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"The role of visibility in containerized shipping industry"

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"This dissertation is dedicated to my husband who supports me and cares about me and my psychosocial well-being all these years.

I want to thank the people that helped me and supported me in order to complete this thesis. These years that I studied in this program were a personal challenge to me but also a great journey.

Knowledge is an asset that no one can take back from you, and through my studies in this program I gained so much of it. I am thankful to all my professors for their patience, guidance and willingness to share their knowledge with me."

Abstract

In the shipping industry, visibility refers to the ability to track and monitor the movement and status of cargo and vessels as they move through the supply chain. This can include information such as the location of a vessel, the estimated time of arrival at a port, and the status of the cargo on board. Visibility is important in the shipping industry because it helps stakeholders make informed decisions, optimize logistic procedures, and reduce uncertainty. There are various technologies and systems that can be used to improve visibility in the shipping industry, including GPS tracking, RFID tracking, and many different cargo management software. In this dissertation the role of visibility in the maritime shipping industry will be presented, and especially in containerized cargo shipping industry.

An overall review will also make the reader understand how the evolved technology influences logistics operations, the difficulties that were previously faced due to lack of visibility, as well as the benefits that were gained for both parties at origin and destination through the technology evolution. However, digitalization and virtuality are not the only factors that affected the end-to-end visibility in the overall supply chain of maritime industry, but also complexity, disruptions in the supply chains and the way they were managed. In addition, this dissertation will enable the reader to understand the importance of new technologies, online platforms, tools and certain methods that are used in the industry among customers, warehouses, ports, freight forwarder companies and brokers.

In addition, some case studies will also show how certain collaborations between companies and new technology implementations benefited the industry and created an advantage up until now.

Finally, the importance of internet and the internet-connected systems will be analyzed as well as the benefits and the risks that its usage causes.

Keywords

Master Thesis

Ο ρόλος της ορατότητας στην ναυτιλιακή βιομηχανία εμπορευματοκιβωτίων

Βασιλική Ποιμενίδου

Περίληψη

Στη ναυτιλιακή βιομηχανία, η ορατότητα αναφέρεται στην ικανότητα παρακολούθησης της κίνησης και της κατάστασης του φορτίου και των πλοίων καθώς ταξιδεύουν στην αλυσίδα εφοδιασμού. Αυτό μπορεί να περιλαμβάνει πληροφορίες όπως η τοποθεσία ενός σκάφους, η εκτιμώμενη ώρα αναχώρησης και άφιξης σε ένα λιμάνι και η κατάσταση του φορτίου επί του πλοίου. Η ορατότητα της εφοδιαστικής αλυσίδας είναι σημαντική στον κλάδο της ναυτιλίας καθώς βοηθά τους ενδιαφερόμενους να λαμβάνουν τεκμηριωμένες αποφάσεις, να βελτιστοποιούν τις διαδικασίες logistics και να μειώνουν την αβεβαιότητα. Υπάρχουν διάφορες τεχνολογίες και συστήματα που μπορούν να χρησιμοποιηθούν για τη βελτίωση της ορατότητας στη ναυτιλιακή βιομηχανία, όπως η παρακολούθηση μέσω GPS, η παρακολούθηση RFID και διάφορα λογισμικά διαχείρισης φορτίου. Στην παρούσα διπλωματική εργασία θα παρουσιαστεί ο ρόλος της ορατότητας στη ναυτιλιακή βιομηχανία και ιδιαίτερα στη ναυτιλιακή βιομηχανία εμπορευματοκιβωτίων.

Μια ανασκόπηση θα κάνει επίσης τον αναγνώστη να κατανοήσει πώς οι νέες τεχνολογίες επηρεάζουν τις διαδικασίες logistics, τις δυσκολίες που αντιμετωπίστηκαν καθώς και τα οφέλη που αποκομίζονται και απο τα δύο μέρη, τον αποστολέα και τον παραλήπτη, μέσω αυτής της εξέλιξης. Ωστόσο, η ψηφιοποίηση και η εικονικότητα δεν είναι οι μόνοι παράγοντες που επηρεάζουν την ορατότητα από άκρο σε άκρο στη συνολική εφοδιαστική αλυσίδα της ναυτιλιακής βιομηχανίας, αλλά και η πολυπλοκότητα, οι διαταραχές στην αλυσίδα εφοδιασμού και ο τρόπος διαχείρισής τους. Επιπλέον, αυτή η εργασία θα επιτρέψει στον αναγνώστη να κατανοήσει τη σημασία των νέων τεχνολογιών, των διαδικτυακών πλατφορμών και ορισμένων μεθόδων που χρησιμοποιούνται στον κλάδο μεταξύ πελατών, αποθηκών, λιμανιών και εταιρειών διαμεταφορέων. Επιπλέον, ορισμένα case studies θα δείξουν επίσης πώς συγκεκριμένες συνεργασίες μεταξύ εταιρειών και εφαρμογές νέων τεχνολογιών ωφέλησαν τη βιομηχανία και δημιούργησαν πλεονέκτημα ακόμη και μέχρι σήμερα.

Τέλος, θα αναλυθεί η σημασία του διαδικτύου και των συνδεδεμένων στο διαδίκτυο συστημάτων καθώς και τα οφέλη και οι κίνδυνοι που μπορει να προκαλέσει η χρήση τους.

Λέξεις – Κλειδιά: θαλάσσια μεταφορά, ναυτιλιακή βιομηχανία, ορατότητα εμπορευμάτων, ορατότητα εφοδιαστικής αλυσίδας, ανταλαγή πληροφοριών, παρακολούθηση φορτίου

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List of Abbreviations and Acronyms

(alphabetically)

AI	Artificial Intelligence
AIS	Automatic Identification System
API	Application Programming Interface
CSR	Corporate Social Responsibility
CTD	Container Tracking Device
DCSA	Digital Container Shipping Association
DGPS	Differential Global Positioning System
DSS	Decision Support System
EDI	Electronic Data Interchange
ERP	Enterprise Resource Planning
ETA	Estimated Time of Arrival
FCL	Full Container Load
GPS	Global Positioning System
GT	Gross Tonnage
GTIN	Global Trade Item Number
IBM	International Business Machines Corporation
IMO	International Maritime Organization
IoT	Internet of Things
LCL	Less than a Container Load
MASS	Maritime Autonomous Surface Ships
MMSI	Maritime Mobile Service Identity number
MSC	Mediterranean Shipping Company
NVOCC	Non-Vessel Operating Common Carrier
RFID	Radio Frequency Identification
SOC	Shipper Owned Container
VM	Virtual Machine

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VoIP	Voice Over Internet Protocol
WSN	Wireless Sensor Network

1. Introduction

Visibility literally means the quality or the state of being able to see or be seen. (Roy, 2021) Although it is a well-known concept in logistics and has been studied by many authors, there is no unique definition of the concept. Some of them refer to it as the ability to access and exchange information through the supply chain and to use this information in real time. It is important to mention that not all information is able or meant to be shared, but only the relevant and meaningful. (Caridi et al., 2010)

One of the most valuable piece of information that should be shared is the ability to track or determine the location of a shipment while it travels through the supply chain. In order for a company to maintain successful operations, demand and supply have to be coordinated together with the movement of goods and information through the supply chain. But, in order to gain visibility, it is necessary not just to determine the location of a shipment, but also to close the loop between planning and execution, from raw materials to the delivery to the end customer.

The importance of visibility is widely known, as this situation affects performance and therefore is responsible for profit or loss depending on how the available information is used. Visibility is a prerequisite to supply chain agility and responsiveness. For example, a company that can determine the location of a shipment could better optimize its operations using the just-in-time system, therefore costs could be better managed through inventory management and loss from excess inventory could be eliminated.

In addition, visibility enhances the sense of control, while both shipper and consignee are sharing valuable information and that in real time. Having this knowledge, a company could eliminate fines or penalties caused by tax or customs compliance regulations. This of course leads to better communication between stakeholders and as a result better collaboration, better customer service, increased customer satisfaction, increased reliability and builds trust between parties.

Freight visibility and shipment tracking are widely used by customers and shippers who want to have a transparent shipping experience. From a single envelope to vessel tracking, supply chain visibility nowadays enables the customer to be informed of any changes regarding its shipment, the schedule, departure and arrival times, place and time of delivery, etc. It is important to mention that the information that flows through the supply chain can be measured and evaluated in terms of quantity and quality.

Many scholars agreed that visibility in the supply chain is required to achieve competitive advantage. In addition it is believed that visibility across the supply chain is an important aspect in supply chain competition and all members of the supply chain should have access to accurate information and performance status of their partners.

Although there were numerous attempts to quantify the value of visibility, most of the researchers focus on simplistic, two-tier or linear supply chains. That is the reason visibility analysis has been limited. The score that comes from visibility analysis allows supply chain leaders to compare and evaluate the degree of visibility among the supply chain and focus on

improvement. For example, good visibility of a company's suppliers could prevent the effect of stock-outs, improve inventory management, improve planning process and is perfect for companies that follow the just-in-time principle. (Caridi et al., 2010)

By sharing information, a company understands more about how their supply chain works in the upstream and downstream layers. By gaining more visibility, companies are able to reduce complexity, react fast, manage efficiently the uncertainties and improve decision making. Another important part that provides transparency and important information sharing is the concept of traceability, and the fact that it is closely related to visibility.

They are both essential for improving functionality through information sharing, leading to interchangeable deployment of these terms. (Roy, 2021) In some contexts, the terms "visibility" and "traceability" are used interchangeably, but they can have quite different meanings depending on the specific industry or application. The main difference of those terms is that instead of knowing a product's entire journey, visibility focuses on knowing every touchpoint in the supply chain.

The main goal of this thesis is to present, to highlight and to understand the role and importance of visibility in containerized shipping industry. The benefits and improvements from the different tools and equipment will be presented, as well as the negative effects that the lack of visibility can cause.

In the following chapters visibility tools and their usage will be presented. Furthermore, it will be analyzed how different disruptions over a period of time affected visibility levels in the shipping industry's supply chain. Moreover, the different case studies will show how the implementation of new technologies affected the levels of visibility and how important it is for companies to provide visibility to their customers and what they did to accomplish that in order to optimize their operations, gain new customers and to be competitive in the market.

However, it is a fact that the shipping industry was one of the last industries to trust and adopt new technologies and visibility tools. As a result, the visibility levels were low for many years. This action led to frauds and mistakes which were common and expected in this industry. Nonetheless, maritime transportation was considered to be the safest mode of goods transportation until it entered an era where digitization and automation took hold of logistic procedures and new threats and risks emerged and needed to be addressed.

Lastly, through this thesis, I want mostly to present how digitization reshaped the shipping industry and how visibility over the supply chain is affected by it. Not only visibility is affected by digitization but also, security of the transported items and sometimes the physical integrity of the on-board crew. After all, human lives are the most valuable "cargo" on board and should be protected by all means.

2. Visibility in shipping industry

2.1 How is visibility achieved in containerized shipping industry.

Containerization in the shipping industry is the action of the consolidation of multiple cargo shipments in an ocean container which will be transported as a unit. Containerization born in 1956 by Malcolm McLean, an American entrepreneur who came up with the idea to ship cargo in locked containers. This concept proved to be successful as it minimized time and costs. In the following years, ISO standards were established and containerized cargo transportation became popular worldwide.

One ocean container could hold cargo from different shippers, this procedure is known as Less than a Container Load (LCL) or a container could hold cargo from only one shipper, Full Container Load (FCL). LCL is a process that is widely used, it is more affordable than FCL because in this situation the shipper transports his items packed in boxes and on pallets, in a container which he shares with other shippers and they all together share the container costs.

In this process, all items in a shared container must be in the same category, either general cargo or dangerous goods. Dangerous goods are classified by many different categories as per IMO regulations and must be packed separately, to prevent accidents or interactions between shipped items. By an FCL transportation process, a whole container is booked for the shipper to transport his items regardless of the volume of the shipped items as long as they pass in the container. This process provides more security and a lower risk of damage, theft or lost items since the container is sealed by the shipper and is opened again by the consignee at destination.

The term "container" can have different meanings for different industries, but in the shipping industry "container" refers to an intermodal freight container, a reusable box made of steel or aluminum. A standard container is available in two sizes, 20ft and 40ft. There are also other types of containers such as high cube containers, with additional height, and are also available in two sizes of 40ft and 45ft.

A special type of container is a Reefer container which can be 20ft or 40ft and carries temperature-sensitive items. Reefer containers are basically container-sized refrigerators and as in any refrigerator the temperature could be set up and temperature-sensitive items could be transported for a long period of time without spoiling them. Reefer containers usually carry fruits, meat, ice cream or medicines and this procedure is known as cold supply chain because it needs constant coordinated actions to maintain temperature-controlled environments at all stages of the supply chain, from the production, the storage, the transportation until the delivery to the customer.

Similar are the insulated containers, which have a double door and the air inside is vacuumed so that it prevents heat or cold from entering inside of the container. This type of container keeps the same temperature inside of the container regardless the temperature outside and can also carry temperature-sensitive goods. Other types of containers are standard double-door containers, open-top containers, pallet-wide containers, side-door containers, flat-rack

containers and tank containers. Different types of containers are used for the transportation of different types and sizes of goods.

Visibility is a critical concept in containerized shipping industry, it refers mostly to the ability to track and monitor the movement of vessels and containers throughout the supply chain. In other words, visibility in shipping refers to the ability to know the location, the status, and the condition of goods at any point in time. It allows shippers, carriers, and other stakeholders to optimize their supply chain and improve their customer service. Common ways to achieve visibility in shipping industry is:

- Shipment tracking

Shippers and carriers are able to track the movement of their valued goods from origin to destination. This situation ensures that the shipment will be delivered on time, increases customer service, reduces costs, enhances performance and creates competitive advantage. Without tracking systems, it is almost impossible to determine the position and the condition of delivered items and inform the customer of their arrival. In different cases, these items are often considered as lost or stolen which causes business loss, customer dissatisfaction and reduced reliability of the company. Industries often face coordination problems in their supply network due to lack of shipment tracking through the logistic chain, from source to destination.

There are several tracking systems available like GPS, DGPS, GTIN, RFID, Barcodes, hyperbolic radio navigation systems and IoT sensors. However, not all of those systems are compatible for every industry. (Shamsuzzoha & Helo, n.d.) In the shipping industry, tracking systems are based on information architecture, where information is collected by the provider of the tracking service. Tracking systems are used for both vessel tracking and container tracking. Shippers and consignees, using advanced tracking capabilities, are able to track either the vessel or the container and be informed of delayed arrivals and departures, or any changes in schedule or their cargo status.

In order to determine the position of a vessel or a container, a unique identifier is used, either an automatic identification system (AIS) or a container-tracking device (CTD). All vessels over 299 GT which engage in international voyages and cargo vessels over 500 GT that do not engage in international voyages are from 2004 required to have an AIS. This regulation applies also to all passenger vessels regardless their size and destination. AIS is a system which automatically, every 10 seconds, transmits information like AIS positioning, the maritime mobile service identity number (MMSI), the rate of turn, the position coordinates, the heading and the course over ground. (International Maritime Organization, accessed on 25.05.2023.)

Other relevant information is transmitted from the on-board crew, every 6 minutes, regardless of the vessel's movement. Such information is the IMO number, the name, type and dimensions of the vessel as well as the destination and the ETA. AIS transmitting is required at all times in exception when international agreements or rules applied for the protection of navigational information or when it is believed that the transmitted information will compromise the safety and security of the ship and its on-board crew. Otherwise, it is not only illegal to turn off AIS transmission but also extremely dangerous. (International Maritime Organization, accessed on

25.05.2023.)This information is also used by authorities and maritime operators in order to optimize operations and ensure see safety. (Yang et al., 2019)

On the other hand CTDs are devices that are attached to the outside of the container. They use GPS and cellular communication technologies to track the location, the speed, the humidity and any changes in temperature or other environmental conditions that could impact the condition of the transported cargo. The advantage of CTDs is that they can also be used at areas that are not covered by AIS, for example, on small vessels that are not obliged to have AIS or on containers that are travelling intermodal after their unload at port, with train or truck to reach their destination. Studies have shown that containers that have CTDs have less chances of being stolen or lost. Some new generation CTDs even have additional security features and alerts, which notify the monitoring system in case the container is unauthorized opened or tampered with. (Miler, n.d.)

- Real-time monitoring

It allows stakeholders to monitor the status and condition of goods in real-time, especially in cold supply chain operations the constant real-time monitoring is essential and is required in order to guarantee that the strict transportation conditions are being held. (Mejjaouli & Babiceanu, 2018) Sensor devices, like RFID and/ or WSN (Wireless Sensor Network) can be placed inside the container to monitor temperature, humidity, and other environmental factors that could impact the quality of the goods.

The use of RFID-WSN devices, especially in cold chain operations, has been proven to reduce waste significantly. Studies have shown that 40% of food is wasted every year in the US. (City et al., 2012) This percentage could be reduced using integrated technologies and closely monitoring the supply chain operations. Not only is food transportation being impacted but also pharmaceutical products which are also transported through cold chain process.

In order to minimize loss for cold supply chain operations, virtual machines (VM) use the information retrieved from RFID-WSN for operational real-time decision making. The VM controller, based on this information, decides if a transportation failure has occurred or not and decides whether to reroute, stop the transit or continue with the initial route. In Fig.1 it is clearly shown how the monitoring and control system works, how the information is flown and the decision options that are available for the VM controller. This integrated technology eliminates loss, maximizes visibility and ensures that the ordered goods will be delivered in good condition.
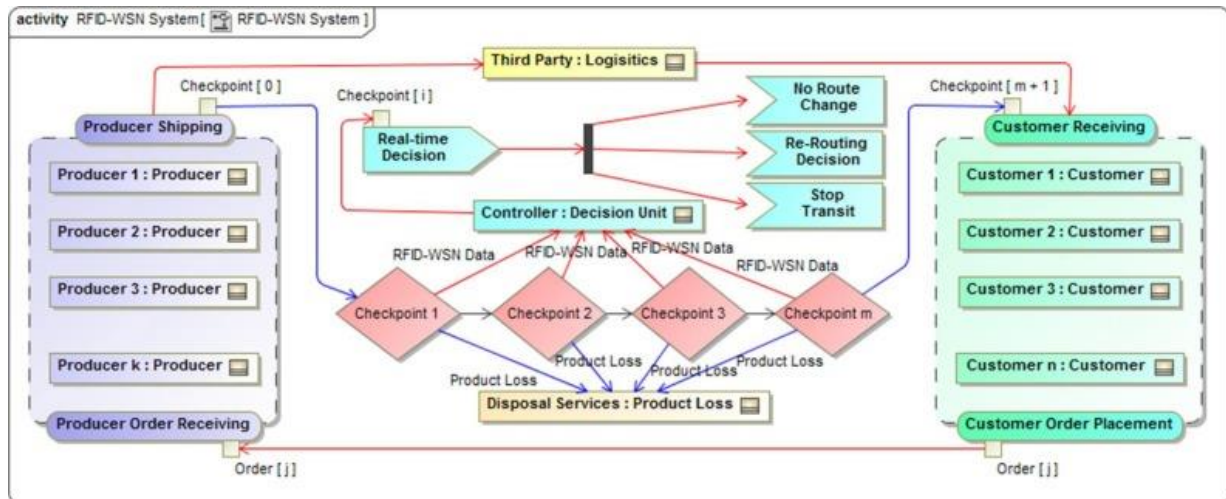
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Figure 1 Flow of goods and information in the logistics RFID-WSN monitoring and control system.

Source: S. Mejjaouli, R.F. Babiceanu / Computers in Industry 95 (2018) (p. 70, Fig.1)

- Inventory management

Inventory management can significantly increase visibility in the shipping industry by providing real-time information on the availability and location of goods. It is used to manage inventory levels and ensure that there is enough stock to meet customer demand. By tracking shipments and inventory levels in real-time, stakeholders can optimize their supply chain and reduce the risk of stockout or overstocking. The most valuable information in inventory management is the value of the demand.

The lack of this information can lead to an increase in the bullwhip effect and a reduction of the average service level as moving upstream in the supply chain. The bullwhip effect is a distortion in demand that causes amplified fluctuations within the supply chain infrastructure and can cause serious effects to all members of the supply chain if it is not managed. (Lee et al., 1997) However, this phenomenon can be reduced by the use of different inventory models and decision support systems (DSSs) within inventory management and route planning. (Costantino et al., 2014) By having real-time visibility into the inventory levels, stakeholders can plan an optimal shipping route and ensure that there is enough capacity to transport the required goods on time.

Studies have shown that there is a beneficial situation by combining inventory management and route planning in maritime transportation. Although manual planning is commonly used for routing, scheduling and inventory management, it has lately been observed that shipping companies plan to implement optimization based DSSs for routing and scheduling based on their individual needs. For those companies facing inventory management and routing problems in the shipping industry, there are already integrated systems under development. (Andersson et al., 2010) As a result of implementing those systems, there are financial benefits and an increase in service flexibility and agility.

- Electronic Data Interchange (EDI)

EDI is a computer system that enables the electronic exchange of documents between stakeholders. EDI helps to reduce human intervention and eliminates the need to exchange paper documents through email or fax. In shipping industry, customers, carriers, freight forwarders, brokers and even port authorities, are mostly communicate through EDI for the purchase orders, the shipping instructions, invoices, custom documents and other important documents regarding the cargo, the ship and the overall transportation process.

In the containerized shipping industry, EDI plays a very important role for the overall operations. If we consider that every container vessel can carry over 4.000 containers at a time, which loads and unloads in different ports all over its route, EDI is the only possible way to exchange documentation on time and in real-time about the containers, their final destination, their weight, their content and their position on board. EDI saves time, eliminates human errors and employs up to date information. (Garstone, 1995).

In Fig.2 it is shown how EDI is used. Every step through the supply chain is confirmed, thus visibility is enhanced through the whole transportation process until the cargo arrives at its destination and the invoice is issued. All supply chain stakeholders share information and are able to have an overview of the cargo as it travels through the supply chain.
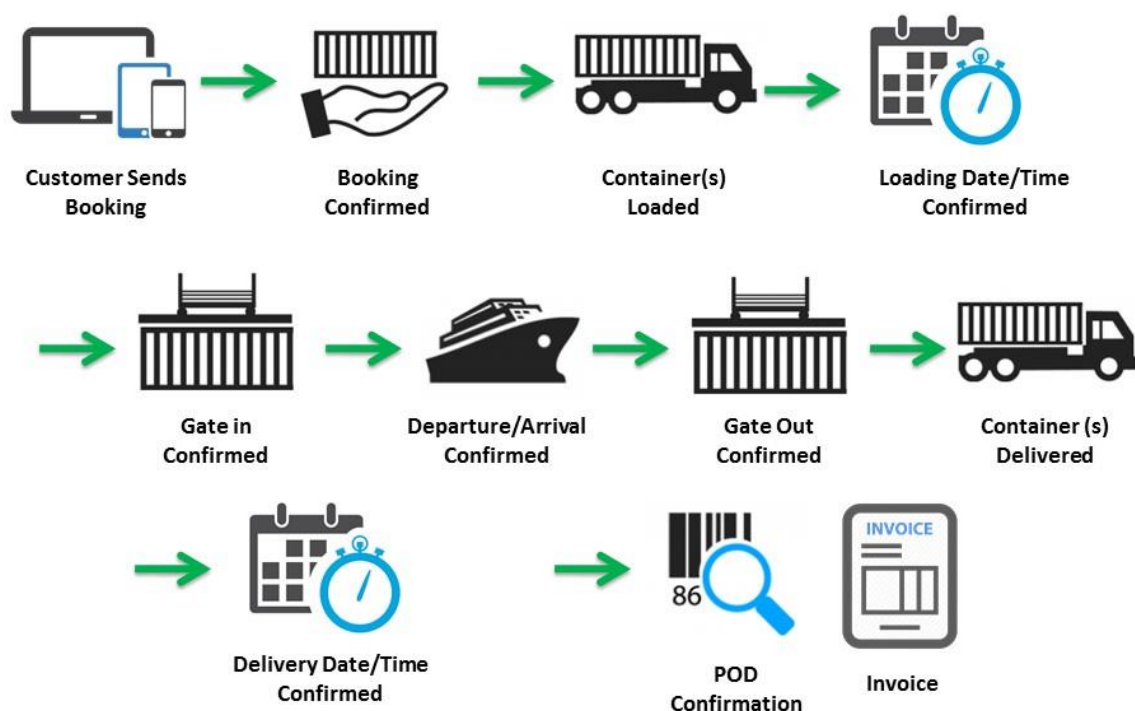

Figure 2 The use of EDI in shipping industry.

Source: https://www.eucon.nl/ (accessed on 30.03.23)

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- Internet of Things (IoT)

Internet of things has entered many industries, not just the shipping industry. According to the Internet of Things principle, all devices and objects (things) are converted from conventional into "smart" with sensors, new technologies and software that communicate, process the information and data received from other devices on the internet and can be controlled remotely. This information is analyzed and used in real-time or in near-real-time to optimize operations, create efficiency in the transportation process and improve decision-making by completing effectively automating tasks. Data is incorporated by multiple types of sensors which create a worldwide network of devices that connects people and things all over the world using the internet. (Aslam et al., 2020) In containerized shipping industry, "things" can be devices associated with the ship, the port or the transportation process, for example, containers, cranes, on-board equipment, navigation devices or ship engines.

By connecting those devices and by sharing this information, many intelligent applications have become available. Like for instance: route planning optimization, decision making in crucial situations, cargo tracking, emissions measuring, fuel consumption measuring, and automated berthing. All those applications enhance visibility and the fact that this information comes from different devices like, AIS, tracking and tracing devices, bridge data network, performance and weather monitoring make the operation processes easier and more efficient.
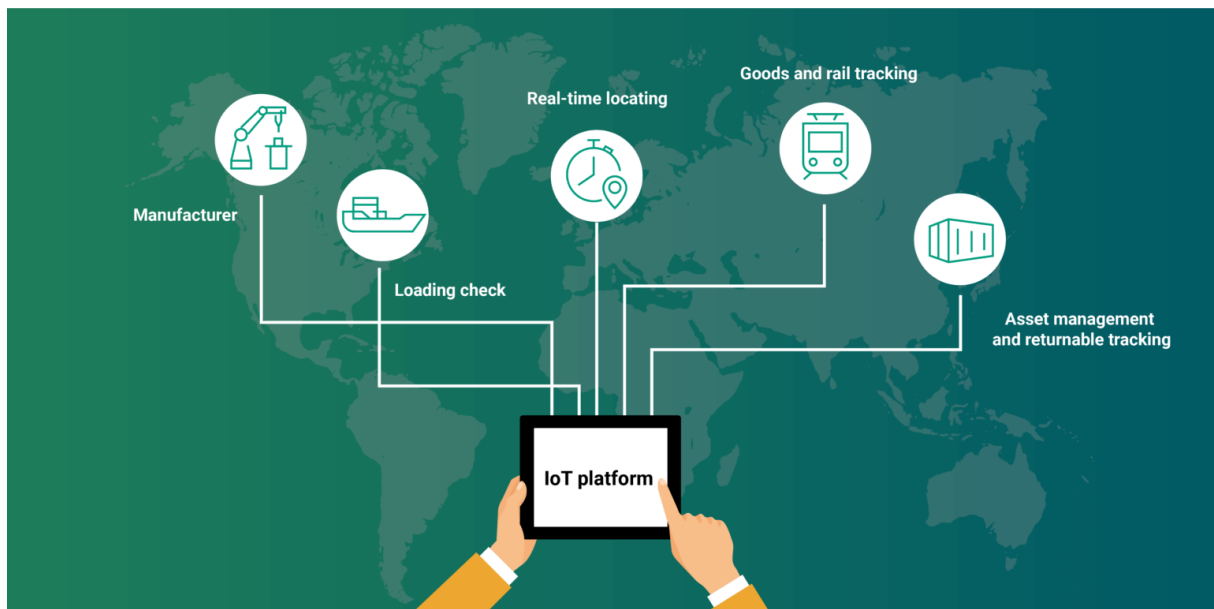

Figure 3 Internet of Things (IoT)

Source: https://www.container-xchange.com/ (accessed on 04.05.2023)

- Blockchain technology

Blockchain technology can be used to create a tamper-proof record of all the transactions and events in the supply chain. This provides a high level of transparency and accountability, which can help reduce fraud and errors. It creates authenticity and traceability by storing supply chain data and making it difficult to change once they are uploaded. (Rogerson & Parry, 2020) Although blockchain application provides continuous visibility, improves customs clearance and provides logistic transparency in the containerized supply chain, it significantly increases operational and set up costs. (Wang et al., 2021) Maritime transportation is considered to be low-cost and a high-efficient mode of transportation, it involves a large number of transport documents which delay the transportation process and eventually the cargo's on-time delivery.

Even though the implementation of blockchain technology increases set up costs, the efficiency and the transparency that it provides promotes long term cost-saving due to reduced errors and mistakes that previously led to money loss. Blockchain technology is applied in the shipping industry in order to enhance service and visibility through digital documentation and real-time cargo tracking. As a result, real-time optimization is achieved, and the decision-making process becomes more efficient. It is also known that blockchain can improve security, integrity and efficiency and it is seen as a tool that will fasten procedures and mostly custom clearance procedures which is the main reason a container is not released from port and delivered to its recipient.

- Cloud-based platforms

Cloud-based platforms can be used in the shipping industry to centralize and manage data from different stakeholders and increase visibility in the supply chain. This allows real-time visibility and collaboration between different parties, such as shippers, carriers, and logistics providers, to access and share data in real-time. Cloud-based platforms implement data storage and service analysis for large vessels, with the purpose of providing valuable insights during the transportation process.

The platform can store large data from different parties and provides analysis, for example, the shipping instructions and transportation documents that are uploaded from shipper, vessel and schedule information from carrier, shipment status and location from logistics providers. Having this information, the platform provides analytic insights which help stakeholders to optimize their supply chain, to communicate and collaborate for the most efficient outcome. Cloud-based platforms also integrate with other systems such as ERP for end-to-end visibility and better control over the supply chain. It is a flexible and secure solution which enhances collaboration between stakeholders and improves visibility in the supply chain. Stakeholders are able to reduce costs, improve operational efficiency, and enhance customer satisfaction.

Overall, visibility can be achieved by many ways and means like, platforms, devices, tools and technologies, either using their own information or using data retrieved from multiple devices, depending on which information is meaningful at the specific time and provide analytic

overviews to stakeholders. This way, stakeholders are able to plan and manage their operations for the most efficient outcome. In order for visibility to be achieved and thus all its benefits to be earned, it is important that stakeholders trust each other, collaborate and share information with each other to gain control and better insight over the supply chain.

2.2 The benefits of gaining visibility.

2.2.1 Environmental and social responsibility

During the last decade it has been observed that there are negative environmental and social impacts caused by the shipping industry. It is a fact that the shipping industry has a massive impact on the environment. It is responsible for air pollutant emissions, oil and chemical discharges, litter and sewage in the water. In addition, there is often an abuse in maritime policies, like the use of flag of convenience which is actually a way to avoid national or regional regulations and lead to tax evasion. However, there are not only environmental impacts but also reduced safety levels in shipping activities and social problems between employees on board. (Parviainen et al., 2018)

Although there are international maritime policies and regulations set by United Nations' International Maritime Organization (IMO), there are also voluntary measures that are taken lately to promote environmental and social responsibility in shipping industry. Corporate social responsibility (CSR) practices have been widely studied in different businesses, however there are numerous definitions, as its perspectives change over time. CSR mostly refers to situations where organizations act privately and voluntarily *"beyond compliance or requirement by law"* (McWilliams et al., 2006) and pursue solutions that will benefit the organization in a social level.

Environmental and social responsibility in the shipping industry is driven by the need to gain a more environmental-friendly image which will bring, among other things, also competitive advantage and better financial performance. But, unfortunately less attention is given to different social issues that need to be addressed, such as work safety, labor rights, customer relations and the increased transparency in operations. (Parviainen et al., 2018) CSR activities in shipping industry are evolving, as new demands appear from regulators, customers and investors. From pollution prevention to ocean resilience, from philanthropy to sustainable product trade. But how does visibility help an organization overcome environmental and social issues?

As it is already mentioned, there is still no concrete definition of visibility, but scholars mention visibility as information-sharing across the supply chain and the use of this information in real time. Visibility also strengthens the relationships between stakeholders, by sharing meaningful information with each other and effectively collaborating. Based on Baah et al., 2022 *"supply chain collaboration positively and significantly interacts with supply chain visibility, stakeholder trust, environmental and financial performances."* Based on this study the collaboration between stakeholders not only enhances performance but minimizes environmental and social issues.

Nowadays, stakeholders insist that their organizations operate with environmental consciousness and adopt practices that enhance corporate sustainability, environmental and social responsibility. However, the collaboration between stakeholders and thus the implementation of environmental and social practices completely depends on the information that is shared among stakeholders. This means that visibility plays a significant role in the way an organization operates in relation to environmental and social issues. The more information is shared through the supply chain and visibility is gained, the more effectively an organization can act.

For example, by having visibility and real-time insights into the movement of a shipment, a company can optimize its resource utilization, by consolidating shipments or by optimizing routes for its benefit. This way fuel consumption is minimized, and carbon emissions are reduced. Many visibility platforms provide accurate data on transportation activity. By optimizing transportation routes and modes, companies are able to measure and manage their carbon footprint. By implementing eco-friendly initiatives, it is observed that companies can reduce their overall carbon emissions associated with their freight operations.

By providing information about suppliers' transportation practices and carriers environmental performance, companies can wisely select suppliers and carriers who align with their sustainability goals. Collaborating with suppliers and carriers who share the same mindset, businesses can promote their environmentally responsible practices throughout the supply chain and create competitive advantage.

Also, by monitoring and sharing information about carbon emissions and other environmental impact indicators, a company can ensure compliance with regulations and emissions standards, avoid penalties and sustain a positive environmental reputation. Visibility plays an important role in corporate social responsibility, especially lately when stakeholders are concerned about environmental sustainability. Visibility enables companies to demonstrate transparency in their operations and actively manage and minimize their environmental impact. This way companies meet stakeholders' expectations, maintain an eco-conscious reputation and attract more environmentally conscious customers. (Hasan, 2013)

2.2.2 Improve performance

Supply chains nowadays have become more complex, and visibility is the key to achieving long-term competitiveness in the supply network. The primary purpose of supply chain visibility is to improve the company's performance, reduce losses and raise profit. However, collaboration between stakeholders and information sharing is essential to gain visibility of the supply chain. (Bartlett et al., 2007) It is very important for stakeholders to have knowledge about their planning, production and transportation processes in order to recognize any potential problems or discrepancies that can pass from one part of the supply chain to another. The aim is not only to act fast to solve the problem but also to prevent delays that will be caused by them further down in the supply chain.

Visibility will enable different parties to work together in a unified manner, based on an optimized performance plan. Having an optimized performance plan, stakeholders are provided

with a level of requirements and demands that need to be met to optimize operations. Having this standard, it is better to recognize when and where improvements are necessary. For example, "improved performance" can have many meanings, for some companies it could be better customer service or even cost control. For a company that struggles to gain customers, new customer contracts can be a great success. A company that needs to manage its costs and finances could improve its performance and reduce costs by providing meaningful information to stakeholders and together creating an optimized performance plan. (Yu & Goh, 2014)

To improve performance, it is necessary to recognize what "improved performance" is for the specific company and what improvements could be made to reach this goal. Greater visibility gives information to stakeholders and based on that information an optimized plan could be created with the necessary improvements.

2.2.3 Reduce risk

Lately the vulnerability of the supply chains towards disruptions has increased dramatically. This has less to do with unexpected events such as wars, terrorist attacks or pandemics, but mainly with business strategies that companies lately adopt. Based on Christopher & Lee, 2004 companies tend to adopt "lean" practices, outsourcing and they often reduce the size of their supplier base. These practices often expose supply chains to risks as a company becomes less agile and less flexible. This way companies are more likely to face risks and it would be more difficult for them to make optimal decisions.

Greater visibility throughout the supply chain enables stakeholders to predict and prevent potential risks and disruptions. By identifying vulnerabilities stakeholders can control and mitigate escalations and are able to make informed decisions. Supply chain visibility provides the opportunity to better understand the issues and risks associated with the specific supply chain and through monitoring analytic data, to evaluate suppliers, logistic providers and other stakeholders. The increased communication and collaboration between stakeholders and the information that is shared is useful to make forecasts and take effective decisions.

Supply chain visibility and the ability to monitor risks and threats can also build flexibility and resilience in a company. It provides the capability to make decisions about events that will happen in the future and take actions to minimize the impact of an unexpected event. Such events could be natural disasters, geopolitical disruptions, wars or pandemics. Visibility helps a company to be agile and adaptable towards challenges, for example with optimal route planning or to find alternative suppliers in the same area (which during COVID-19 was essential for a company's existence).

Of course there are risks that although they are forecasted, their impact cannot be minimized. Such events are for example port congestions during the pandemic and the resulting delays due to lack of port staff.

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2.3 Visibility vs. Traceability

It is commonly seen that the concepts of supply chain traceability and supply chain visibility are used interchangeably in order to express information sharing among the supply chain. Although they are related concepts, scholars have proved that they refer to different aspects of the supply chain. (Roy, 2021)

As mentioned, visibility often refers to the ability to monitor and to track the products as they travel through the supply chain. Visibility enables us to monitor inventory levels, transportation routes and the condition of the cargo in real-time. Although there are many different definitions of traceability, for example: ISO 9000, ISO 22005, the EU General Food Law/Regulation 178/2002, they all agree to the fact that traceability refers to the ability to trace or follow the origin and the movement of a product from the beginning of the supply chain to the end of the supply chain. (Olsen & Borit, 2013)

Based on Moe, 1998 traceability is managed by traceability systems and can range from in-house traceability in the production plant, to traceability in the whole production chain, from raw materials to end-customer. Based on Dabbene & Gay, 2011 its main goal is to "*log the history of the location of the different products along the supply chain*". Traceability enables stakeholders to follow the journey of raw materials as they are heading towards manufacturing up until the end-product reaches the end-customer.

Using traceability systems, the information that is gained from the origin could be about how the products were produced, processed, packed and transported. Information about the container, how it is stowed, at what temperature the container is adjusted or the status of the cargo at any given time as it travels. This information is necessary to ensure product quality, product safety, compliance with regulations, and ethical sourcing practices. In addition, it could help companies to identify a potential source of quality issues in terms of defective items, to reduce cost and demonstrate their compliance with regulations.

Overall, traceability's main purpose is to inform the end-customer about the whole life-cycle of the product and provide validity. It is mostly used in the food, medicine and agriculture transportation, and is a fundamental and mandatory requirement in all developed countries (Dabbene & Gay, 2011) as it is directly connected with safety and public health in a way to diminish food epidemic incidents. (Demestichas et al., 2020)
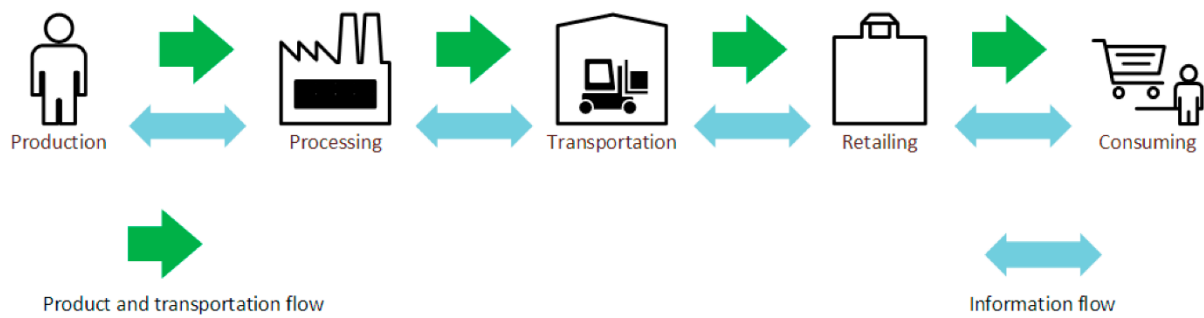
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Figure 4 Traceability system product and information flow.

Source: (Demestichas et al., 2020)

Similar with visibility equipment, traceability systems gather their information from RFID sensors, IoT, blockchains etc. Traceability methods are not only used to trace the life-cycle of a product but also used to secure documentation and assure stakeholders about a smooth operation procedure. It is known that in the shipping industry, in multi-tier supply chains, the paperwork is extreme. Traceability systems are also used to find the origin of a document, to trace it back to its source in order to ensure the compliance with regulations and ensure the quality of the process. Also, due to the complexity in the industry and the lack of trust and information sharing between stakeholders, documentation procedures are becoming even more time consuming. Due to these delays, costs emerge during the shipping process. (Elmay et al., 2022)

To eliminate the costs and optimize the shipping procedure, traceability methods are commonly used. The most common implementation in the shipping industry in terms of documentation tracing is blockchain technology. Using blockchain technology, we are able to trace the movement and exchange of documents, such as bills of lading, certificates of origin, dangerous goods declaration or customs declaration, ensuring the accuracy and completeness of documentation.

By using traceability systems, the operational efficiency is improved, excess effort is reduced, costs are reduced, delays and penalties are eliminated. Traceability is a similar concept but quite different from visibility. However, the information that is gained through traceability systems and methods enhances the overall supply chain's visibility and is an essential part that provides correct solutions and an advantage in the whole transportation procedure.

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3. How disruptions affect visibility in containerized shipping industry

3.1 Financial crisis 2008-2009

Goods and materials were not always located where they were required, and so global transportation services were desperately needed. Ocean transportation became an important part of the global economy as it could move big amounts of goods and materials to points of consumption. Globalization played a major role in this situation; it transformed the shipping industry and forced it to serve its demands. Globalization increased the amounts of traded goods and therefore larger container vessels were needed. Containerization also brought an advantage to globalization and to the shipping industry as freight could be transported with different modes even if the consumption point is not near the port of delivery. (Corbett et al., n.d.)

From the years 2000 until 2009 there was rapid growth and expansion in the shipping industry. Freight rates were high, cash was available, and banks were lending at competitive rates to ship owners for their vessel expansion. This era is known as the booming period in shipping industry, the construction of more advanced and with increased capacity ships, the expansion of ports and the introduction of new shipping services were the reasons that the industry was very successful and profitable in addition with the increased demand of goods and materials from developing economies. (Kalgora & Christian, 2016)

However, besides this booming era, the shipping industry was strongly affected by a financial crisis in 2008. The resilience and flexibility of a system are tested by every crisis. The demand and supply of goods, raw materials and shipping services is driven and affected by the economy, the global trade, and most important, by politics. A decline in economic activities and consumption resulted in an immediate drop in international trade.

Since 90% of international trade is transported by ocean transportation, the impact was enormous. During 2008 the freight rates reached the lowest point in the history of containerized shipping industry, while ship owners struggled with low demand for their vessels. During this time, the global financial and economic crisis strongly impacted the demand for containers and vessels, resulting in overstocked ports with empty vessels waiting for the crisis to be over. The fall in freight rates challenged ship owners and logistic operators, and unfortunately not all companies could survive the crisis and the competition resulting in bankruptcy.

Companies struggled to remain profitable, they had to reduce their fleet and their staff and cut costs to survive. During that period, banks were skeptical about lending money to ship owners and investing in the industry, which made it difficult for companies to obtain funding for their projects, to raise capital and be able to survive. These actions caused a decline in visibility, as companies were no longer able to operate at the same level as before the crisis. The reduced number of vessels in operation made it difficult for companies to manage cargo effectively.

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Visibility is strongly connected to trust, communication and information sharing between stakeholders and affects the performance of the whole supply chain. During the financial crisis, the efficiency in operations was heavily impacted not only due to companies' downsizing but also due to lack of staff. In 2008 companies did not have the technology that they have now, automation or sensors, and information sharing was more challenging than it is now. With lack of staff and desperate for cost reductions, companies made limited investments in new technologies, tracking and tracing systems to be able to monitor cargo, which led to a long-term impact of visibility.

The reduced world economic activity did not affect only the ship owners, but also ports and logistic operators. Companies were led to bankruptcy which disrupted supply chains and reduced visibility over cargo. In general, the financial crisis had many negative impacts on visibility in the shipping industry. However, these effects were mitigated by the reduction in shipping volumes and the increased focus on efficiency and cost reduction in the industry. (Notteboom et al., 2021)

3.2 Covid-19

It is known that disasters usually happen at a local level and rarely reach global proportions. However, Covid-19 caused a global emergency, similar to the financial crisis in 2008-2009, and it was characterized as a catastrophic event. Covid-19 was a health crisis, which caused the ripple effect and affected the global economy and international trade. The ripple effect describes a situation where disruption propagation impacts supply chain performance as well as supply chain structural design and planning. (Dolgui et al., 2018)

From the beginning of the pandemic, many countries trying to contain the infection spread, closed their borders, shut down manufacturing companies and applied an obligatory social distancing. The transport network and operations were first impacted by the new regulations.

However, the cargo shipping segment did not shut down completely, but it was heavily impacted. During the pandemic, shipping networks were affected the most, resulting in miscommunications and lack of information about vessel position and vessel status. The reason behind those disruptions is still unknown, could be the lack of port staff due to port restrictions, a reduction in demand or the collapse of industrial production in different ports. (Dirzka & Acciaro, 2022)

At the beginning of the pandemic, only Asian ports adopted restrictive measures, however as the virus spread across the globe, other foreign ports followed the restrictions. Covid-19 caused disruptions to global supply chains, which led to delays, port congestion and capacity limitations. As a result, shippers faced difficulties in tracking and monitoring their cargo movements which then led to poor visibility in operation procedures and global supply chains.

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During the pandemic, there was a sudden need for medical supplies which caused an increase in demand. Restrictions in manufacturing and in transportation operations led to shortage in containers and lack of capacity on vessels. Delays and longer transit times made it difficult for shippers to track and monitor the status of their cargo effectively.

Furthermore, as the virus spread across the globe, border closure and quarantine measures affected labor and dramatically increased operational costs. Considering these challenges and the poor visibility, it was difficult for shippers to make informed decisions about routing and delivery schedules.

In order to address these challenges, logistic providers and carriers implemented new technologies to improve visibility, like real-time tracking systems which provide up-to-date information about the location and status of the shipment or digital platforms and communication tools to improve collaboration through the supply chain. Also, real-time congestion data were available, that shows waiting times at ports, as well as border-crossing waiting times for over-the-road loads.

In sum, Covid-19 had a significant impact on visibility in the shipping industry. Nonetheless, the pandemic highlighted the importance and the need of visibility and adaptability in ocean transportation. Despite the demand reduction and the reduced profit, companies had to invest in new technologies and processes to improve visibility and to optimize their operations in order to stay competitive. Not to mention trade agreements and new regulations that were established and are meant to challenge the future of the shipping industry.

3.3 Container crisis

The container crisis is a term that was used during the pandemic, where lockdowns, lack of staff and limited operations in ports set off a chain reaction of disruptions. During the pandemic, the sudden increase in demand of medical supplies caused a severe container shortage which affected the global port network. Limited operations in ports due to lack of port staff resulted in anchored vessels that patiently waited their turn to be unloaded. This situation lead to a delay in acquiring the empty containers in order to be available for the next customer to use.

Figure 5 The container shortage crisis

Source: https://www.wsj.com/ (accessed on 30.04.2023)

From the second half of 2020 the container shortage crisis strongly influenced the market. The cost per container reached approximately 280% higher than it was a year ago and the container shortage forced shippers to consider other possible methods of transportation. (Guerrero et al., 2022) Not only the lack of port staff but also the lack of truck drivers led to a general shortage of workforce that move goods.

Shippers had to come up with new ideas and techniques to handle the container shortage. They tried to use breakbulk shipping for their cargo instead of containers or to use the cross-docking procedure, where the received goods are sorted in a warehouse at the port according to their destination and then moved to the outbound transportation dock and loaded to outbound vehicles. This procedure enables containers to be quickly available for the next customer.

But the lack of visibility into shipping status aggravated the container shortage. In order to bring containers quickly back in rotation, new technologies like container tracking API were used to provide real time container tracking information and digitize the transport operation. At this stage visibility tools were essential to provide information about the container, its movements and when it will be available again for the next customer. In addition, modern AI

helped stakeholders to optimize their logistics planning in terms of container management, such as empty container repositioning, maintenance and storage.

Nonetheless, two years later, at the end of 2022 the global shipping industry faces the exact opposite problem, too many empty containers. Shippers say that the global consumer demand declined, and this phenomenon is not, as they initially thought, a sign that the economy is normalizing. As a result, container depots are filling up with containers, leaving them no option but to decline requests for depot service agreements.

In conclusion, during this 2-year period a lot has changed in the global shipping industry. The importance of visibility into container and shipping status is crucial for efficient operations and helps stakeholders to be agile, prepared and be able to take actions for every situation regardless of the circumstances.

3.4 Ukraine/Russia conflict

Around the beginning of 2022, another operational issue affects visibility in the shipping industry. The conflict in Ukraine and the invasion in Crimea which was annexed by Russia in 2014. This conflict caused the disruption of shipping routes in the Black Sea region, due to closure of several Ukrainian ports. Companies had no other option but to cancel or reschedule their shipments, resulting in business loss. For shipments that had to pass through ports with high risk, increased insurance costs had to be applied.

The ongoing conflict led to tensions in the region which impacted the safety and security of vessels. Concerns about piracy or other security risks make it difficult for companies to operate. It is important to mention that Russia and Ukraine are responsible for a major disruption in international trade and supply chains, inflation and immigration. (Orhan, 2022) Also, the war impacted the worldwide political stability. (Jagtap et al., 2022)

In addition to that, port congestions, container shortages and surcharges are a few more impacts of the Ukrainian conflict. But how did the Russian/Ukrainian conflict affect visibility? In the beginning of the conflict, in many Ukrainian regions there was electricity blackouts which led to limited communications which worsens the vessel and cargo operations, as well as visibility and information sharing. However, it was indicated that vessels who pass through Ukrainian ports should continue to transmit AIS signal containing only basic information as there was high risk of GPS jamming, AIS spoofing, communications jamming, electronic interference and cyber-attacks.

Visibility in shipping industry is based on accurate and meaningful information, if this information is by any means falsified, the result could be disastrous. Mostly because companies rely on this information in order to ensure the position of the vessel and the status and security of their cargo and the onboard crew.

3.5 European energy crisis

There are many reasons and combinations of events that resulted in the European energy crisis that is happening in Europe. During Covid-19 there was a great demand for natural gas as countries applied shutdowns and quarantines, making it more expensive to import fuel from Russia and other countries towards Europe. Also, the fact that the previous winter was cooler than usual and the low production in Russia, led to high prices.

Moreover, the shortage of renewable energy production due to bad weather conditions meant that countries were more dependent on fossil fuels to meet their energy needs. As a result the prices reached record high levels leading to concerns about energy security and supply.

The European energy crisis did not leave the shipping industry untouched. The main factor in this crisis is the increase in natural gas prices, which lead to an increase in electricity and heating fuel prices. Shipping vessels rely on natural gas or fuel oil for their power and an increase in prices results in higher operational costs. High operational costs lead to increased shipping rates or reduced profit which can impact competitiveness.

Similar to some European countries that faced fuel shortages during that time, it is possible that companies also faced difficulties in securing fuel for their vessels. In this case it is possible that companies could adjust their schedules or routes to preserve fuel or find alternative sources. Fuel shortage problems could result in surcharges, cancelations, delays or disruptions in operations with a wider impact on global trade and supply chains.

Supply chain disruptions due to energy crisis also impacted visibility in the shipping industry. Shortages of raw materials and components or disruption in transportation processes make it more difficult for stakeholders to share accurate information about their cargo. Yet, visibility is only indirectly impacted by the energy crisis as it is an operational issue, and it is not directly affecting information sharing or visibility tools and technologies.

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4. The effects of poor visibility in containerized shipping industry

Freight visibility as I mentioned is essential for well-coordinated operation procedures. Not only shippers benefit from transparency and information sharing but all stakeholders throughout the supply chain. The lack of transparency and visibility causes complexity in the supply chain. However, a few years ago shippers were happy only to receive a notification that their shipment was on its way, nowadays a text is not enough, and shippers demand more accurate information and that in real-time.

As technology evolves, stakeholders have the ability to track and trace shipments from the point of collection to the point of delivery, including the hubs it crosses, its transit location and other more specific details of the cargo. But this was not always the case. There were situations where information sharing was difficult and visibility levels were low, especially during disruptions or crises (Covid-19, financial crisis, wars) that led stakeholders in a position to take immediate actions in order to meet operational goals. However, despite the preparation and the company's agility there is no way to prevent those undesirable events. (Berle et al., n.d.)

Nonetheless, scholars argue that although technology evolves and new platforms, tools and equipment are now available, the adoption in the shipping industry is relatively slow. A survey (*How Do Companies Book Ocean Freight for SOCs?*, 2022) in Copenhagen Business school highlights the situation and shows that over 80% of the participants (freight forwarders and NVOCCs), source quotations via email and phone, the reason behind this decision is mostly the lack of trust in online platforms and quotation solutions. Around 70% of the participants use the same process to place a booking.

For a very long time in the shipping industry, the lack of visibility and digital processes led to inefficiency and mistrust. Often the data quality is questionable because of the lack of a common communication system, which is not only time-consuming but also costs money. Yet, that is not the only negative effect of poor visibility. Poor collaboration, misunderstandings, low network optimization, high costs and additional charges are some of the results of limited or no access to a logistic visibility platform and limited application of tools and data.

It is also important to mention the ripple effect, which is created due to poor freight visibility and the issues that come with it. The longer delivery times, the increased costs, the delayed process of freight and shippers in a reactive state. Repercussions can be caused even by a minor issue in the supply chain and small inefficiencies quickly evolve into significant disruptions that cost companies not only money but also resources and time.

Without reliable and accurate shipment visibility, shippers could face slow response times, higher error rates, missed loads, damaged goods, and more. In addition, problems with scheduling and collaborating can emerge due to limited visibility in terms of shipment movement, as the on-time arrival of goods is vital for every company, especially for companies that rely on just-in-time inventory management.

Limited freight visibility can also cause some inaccuracies in routine processes. Invoices, freight bills and customer payments are some of the documents that present a great opportunity for errors and mistakes. Those mistakes could only be a few dollars but imagine the frequency and the duration that those mistakes could be made. Limited logistic intelligence leaves those mistakes unreported, unaddressed and a company that losses money.

I mentioned before that visibility strongly affects the collaboration between stakeholders, the agility and the overall performance of the supply chain. Information sharing among stakeholders is a key to enhancing competitive gains. The ability to share information across the supply chain will enhance collaboration, build trust among stakeholders, enhance agility, improve supply chain performance and will create a competitive advantage. (Baah, Opoku Agyeman, et al., 2022)

By sharing meaningful information, financial documents and materials with the stakeholders, supply chain connection and visibility are improved. But what happens when there is limited or no visibility? The combination of limited information, limited network collaboration, and outdated processes and procedures can cause a major profit loss, mistrust among stakeholders, customer dissatisfaction and stakeholders that are no longer able to meet volume fluctuations.

Another factor that is influenced by visibility levels is the reliability of a company. Stakeholders improve reliability using tools and equipment in order to be competitive in the market. An unreliable company will face customer dissatisfaction and customer turnover which leads to capital loss and difficulty in attracting new customers. Reliability is strongly connected with a company's image and affects the ability to attract new customers and maintain them.

Blockchain technology was initially used in shipping industry among stakeholders to manage documentation, such as bills of ladings and invoices in order to be tamper-proof and to be accessed in real-time only by authorized parties. (Korepin et al., 2021) This action dramatically improved reliability and trust in maritime transportation and is now used by many companies with great success. It is a tool that promotes trust and reliability throughout the supply chain and creates competitive advantage.

In conclusion, visibility in containerized shipping industry is a key as the industry becomes more digital. The effects of poor visibility throughout the supply chain are tremendous, but above all, in order visibility tools and equipment to be widely used the most important is trust. The lack of trust in new technologies and platforms is the main reason that the shipping industry took so long to adopt them and the reason that visibility levels for many years were at a very low level.

5. The dangers of digitization

The digitization of shipping industry not only brings an advantage in global international trade, increases visibility and promotes information sharing, but also poses great threats and risks. Attacks and risks were common issues in the shipping industry as soon as the implementation of new technologies and the use of internet was widely established. Every crime that involves violating a technology tool, a computer system or involves the use of internet is categorized as cyber-crime or cyber-attack. (Clark, 2018) However, for a cyber-attack to occur there needs to be a target, a driving motive and a chance for the crime to happen. (Lallie et al., 2021)

For many years, the maritime transportation was mainly considered a secure transportation mode due to the lack of internet connectivity and the inaccessible location of ships in the open sea, but recently there is observed a great increase in security breaches as the industry becomes more digital. Over the years the number of cyber-attacks has rapidly increased, resulting in financial loss, damaged reputation and loss of trust between stakeholders. (Akpan et al., 2022)

As the technology evolves so increases the need for security in cyberspace. Information and personal data breaches are an everyday issue that needs to be addressed, especially after the Maersk incident. In 2017 the major ocean carrier, Maersk, had to temporarily shut down all of its systems due to a cyber virus that infiltrated into its systems. Every internet connected device was infiltrated, servers, routers, VoIP phones, physical access settings and other infrastructure. The virus spread rapidly throughout the company's network. A few hours later, the company's network was deeply corrupted, and the company had no other option but to shut down its operations.

The company struggled 10 days to rebuild its network, and months to bring the software functionality to normal levels. Considering that Maersk is responsible for the one-fifth of global trade and operates with more than 800 vessels in more than 70 ports, this cyber-attack caused the company to lose around $ 200 million to $ 300 million. The loss was not only monetary, but transported goods like commercial and humanitarian agricultural goods spoiled and raw materials for factories failed to be delivered, impacting economy around the world. However, it was later discovered that Maersk was not the initial target, but Maersk was attacked accidentally.

The Maersk attack was an example of how much a cyber-attack can affect financially not only a company but the global economy and trade. This incident pointed out the need for education in promoting cyber security measures. However, it is observed that in maritime transportation, 100% cyber security is nearly impossible to be achieved, due to continuous satellite internet communications. (Dimakopoulou et al., 2019)

Figure 6 Trucks in port of Mumbai after "NotPetya" attack in Maersk's system

Source: https://www.hypr.com/security-encyclopedia/notpetya (accessed on 01.06.2023)

Another great example of cyber-attack is the incident in the port of Antwerp in Belgium back in 2011. Over a long period of time, an organized criminal group managed to remotely gain access to IT systems that control the movement and location of containers. This criminal group managed to retrieve data regarding the security details of containers, and eventually they gained control of the movement and the location of containers for over a period of two years.

The criminal group hired high level hackers to infiltrate the IT systems of at least two companies that operate in the port of Antwerp and access secure data with the aim to steal the transported cargo from the containers. In addition, they used this information to smuggle drugs and weapons in the containers and extract them right before the legitimate owner of the cargo arrived to empty the container.

Unfortunately, the port was able to discover the compromise only after entire containers went missing with no explanation. As soon as the software was discovered and neutralized the criminals violated the computers in offices that were connected to everyday objects in order to intercept data from systems. (Clark, 2018) Such a complex attack led experts to believe that attacks on shipping and port infrastructure will continue and the supply chain's security should be a priority. Police enforcement and governments should be well informed and ready to cope with cyber-attacks and the manipulation of the internet-connected systems.

Not only port operations, but also vessels are under attack. More recently, during COVID-19, vessels were targeted due to their cargo, mostly because they carried food, medical supplies or vaccines. It is known that the pandemic impacted people's lives and the socioeconomic system.

During the pandemic, the increased anxiety and poverty could lead people to engage in criminal actions. Criminal actions towards shipping vessels were common issues over the years from criminals who aimed to physically take over the ship in order to take hold of the cargo. Recent reports reveal that physical piracy acts and armed robberies at African waters in regions outside Somalia and the Gulf of Aden have decreased, but the threat always remains. However, the Gulf of Guinea is a region that maintains high levels in piracy and organized crime.

Even though piracy acts and armed robberies in many regions have been reduced, digitization reveals threats about which we should very much worry. Cyber piracy is the new generation of piracy, where criminals take control of vessels through their internet-connected systems. Because today's vessels rely heavily on technology and digitally connected devices, cyber pirates aim to disable or hijack the internet-connected systems of a vessel. GPS, loading operations, emissions control, or asset tracking are systems that are connected to internet and cyber criminals target in order to distract, divert operations or reroute the vessels into more isolated areas for theft. After all, vessels can carry valuable goods that cost billions of dollars.

Cyber security has become even more an issue since autonomous ships started operating. Autonomous ships are more vulnerable to cyber-attacks since they operate with increased on-board digitization and increased autonomy, often referred to as "Shipping 4.0". The fourth industrial revolution will affect maritime transportation with new technology implementations such as AI, Big Data Analytics and will replace traditional vessels with autonomous, "smart" ships with enhanced efficiency. (Aiello et al., 2020) However, an autonomous ship's digital infrastructure is highly exposed to cyber-attacks and cyber risks. (Kavallieratos & Katsikas, 2020) The hazards that a MASS is facing are less for the ship itself or the cargo it carries, but the threat of a ship under external command, in case it is used to cause structural damage on shore or along the coast. (Haugen et al., 2018) Unfortunately no study to date has analyzed and identified the potential cyber threats and cyber risks of remote controlled or fully autonomous ships. (Kavallieratos et al., n.d.)

Overall, although digitization as it is mentioned brings advantages to shipping industry, enhances visibility and trust among stakeholders, it can cause major threats and attacks that can cost not only money, but also reputation, reliability, and in extreme cases could cause human lives. Therefore, security in all forms should be a priority to minimize threats and secure a safe operation procedure.

6. Case studies

6.1 Maersk-IBM and TradeLens

It was 2016 when Maersk noticed that paperwork in the shipping industry was overwhelming. For decades, physical movement of large amounts of paper documentation was necessary in this industry and as a result it was associated with delays, human errors, and fraud. (Jovanovic et al., 2022) For a single shipment, more than an inch-thick pile of paperwork was needed. Often delays in shipments were caused due to paperwork not being on the right hand at the right time.

Sometimes cargo was waiting at the port but could not be released from customs because paperwork was wrong or not even there. Needless to mention the errors and mistakes that sometimes hinder the whole shipping procedure. Maersk saw an opportunity to optimize ocean transportation procedures by partnering with IBM and together they developed a platform that will change ocean transportation forever.

IBM is a technology company that provides blockchain solutions. Blockchain technology is an encrypted system which ensures that the data in a network is monitored, validated, permanently recorded and stored by the users that have access to this network. (Öz & Gören, 2019) During this time blockchain technology was used in cryptocurrencies and gained much population, but Maersk and IBM were interested in blockchain for reasons beyond cryptocurrency.

In the middle of 2016, Maersk and IBM began a series of pilots to evaluate blockchain. Using Maersk Lines ships and customers like Tetra Pack or Dow Chemicals, the value proposition and the technological capabilities were tested by running the customer through the trade lane. As soon as the shipment was completed, through different examples it could be identified where value could be generated. The result was improved process flow and greater visibility. The only remaining concern were the privacy and the security issues, which Maersk and IBM encountered working with customs and government agencies such as Customs Administration in Netherlands and Homeland Security in the US. (Lal & Johnson, 2018)

In 2017 Maersk and IBM announced their intent in creating a global trade digitization platform that will be used by the whole shipping industry. A secure digital solution for the exchange of digital documents which will increase visibility in the supply chain and optimize operations. The platform's goal is to provide transparency and simplicity in the global trade movement.

The platform will be available to every stakeholder, but the value proposition will be different according to the person's position in the shipping industry e.g., different value proposition will have a shipper, and different a customs authority. The platform will use blockchain technology to provide security in documentation and permissioned access to ensure access only to those that are involved in the transaction. Trusted stakeholders could digitally access documents and approved parties could digitally sign those documents. (Lal & Johnson, 2018)

In 2018 Maersk and IBM launched a digitized, shared and neutral platform, TradeLens, to provide customers digital freight solutions. TradeLens created a digital revolution providing greater visibility in the supply chain, security and trust among stakeholders, and eliminated time-consuming processes regarding documentation. After its launch other companies followed with similar platforms.
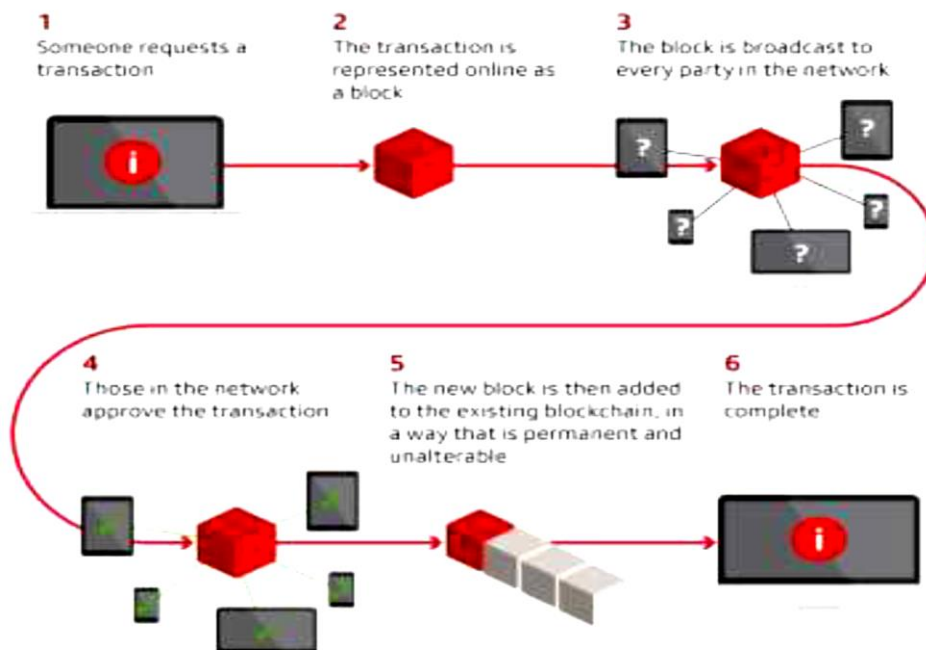

Figure 7 Blockchain Process

Source: Crosby, 2016

Despite the platform's functionality and success, in November 2022 TradeLens team announced the discontinuation of the platform. Maersk and IBM stated that the platform did not reach the level of commercial viability which was necessary in order to continue its use. Later on, he team started to withdraw offerings and the platform was planned to shut down by the end of March 2023. However, Maersk and IBM will continue their efforts to digitize the supply chain through other solutions.

6.2 Flexport and DCSA

Flexport is an American logistics platform established in 2013, that provides digital freight solutions. Its goal was to restore the user experience in global trade and is designed to provide visibility and control of the supply chain. The company is globally recognized and over the time has received many awards for its operations, its work environment and its fast expansion in the industry. (Flexport.Com, accessed on 11.05.2023)

Shippers nowadays expect accurate information about the status of their shipment in order to better plan their operations, manage their inventory and quickly respond to disruptions. Flexport is a platform which cooperates with multiple parties such as carriers, shippers, and customs authorities. But often these parties use their own systems which makes information sharing among stakeholders slow and complicated.

In an attempt to make information sharing among parties less complicated and more efficient, Flexport integrated a Track & Trace API into its platform. The DCSA Track & Trace API standard, which was also used by MSC, a major ocean carrier. This standard enables cross-carrier shipment tracking and can be used by shippers, carriers and third parties. It enables shippers and third parties to digitally communicate with all carriers in a unified way.

DCSA is established in 2019 by a group of major ocean carriers with an aim to further digitize the container shipping technology standards. (*Digital Container Shipping Association Established*, 2019) A few years later, the majority of the shipping carriers are already using DCSA Track & Trace (T&T) standards. DCSA T&T API allows shippers to receive real-time and cross-carrier data about the position of their containers.

Using this standard, visibility and real-time responsiveness could be further increased if the DCSA standard was widely adopted and used by a majority of companies. The digitization of the shipping industry is an important aspect in order to improve efficiency, transparency and better customer service.

The implementation of DCSA Track & Trace API in Flexport's platform created multiple benefits for its customers. Shippers now have up-to-date information and high-quality tracking capabilities. In addition, Flexport ensures that errors will be eliminated through less manual work and digitized procedures, complexity will be reduced and visibility for all involved parties will be enhanced, leading to better and efficient operation procedures.

6.3 Grydd and ORBCOMM

In recent years shippers have a greater need to have accurate information and control of their supply chain. But, while there is a huge amount of information, it is often buried in multiple data silos, not able to be shared, or the information is not reliable at all. Data inputs are mostly manual on paper or stored in basic IT systems that could be easily lost or forgotten. New generation innovators have tried to digitize data across supply chain, just like Grydd did.

Grydd is a logistics and supply chain technology solutions provider that integrates all the elements of the Supply Chain network into one intuitive platform. It was founded in 2019 in Washington, US, by a group of executives with many years of experience in the shipping industry. The platform provides operating and predictive data consolidation and analysis. It collects internal and external variables and data in order to build a predictable and efficient environment.

Grydd recognized the importance of location and status of a shipment as it travels through the ocean. Over the years the cross-border supply chains have become longer and even more complex than they were before. Grydd tried to mitigate the customer's frustration due to unreliable or missing data and provide logistic and freight specialists, digital tools in order to manage and monitor the status and location of their cargo from origin to destination. Shippers nowadays demand freight visibility at every movement of their cargo. (Grydd.Com, accessed on 11.05.2023)

That is when Grydd turned to ORBCOMM, a provider of maritime AIS data, in order to ensure real-time visibility into ship movements. The tools that ORBCOMM uses are IoT telematics and sensors attached on cargo transport assets along with maritime AIS technology as a tracking tool of vessels near shore, in ports and in the open sea. (Ilcev, 2011)

ORBCOMM provides automated, trusted intelligence on global vessel location and movement that is integrated in Grydd's platform. ORBCOMM's maritime AIS satellite is the world's largest provider of vessel visibility which processes daily messages from hundreds of thousands of ships.

Grydd can now provide its customers with a live view of ship location and status as it travels through the supply chain. Regardless if its physical position is on shore, on land or in the open sea the customer has the ability to track his assets location in near- real-time wherever it is, using information retrieved from satellite. Giving them access to near-real-time information, customers are now able to make better decisions and optimize their operations. Also it is observed that connectivity, trust and collaboration between parties are enhanced. (*Supply Chain Visibility Provider Grydd Partners with ORBCOMM for Global AIS Vessel Location Data*, 2020)

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7. Conclusion

The prime intention of this thesis is to present the role and importance of visibility and information sharing in shipping industry and especially in containerized shipping industry. It is important to mention how visibility throughout the supply chain influences operation procedures and how connected it is with the company's profit.

It is understood that the shipping industry faced many difficulties over the years due to some major disruptions and also due to the late implementation of new technologies. Although the shipping industry was one of the last industries to trust and adopt new technologies, I believe that as time passes and a new generation of shippers, carriers and logistic specialist enter the industry, the implementation of new technologies, platforms and tools will be unquestionable, along with the evolution of technology.

During the last decade, digitization played a major role not only in containerized shipping industry but generally in global international trade. New technologies and the use of internet were necessary for every company in order to ensure the efficiency in operations, to make predictions, and to be agile and responsive towards uncertainties.

All this would not be possible without accurate and meaningful information. But information alone does not bring any advantage to the company if it is not shared and thus not able to be used. As already mentioned in this dissertation, information could be stored, lost or not available at the right time, which could cost a company not only resources, but also time to respond in different situations and disruptions.

This thesis showed that through the implementation of new technologies, greater visibility could be achieved, meaningful information could be effectively shared at the right time and to the right person, delays could be avoided or managed, and costs could be eliminated. Especially now that the growing complexity of the industry demands synchronized actions to overcome the blind spots, visibility over the supply chain is a key for a company to increase its agility and be successful in a such competitive industry.

To better understand this situation, a number of references in the form of case studies were presented. The first case study in this thesis names one of the major global ocean carriers, Maersk. Maersk together with IBM, a technology company, created a logistics platform and implemented blockchain technology in order to achieve visibility and accuracy regarding documentation between stakeholders. This action was a fundamental step towards documentation digitization in shipping industry. It eliminated fraud and mistakes, provided security in documentation and made customs procedures easier and less time-consuming. However, after 6 years of use, Maersk and IBM announced the discontinuance of TradeLens.

The next case that was mentioned in this thesis, refers to a logistics platform, Flexport, which provides digital freight solutions to its customers. The founders of Flexport saw a need in the industry for cross-carrier shipment tracking and seized the opportunity. Flexport implemented a Track & Trace API into its platform to enable customers to track their containers through different carriers using an API designed by a group of major ocean carriers like MSC, Maersk,

Hapag-Lloyd and others. This innovation brought an advantage to the industry and to customers that deal with multiple carriers at a time.

Similarly, in next case study, that of Grydd, an American logistics platform, whose founders also wanted to enhance visibility for their customers. Grydd realized how important it is for its customers the exact location of their valued shipment and its movement in real-time. At some point Grydd made a collaboration with a company that specializes in maritime AIS data. This company uses sensors and tools which work with IoT and telematics to ensure real-time shipment location and movement near the shore, in port and even in the open sea. Using satellite information, sensors and IoT, Grydd managed to provide its customers with accurate near-real-time location data.

It is clearly understood that companies have started to slowly prioritize the visibility of their supply chain. Either implementing blockchain, Track & Trace APIs or analyzing AIS data, the main goal is to provide customers with as much information as possible about the status, location, quality, and customs status of their cargo.

A great role in this evolution in information exchange played of course the internet. But not everything that is "moving" through internet is and should be trusted. For example, as it is mentioned in Chapter 3 in this dissertation, during the Ukrainian conflict, stakeholders faced a major challenge with vessels traveling through high-risk ports. Although AIS data transmission from vessels is at any time obligatory, there were fears of cyber-attacks and communications jamming, which made operations even more difficult than usual.

Cyber risks due to increased digitization and automation in the shipping processes is a serious issue, can affect global systems and should be directly and carefully managed. Two examples of cyber-attacks were mentioned in this dissertation in Chapter 5, the "NotPetya" attack towards Maersk. A cyber-attack which cost the company nearly $ 300 million, a backlog of traded goods and a major disruption in international trade. The other example is the cyber-attack in port of Antwerp which was organized by drug dealers. They target the computer system of two companies that operate in port of Antwerp in order to have access to container security information and location. Their goal was to be able to smuggle drugs and weapons in the containers and retrieve them before the owner opens the container.

Not only companies but also vessels could be a target. Vessels are constantly connected to internet, and to technology applications and carry valuable cargo, which makes them a great target. The interconnected systems increase the vessel's exposure to cyber-attacks and cyber security risks. In a case of such a cyber-attack, vessels are targeted mostly for their cargo, these actions could cause a major economic damage, delays and even a political or social crisis.

That is maybe one of the reasons why companies where skeptical about the operation of fully autonomous unmanned ships, because they are more exposed to threats and attacks due to the absence of physical presence on board. On one hand, this could be the solution and the end of piracy and hostage situations of crew members that happened in previous years. On the other hand, autonomous unmanned ships could be the end of seafarer as a profession.

In conclusion, there is a great future and room for development in containerized shipping industry. Greater visibility will play a major part in businesses which deal with global trade. Also important is that ocean transportation moves more than 90% of world's traded goods, so any changes and implementations from now on will have a direct impact on many different businesses around the world, either positive or negative.

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