons in 2030; the estimated total container throughput at container ports in the world will be 906.104,1 thousand TEU in 2023, 959,701,5 thousand TEU in 2025 and 1,093,695 thousand TEU in 2030. It has been concluded that the total global maritime trade and amount of containers handled will gradually increase.

Future, studies may be conducted on the cost of the maritime sector of the Covid-19. It is thought that the study will contribute to future research and the literature related to the impact of the Covid-19 on the maritime and logistics sectors.

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