The impact of COVID-19 on the supply chain of maritime freight transportation and the implementation of innovative technologies to mitigate its effects.

Graduating Project.

Paula Alejandra Ortega Hurtado.

Escuela de administración

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With humility and gratitude,

Paula Alejandra Ortega

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Paula Alejandra Ortega Hurtado

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Resumen

La industria marítima de mercancías desempeña un papel fundamental en el comercio global, siendo responsable de la mayor parte del transporte de bienes a nivel mundial. Sin embargo, la pandemia de COVID-19 tuvo un impacto significativo en esta industria, generando desafíos considerables en la cadena de suministro. La propagación del virus provocó la disrupción de las operaciones marítimas y la cadena de suministro en su conjunto. Las medidas de confinamiento y las restricciones de viaje afectaron a la tripulación de los buques y la capacidad de operación de los puertos. Además, la caída de la demanda y la incertidumbre económica llevaron a la cancelación de rutas y la disminución del volumen de carga.

Para hacer frente a estos desafíos, la industria marítima ha recurrido a tecnologías innovadoras. La digitalización ha sido un cambio clave, permitiendo una mayor visibilidad y trazabilidad de la carga, lo que ha ayudado a minimizar la congestión en los puertos y a optimizar las operaciones.

Palabras clave: Industria Marítima, Covid-19, Supply Chain, Logística, Nuevas tecnologías, Digitalización, Comercio Internacional.

Abstract

The global outbreak of COVID-19 has triggered profound disruptions across industries, with the maritime freight transportation sector being no exception. This study investigates the multifaceted repercussions of the pandemic on the maritime supply chain and explores the pivotal role of innovative technologies in mitigating its effects. Employing a mixed-method research approach, including surveys and secondary data analysis, the research comprehensively assesses how the industry has navigated the challenges posed by the pandemic and adapted through technological interventions.

Through data collected from 60 experts via a structured questionnaire, interviews with 4 industry experts, coupled with insights from reputable sources such as UNCTAD, WTO reports and industry articles, the study reveals a complex web of transformations that have unfolded. Notably, over half of the respondents indicate a positive impact of COVID-19 on the maritime freight transportation industry. This impact is attributed to dynamic shifts in logistics services, increased transport costs, amplified technological adoption, and evolving cargo priorities.

The research underscores the crucial role of digitalization and innovative technologies in bolstering the industry's resilience. The analysis elucidates that technologies such as bigdata, artificial intelligence, real-time tracking systems, and blockchain are emerging as pivotal enablers in streamlining operations, enhancing visibility, and facilitating efficient decision-making. Despite encountered challenges, including resistance to change and interoperability issues, the implementation of these technologies has proven instrumental in addressing the pandemic's disruptions.

Moreover, the study sheds light on the progress made in recent years in the adoption of digital solutions within the maritime domain. The substantial growth experienced by the industry prior to the pandemic laid the groundwork for rapid digitalization, positioning the sector for continued technological advancements. While immediate impacts have been subtle, the collective efforts towards digital transformation are poised to yield substantial benefits in the years ahead, offering sustained optimization and adaptability in an ever-evolving market.

Keywords: Maritime freight transportation, Supply chain, Innovative technologies, Digitalization, Resilience, Logistics**,** International trade, Covid-19.

1.Introduction

The transportation industry has been a significant aspect of the economy since its inception, primarily responsible for the movement of goods and people locally, nationally, and internationally. Throughout prehistoric times, transportation has evolved into a large and complex industry, divided into several modes and sectors, each with its unique characteristics and challenges, such as maritime, aerial, and terrestrial transportation.

Nowadays, freight transport plays an important and inseparable role in the global economy, enabling different markets to connect, obtain products, and generate jobs and business opportunities in different places. First, the movement of goods has a positive effect on international trade by allowing goods to move from one place to another, positively affecting economic growth; second, it has a positive effect on the supply of goods since it allows businesses to obtain the materials needed for production or allows consumers to buy the products they need; thirdly, freight transport plays a key role in the supply chain, transferring products from manufacturers to distributors, retailers, and finally consumers (Nistor, 2014).

Freight transportation has a strong interdependence with diverse transportation modes, which is contingent upon factors such as geographical location, kind of commodities, distance, and intended objective. Rail transport is a crucial mode of transportation for the efficient movement of goods over vast distances, both domestically and internationally. It plays a significant role in facilitating the passage of heavy commodities, such as machinery, between nations. Air transportation is considered highly suitable for the transportation of perishable goods of high value and for short-distance

travel. Additionally, it is deemed particularly advantageous for the urgent transportation of freight in emergency situations. Maritime transportation is widely employed as the predominant means of long-distance product conveyance, particularly for the shipment of substantial and voluminous cargoes, such as raw materials and bulk commodities. In addition, sea transportation plays a crucial role in facilitating international trade and fostering economic development (Thompson & Taniguchi, 2017).

On the other hand, the COVID-19 pandemic is one of the largest and most impactful health crises that humanity has faced in recent years. Due to movement restrictions and quarantines, the virus has paralyzed businesses, disrupted supply chains, canceled events, and reduced consumption. As the disease spread rapidly around the world, many industries were affected, including shipping and the cargo supply chain (Yilmazkuday, 2022). Disruptions in transport services and restrictions on the movement of people and goods have had a significant impact on logistics and world trade.

According to the analysis and data, the shipping industry and its supply chains have been significantly affected by COVID-19, which has adversely affected the flow of goods worldwide. Border closures, travel restrictions, demand reduction, and increased operating costs have created significant logistical and financial challenges for the industry (Gavalas et al., 2022).

The COVID-19 pandemic has had a major impact on the global shipping industry. Since the beginning of the pandemic, the demand for shipping and the availability of resources in the industry have changed significantly, creating important logistical and financial challenges (Xu et al., 2022).

Among the main impacts of COVID-19 on the shipping industry are, according to UNCTAD:

1. Demand reduction: The pandemic has reduced demand for shipping, especially on trade routes that have been most affected by the crisis, such as Asia-Europe and Asia-North America. Declining demand has affected shipping revenues and resulted in lower freight rates.

2. Port closures and travel restrictions: Many countries have closed ports or imposed restrictions on international travel, causing delays in supply chains and affecting the availability of resources in the industry.

3. Increased operating costs: The pandemic has increased the industry's operating costs, particularly in terms of the cost of personal protective equipment and health and safety protocols to be implemented on board ships and in ports.

4. Supply chain disruption: The pandemic has disrupted shipping supply chains, particularly in terms of container availability and inventory management.

Faced with these challenges, the shipping industry has had to adapt and seek innovative solutions to maintain operations in times of pandemic (Rothengatter et al., 2021). The introduction of innovative technologies in freight shipping is becoming increasingly important to mitigate the impact of COVID-19 on supply chains. Technology can help improve efficiency in supply chain management, optimize route planning and inventory management, and improve communication and coordination among freight transport actors.

Therefore, this study aims to provide a comprehensive and well-founded perspective on the impact of COVID-19 on the maritime supply chain and to identify the key challenges and obstacles faced by the industry in this context. It also seeks to analyze and

gain a more precise insight into the innovative technologies introduced in the industry to mitigate the COVID-19 impact on supply chains and to assess their effectiveness in supply chain management. Through this research, the goal is to contribute to an understanding of the current situation in maritime freight transport during the COVID-19 pandemic, drawing on prior investigations, and to offer recommendations for enhancing the efficiency and resilience of the sector's supply chain through the implementation of innovative technologies.

2. Literature Review

2.1 Introduction

The purpose of this section is to provide a critical exploration and extension of existing research and case studies. Through the analysis of specific subtopics, the aim is to offer a comprehensive view of the impacts and challenges posed by COVID-19 on the maritime transportation industry, as well as to highlight how the implementation of innovative technologies contributes to mitigating these effects. Through this contribution, it is anticipated that a more nuanced perspective will emerge, which will be greatly beneficial for the various stakeholders involved, enabling them to conduct deeper and more detailed analyses of the situation.

2.1.1 Freight transport & international trade

To begin with, the transport of goods refers to the physical movement of goods and products from one place to another; it can be carried out by different means of transport, such as road, rail, sea, air, and river, among others. For decades, the transport of goods and economic activity have developed and complemented each other, making it essential for the

trade and exchange of goods and products between countries and regions (Verny, 2007). The presence of transportation is crucial for the successful delivery of goods to their intended destinations, hence playing a significant role in the global economy. Additionally, it is important to emphasize that transportation is necessary for facilitating the supply chain and ensuring the efficient distribution of products to end customers. This facilitates the procurement of essential raw materials and components by enterprises for their manufacturing processes, as well as enables the transportation of their finished goods to both domestic and global markets.

Conversely, the process of economic growth also engenders a need for transportation services. When a nation experiences economic growth, there is an increased demand for commodities from enterprises, necessitating a corresponding increase in transportation services to fulfill the growing demands of the economy. Hence, the expansion of the nation's economy may serve as a catalyst for the creation of fresh markets and prospects, thereby augmenting economic demand. The concept of transport refers to the movement of people, goods, or information from one location Transport demand is propelled by economic activity, while the presence of transport infrastructure facilitates the growth and expansion of economic endeavors.

Transportation has a crucial role in the global economy, since it facilitates the flow of products and supports commercial operations in the context of globalization. In this particular instance, one may suggest that the global economy is reliant upon the transportation of commodities (Rodrigue, 2007).

Transport also plays an important role in determining the price and availability of goods in international markets. Transportation costs can significantly affect product profitability, and changes in fuel prices and taxes can significantly affect transportation costs (Ślusarczyk, s/f). Throughout the years, there has been evident and steady growth in the goods industry and the transportation sector, which has significantly contributed to the expansion of economic globalization. This symbiosis between both areas has generated an increase in connectivity between nations and has enabled the smooth flow of goods across borders. A critical component in the supply chain of the goods industry lies in the analysis of transportation costs, as this aspect can exert a considerable impact on the procurement and prices of products (Kiani et al., 2022).

Distribution is important for globalization, allowing products to reach customers around the world and facilitating international trade. However, this phenomenon also comes with several problems. One of the biggest problems is the transportation area, which may not be enough in some areas and increase the cost of transportation (Engebrethsen & Dauzère-Pérès, 2019).

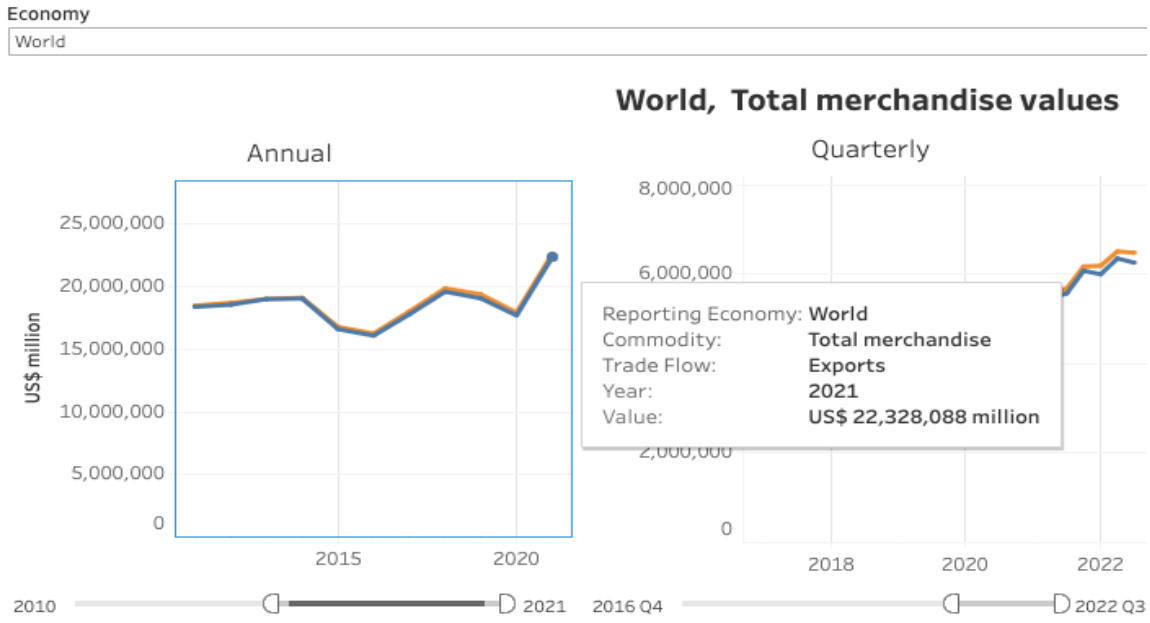
Transportation costs can also be a barrier for companies that want to compete in international markets (Ślusarczyk, s/f). International regulations, safety, and durability are other key points that must be addressed to ensure the efficiency and effectiveness of the goods transport industry.

Globalization has created an increased demand for international transport, which has increased the complexity of transport operations. Regulation and security are two important

issues facing the industry in an increasingly global world. In addition, technological developments are changing the logistics industry, and companies that do not adapt to these changes may lag in terms of productivity and competitiveness. Overall, the logistics industry and globalization present many challenges that must be addressed to ensure the success of companies and their ability to meet the needs of customers worldwide.

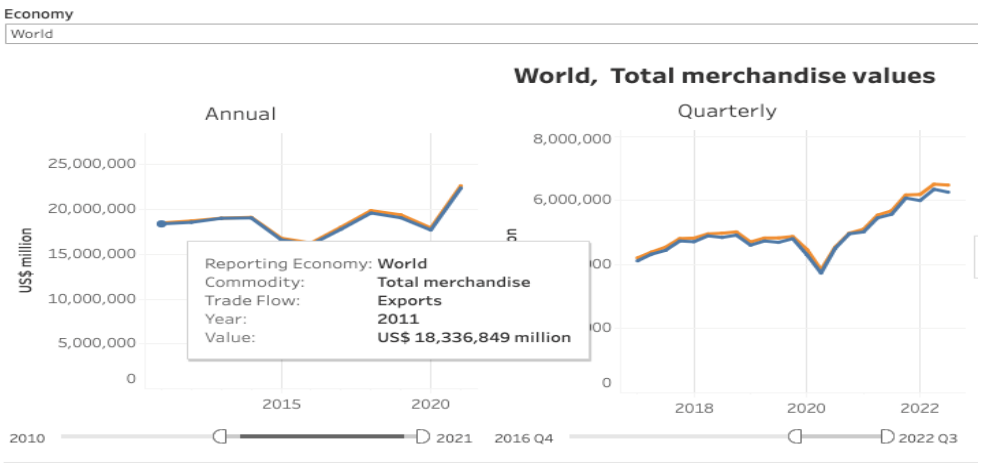
Figures 1.and 2 provided by the World Trade Organization (WTO) show the total value of goods in terms of exports:

Figure 1. *Total merchandise values by World Trade Organizations*



Note. (*Merchandise Trade*, WOT 2022)

Figure 2 . *Total merchandise values by World Trade Organizations*



Note. (*Merchandise Trade*, WOT 2022)

It is inferred that between the years 2011 and 2021, the growth was approximately U.S 4,000,000 million, additionally evidenced in the year 2020 the total value of the goods had a fall due to the present pandemic COVID-19 (*Merchandise Trade*, s/f).

In summary, the transportation and exportation of goods play a crucial role in fostering economic growth and progress in both domestic and international contexts. It is imperative for governmental bodies and businesses to collaborate in addressing the challenges encountered by the transportation industry and overseas markets, while also capitalizing on the potential opportunities that arise. These dimensions of economic development and human welfare should be duly considered.

2.1.2 Freight Maritime Transport & Ports

In contemporary times, shipping has assumed a significant role in the realm of global commerce, facilitating the efficient transfer of substantial volumes of merchandise over the vast expanses of the Earth's seas. (Ferrari, 2018). This form of transport has been used for hundreds of years and has evolved with new technologies and methods.

The shipping sector plays a vital role in global products distribution, owing to its capacity for long-distance transportation at a relatively cheap cost. As a result of this characteristic, the industry has lately seen a shift in its trajectory. (Baldini et al., 2010). The shipping industry is characterized by flexibility in terms of location and terminals (Ascencio et al., 2014a). At present the logistics and handling of the distribution of goods becomes more complex, aspects such as routes, destinations, volumes, supply chain, and shipping agents must be taken into account.

The significance of ports stems from their role as intermediaries between maritime and terrestrial transportation, facilitating the efficient delivery of goods to their intended destinations. However, the port industry encounters significant challenges, particularly in relation to port utilization. It is imperative to maximize the utilization of ports with sufficient capacity, ideally reaching or exceeding 100%, as failure to do so can result in substantial financial losses. (Ślusarczyk, s/f).

There are many ports around the world, but some of the most important ports with the highest volume of cargo, according to UNCTAD information, are:

1. Port of Shanghai, China: It is the world's largest port by volume of cargo and handles a wide variety of goods, from containers to oil and natural gas.

2. Port of Singapore, Singapore: It is the largest port in Southeast Asia and one of the most active ports in the world, with the largest flow of cargo to and from Asia.

3. Port of Rotterdam, Netherlands: It is the largest port in Europe and the main port of entry for goods in Europe, mainly from Asia.

4. Busan Port, South Korea: It is the largest port in South Korea and one of the most important in Asia, with a lot of cargo and an important transport function.

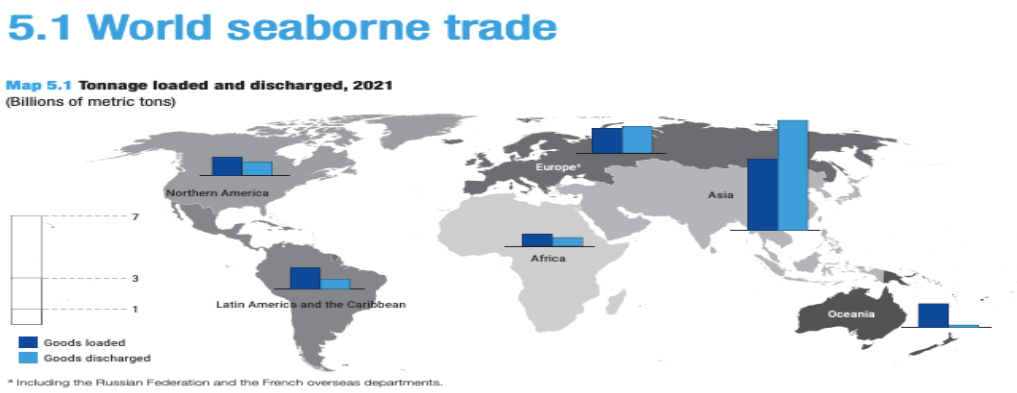
5. Hong Kong Port, China: It is an important commercial port in Asia, with high container traffic and a good location near Chinese markets.

6. Port of Dubai, United Arab Emirates: It is an important port in the Middle East and an important route to Asian and European markets.

7. Port of Los Angeles, United States: It is the largest port in North America and one of the most important ports in the world for trade with Asia.

In the chart below, UNCTAD shows the tons loaded and unloaded in 2021 on the six continents:

Figure 3. *World seaborne trade by OMI*



Note. (“UNCTAD Handbook of Statistics 2022”, 2022)

It is concluded that Asia continues to lead maritime trade; as mentioned above, this continent has strong competitors in terms of port areas and has approximately 118 ports, making Asia the leader (“UNCTAD, 2022). It should be emphasized that Asia is an important region in maritime trade due to its strategic geographical location, its large population, and its important role in the production of manufactured goods and raw materials. Asian countries, such as China, Japan, South Korea, Taiwan, and Singapore, have some of the largest and most active ports in the world, allowing them to handle numerous goods and connect Asia with other global markets (*UNCTAD, 2017*). In addition, many of these ports have a special location concerning major international transport corridors. In recent decades, the Asian economy has experienced significant growth, resulting in increased production and increased demand for raw materials, leading to the growth of maritime trade in the region; In addition, many Asian countries have invested

heavily in port infrastructure to transport goods and increase their competitiveness in the global market.

In conclusion, the proper use of maritime transport in terms of operation and management allows the transport of goods worldwide and the economic growth of regions within them.

2.1.3 The supply chain of maritime freight

Due to globalization, global logistics has presented new challenges in recent years, transport has become a strategic part of the supply chain; it is the intermediate point that connects manufacturers and producers with consumers; for this reason, strategies are an essential part of good execution in this.

Some of the actors of the supply chain of the marine transport of goods can be summarized according to Ascencio (Ascencio et al., 2014b):

1. Suppliers of materials: Suppliers provide the necessary equipment for the production of goods and goods transported by sea.

2. Manufacturers and producers: Manufacturers and producers are responsible for the production of products and goods that are transported by sea. These can be food, chemicals, textiles, and automobiles, among others.

3. Logistics and transport companies: Logistics and transport companies are responsible for managing and coordinating the supply of goods in the shipping industry. These companies are responsible for coordinating transport and storage, as well as customs clearance and necessary travel documents.

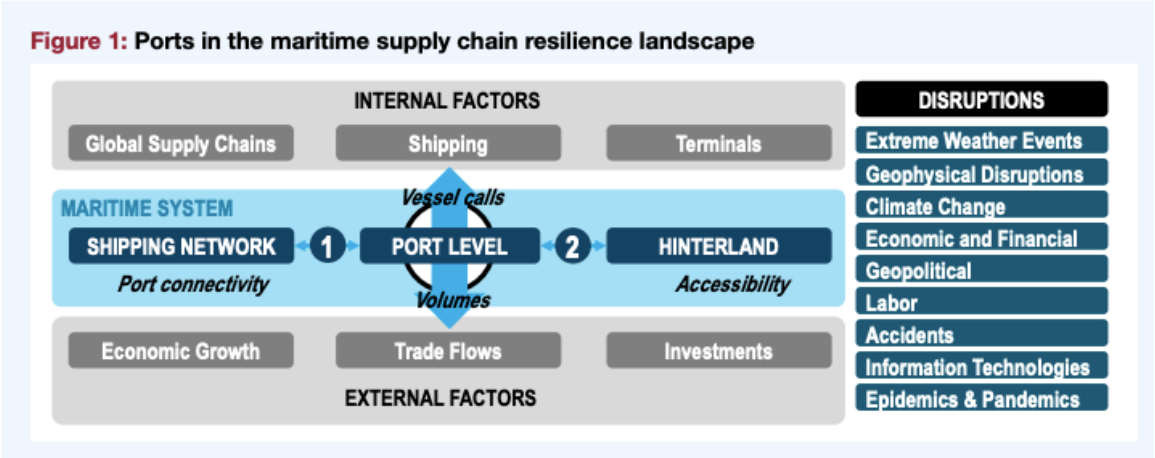
4. Seaports and terminals: Seaports and terminals are points of entry and exit for goods transported by sea. This is where goods are loaded and unloaded, then loaded and unloaded.

5. Shipping companies: Freight companies are transport companies that transport goods and materials from one port to another. These companies own ships and cargo ships that are used to transport goods.

6. Recipients: Recipients are undertakings or natural persons receiving goods at the port. Companies or individuals may be end users or companies that use materials as input to manufacture other products.

Another point of view that is important to analyze again in depth is the importance of seaports; it takes as its reference the graph of the maritime supply chain from UNCTAD:

Figure 4. *Ports in the maritime supply chain by UNCTAD*



Note. (*UNCTAD_TCS_DTL_INF_2022_3 WEB_23 August.pdf*, s/f)

Seaports are critical components in the supply chain; they are areas of ship movement and freight loading and unloading, as well as areas of inspection, contracting and storage, and distribution services (United Nations, 2022).

The importance of ports in the supply chain lies in their ability to connect different modes of transport and provide a critical logistics infrastructure (*UNCTAD, 2022*). Modern terminals are outfitted with sophisticated control and tracking systems that enable chain conveyors to watch and organize cargo movements in real-time, increasing the effectiveness and speed of loading operations while decreasing delays and transit costs.

Lastly, two critical elements of the transportation business are digitization and logistics. The supply chain refers to the movement of products and services from the

beginning stage to consumption, whereas digitization refers to the change of conventional systems and processes into digital ones. (Merk, 2017).

The digitization of the freight shipping industry has led to greater efficiency and cost reduction throughout the shipping process. The digitalization of the shipping industry has led to greater efficiency and reduced costs throughout the shipping process. Advances in digital technology, such as automation and artificial intelligence, have improved the ability to track shipments, allowing better planning and transparency in the supply chain and increasing transport security, reducing the risk of damage and loss.

2.1.4 Impacts of COVID On The Supply Chain Of Maritime Freigth Transport

Based on a study, in 2019, a pandemic, more commonly known as COVID-19, was unleashed. Its beginnings were in China, and this virus was rapidly expanding throughout the world, reaching every corner of each continent, thus bringing a crisis, an economic recession, and a health emergency (Kwon, 2020). As a result, international trade was directly affected, and the economy showed a decline never seen before. A large percentage of industries faced a complete halt to their activities and faced this situation and the challenges it brought with it (Kiani et al., 2022).

The COVID-19 epidemic has exerted a substantial influence on the supply chain pertaining to the transportation of commodities. The closure of factories and a decline in product demand have resulted in disturbances within the supply chain and congestion at

ports. Furthermore, the implementation of travel restrictions and quarantine protocols has had a significant impact on the ship's crew, resulting in disruptions and delays in both the loading and unloading processes. (Mwajita, 2022).

One of the primary consequences resulting from the pandemic has been a reduction in the quantity of ships as a result of less demand. This decline has subsequently led to a fall in shipping expenses and a surge in competition among ship operators. Additionally, a decline in the quantity of port calls occurred as a result of order cancellations and diminished demand.

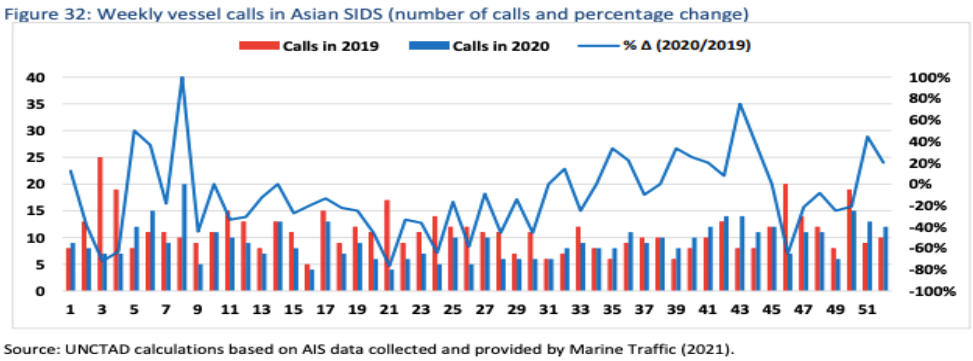
It is important to analyze the impact that COVID-19 had on the supply chain of this industry. We have as a reference the continents of Africa, Asia, and Latin America to evaluate the impact that this virus had and the challenges that it generated during this time, according to UNCTAD:

- Asia: As mentioned above, it is one of the leaders in the maritime industry because of the number of ports it contains. It is also important to highlight that it is one of the continents that most contribute to economic development in terms of trade. The supply chain of this industry in Asia was affected in various ways: in the first instance, there was a decrease in demand, which affected the amount of cargo moving through the ports, generating inconveniences concerning the profitability capacity; as for the closure of ports, the carriers faced difficulties since some of them closed temporarily, preventing the delivery of their loads; transport delays: due to the availability of scarce labor, this resulted in a delay in the timely delivery of cargo and, finally, increased costs, as additional security measures had to be implemented; and finally, problems with the availability of containers

because factory operations were interrupted, which led to an increase in the cost of container transport; and a shortage in Asian ports (UNCTAD/ 2021).

In the graph that is shown below, UNCTAD shows the percentage variation of ship calls that were presented during the years 2019 and 2020; it is concluded that a significant negative impact, in 2020 had a large percentage decrease compared to the call of Ships, generating economic losses.

Figure 5. *Weekly vessel call in Asian SIDS by UNCTAD*



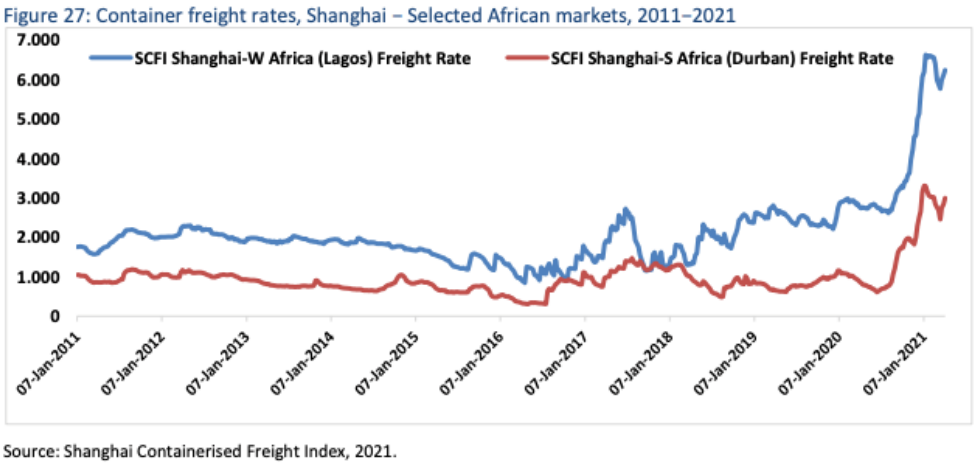
Note. (*COVID-19 and Maritime Transport: Navigating the Crisis and Lessons Learned*, s/f)

- Africa: The region in question also saw the impact of reduced demand, resulting in a decline in ship calls throughout the year 2020. This had a direct effect on shipping lines and routes. One salient aspect deserving attention is the significant effect experienced by the industrial sector in Africa as a result of the escalated expenses associated with marine freight. The process of importing raw materials has presented

difficulties due to the associated expenses and delays in arrival. Additionally, the utilization of container classes has further contributed to the rise in costs. (*UNCTAD 2022*).

In the graph presented below by UNCTAD, it can be analyzed that during the years 2011 and 2019, the variation of tariffs does not present a very noticeable increase; During the year 2020 it can be evidenced that it initiates an increase in freight rates, leaving it almost 4000 times higher, it is concluded that this occurred concerning the recession that occurred, the shortage of transport and containers mainly.

Figure 6 . *Container freight rates, Shangai by UNCTAD*



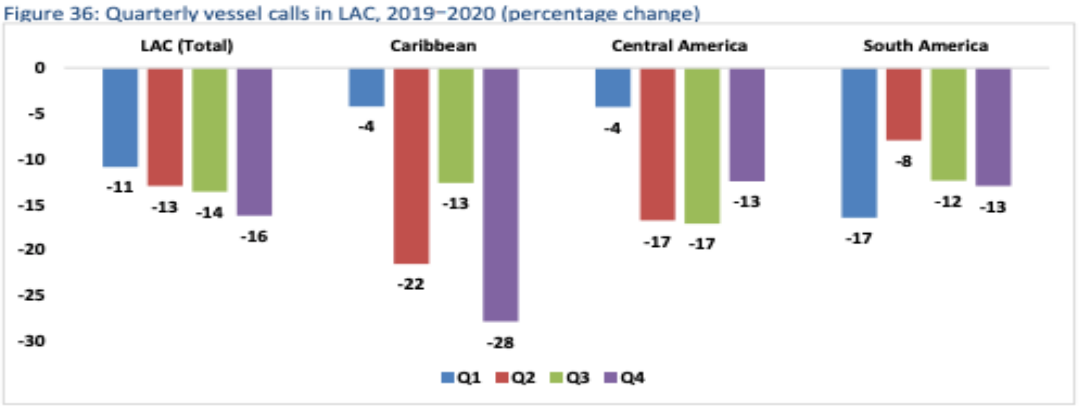
Note. ("UNCTAD Handbook of Statistics 2022", 2022)

- Latin America and the Caribbean: given the closure of borders, this continent presented an economic crisis with a great impact. Latin American countries were

affected in their imports and exports with a decrease of -33 and -21 percent, according to UNCTAD reports (*UNCTAD/2021*).

The decrease in imports and exports which was affected by COVID-19 also affected part of the processing, more precisely the vessels, and the Containers; in the graph presented below by UNCTAD, can detail how the regions were impacted by COVID-19 and its effects; the most affected region was the Caribbean area with a –28 percent in 2020 (UNCTAD/2022).

Figure 7. *Quarterly vessel calls in LAC by UNCTAD*



Note. (“UNCTAD Handbook of Statistics 2022”, 2022)

In short, the pandemic of COVID-19 had several repercussions on the supply chain of the shipping industry of goods. The greatest repercussion that was seen in this industry

was the shortage of containers and transport, which meant that the goods and products could not be delivered on time as there were no available means of transport to move around. As well, labor shortages generated major impacts on the manufacturing, production, and operation of goods, thus directly affecting international trade. Digitization is a key factor that the supply chain must implement because these new technologies can improve the efficiency, transparency, and security of the entire supply chain, thus allowing positive results to be seen in the reduction of time and costs in terms of information processes. Management systems that are based on digitization will also make the different parties acting in the supply chain more visible (Mwajita, 2022).

2.1.5 Industry 4.0, technologies & digitalization

To begin with, in the 18th century, the industrial revolution in England was born (*Deirdre McCloskey*, 2008). This event was characterized by a transformation in the production and manufacturing of goods and services of companies, this was aimed at the transformation of production to generate more efficient products and services, faster, with lower costs and higher quality (Ghobakhloo, 2020). In the First Industrial Revolution, the steam engine and the mechanization of production were introduced, thus improving manufacturing processes (Freeman et al., 2001). The industrial revolution brought about social and economic change.

At the end of the 19th century and the beginning of the 20th century, the second industrial revolution took place, this event brought with it a great technological advance in terms of production, introducing the first technologies such as electricity, the assembly line,

allowing a great advance in production, additionally characterized by generating a great impact on transport and communications (Steenhuis & Pretorius, 2017). In this era of the second industrial revolution, it is noted that it had a positive impact on the production of goods and services, until today the way to communicate and transport, all thanks to technological evolution (Groumpos, 2021).

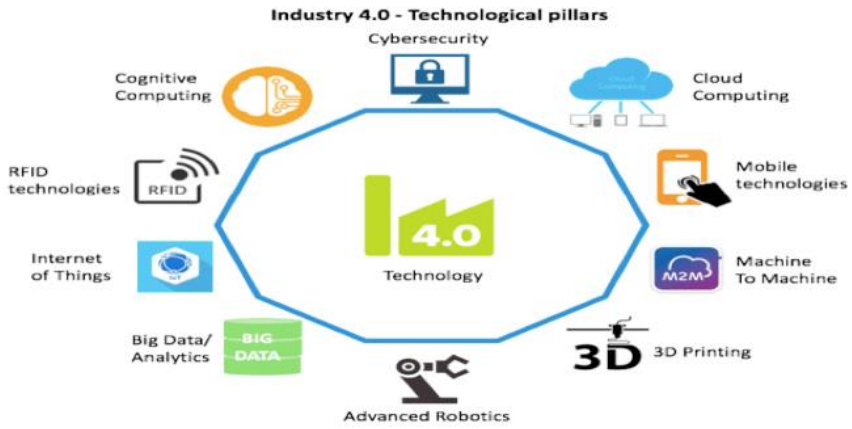
The third industrial revolution emerged around the 1960s and persisted into the 2000s. This transformative period marked the onset of a digital revolution characterized by advancements in computers, telecommunications, automation in manufacturing, and the integration of electronics and information and communication technologies (ICT)(Fitzsimmons, 1994). During this period, electronic devices such as phones, televisions, radios, and DVDs, among others, had a boom, as their production and consumption were massive, thus captivating people and turning this into a social and economic impact (Clark & Cooke, 2010). The third industrial revolution transformed the global economy, society presented challenges and new forms of communication and working models, it is claimed that this revolution gave the first foundations to the fourth industrial revolution or known worldwide as "Industry 4.0".

In 2011 in Germany, the so famous "Industry 4.0" emerged (Klingenberg et al., 2022). As mentioned above, the third industrial revolution had a significant impact on the development and evolution of the fourth industrial revolution, these two revolutions have a connection through digitization and information technology; both had an impact on improving the efficiency and productivity of industries through new technologies and their automation, were driven by innovation (Marwala, 2023). This new era of digitization

allowed, through technological tools such as the Internet of Things, artificial intelligence, big data, and robotics, among other new technologies, companies had an integrated intelligent production and manufacturing system, thus causing production errors to be minimal by automating processes, they could also produce more detailed data analysis and in a shorter time (Groumpos, 2021).

The following is an image, showing exactly the pillars of technology in industry 4.0 according to Peter P. Groumpos:

Figure 8. *The technological pillars of Industry 4.0*



Note. (Groumpos, 2021)

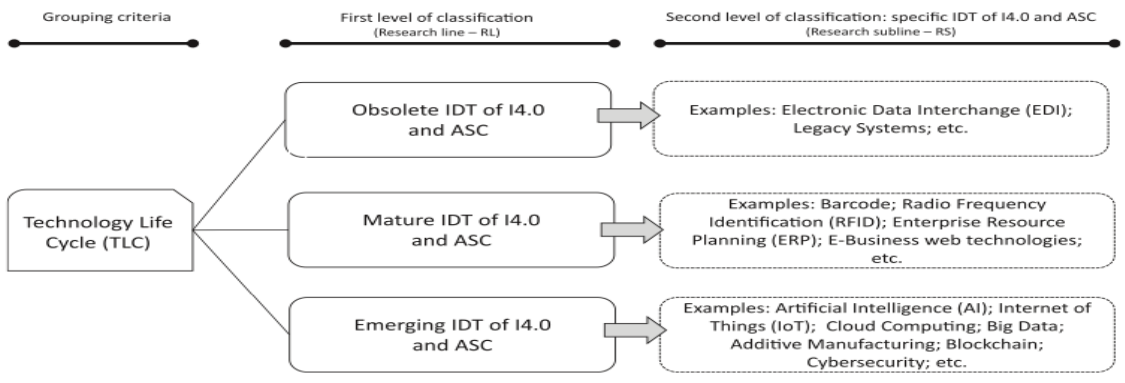
It is important to assert that in contemporary times, technology has evolved into an indispensable requirement for both industries and people. It is noteworthy to mention that the emergence of technological tools, which are now readily available for use, has facilitated scientific and technological advancements. These advancements have led to

enhanced efficiency and productivity through the utilization of data analysis and process automation. Consequently, this has had a positive influence on economic growth, as the implementation of industry 4.0 has enabled industries to transform into intelligent and resilient entities. (Schiele et al., 2021). Thanks to digitization and technology, humanity will be able to face challenges more innovatively and intelligently.

As previously mentioned, the advent of industrial revolutions has introduced novel digitization tools that hold significance in the management and coordination of the worldwide supply chain. Consequently, it becomes crucial to comprehend and evaluate the foremost innovative and emerging technologies that contribute to the enhancement of industrial processes and foster economic development.

Below is a graph where you can see the life cycle of the technology and its evolution, this analysis will focus on the emerging technologies of industry 4.0:

Figure 9. *Ciclo de vida de la tecnología*



Note. (Oliveira-Dias et al., 2022)

The following new technologies are presented in greater depth, to understand the existence and impact of these in different fields and areas:

- Artificial intelligence (AI): the origins of artificial intelligence were given in the mid-1950s, AI aimed to be able to explore and create machines capable of performing tasks that previously could only be performed by humans; a concise example of the objective of the AI, was when one of the founders of the field of artificial intelligence, Herver Simon, predicted that the computer would be able to be the winner of a chess game, 40 years later this became reality, technological advances reached such a point that today that is a basic example of what a machine can be (Ein-Dor, 2023). Artificial intelligence can continue to be defined as an emerging technology, even if it has emerged more than 50 years ago, this technological innovation will continue to be reinvented due to the availability of databases and information that allow the continuous development and evolution of the IA.

"Artificial intelligence simulates human intelligence by creating intelligent systems" (Ein-Dor, 2023). Informatics continues to develop and this drives learning techniques to continue advancing, today artificial intelligence uses applications such as medicine, safety, and transport thus allowing to manage operations more efficiently (Leszkiewicz et al., 2022).

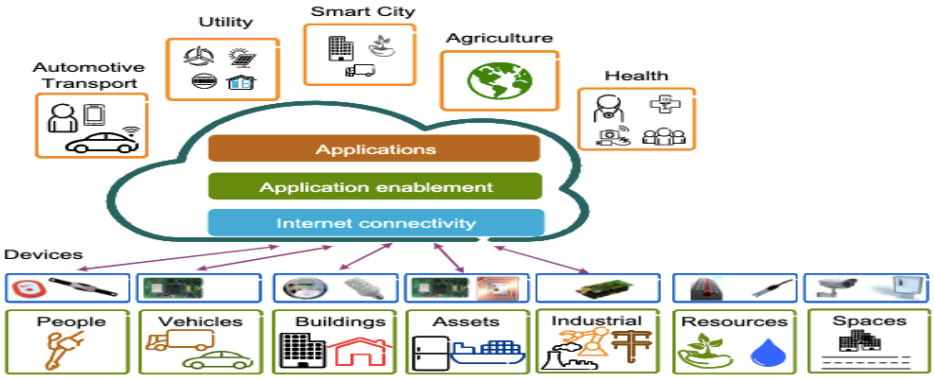
- Internet of Things (IoT): The origin of this innovative technology was born in the 1980s, through the development of the first technologies of identification by radio frequency (RFID) (Gacovski, 2019). With the

development of mobile phones initially only used to communicate via wireless networks, over the years in the 21st century the Internet of Things begins to develop and evolve in a strong and fast way, for in this decade various technologies such as artificial intelligence, sensors among others.

The application of the Internet of Things has and will continue to positively impact improved learning and also the perspective of the users' business, in addition to the logistics, retail, supply chain management, product life cycle, and the goods transport industry.(Gacovski, 2019). In conclusion, the Internet of Things (IoT) is undergoing constant evolution as a result of the emergence of novel applications and technologies that necessitate engagement with this domain. It is noteworthy to emphasize that this technology, along with others, has had a beneficial influence on our work, lifestyle, and communication practices. (Jan Holler et al., 2014)

The impact of IoT can then be seen through its development and evolution:

Figure 10 *IoT*



Note. (Jan Holler et al., 2014)

In summary, the Internet of Things (IoT) is undergoing continuous development as a result of the emergence of novel applications and technologies that necessitate engagement with this domain. It is noteworthy to emphasize that this technology, along with others, has had a beneficial influence on our professional, personal, and communicative spheres.

- Big Data: The history of this technology was born in the 1970s, which is also part of industry 4.0. This term began with the function of describing and referring to the large amounts of data that companies had and could not handle and process at the time, because there were no technological tools that facilitated this procedure (Grander et al., 2021). As the decades passed, digitization and globalization spread exponentially and this was one of the reasons that forced man to emerge with new ideas (Capurro et al., 2021). During the 1990s, some databases emerged to kick-start this technology boom; in the 2000s, one of the most important and impactful technology tools emerged, Web 2.0 and storage clouds, which brought with it the ability to store unimaginable amounts of data and able to process these as well, thus allowing cloud data to be handled more effectively (Bormida, 2021).

It is important to know and analyze the five pillars that Big Data has and how its structure and functioning according to Bormida (2021):

1. Volume: This feature refers to the data that can be generated and how it is collected from different sources.

2. Variety: The data that are collected come from different sources and formats, this means that they are heterogeneous and diverse data, among them can be understood in both texts and audio and video and images.

3. Velocity: Another key feature of Big Data that has great relevance is the speed at which data can be processed and managed, Nowadays, companies handle a huge volume of data and for this reason, it is necessary a good capacity concerning speed.

4. Veracity: During the data collection, it is necessary to be completely free of errors so that the result is completely reliable and generates a quality analysis.

5. Value: Finally, and one of the most important, the purpose of Big Data, is by collecting data to be able to make strong and effective decisions based on the analysis of these and thus improve the performance of companies and generate competitive advantages.

In short, Big Data has taken on great strength and today is one of the great allies of business and large industries: over the years and the same industries have realized that the amount of data that is usually handled daily is increasingly exorbitant and this forces to implement technological tools that allow the storage and processing of data in a way efficient, excellent and free of errors. This technology is also already working in various fields, such as medicine, the financial sector, and the logistics sector among others (Bouwman et al., 2018).

- Blockchain: This technology can be considered to be relatively new; it could be defined that its origins were during 2008 along with the boom of cryptocurrencies. The term 'Blockchain' comes to light thanks to the creation of the Bitcoin system, this technology allowed decentralized and transparent transactions, thus attracting the public with the reliability provided by this technological tool. Blockchain brings with it infinite benefits for different industries and fields; one of them and in which more can be emphasized is in the area of the supply chain, why it has had an important impact on all logistics processes, from the start of storage to the delivery of your consumers and the entire transaction process (Tijan et al., 2019).

Blockchain is described as a digital ledger that allows during operations everything to be in total transparency, irreversible, and comprehensive as well as real-time and decentralized (Seebacher & Schüritz, 2017). This technology has found applications across several sectors, demonstrating particular efficacy in areas such as supply chain management, intellectual property protection, and electronic voting, among other domains. The technical instrument in question offers both transparency and security. The storage infrastructure is interconnected through nodes on both ends, ensuring a high level of reliability and dependability for the system. (Francisco & Swanson, 2018).

In a nutshell the blockchain, as a cutting-edge technology, has emerged and is poised to revolutionize various industries by facilitating secure and efficient verification

and transfer of digital data and transactions. By eliminating intermediaries and reducing errors, the blockchain offers comprehensive efficiency throughout the entire process.

- Machine Learning: history of this innovative technology was born in the twentieth century, with the idea that a machine could learn to perform processes and improve its performance through knowledge and experiences, this technology has represented a major change and advance in computer science and data systems (Mahesh, 2019).

Thanks to the technological progress that has been developed in recent times, the use and understanding of data are increasingly important as one of the purposes of Machine Learning is by collecting data to be able to analyze and learn from these (Mahesh, 2019).

Machine learning has three fundamental pillars for its learning process, namely supervised learning, unsupervised learning, and reinforcement learning. These pillars are categorized based on the nature of the data and its interaction inside the learning framework. The present algorithm possesses the capability to facilitate the acquisition of knowledge by means of interactive engagement and provision of feedback.(Zhou, 2021).

New technologies have seen significant advancements and are expected to continue evolving. These technical tools are now being utilized across several sectors, leading to enhanced performance in certain activities. Undoubtedly, these advancements have had a transformative impact on globalization through the process of digitization.

2.1.6 Post COVID-19: technologies & digitalization applied on the supply chain of maritime transport .

During COVID-19, there were several logistical and operational challenges described above; this crisis has led the maritime transport industry to adopt and implement digitization and innovative technologies to mitigate the effects of this pandemic and ensure efficient use of operations, continuity, and quality of the supply chain.

The maritime transport industry and supply chain are fully interconnected and are a fundamental part of the economy, all because of international trade. This industry is recognized by the number of stakeholders involved in it, ranging from shipping companies, such as operators, seaports, and consumer companies, among other entities, involved (Jović et al., 2019).

The maritime sector requires the use of novel technologies in order to enhance operational efficiency, owing to the fast proliferation of digitalization. The aforementioned technologies, namely artificial intelligence, Big Data, Blockchain, the Internet of Things (IoT), and Machine Learning, have been found to have a significant and beneficial influence on this particular industry (Wang, 2010). The freight shipping sector is poised to make investments in technology that will lead to cost reduction in the future. This is mostly due to the anticipated enhancement of operational efficiency. Additionally, a significant contributing aspect is the ongoing development of the supply chain in terms of quality. (Li et al., 2022).

As previously stated, the virus has resulted in adverse consequences like reduced demand, container shortages, port closures owing to border closure rules, as well as significant aspects such as mishandling of data and inefficiency. The implementation of novel technology has the potential to alleviate the adverse consequences of the pandemic on the supply chain. According to Jović, the marine transport business encompasses several categories of data, including but not limited to traffic data, cargo data, weather data, and equipment data. (Jović et al., 2019).

Referring to artificial intelligence, this innovative technology can analyze large amounts of data (Sanchez-Gonzalez et al., 2019). Once again, it is said that this particular industry possesses a substantial amount of data categorization and necessitates the utilization of a tool capable of optimizing routes and maritime traffic. The concept of artificial inter-licensing entails the utilization of advanced technologies to effectively manage shipment data, accurately forecast demand for goods, and then optimize the shipping process to meet specific requirements while minimizing freight costs (Smith, 2020). The ability to effectively manage the supply chain in accordance with established routes is of significant importance. An further notable aspect to consider is that artificial intelligence has the potential to streamline many operations within the supply chain, such as the planning of ship loading and unloading activities. This automation may help prevent excessive workforce reductions while enhancing the overall efficiency of management optimization. (Jurdana et al., 2020).

The Blockchain, a technology associated with Industry 4.0, holds significant significance and value. It serves as a beneficial tool for mitigating the adverse impacts that

the COVID-19 pandemic has had on the marine industry's transportation of products. Transparency and traceability, together with process automation, constitute key attributes of Blockchain technology. Smart contracts that utilize blockchain technology serve as a prominent illustration (C.-S. Yang, 2019). The implementation of automation facilitates the streamlining of operations, resulting in reduced runtime and minimized human interaction. Additionally, it encourages the attainment of 100% dependability in documentation (Kiani et al., 2022). Conversely, with regards to cost reduction, the implementation of Blockchain technology can serve as a strategic investment that enhances the efficacy of the supply chain. By eliminating intermediaries, this technology streamlines payment and shipping procedures, fostering transparency and traceability for customers, and facilitating improved coordination within the supply chain. (Munim et al., 2020).

To give a little more context, the case of the shipping company Maersk is presented, which is a company from Denmark, responsible for shipping containers by sea (Jonathan Saul, 2017). This company has decided to make an investment in Blockchain technology and the Internet of Things (IoT), intending to improve operational processes in terms of security and transparency of data towards its customers as well as reduce costs.

The final panel discussion touched at the role of blockchain technology within the maritime sector. This technological advancement enables enhanced container tracking capabilities, ensuring timeliness and precision (Tan & Sundarakani, 2020). It also automates the shipment and payment processes, thereby optimizing supply chain operations. Furthermore, it offers a customer-centric advantage by providing convenient and accessible tracking of goods, resulting in timely and cost-effective data retrieval(Peter,

2005). The supply chain of this business is significantly influenced by big data and the Internet of Things. The combination of these technologies may effectively aid in the monitoring of port and marine terminal capacities. Through data analysis, it becomes possible to mitigate container delays and devise tactics that enhance precision during the distribution of shipments (Sarkar et al., 2022).

The utilization of big data and the Internet of Things (IoT) holds significant significance within the supply chain of this particular industry. These technologies, when employed in conjunction, have the potential to greatly facilitate the monitoring of port and maritime terminal capacities. By leveraging data analysis, these technologies enable the prevention of container delays and the implementation of more precise distribution strategies for shipments (esarley, 2018).

During the pandemic there was no early detection of product supplies and supply, this also meant that there was poor inventory management. As for Machine Learning, through this technology, it is possible to analyze demand patterns to detect the origin of the problem and how to turn it into a solution before going back to live a crisis. Machine Learning can detect when there is a drop in demand for products and thus take appropriate measures to avoid shortages (Akyuz et al., 2019). This new technology can play a major role in the two important processes of the freight transportation supply chain, which are related to the part of the shipment and the part of the ports, can make projections of routes and routes allowing a greater understanding of (Yan et al., 2021).

The utilization of big data and the Internet of Things (IoT) has significant significance inside the supply chain of this particular business. These technologies, when used in conjunction, have the potential to enhance the monitoring of port and maritime terminal capacities (Wiafe et al., 2020). By analyzing data, they may help prevent delays in container handling and enable the implementation of more precise plans for cargo allocation (Kiani et al., 2022). The integration of big data and the Internet of Things (IoT) holds significant significance within the supply chain of this industry. These technologies work in tandem to facilitate the monitoring of port and maritime terminal capacities. By analyzing data, they enable the prevention of container delays and the implementation of precise distribution strategies for shipments. (D. Yang et al., 2019).

To conclude, it is valid to affirm that the freight maritime transport industry works constantly with data, extensive operations, and equally wide information, to the application of previously seen technologies, it can be affirmed that if they have validity to be able to mitigate the effects that left the COVID-19, in terms of projection of the demand, delays in the shipments by port arrest or stagnation. Each of these technologies has its role and would play a very important role in improving efficiency, traceability, and process automation during the supply chain of shipping, it is also important to highlight that they are technologies that allow more precision in terms of data analysis, route paths, goods counting, payment documents and shipments with customers, economic development through international trade through logistics and transport.

3.Methodology

3.1 Introduction

The purpose of this research is to analyze the implications of the COVID-19 effects on the supply chain of the maritime goods industry, with a focus on the company CMA CGM (a maritime transportation company). The central objective is to analyze the type of impact it has had on various areas of the supply chain, the strategies that have been implemented, from the year 2019 to the present. Additionally, the aim is to explore how the implementation of technologies and digitalization have contributed to reducing the adverse effects generated by the health crisis, thereby enhancing the efficiency and resilience of the supply chain.

3.2 Research Question

The purpose of this document is to investigate and analyze the research question *The impact of COVID-19 on the supply chain of maritime freight transportation and the implementation of innovative technologies to mitigate its effects* and understand how new technologies will enable the maritime industry to solve challenges in the future.

3.3 Research Design

The incorporation of mixed methods methodologies is imperative in order to attain a comprehensive, reliable, and situational comprehension of the repercussions of COVID-19 on the supply chain of maritime transportation, along with the use of cutting-edge technology to alleviate its consequences. The subject matter has acquired substantial

international significance due to the emergence of COVID-19, which has presented unparalleled obstacles to several sectors, hence requiring the formulation of novel approaches. The maritime transportation market for commodities is of significant significance for both nations and the global economy, since it plays a crucial role in facilitating international trade. The aforementioned system plays a crucial role in easing the transportation of imports and exports across seas, hence fostering economic expansion and enhancing the availability of key resources and commodities across nations.

Over the course of time, the progression and enhancements in shipping have encouraged corporations to embrace modern technologies that facilitate enhanced efficiency and efficacy in logistical operations. Hence, the primary objective of this study was to investigate the effects of the COVID-19 pandemic on the freight maritime industry, with a specific emphasis on CMA CGM, a prominent player within this industry. In order to accomplish this objective, a combination of specialist knowledge, case studies, literature research, audiovisual resources, and interviews were employed. The objective of employing these several methodologies was to offer a comprehensive and important examination that facilitated the comparison of outcomes and the formulation of inferences on the impact of COVID-19 on this particular sector.

This investigation was based on descriptive research, which was reinforced by the use of both qualitative and quantitative analyses. Methodological triangulation was employed to enhance the strength and reliability of the findings. Furthermore, the investigation employed a logical reasoning methodology, employing an inductive framework to draw conclusions and conduct analyses grounded in the observations and evidence gathered.

3.4 Research Approach

The research was carried out from September 2022 to August 2023. However, it is important to acknowledge that this research may possess significant limits attributable to the fact that CMA CGM is the exclusive organization providing comprehensive and precise data.

The study was organized into distinct phases in order to effectively analyze both quantitative and qualitative data. These phases began with the collecting of data, identification of sources, and implementation of methodological methods.

During the preliminary phase, data was collected from a variety of sources, such as scholarly literature, case studies, and interviews. The preliminary phases facilitated the examination and comprehension of fundamental principles pertaining to the supply chain within the commodities sector, alongside the contemporary ramifications of the COVID-19 pandemic. This established the essential foundation for carrying out the study.

During the following phase, the analysis predominantly relied on secondary sources, specifically UNCTAD and WTO, to examine statistical data pertaining to port zones and the repercussions of the COVID-19 pandemic on the goods container sector. Additional sources were utilized to examine a wide range of effects and arrive at robustly substantiated results.

During the third part of the study, a total of four interviews were carried out with persons who are employed directly at CMA CGM and its subsidiaries. These interviewees had accumulated over 10 years of experience working inside the organization. The conducted interviews yielded comprehensive and accurate information pertaining to the effects of the COVID-19 pandemic on the organization, with an examination of the company's historical and contemporary technical advancements. The conducted interviews enabled a thorough examination of the influence and the methods employed to minimize its consequences, providing many viewpoints and firsthand accounts.

The fourth step encompassed the execution of 60 interviews with professionals that possess expertise in the respective topic of inquiry. The impact of the COVID-19 pandemic on the supply chains of the maritime freight industry was assessed by a panel of experts. Additionally, the experts examined the importance of digitalization in reducing the adverse consequences of this impact. To gather a varied variety of viewpoints, a Microsoft questionnaire was utilized and disseminated to corporate workers by email.

The fifth and ultimate phase encompassed a combination of quantitative and qualitative research endeavors with the purpose of substantiating the previously posited hypotheses and ideas. The objective of this phase was to conduct an analysis of organized and precise data in order to augment the credibility of the research. It is essential to underscore that this study is rooted on subjective encounters and has been derived from these encounters as a foundational basis.

3.5 The Population of Study

During the third part of the study, a series of four interviews were carried out with individuals who had expertise in the relevant topic of inquiry. These individuals possess current understanding of the market, have firsthand experience with the impacts of COVID-19, and have actively monitored the advancements in CMA CGM up to the present day.

Figure 11. *Table Position/Role of interviews*

ID Company	Company	Position/Role
1	CMA CGM	VP Commercial E&W Lines
2	CMA CGM	Business Process Expert
3	CMA CGM	Cargoflow Manager
4	CEVA LOGISTICS	International Logistics Manager

Note. Personal own

In the fourth phase of the research, a sample of 60 employees who are now engaged in the supply chain and logistics departments of the firms CMA CGM and its subsidiary CEVA LOGISTICS and BOLLORE was analyzed. The selection of this particular group was predicated upon their extensive tenure within the supply chain domain and the maritime freight sector. The subsequent section will provide a more comprehensive overview of the 60 participants, encompassing their present departmental affiliations and the specific roles they have within their various organizations.

Figure 12. Table Position/Role of respondents

ID Company	Company	Position/Role
1	CMA CGM	Key Account Officer
2	CMA CGM	Cargoflow
3	CMA CGM	IT Assistant in datascience
4	CMA CGM	IT Purchaser
5	CMA CGM	Cargo Flow Officer
6	CMA CGM	Treasury Officer
7	CMA CGM	Tender Officer - Strategic Accounts
8	CMA CGM	Cargo flow officer
9	CMA CGM	VIP/Special Desk sales officer
10	CMA CGM	Cargo Flow Officer
11	CMA CGM	Intern at Bunkering and Energy Transition Department
12	CMA CGM	Area Manager
13	CMA CGM	Cargo Flow Officer
14	CMA CGM	Cargo Flow Officer
15	CMA CGM	Data analyst
16	CMA CGM	Business Control officer
17	CMA CGM	Cargo Flow Officer
18	CMA CGM	Business developer
19	CMA CGM	Cybersecurity engineer in workstudy contract
20	CMA CGM	Marketing Officer
21	CMA CGM	Cargoflow officer
22	CMA CGM	Cargo Flow Officer
23	CMA CGM	Cargoflow
24	CMA CGM	Area manager
25	CMA CGM	Pricing and procurement manager
26	CMA CGM	Supply Chain Transit
27	CMA CGM	Trade manager
28	CMA CGM	R&D Inland Logistic Manager

29	CMA CGM	Line manager
30	CMA CGM	Cargoflow manager
31	CMA CGM	Agent de tránsit
32	CMA CGM	Operations manager
33	CMA CGM	Business process expert
34	CMA CGM	Business process manager
35	CMA CGM	Business process expert
36	CMA CGM	Commercial manager
37	CMA CGM	Global Business Manager
38	CMA CGM	Cargoflow officer
39	CMA CGM	Ops manager
40	CMA CGM	Ops department
41	CMA CGM	Business process expert
42	CMA CGM	Commercial Line Manager
43	CMA CGM	Area Manager
44	CMA CGM	Cargoflor supervisor
45	CMA CGM	Cargo flow Supervisor
46	CMA CGM	Cargoflow Supervisor
47	CMA CGM	Operational department
48	CMA CGM	Excellence Business Process
49	CMA CGM	Commercial Line manager
50	CMA CGM	Trade Manager
51	CMA CGM	Logistics Officer
52	CMA CGM	Logistics officer
53	CEVA LOGISTICS	Global Business Expert
54	CEVA LOGISTICS	Global Business Expert
55	CEVA LOGISTICS	Global Business Expert

56	CEVA LOGISTICS	Supply Chain Transit
57	CEVA LOGISTICS	Logistics Assistant
58	CEVA LOGISTICS	Procurement Officer
59	BOLLORE	IT Assistant in datascience
60	BOLLORE	IT Assistant in datascience

Note. Personal own

3.6 Sampling & Sample Size

This research effort focuses on a vital feature within the maritime freight company, namely the sampling and sample size, in order to get a deeper knowledge and improve the complex dynamics of the supply chain. Additionally, it examines the integration of digitalization processes in this context. The present introductory chapter explores the analytical approach utilized to get a complete and insightful understanding of the interface between human experience and digital technology within this particular setting.

In order to facilitate the progress of this investigation, a methodology involving the utilization of interviews and surveys has been implemented. These research techniques have been employed to gather data from two distinct cohorts that hold significant relevance within the field. The first cohort consists of four esteemed experts who possess extensive knowledge and expertise in the maritime freight industry and supply chain. Their participation in the study has contributed to the acquisition of profound and specialized insights. The second cohort comprises a total of 60 leaders and professionals who are actively involved in the study area and engaged in digitization processes within the

aforementioned industry. The survey administered to this cohort has facilitated the collection of valuable information. These individuals are notable for their extensive expertise and significant contributions in the development and administration of digital solutions that enhance efficiency and foster innovation within the maritime supply chain.

The selection of this sample methodology is primarily intended to encompass a diverse array of viewpoints and methodologies, encompassing both scholarly voices that provide comprehensive theoretical insights and practical voices that directly apply and encounter digital technology in their daily operational activities. This hybrid methodology aims to enhance the comprehensive comprehension of the effects of COVID-19 on the maritime freight supply chain and the transformative and optimizing influence of digitization on the maritime freight supply chain. Additionally, it allows for the examination of potential disparities and convergences between theoretical frameworks and practical implementations.

The subsequent chapters will provide an in-depth examination of sample methodologies, participant selection tactics, and the execution of interviews and surveys. The objective of employing these approaches is to offer a thorough and equitable study that enhances the holistic comprehension of the interplay between human and digital components within the marine freight supply chain.

3.7 Data Collection

The analyzed data were collected in the following manner:

3.7.1 Primary data

The primary data for this study were obtained via administering a questionnaire consisting of five open-ended questions for interviews, as well as a structured online questionnaire. These instruments were particularly tailored to gather insights and firsthand experiences from professionals who had expertise in the domain of supply chain and logistics technologies. A series of interviews were carried out with a cohort of four participants, while a questionnaire was delivered to a specific sample of 60 experts who had extensive expertise in the maritime freight industry as well as logistics. The questionnaire was stored on the Microsoft Forms platform. The survey consisted of a combination of open-ended and closed-ended questions, allowing for the exploration of ideas and opinions as well as the collection of quantitative and measurable data.

The current research employs a comprehensive and varied methodological framework to examine the challenges and changes that have arisen in the maritime supply chain as a result of the pandemic. Additionally, it seeks to investigate the ways in which innovative technologies are being implemented and modified to effectively tackle these challenges. The aim is to integrate the qualitative depth of open-ended replies with the quantitative impartiality of closed-ended responses in order to construct a holistic narrative that makes a substantial contribution to the comprehension of the crucial junction between the global crisis and technological progress.

Questionnaire Interview:

1. What has been the main challenge CMA CGM has faced in its maritime freight supply chain due to COVID-19, and how has this affected the company's operations and services?
2. The COVID-19 pandemic has highlighted the importance of resilience in the supply chain. What measures has CMA CGM implemented to improve resilience and responsiveness to disruptions caused by the pandemic?
3. Collaboration and coordination among supply chain actors are critical in times of crisis. How has CMA CGM worked with its customers, suppliers and partners to jointly address the challenges of COVID-19 and maintain an efficient flow of goods?
4. Digitization and the implementation of innovative technologies are key to meeting the challenges of COVID-19. What types of digital technologies have been implemented at CMA CGM to improve visibility and monitoring of the maritime supply chain during COVID-19? How have these technologies helped mitigate disruptions and delays?
5. For you, what role has digitalization played in the maritime supply chain during the pandemic at CMA CGM?

Questionnaire:

1. Select the company you are currently working for: *

CMA CGM

CEVA Logistics

Other

2. Indicate your position/role in the company: *
3. Do you believe that COVID-19 has negatively or positively impacted theefficiency of the maritime freight transportation supply chain? *

- ○ Yes, it has had a negative impact.
- ○ Yes, it has had a positive impact.
- ○ No, it has not had a significant impact.
- ○ Do not know.

4. Which types of significant changes have you been able to observe infreight shipping routes since the beginning of the COVID-19 pandemic? (Select all that apply) *

- ☐ Increased transit times.
- ☐ Reduced carrying capacity.
- ☐ Increased use of technology and digitization.
- ☐ Changes in trade routes.
- ☐ Increased transportation costs.
- ☐ Increased use of logistics services.
- ☐ Changes in

freight priorities.

- ☐ Increased customs and sanitary regulations.

5. How long do you estimate that maritime freight transportation has been affected by COVID-19? *

- ○ Less than 6 months.
- ○ Between 6 months and 1 year.
- ○ Between 1 and 2 years.
- ○ More than 2 years.

6. Indicate the type of impact that COVID-19 had on the routes formaritime freight transportation: *

	Positiveimpact	Medium impact	Low impact	Negative impact	No impact
Transpacific routes (Asia -North America)	○	○	○	○	○
Transatlanticroutes (Europe - North America)	○	○	○	○	○
Intra-Europeanroutes	○	○	○	○	○
Intercontinental routes (outside of	○	○	○	○	○

Asia, North

America, andEurope)

7. Have you experienced a significant increase in the costs of maritimefreight transportation due to COVID-19? *

- ○ Yes, costs have increased significantly.
- ○ Yes, costs have increased moderately.
- ○ No, costs have remained stable.
- ○ Do not know.

8. Select the impact of COVID-19 for the following stages of the maritimefreight transportation supply chain *

	Low	Medium	High
Production and manufacturing	○	○	○
Logistics andstorage	○	○	○
Marketing and sales	○	○	○
Transportation and distribution	○	○	○

9. Do you believe that the implementation of innovative technologies canhelp mitigate the effects of COVID-19 on maritime freight transportation? *

- ○ Yes, definitely.
- ○ Maybe.
- ○ No, I don't think technologies are effective in mitigating the effects.
- ○ Do not know.

10. Which technologies do you consider to be most useful in mitigating the effects of COVID-19 on maritime freight transportation? (Select all that apply) *

- ☐ Real-time tracking and monitoring

systems

- ☐ Process automation and robots
- ☐ Artificial intelligence and data analysis
- ☐ Mobile applications and digital platforms
- ☐ Blockchain technology
- ☐ Other

11. If you select other, please specify:
12. How do you think the adoption of new technologies in the maritime freight transportation supply chain has been implemented during COVID-19? *

- ○ It has been implemented efficiently and effectively.
- ○ It has been implemented but with difficulties.
- ○ It has not been implemented significantly.
- ○ Do not know.

13. What do you consider to be the main benefits of implementing new technologies in the maritime freight transportation supply chain duringCOVID-19? (Select all that apply) *

- ☐ Improvement of operational efficiency
- ☐ Reduction of transit times
- ☐ Increased visibility and traceability of goods
- ☐ Optimization of resources and cargo capacity
- ☐ Other benefits (please specify)

14. If you select other benefits, please specify:
15. Have your company made investments in technologies to improve themaritime freight transportation supply chain during COVID-19? *

- ○ Yes, significant

investments.

○ Yes, moderate investments.

○ No, no investments have been made.

○ Do not know.

16. If yes, Indicate what type of investments?
17. What obstacles do you think could hinder the effective implementation of innovative technologies in maritime freight transportation during COVID- 19? (Select all that apply) *

☐ Lack of financial investment

☐ Resistance to change by industry stakeholders.

☐ Interoperability issues between systems and platforms.

☐ Lack of training and technological knowledge.

☐ Other obstacles (please specify)

18. If you select other obstacles, please specify:
19. Do you believe that collaboration among industry stakeholders in maritime freight transportation is crucial for successfully implementinginnovative technologies during COVID-19? *

- Yes, it is crucial for the implementation's success.

○ No, I don't think collaboration is necessary for success.
○ Do not know.

20. On a scale of 0 to 10, to what extent do you consider that demand for shipping services has increased due to changes in consumption patterns because of COVID-19? *

0	1	2	3	4	5	6	7	8	9	10

Low Increase

Hig h increase

21. What role has digitalization played in the maritime supply chain duringthe pandemic in your company? *3.7.2 Secondary Data

This research undertakes an in-depth investigation into the interplay among the effects of the COVID-19 pandemic, emerging technology, and managerial approaches in

the supply chain of the maritime freight industry. In order to attain a thorough comprehension of this complex phenomenon, this research utilizes a blend of secondary data derived from diverse reference sources. These sources encompass reports from the United Nations Conference on Trade and Development (UNCTAD), specialized articles within the relevant field of study, literary analyses, market reports, and audiovisual sources.

The secondary data included in this study are derived from reputable and established sources that represent a diverse variety of opinions. UNCTAD publications offer a comprehensive framework for understanding global economic and trade patterns, especially in relation to the ongoing epidemic. Scholarly articles in the field of research and literary analyses contribute to the analysis by providing critical and insightful debates on the interplay between essential factors, including supply chain, COVID-19, technology, and strategies.

This study focuses on key elements within the maritime products industry's supply chain, including demand reduction and transportation capacity, interruptions at ports, and shifts in consumer habits. The impacts of COVID-19 have been amplified on a worldwide scale, leading to exceptional problems in the fields of logistics and shipping. As the progression of the epidemic unfolded, novel technologies emerged as crucial instruments to tackle these challenges. The research examines many technological advancements, such as port automation, remote asset monitoring, and the utilization of sophisticated data analytics for decision-making purposes.

3.8 Validity & Reliability

The current investigation is built around a solid framework of methodological rigor, under the guidance of professional supervision, and supported by reputable and contextually relevant materials. This introductory section provides a thorough explanation of the factors that support the credibility and dependability of this thesis. It demonstrates how meticulous preparation and implementation at every level of the research process have played a role in producing an accurate and well-supported interpretation of the findings.

The research benefitted from the involvement of the supervising authority from the beginning, as their knowledge and ideas were important in determining and narrowing down the key areas of focus for this inquiry. The inclusion of field experience in the research process guaranteed that the most important and pertinent elements were integrated, so offering a solid and cohesive framework for the advancement of the inquiry.

In addition, the research instruments utilized to investigate the study topic were granted permission and gained useful comments from the overseeing authority, which provided ideas for their enhancement. This collaborative effort guaranteed that the questionnaires and data collecting instruments were suitable and capable of accurately capturing the key elements of the study. The expert validation of these instruments provides strong evidence for the reliability and validity of the gathered data.

The main and secondary data included in this research have been obtained from reputable and authoritative sources that are directly relevant to the scope of the investigation. Bibliographic references and papers sourced from reputable organizations

such as UNCTAD serve to guarantee that the data presented is in accordance with prevailing trends and advancements within the marine goods business, as well as in the realm of mitigating the impacts of the COVID-19 pandemic. The data analysis has been conducted in a clear and practical manner, adhering to a systematic framework that mitigates the risk of misunderstanding.

3.9 Data Analyst

Within the framework of this research, a comprehensive and varied methodology has been utilized to examine qualitative and quantitative data, with each offering distinct insights into the dynamics of the maritime freights supply chain, the ramifications of COVID-19, and the implementation of mitigation technologies. This section will provide an overview of the methodologies and procedures employed for the classification, interpretation, and analysis of the data. It will also discuss how these processes intersect to answer the research question, derive significant findings, and offer valuable recommendations for future endeavors.

The systematic procedure of categorizing and coding has been utilized to undertake the analysis of qualitative data. The open-ended responses collected from professionals in the maritime and logistics industry were subjected to meticulous examination, with the aim of detecting recurring patterns, themes, and emerging trends. The replies were organized into appropriate categories, enabling a comprehensive and contextual analysis of participants' perspectives and encounters. The utilization of triangulation and ongoing evaluation of these findings serves to preserve the integrity and dependability of the

conclusions derived from qualitative analysis. In contrast, the examination of quantitative data entails the meticulous process of condensing and displaying measurable data in a manner that is both understandable and applicable. The numerical data, which was obtained through surveys and reliable sources, was subjected to both descriptive and statistical analysis. An successful synthesis of developing quantitative patterns pertaining to the influence of COVID-19 on the maritime supply chain was accomplished through the identification of trends, measures of central tendency, and dispersion. The process of condensing data into understandable outcomes enables the detection of causal and influential connections among crucial factors.The integration of qualitative and quantitative analysis yields a comprehensive and insightful viewpoint on the subject of study. The integration of perspectives from industry experts, coupled with quantitative evidence, offers a complete analysis of the impact of the pandemic on the maritime freight supply chain. Furthermore, this synthesis highlights the role of emerging technology in mitigating these consequences. The outcomes derived from rigorous analytical methodologies will serve as the foundation for generating meaningful findings, formulating well-supported recommendations, and proposing future avenues for exploration. This contribution serves to enhance understanding and application within the respective subject.

4.Ethical Consideration

The maintenance of ethical integrity in research is of utmost importance in order to guarantee the reliability, credibility, and ethical consideration of the collected findings, while also taking into account the well-being of the research participants and the broader academic community. During the duration of this study, meticulous ethical considerations

have been implemented in order to preserve the integrity of the results, maintain the anonymity of the participants, and guarantee the appropriate utilization of vital data. This study addresses the procedures that have been adopted to avoid plagiarism, properly acknowledge the contributions of others, and protect the privacy of respondents. These methods underscore the research's dedication to upholding the utmost standards of academic ethics.

One of the primary focal points in this research has been the mitigation of plagiarism and the appropriate acknowledgment of external contributions. The information and ideas obtained from external sources have been thoroughly recorded and referenced. Ensuring the intellectual integrity of research necessitates the appropriate recognition and acknowledgement of the voices and contributions made by others. Likewise, within the realm of administered surveys, there has been a notable emphasis placed on safeguarding the anonymity and privacy of participants. All necessary measures have been implemented to protect personal and sensitive data, guaranteeing that the information shared by participants is maintained within a secure and confidential setting.

5. Analysis & Results

The fundamental aspect of every research endeavor is in the thorough examination and subsequent analysis of gathered data. This chapter presents the result of an extensive analytical process, in which both qualitative and quantitative data have been subjected to rigorous procedures.

In accordance with the technique previously defined, the findings will be presented in a clear and logical manner, use tables, graphs, and specific instances to emphasize significant aspects. The integration of qualitative and quantitative data in the presentation of results facilitates a comprehensive and insightful comprehension of the interplay of the variables under investigation.

According to analysts, the maritime freight industry's supply chain has encountered a variety of unprecedented obstacles during the worldwide shift brought about by the COVID-19 pandemic. CMA CGM faced a range of obstacles inside its maritime logistics network, resulting in substantial disruptions to its operational efficiency and service delivery. One significant obstacle encountered by the corporation was the widespread congestion observed in ports globally, which resulted in issues within the company's logistical operations. The congestion observed in this context can be attributed to a decrease in the available workforce at ports, leading to significant delays in the handling of goods. The aforementioned delays had a subsequent impact on the entire market capacity and resulted in a negative effect on consumer satisfaction.

The supply chain disruption was further intensified by the scarcity of container equipment, so impeding the effective planning and execution of operations. The limited availability of containers has had a significant impact on the duration of transportation and has also heightened the level of unpredictability in the delivery of products. Furthermore, the company's efficiency in meeting demand was immediately impacted by the decrease in transport capacity and the limited quantity of containers. Nevertheless, it is captivating to

note the manner in which this crisis has incited a sequence of transformations that finally yielded a favorable outcome for the industry.

Before the emergence of the COVID-19 pandemic, the industry was consistently progressing along a specific trajectory, maintaining its conventional practices and standard capacity. Nevertheless, the advent of the pandemic resulted in a substantial upheaval, compelling the industry to reassess its strategies and implement inventive methods in order to address emerging needs and obstacles.

One of the most remarkable and paradoxical discoveries was the pervasive awareness of a favorable influence of COVID-19 on the maritime freight business, as unveiled by the outcomes of the study.

Among the sample of 60 participants, a significant majority of 58% expressed a clear and unambiguous perspective that COVID-19 had a favorable influence. Likewise, the cohort of persons who were questioned had a favorable outlook for the influence of the COVID-19 pandemic on the expansion of the shipping transport sector. This unexpected reaction presents a counterargument to the conventional assumption that a worldwide crisis, such as a pandemic, would invariably result in adverse effects on many economic domains. Nevertheless, the data obtained suggest that within the maritime freight industry, the pandemic served as a catalyst for transformative reforms that ultimately had favorable outcomes across several dimensions.

Figure 13. The impact of the covid 19 in the efficiency of the maritime freight transportation supply chain

Note. Personal own

The COVID-19 epidemic has presented significant challenges to the fundamental aspects of commercial and logistical operations, while simultaneously instigating a series of major transformations within the maritime freight industry. Significant transformations have been witnessed in the functioning of this business, which plays a crucial role in facilitating global commerce, since the commencement of the crisis.

Based on the examination of data, a prominent and noteworthy transformation has been observed in the form of a notable surge in the demand for and consumption of logistic services. In the face of limitations and disturbances within the supply chain, corporations have turned to logistic services as a means to guarantee dependable and effective product distribution. The increasing reliance on logistics highlights the strategic significance of this field as a crucial enabler for sustaining commerce and ensuring the efficient distribution of commodities, particularly under difficult circumstances. The field of logistics has emerged as a critical infrastructure for efficiently responding to dynamic circumstances, facilitating

the timely and efficient delivery of goods to their intended recipients. This, in turn, plays a crucial role in fostering economic stability and promoting the welfare of global societies.

Concurrently, the global health crisis has resulted in a rise in transportation expenditures. The imposition of mobility limits, constraints on capacity, and the dynamic nature of regulatory frameworks have exerted significant strain on the existing resources for freight transportation. The aforementioned circumstances have resulted in an increase in shipping expenses as organizations strive to maintain uninterrupted operations in the face of exceptional logistical difficulties. The rise in costs is a financial obstacle, but it has also prompted firms to investigate more effective and environmentally friendly alternatives within the supply chain.

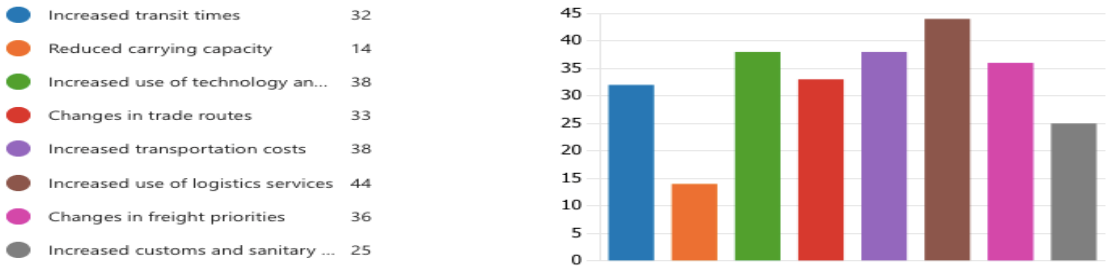
One notable transformation that has been witnessed is the increased utilization of technology and digitization within the maritime freight industry. The utilization of tracking and tracing solutions, as well as the implementation of cloud-based inventory management systems, has demonstrated the crucial role of technology in adapting and addressing present difficulties. The advent of digitalization has enabled more visibility and control inside supply chain operations, hence enabling more informed decision-making and improved resource utilization in a dynamic and evolving context.

Furthermore, the shifting demand patterns and the imposition of mobility limits have resulted in a modification of the priorities assigned to carried commodities. Certain items and sectors have witnessed a surge in demand, whilst others have encountered a decline. The reassessment of company goals has resulted in the restructuring of cargo

composition and the implementation of agile strategies to effectively respond to evolving customer demands.

The aforementioned alterations collectively signify an important transformation within the maritime freight industry as a direct response to the COVID-19 outbreak. The ability to adjust to changing conditions has showcased the resilience and potential for innovation within this key business. The marine products business has demonstrated its capacity to address exceptional difficulties and adapt to a new era of global commerce through the adoption of technology, reevaluation of priorities, and utilization of logistic services.

Figure 14. Types of significant changes in the freight shipping routes since the beginning of the COVID-19 pandemic

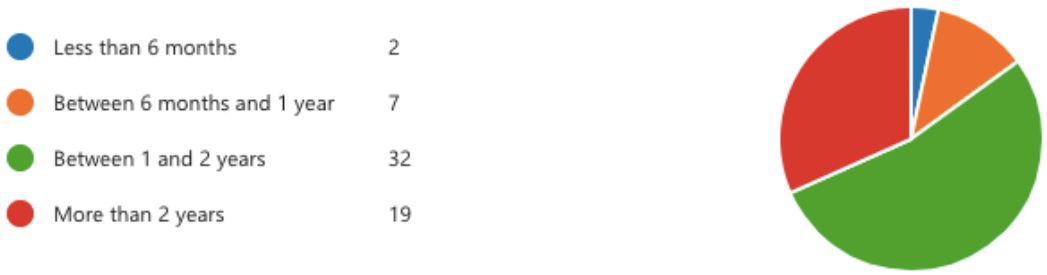


Note. Personal own

It is imperative to underscore the fact that the COVID-19 epidemic has had a substantial influence on several stakeholders of the CMA CGM firm and its subsidiaries. The survey findings indicate that the prevailing perception among respondents is that CMA

CGM has encountered the repercussions of this crisis for a period typically spanning between one and two years. It is worth noting that a substantial proportion of participants, namely 32%, have expressed that the effects of COVID-19 have persisted for a period beyond two years. This finding emphasizes the profound and enduring difficulties that this prominent maritime organization has faced in terms of its operations and future prospects. The aforementioned findings highlight the intricate nature and enduring nature of the difficulties that marine firms have experienced and are still confronting as a result of this unparalleled global crisis.

Figure 15. Impact time of Covid-19 on the freight maritime transport industry



Note. Personal own

CMA CGM works on a diverse range of strategically significant maritime routes on a worldwide scale. The main routes of this transportation system include transpacific, transatlantic, intra-European, and intercontinental lines. These routes are of significant importance in facilitating connection and the movement of products. Based on the findings of the study, it is evident that these routes have encountered a range of effects due to the COVID-19 pandemic. Currently, they depict a varied representation of the company's capacity to withstand and adjust to a dynamic and evolving context.

Significantly, CMA CGM's transpacific and transatlantic routes have emerged as the most prominent in terms of generating good effect, both during the epidemic and in the current context. The respondents have identified these routes as areas of strong activity and growth throughout the crisis, since they connect important trade locations in Asia and North America, as well as between Europe and North America. The good influence may be ascribed to several variables, such as the consistent demand for certain items, the effective application of safety protocols, and the flexible adjustment to constantly evolving constraints.

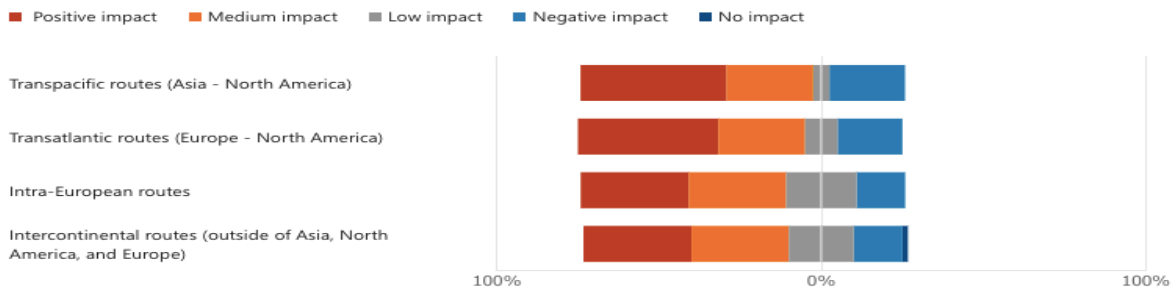
Routes within Europe and between continents, while experiencing a relatively less degree of effect compared to other locations, have been recognized as regions with a moderate level of influence. The aforementioned transportation networks, which facilitate interregional travel within Europe and enable connections across other continents, have exhibited a commendable capacity to sustain a satisfactory level of stability and operational continuity. Nevertheless, the appraisal of the impact of these routes has been impacted by the constraints provided by their relative complexity in the face of movement limitations and changes in demand.

It is noteworthy to emphasize that the transpacific and transatlantic routes are regarded as two of the most significant lines of operation for CMA CGM. These transportation lines serve as vital channels for global commerce and have demonstrated their significance in the company's strategic approach, especially during periods of economic downturn. The ability of these routes to sustain favorable and continuous

operations highlights the significance of flexibility and diversity in CMA CGM's operational approach, enabling them to adeptly address obstacles and leverage growing prospects.

The examination of CMA CGM's primary routes demonstrates the organization's capacity to effectively adapt and prosper amongst dynamic and demanding circumstances. The variation in observed effects among different routes underscores the need of adaptability and nimble reactivity in ensuring operational continuity and sustained expansion in the worldwide maritime sector.

Figure 16. The type of impact that COVID-19 had on the routes for maritime freight transportation



Note. Personal own

In a similar vein, it is crucial to emphasize that a substantial 84% of the participants have said that transportation expenses within this sector have witnessed a rise as a direct outcome of the prevailing health issue. The aforementioned scenario exemplifies

a prevalent pattern that has been extensively documented within the industry and may be ascribed to a network of interrelated causes.

The extensive disruption of global supply networks has emerged as a key driver behind the increase in costs. The implementation of measures aimed at mitigating the transmission of the virus, such as the closing of borders, the enforcement of quarantines, and the adoption of social distancing protocols, has had a discernible influence on the efficient functioning of ports, logistical infrastructures, and loading and unloading terminals. The aforementioned interruptions have resulted in delays in the delivery process, congestion at ports, and difficulties in effectively coordinating various components of the supply chain. Consequently, there have been additional expenses incurred in redirecting, storing, or managing commodities.

Furthermore, the implementation of security measures in reaction to the pandemic has necessitated an augmented allocation of resources towards personal protective equipment, cleaning procedures, and health protocols. The imperative to ensure a secure environment for port and transportation personnel has resulted in additional financial burdens, as precautionary measures are implemented and novel operating protocols are instituted. The aforementioned expenses, which are crucial for safeguarding the health and welfare of those concerned, have played a role in the total escalation of expenses within the marine freight sector.

Similarly, the variability in demand and supply has also had an effect on transportation expenses. The availability of cargo and the efficiency of transportation have been impacted by variations in consumption patterns and production capacity. The

necessity to modify routes, timetables, and transportation capacities in order to accommodate these fluctuations has generated operational intricacies and subsequently led to a rise in expenses.

Figure 17. Increase in the costs of maritime freight transportation due to COVID-19

Note. Personal own

In contrast, the evaluation of several phases of the supply chain within the framework of the COVID-19 pandemic has yielded a complex and illuminating depiction of the diverse regions' reactions and adjustments to the disruptions engendered by this unparalleled disaster. The assessment of four primary elements of the supply chain, specifically production and manufacturing, logistics and storage, marketing and sales, and transportation, reveals discernible disparities in terms of perceived influence. This analysis provides insights into the sectors that have exhibited higher levels of adaptability and those that have encountered more substantial difficulties.

The respondents identified transportation and distribution as the component that has the most significant positive influence, with a notable 75% evaluating it as having a strong impact. This implies that despite encountering operational challenges and limitations, the capacity to convey indispensable and crucial commodities has not only been preserved but has actually flourished. The presence of agility and flexibility in this domain

is apparent, as demonstrated by the implementation of novel strategies and a strong emphasis on optimization. These factors have enabled the seamless movement of essential commodities, even in the face of difficult conditions.

Within the domain of production and manufacturing, a significant proportion of the participants, specifically 56.7%, reported a substantial influence. Despite encountering challenges related to interruptions in the supply chain and changes in demand, this sector has exhibited significant capability in efficiently sustaining production and manufacturing operations. It has successfully adapted to these swings, so maintaining the consistent availability of goods in the market.

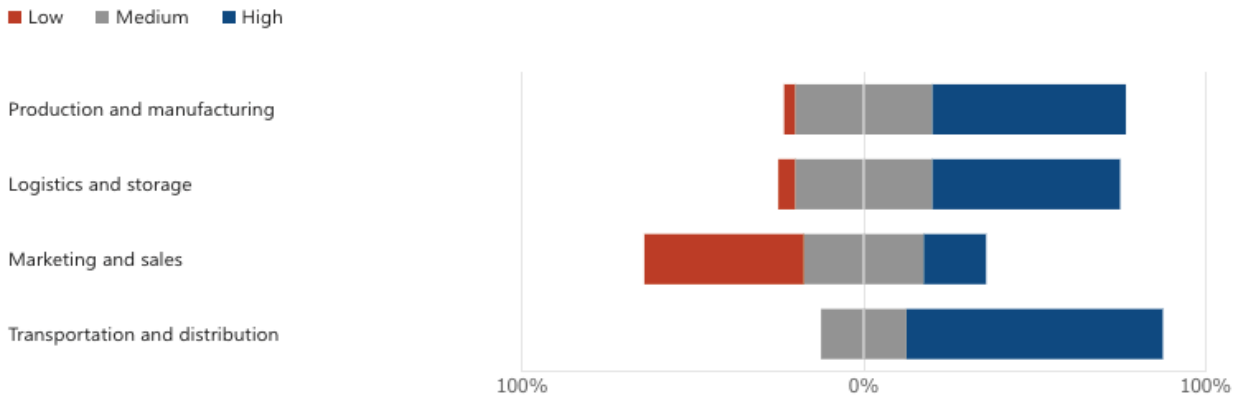
Conversely, the importance of logistics and storage within the supply chain is underscored, as indicated by a significant influence reported by 55% of the participants. The necessity to modify operational strategies and uphold effective asset management has resulted in heightened capital allocation towards technology and inventive logistic methodologies. This answer highlights the significance of continuous adaptation in this domain to maintain the smooth functioning of supply chains and meet consumer demand effectively.

Nevertheless, the domain of marketing and sales exhibited a very modest influence, as indicated by 46.7% of respondents evaluating it as high. This highlights the difficulty of modifying marketing and sales tactics to align with the novel circumstances brought forth by the epidemic. The evaluation may have been impacted by consumer

demand volatility and constraints on physical encounters, indicating the necessity for new and flexible techniques in this domain.

When considering these four essential components of the supply chain collectively, it becomes evident that there exists an intricate interaction between operational domains and their respective adaptations to the difficulties posed by the COVID-19 pandemic. The domains of transportation and manufacturing have demonstrated commendable resilience, while logistics and storage have efficiently addressed the obstacles they have encountered. On the other hand, marketing and sales have identified areas that provide potential for enhancement. The aforementioned segmented evaluation highlights the necessity of adopting a comprehensive approach to supply chain management, whereby each constituent element is suitably adjusted to guarantee the smooth and efficient movement of products.

Figure 18. Impact of COVID-19 for the stages of the maritime freight transportation supply chain



Note. Personal own

The survey conducted among key stakeholders of CMA CGM has yielded a consensus that technological innovation and investment in digitalization are the primary factors that have not only addressed the challenges posed by the COVID-19 pandemic but also contribute to the development of a resilient and adaptable future for the maritime freight industry. Within this particular environment, the utilization of new technologies has become imperative in order to address and manage uncertainties and interruptions, while simultaneously enhancing optimization and efficiency throughout all facets of the supply chain.

The dominant technologies in the sector, as stated by survey respondents, are artificial intelligence and data analysis. These solutions facilitate well-informed and strategic decision-making by effectively processing and interpreting large volumes of data. As a result, they offer a comprehensive understanding of trends and patterns that guide operational strategies. The capacity to foresee and adjust to variations in demand and interruptions in the supply chain assumes paramount importance in an uncertain setting,

and it is in this context that artificial intelligence and data analysis emerge as indispensable instruments.

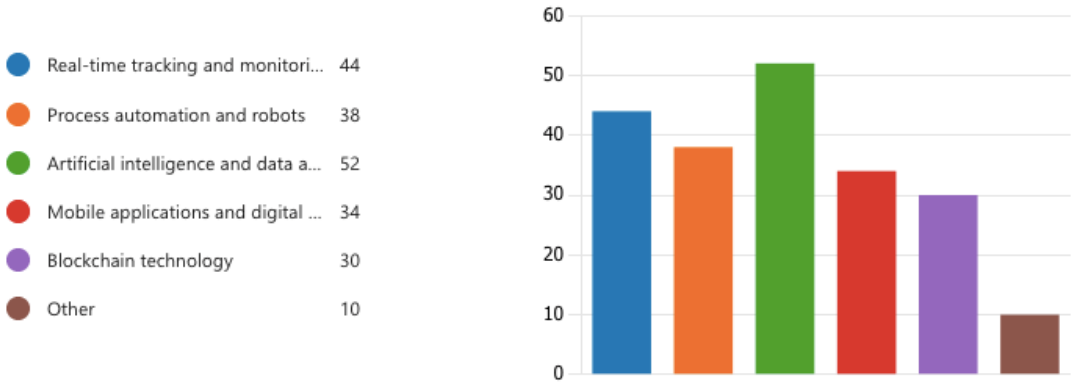
Real-time monitoring and tracking systems are recognized as indispensable technology. The utilization of real-time tracking technology presents the potential to boost visibility inside the supply chain by allowing for the monitoring of items' location and status. This capability not only improves the overall visibility of the supply chain, but also enables prompt decision-making processes. The capacity to foresee possible obstacles, such as transport delays or delivery concerns, is of utmost importance as it allows for a timely and efficient reaction to mitigate any negative consequences.

The utilization of automation and robots has been demonstrated to be essential in addressing many difficulties. By mitigating reliance on manual labor, these technologies not only enhance productivity but also guarantee uninterrupted operations during periods of limited human resources. The integration of mobile and digital apps, in conjunction with Blockchain technology, has facilitated the establishment of transparency and traceability within the supply chain. This has resulted in increased confidence among various stakeholders and the acceleration of administrative procedures.

Moreover, a significant number of participants emphasized the incorporation of the Internet of Things (IoT) and the analysis of large-scale data as crucial elements within the plan for mitigating the issue at hand. The enhanced connection of devices and the ability to gather and analyze real-time data contribute to a more thorough comprehension of

assets and operations. This, in turn, facilitates prompt responses and early detection of possible difficulties.

Figure 19. Technologies for the mitigating the effects of COVID-19 on maritime freight transportation.



Note. Personal own

The pandemic has resulted in an unprecedented need to adopt new technical solutions in the shipping business, in order to address the problems posed by the catastrophe. Nevertheless, the shift towards a more computerized and robust supply chain has encountered many challenges. CMA CGM and its affiliated entities have made considerable endeavors to embrace novel technology, including digital platforms, with the aim of enhancing operational efficiency and ensuring sustainability in a dynamic context.

While there has been some progress in investing in digital platforms and emerging technologies, there have also been noticeable challenges encountered along the way. One of the primary obstacles encountered in the marine business is to the entrenched

reluctance towards implementing changes. The use of novel technology necessitates a change in cognitive perspective and operational procedures, frequently encountering a degree of resistance. The presence of established practices and the inherent unpredictability linked to the integration of novel approaches might engender a reluctance to embrace change, so impeding the pace of technological assimilation.

The difficulty of interoperability between various systems and platforms has emerged as a significant barrier. The utilization of various technical solutions may result in the fragmentation of information and provide challenges in attaining a full and unified perspective of the supply chain. The absence of standardized practices and the necessity to harmonize divergent systems might introduce complexities throughout the implementation process and constrain the potential benefits derived from technology investments.

Similarly, a significant barrier is the dearth of information and technology literacy. In order to successfully integrate new technologies, it is important to possess a comprehensive comprehension of their functionalities, ramifications, and prospective advantages. Insufficient training and expertise pertaining to developing technologies might impose constraints on organizations' capability to effectively harness these solutions, hence impeding their ability to effectively tackle the problems posed by COVID-19 and progress towards a more adaptable and robust supply chain.

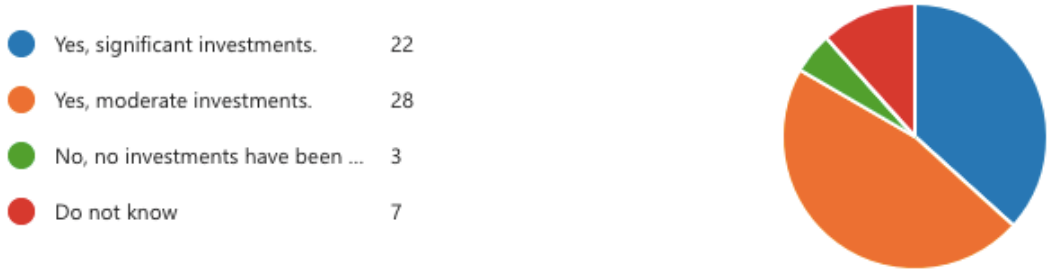
Notwithstanding these obstacles, CMA CGM and its affiliated entities are shown resolute resolve in their endeavor to achieve digital transformation. It is acknowledged that surmounting these challenges is crucial in order to guarantee efficient functioning in the face of the uncertainties posed by the epidemic and in the future. In the context of the

maritime industry's ongoing progression towards complete integration of emerging technologies, it is imperative to prioritize investment in training, encourage collaboration among stakeholders, and cultivate a receptive mindset towards change. These factors are seen crucial for achieving success in this domain.

Figure 20. Adoption of new technologies in the maritime freight transportation supply chain

Note. Personal own

Figure 21. Investments in technologies at CMA CGM



Note. Personal own

Figure 22. Obstacles for the implementation of innovative technologies in maritime freight transportation

Note. Personal own

According to the findings from the interviews, it has been observed that the company has recently made a notable advancement in enhancing its operational processes. This progress has been achieved through the implementation of a novel tool for Corporate Social Responsibility (CSR) and Container Asset Management (CAM). This tool effectively utilizes Internet of Things (IoT) technology and employs big data analytics. The execution of this strategy has resulted in a notable enhancement in the efficiency of the supply chain, hence offering clients a more structured and advantageous experience.

One of the notable tools that has been introduced is the "AQUA Line Monitoring Tool." This privately developed application enables managers to effectively monitor Key Performance Indicators (KPIs), filling speed, and other contributions pertaining to their individual tasks. The functionality of this tool has been enhanced to incorporate the utilization of a maximum of 20 adaptable filters that may be stored as bookmarks, so streamlining the process of accessing pertinent data in a prompt and efficient manner.

One notable feature of this program is its alert module, which enables users to get warnings within the application when there is a deviation in the filling pace of any of the markers, whether it is delayed or accelerated. The adoption of proactive and automated functionality guarantees that managers receive immediate notifications regarding any deviations in processes, enabling prompt decision-making and effective implementation of remedial measures.

The advantages of these instruments are noteworthy. The use of Internet of Things (IoT) and big data technologies has afforded the organization more visibility and operational control, leading to a more responsive and efficient supply chain. The utilization of real-time data monitoring and analysis facilitates the organization in discerning patterns, trends, and areas for enhancement with enhanced accuracy. The use of automated alerts not only enhances the efficiency of issue resolution and decision-making processes but also contributes to heightened operational efficiency and improved customer satisfaction.

The integration of digitization and the use of novel technologies have become essential components within the operational framework of prominent corporations such as CMA CGM and other entities operating in the maritime industry. These technologies have demonstrated their indispensability in the mitigation of possible hazards, adaptation to transportation limitations, and efficient adjustment of methods. Simultaneously, the considerable expansion of the maritime industry in recent times has expedited the process of digitalization, establishing the foundation for a more adaptable and robust future within a constantly changing market.

The integration of novel technology has endowed CMA CGM with the capacity to preemptively mitigate possible hazards. The utilization of tracking and monitoring technologies has enabled the timely detection of possible obstacles within the supply chain, thereby enabling decision-makers to make well-informed choices. The capacity to identify and resolve problems prior to their escalation into critical situations has shown to be crucial in sustaining operational continuity and minimizing the consequences of unanticipated interruptions.

Moreover, the process of digitalization has facilitated corporations in closely aligning with transportation limitations and adapting their plans in real-time. The utilization of real-time data on the whereabouts and condition of merchandise, coupled with data analysis, has granted enterprises the ability to promptly modify their transportation routes, timetables, and methods in order to adapt to unforeseen circumstances. The capacity to adapt has shown to be highly advantageous in a context characterized by rapidly evolving constraints and laws.

The exponential expansion observed in recent years has been a key driver behind the rapid advancement of digitalization within the maritime sector. The growing consumer demand for commodities and products has driven the rapid growth of the maritime sector, necessitating a heightened focus on operational efficiency and optimization. In the present scenario, the use of digital technology has emerged as an imperative measure to effectively align with operational requirements and fulfill the dynamic expectations of a constantly evolving market.

Although the whole ramifications of digitalization may not have been readily discernible during the preceding two years, its impact on the shipping industry has been evident and

continuous, leading to significant transformations. The groundwork established by the process of digitalization in preceding years is facilitating increased acceptance and efficacy in subsequent periods. As corporations persist in allocating resources towards developing technologies and enhancing their digital strategies, it is anticipated that the advantages will escalate, leading to enhanced optimization, efficiency, and flexibility within an increasingly linked global marketplace.

In a nutshell, the utilization of digitalization has demonstrated its immense value as a resource for CMA CGM, enabling the company to effectively manage risks, swiftly adjust to changing circumstances, and proactively prepare for future challenges. The rapid expansion of the shipping industry has facilitated the integration of digital technology, therefore paving the way for continuous evolution in the foreseeable future. The process of digitization has been undertaken as both a reactive measure to address present issues and as a proactive investment aimed at fostering a more robust and prosperous future within the international marketplace.

6. Conclusions & Practical Recommendations

The COVID-19 epidemic has had a significant influence on the worldwide economy, leading to a sequence of alterations in the supply chain of marine freight transportation. This study examines the impact of the COVID-19 pandemic on the

aforementioned chain and explores the use of novel technology as a means to reduce its consequences.

The COVID-19 pandemic has resulted in an unparalleled economic repercussion, exerting its influence on crucial industries as manufacturing, trade, and transportation. The imposition of movement restrictions and border closures has resulted in the disruption of supply chains, resulting in shortages of products and imbalances between supply and demand.

Additionally, the COVID-19 pandemic has had a positive effect on the maritime supply chain, as there has been an increased demand for logistics and transportation services to ensure the delivery of essential and medical products during this crisis. Nonetheless, it also revealed the insufficiency of preparedness and technology assimilation within the marine sector, resulting in notable interruptions in the supply chain caused by scarcities in resources and the absence of flexibility to swiftly adjust to unforeseen circumstances.

Prior to the onset of the COVID-19 pandemic, the marine supply chain functioned within a relatively stable and foreseeable environment, where planning activities relied heavily on historical data and conventional management approaches. Presently, the supply chain has exhibited enhanced dynamism and agility, enabling prompt adaptation to fluctuations in demand and resource accessibility, therefore augmenting its capacity to withstand uncertainties.

The maritime supply chain has experienced growth in business prospects and collaboration among key actors due to the rising demand for logistics and transportation services.

The company's operations were directly affected by global port congestion, which was further intensified by a decrease in staff due to the epidemic. The confluence of these several causes led to notable disruptions in the shipping and logistics of merchandise. The lack of efficient container movement, resulting in delays and inconsistencies, has resulted in a disturbed and disorganized supply chain.

The absence of adequate technical readiness has brought to light the susceptibility of the supply chain to unanticipated crises, underscoring the imperative to embrace modern technology in order to enhance efficiency and mitigate risks.

The utilization of digitization and the integration of advanced technologies, such as real-time tracking, artificial intelligence, and automation, have demonstrated their significance in guaranteeing visibility, coordination, and well-informed decision-making within the marine supply chain.

Investment in technology has emerged as a crucial aspect in addressing forthcoming difficulties, enhancing operational flexibility, and diminishing dependence on conventional approaches.

Future Perspectives: A Critical Analysis of Potential Developments

The application of innovative technologies plays a significant role in establishing a robust and efficient supply chain in the marine freight sector as it undergoes recovery and adaptation to the "new normal" within an ever-changing global environment.

In summary, CMA CGM has encountered and navigated the obstacles presented by the COVID-19 epidemic, while also capitalizing on advantageous circumstances arising from this global crisis. Throughout this endeavor, the organization has exhibited a commendable capacity to adjust, develop, and flourish in diverse facets of the logistics network. The crisis has not only presented challenges, but it has also acted as a motivator for advancement in key sectors including transportation, sales, operations, and storage.

The aforementioned organization, which possesses a historical foundation deeply entrenched in the nautical sector, has effectively utilized the obstacles presented by the COVID-19 pandemic as an opportunity to venture into uncharted territories. The use of route methods has facilitated the identification of nascent markets and the creation of avenues for expansion in previously untapped areas. Furthermore, the drive towards modernization and the integration of novel technologies have consistently played a role in this process of adaptation. However, it is important to acknowledge that the adoption of technology and digitization has occurred gradually through time.

While CMA CGM has exhibited a more slower adoption of technology in comparison to industry frontrunners, the advent of technical developments subsequent to the post-COVID era has instigated noteworthy enhancements in its operational processes. These technological breakthroughs have facilitated not just enhanced operational efficiency but also the mitigation of negative consequences associated with the crisis and the adoption of more efficacious approaches to tackle uncertainty.

It is essential to emphasize that this evolutionary process is in accordance with the increasing recognition of the significance of digitalization within the realm of supply chain management. CMA CGM has demonstrated a renewed dedication to the deployment of technology, acknowledging its essential role in enhancing operational efficiency and facilitating adaptability to forthcoming problems, despite its conventional character.

The journey undertaken by CMA CGM throughout the pandemic serves as a noteworthy example of successful corporate change. The COVID-19 pandemic has presented several problems that have been successfully addressed and utilized to promote holistic growth throughout the supply chain. The company's trajectory towards more digitalization and the use of innovative technology indicates CMA CGM's commitment to enhancing its industry standing and establishing a robust and flexible operational framework in response to the dynamic nature of the business landscape.

7. Limitations & Future Directions

In the course of investigating the implications of COVID-19 on the supply chain of maritime freight transportation and the adoption of novel technologies to alleviate its consequences, several constraints have been recognized that might have impacted the outcomes and methodologies employed. These identified limitations present potential avenues for future research and areas of advancement that might contribute to a more comprehensive comprehension of this essential subject matter.

The study has several limitations:

- The study was conducted within a defined temporal framework that was directly influenced by the ongoing epidemic. The comprehensive depiction of the COVID-19 scenario may not have adequately accounted for the dynamic nature of changing circumstances and the subsequent progression of the disease. Furthermore, the study is centered on a specific setting within the marine sector, thus constraining the applicability of the results to alternative businesses or geographical areas.

- Restricted Data Collection: Despite the utilization of a mixed research methodology encompassing surveys, interviews, and secondary data, the scarcity of comprehensive and current data pertaining to the unique operations and issues of the companies under study may have imposed limitations on the extent of analysis in certain domains.

- Emphasis on Business Perspective: The research predominantly revolved on the viewpoint of the organization CMA CGM and its reaction to the challenge. The inclusion of perspectives from additional relevant stakeholders, such as maritime transportation employees, regulators, and governmental organizations, would have enhanced the depth and breadth of the research.

Potential Areas for Further Investigation:

- *Analysis of Long-Term Resilience:* A potential avenue for future research is investigating the resilience of the maritime supply chain over an extended period, including assessing the ongoing effects of mitigation efforts undertaken during the pandemic on operational dynamics and their adaptability in response to evolving conditions.

- *Comparative Analysis of measures Across Industries:* Additional investigation may be conducted to examine the variations in mitigation measures and the adoption of new technology among industries affected by the pandemic. This would offer a more thorough perspective on the numerous techniques employed in different circumstances.

- *Socioeconomic Impact Assessment:* An other noteworthy avenue of exploration entails the examination of the socioeconomic ramifications associated with mitigation techniques and digitization within the marine supply chain. This analysis would encompass an evaluation of factors such as employment, sustainability, and equity.

- *Examination of developing Technologies:* The examination of developing technologies, including sophisticated automation, robotics, and the utilization of drones within the maritime supply chain, provide an opportunity to get a deeper understanding of their capacity to tackle forthcoming difficulties and improve operational effectiveness.

- *Worldwide and Comparative Perspective:* A potentially intriguing avenue for further exploration would be broadening the scope of study to encompass a worldwide perspective, so enabling a comparison of responses and methods employed in other countries. This comparative analysis would shed light on the similarities and variations observed in the deployment of innovative technology.

This study establishes a robust framework for comprehending the ramifications of COVID-19 on the maritime supply chain and the implementation of mitigation techniques facilitated by novel technology. The constraints that have been discovered and the recommended future directions provide avenues for further exploration in specific domains, so enabling ongoing contributions to the expanding body of knowledge on the resilience and adaptation of the maritime industry in a dynamic global context.

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Appendix A

Interview

13. Appendix

Appendix A

Interview

1. What has been the main challenge CMA CGM has faced in its maritime freight supply chain due to COVID-19, and how has this affected the company's operations and services?

2. The COVID-19 pandemic has highlighted the importance of resilience in the supply chain. What measures has CMA CGM implemented to improve resilience and responsiveness to disruptions caused by the pandemic?

3. Collaboration and coordination among supply chain actors are critical in times of crisis. How has CMA CGM worked with its customers, suppliers and partners to jointly address the challenges of COVID-19 and maintain an efficient flow of goods?

4. Digitization and the implementation of innovative technologies are key to meeting the challenges of COVID-19. What types of digital technologies have been implemented at CMA CGM to improve visibility and monitoring of the maritime

Appendix B

Microsoft Questionnaire

supply chain during COVID-19? How have these technologies helped mitigate disruptions and delays?

5. For you, what role has digitalization played in the maritime supply chain during the pandemic at CMA CGM?

Appendix B

Microsoft Questionnaire

The impact of COVID-19 on the supply chain of maritime freight

Welcome to the questionnaire **"The impact of COVID-19 on the supply chain of maritime freight transportation and the implementation of innovative technologies to mitigate its effects"**

The COVID-19 epidemic has created an unprecedented combination of challenges for the maritime freight industry, harming both logistics operations and the global economy. In this Q&A, we will discuss how the pandemic has affected the freight shipping supply chain, the disruptions to international trade, the measures taken to ensure operational continuity, and the technological solutions being implemented to increase efficiency and resilience in the future.

All responses will be added, with individual answers remaining anonymous. Please **complete** and **submit** the questionnaire by **1 August 2023.**

For any details and questions regarding the questionnaire, please contact: paula-alejandra.ortega-hurtado@rennes-sb.com

1. Select the company you are currently working for: *