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CHALLENGES AND OPPORTUNITIES OF DIGITIZATION ON CONTAINER SHIPPING INDUSTRY IN SUPPLY CHAIN PERSPECTIVE

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Abstract

The purpose of this paper is to explore the challenges and opportunities of digitization particularly in the container shipping industry and supply chain management. The era of technological advancement has caused fierce competition in the maritime industry. Furthermore, the maritime industry has always been fairly volatile and subject to cyclical and structural transformation, and the future is likely to present the industry with even more challenges.

The promise of data-driven decision-making is now being recognized widely, and there is an increase of interest in the notion of "big data" and "digitization". Ultimately, big data is getting prevalent in shipping where large amounts of data are gathered to identify and optimized logistics, emissions, maintenance, vessel performance, and supply chain nodes. As shipping is currently on its way into their next revolution, there are numerous challenges and opportunities in on-line control and off-line analytics.

Therefore, this paper identifies and investigates the issues in implementing digitization to ensure the supply chain is more effective, agile, and customer-centric.

Key Words: Digitization, container shipping industry, supply chain management, Big data, Advance technology.

1. Introduction

The supply chain and container shipping industry have been facing intense pressure to operate more efficiently and profitably while providing the highly sophisticated digital demands of their customers. The situation is promptly changing, digitization is disrupting and changing the global transport supply chains.

Companies are findings ways to maintain their business competitive advantage and reflecting on their operations and processes in order for them to tackle business potential and challenges. The authors are focusing on the application of digitization in the container

shipping line and supply chain industry by deeply explaining the big data. Sorbo (2017) defines big data being high in terms of volume, speed, variety, and variability – structured and unstructured that can be analysed that lead to better decision making and business moves in real-time modes. Fully utilised big data can be a key competitive advantage and it is also turning into a key driver in shipping operations (Castera 2016).

While shipping industry is still on its way into revolution, opportunities and challenges are often there in big data analytics whether it is on-line control or off-line analytics (Rodseth et al 2016). To ensure digitization in supply chain is effective and agile, this paper analyse and investigate the problems in the implementation of digitization by using Maersk as a case study.

Maersk deal with Microsoft and International Business Machines Corporation (IBM) to bring more digitization to the global supply chain. IBM and Maersk are using a block-chain built to manage the supply chain for container shipping. Traditionally, a simple shipment from Singapore to Europe can go through approximately 30 individuals and organizations, including approximately 200 different communications (Groenfeldt 2017). Using a digital record and a blockchain can sharply reduce costs.

Subsequently, Maersk is reshaping global supply-chain innovation with Microsoft application namely, Azure. Azure is a comprehensive set of cloud services that IT specialists and developers use to construct, organize, and manage applications via the usage of Microsoft global network data centers (Microsoft Azure 2017). This application is a digital platform of record to boost Maersk's app store and help to improve business model innovations. Maersk's main objective in the digital supply chain is to abridge and develop transparency in supply chains by providing a smooth transaction of digital experience for the consumers (Burnson 2017). However, several bottlenecks have been faced by Maersk such as delays in production and terminal disruption that could cause major disruptions to the global supply chain. Hence, Maersk has joined alliances with Microsoft Corp in a strategic move to revolutionize supply-chain management and worldwide commerce. Maersk and Microsoft came up with a digital platform, Microsoft Azure to help Maersk's businesses model innovations. Maersk's aim of turning fully to digitization is because they want to heighten the visibility of supply chains by providing a smooth and consistent digital experience for their customers. Additionally, Azure, being their key basis in their digital strategy is providing an effective platform to all Maersk's transport and logistics business whilst improving their operations and drive better business decisions (Burnson 2017). From its connected vessels to its transportation economics, Maersk is betting on Microsoft to fuel growth and power logistics globally. While Maersk is already familiar with the software company's abilities, as its energy group already utilizes Microsoft for its services. Consequently, this partnership will lead them to establish a digital platform and have the potential to transform the shipping industry (Burnson 2017).

2. Drivers of Performance in the Maritime Industry

The maritime shipping industry is in the process of a technology revolution to increase productivity, visibility, and customer service. Transformative technologies have the potential to heighten the chances of improving performance and visibility across supply chain nodes. As the shipping industry begins to adapt to current opportunities that technology offers, consolidating data is significant for more productive operations and wiser decision-making. The consolidation and evaluation of big data have the ability to drive complete visibility across the pipeline inventory and provide new ways of monetization for various service providers (Fruth & Teuteberg 2017, World Economic Forum 2015).

Many players in the supply chain sector are experiencing poor transparency and forecasting around shipments as well as losing revenue attribute to lack of synchronization and insufficient data insight (Navis 2017). Digitalization is becoming a tactical method in shipping operations when it is developed appropriately, besides, it can also be essential for competitive advantage. Table 1 provides an overview of the types of data generated by the shipping companies. Whether there is a need to reduce costs or optimize transit times, it requires both a carrier and a shipper to implement a strategy that takes advantage of this data. Digitization may have a different perspective and might be comprehended differently when talking about technologies, companies, channels, and so forth. However, it is without a doubt a major contributor to financial performance, customer satisfaction, and market valuation (World Economic Forum 2015).

Table 1. Types of data shipping companies are generating

Financial Data	One of the most traditional types of data but also the one that new technologies can help capture more extensively
Operational Data	Data may be generated from onboard systems or other operational systems related to fuel consumption, port-side operations or cargo operations
Telemetry Data	Data that are generated from the vessel itself from a range of onboard systems and instruments

Source: Adapted from Rodseth, Perera & Mo 2016

2.1 The Values of Digitization

Digitization is the process of converting high volume data into a digital format that helps to integrate the collection of information, processing, and the availability of big data in real-time. The supply chain industry is merging customer data, marketing, external data for instance stock prices and news to recognize the connection and causation to help them make more precise decisions. Moreover, digitization helps to generate new opportunities especially for the shipping industry which requires continuous aggregation and reviews of the current market trend. Therefore, there are numerous advantages of digitization. Table 2 highlighted the importance of digitization. One great example of a digitization application in other industries is the delivery company, United Parcel Service (UPS). Big

data are used to examine customer behavior, for instance, the right timing for delivery should be made and why some deliveries take longer than others. Therefore, big data analytics is important in maximizing the delivery efficiency and improve its flexibility (Samuels 2017).

Table 2. Advantages through digitization

Advantages	• Improved operational productivity (e.g. maximize asset deployment) • Can be accessed anywhere via internet • 24/7 availability of access • Easy recovery of information using keywords • Networking possibilities • Perform risk analysis • Offering tailored supply chain operation • Assessing performance and monitoring data

Source: Adapted from Sagiroglu & Sinanc 2013

In contrast for the maritime industry, big data aspire shipping companies to consolidate information to improve vessel productivity. Big data analytic facilitate shipping companies to be aware of their fuel consumption, greenhouse gas emission, voyage data, structure, and machineries. A vessel spends 90% of its time in the ocean taking a beating every day, big data analytics allows shipping companies to gauge when maintenance is necessary. More often, maintenance required only when something already ruptures. Additionally, information such as route, cargo tracking is becoming more transparent for consumers to track their cargoes movement. Shipping companies are able to gather important and meticulous performance information to analyse their vessel and supply chain operation. Furthermore, digitizing supply chain allows shipping company to be attentive to customer demand. More comprehensive data are collected and store into a digital format which results to service that can be adjusted according to the need of the consumer. With the transactional data, shipping company can critically enhance decision-making, diminish risks and unearth valuable insights (Labrinidis & Jagadish 2011).

2.2 Risks and Limitation Factor

Despite all the advantages of digitizing big data, there are still some implications and restriction of converging digitization into the business. In terms of safety, lacking security may lead to access and mistreatment of sensitive information such as bank account detail, consequently facilitate outbreak on other systems (Kaufman 2009). This vulnerability can cause risks to having sensitive information being exploited by an unauthorised individual. There are numerous technological disputes that require a solution in order to maximize the benefit of digitizing big data. Privacy sensitivity and security for volume data are just one obstacle shipping companies need to overcome if the economic advantages of digitization are to be comprehended. One of the most substantial challenges is cyber-attack that recently happened to Maersk Line. Thus, security management is important in addition to digitization (DiRenzo, Goward & Roberts 2015, Fruth & Teuteberg 2017).

2.2.1 Security Management

Companies tend to face significant risks when digital supply chain is adopted into their daily operations. Considering digital supply chain as the focal point for the companies is to communicate, transact, process customer's orders electronically with their suppliers. Occasionally, uncertainty might exist about whether desirable outcomes of adopting a digital supply chain system will occur (Xue et al 2013). Prior to it, the adoption of digitization has made the companies concern about technological and transaction risks.

In recent years, cyber-attacks have become increasingly common in supply chain and container shipping industry. For instance, a cyber-attack can occur and it would be aimed directly at the vessel system which is essential for ship navigation such as changing the vessel's route to cause a grounding, hackers have the access to control the engine and causing the engine fails or even catches fire. Thus, such attacks could cause a disruption of trade worth billions of dollars to the container shipping industry and the company's reputation (Wingrove 2017). ECDIS Ltd project support, Mr George Ward thinks the container shipping industry is not ready for cyber-attacks because of its slow transition towards digitization (Wingrove 2017). Therefore, container shipping companies need to put a lot of time and investment in cybersecurity to prevent from being attacked or being unaware of any hacking. Whilst only some companies feel cybersecurity is important to invest in, little did they know it is very important to protect their business from being a total loss due to cyber-attacks. Besides, IT security policy is also important as it allows the users to of all equipment to be clear as to how company data and information should be used on IT equipment. Thus, another solution is to appoint a cyber-security chief to implement the security correctly and respond to any related issues or system flaws that may be found while maintaining cybersecurity measures within the company (Wingrove 2017).

2.2.2 Combating cyber-attacks by using threat tools

Software cyber threats are becoming commoditised with a broad range of simplified and easily accessible tools now on the market. These tools allow users to simply select the desired target and payload such as spyware and code, which conducts its attack. In June 2017, a container shipping company, A.P. Moller Maersk was hit by the NotPetya cyber-attack – a ransomware attack that prevents people from accessing their data unless they paid $300 in bitcoin (Novet 2017).

Consequently, Maersk's business volumes were negatively affected for a couple of weeks and was only able to take bookings two days after the attack. In response to the cyber-attack, Maersk has put in place different and further protective measures and continuing to review its system to prevent from being attacked (Novet 2017).

3. Methodology

In this paper, the authors use a case study analysis of Maersk Line by using academic journal articles, official websites and other online resources in order to achieve how digitization is influencing Maersk Line shipping operations. It helps the authors to collect relevant findings and evaluate the information related to the research pertaining 'digitization', 'big data' and 'supply chain'. This paper aims to explore how digitization

and big data application integrated by supply chain management, in particular, how operations models have changed as a result of using big data (Roden, Nucciarelli, Li & Graham 2017), hence a case study approach was adopted which focuses on the challenges and opportunities of digitization in supply chain perspective. Systematic literature was conducted to collect relevant publications on big data management in a container supply chain. The University of Tasmania's MegaSearch and other advanced search tools were used to obtain relevant articles. The search also makes use of Google Scholar and is carried out in specific journals, such as Journal of Management Information Systems, Maritime Economics, and Logistics, Procedia Engineering, International Journal of Electronic Commerce, Maritime Policy and Management, International Journal of Information Management, JSTOR Online Journals, Journal of Transport Economics and Policy, Transport Policy, Transportation Journal, International Journal of Shipping and Transport Logistics and Business Journal. The search for relevant articles was limited to the period of 2010 – 2020, with the initial result identified 2350 papers. The study then scanned through the abstracts of the identified articles considering papers that discussed issues concerning the keywords such as digitization, bid data management in supply chain, automation, maritime security and sustainable maritime transport, this process identified 81 relevant articles to the study. In the next stage, these articles are further scanned and reviewed to filter out those that are not relevant to the topic. Thus, a thorough screening was conducted to identify only those articles that study the digitization in supply chain and maritime transport. This process further reduced the relevant articles to 15, these are the articles deemed relevant and were used in the discussion of this paper.

4. Findings and Discussion

Big data in container shipping is a system exploiting shipping data with the objective of improving other areas of vessel optimization, asset maximization, and overall performance.

4.1 Container Shipping

Big data operation in a container shipping company enables to improve fuel efficiency simultaneously reduce emissions of carbon dioxide (Kitsuregawa & Tanaka 2017). Container shipping companies are capable to supervise voyage-related, fuel consumption, also mechanical related. Which comprises information on hundreds of elements such as engine exhaust gas temperature and scavenging pressure (Trodden, Murphy, Pazouki & Sargeant 2015). The warning sign will be alerted if there is any irregularity detected. Data collected from main engines can be analysed with big data analytics which then be used to recognize possible glitches and avoid any mishap in advance.

The application of big data has been signified as predictive analytics, data science, business analytics, supply chain analytics, and big data analytics (Zaman et al 2017). Table 3 shows the main application areas for the shipping industry. Generally, there are two noticeable methods of big data application; it can either optimize current procedures by focusing on existing business opportunities and implication or data can be exploited to create efficient services as new value emerge. Big data can be applied in the supply chain for operational and advancement purposes, value discovery, value innovation, and value capture (Brinch, Stentoft & Jensen 2017).

Table 3. Five application areas of Big Data

Voyage Planning	After evaluating the information such as route, vessel performance and meteorological, ship operators able to employ voyage planning. Data analytics facilitate in recognising suitable route for the voyage, precise estimate arrival time and identify alternative routes in case of disturbances.
Environmental Legislation Monitoring	Legislation force ship operators to observe their fuel and CO2 emissions. Big data analytic allow ship operator to monitor their emissions simultaneously set KPIs for each vessel.
Performance Monitoring and Optimisation	Automation expands the capability of the control of machinery and vessel optimisation. A range of data measurements are required for monitoring and optimising vessel performance and access to historical data is essential for optimising and forecasting.
Condition Monitoring & Predictive Maintenance	The condition and performance of engines, parts, and components will be improved by analysing asset data that is recorded during operation. Sensors help to monitor the machinery and give early warning of the need for maintenance to avoid the potential failure of engine components. This will reduce the cost of asset failures and minimise unscheduled downtime.
Operational Predictability	Vessel operational performance can be monitored in real-time by analysing ship performance data. Ship operators will gain the capability to predict future vessel performance against certain criteria to help in making decisions on maintenance needs.

Source: Adapted from Zaman, Pazouki, Norman, Younessi & Coleman 2017

Non-traditional data are usually issues that can be eluded or solve. Thus, container shipping companies usually use big data solutions to analyse the costs of other routes in the case of unforeseeable disturbances. Subsequently, information on the cargoes are equally important to supply chain players as those data gathered can be used to enumerate shipping costs and work on development. Moreover, big data in the supply chain process bring information together from various sources to forecast future demand and real-time decisions to ensure continuous and efficient logistics pipeline flowing. This application is used to quantify what the shipper, consumer, and other supply chain players have determined is important to the business.

4.2 Supply Chain

In supply chain, core activity processes involve customer relationship management, supply chain management and contract manufacturing these activities are suggested as critical to the organization performance (Rai, Patnayakuni & Seth 2006). Therefore, supply chain strategy using big data in operation is to focus on refining and innovation of end-to-end processes between a company, customers and suppliers. Secondary data are analysed through summarization method of a case study in the digital supply chain. Based on the analysis above, five main components are emphasized in this revolution to the digital supply chain as highlighted in Table 4. Digital Supply chain objectives are to find solutions to increase the productivity and communication of relevant information as a method to improve efficiency and output.

Table 4. Traditional supply chain vs Digital supply chain

	Traditional Supply Chain	Digital Supply Chain
Transparency	Restricted content of Supply Chain	Comprehensive content of supply chain
Communication	Slow transmission of information as it goes through every key player at a time.	Information is accessible to all supply chain players concurrently.
Collaboration	Restricted visibility to the entire chain, obstructing potential collaboration	The natural development of collaboration depth to capture inherent supply chain value
Flexibility	Customer demand is measured inaccurate as data progress in the material path	Constant changes in customer demand are promptly evaluated
Responsiveness	Uncommon planning pattern causing in delays and dissimilar responses across multiple tiers	Real-time response on planning and execution level (across all tiers to demand changes)

Source: Authors

Sethuraman and Kunadharaju (2013) points out that "big data improve agility to respond to business dynamics and ensure a proactive response to business-critical issues before they escalate". As shown in Table 5, when properly applied, big data can stimulus the logistics, operation, and marketing. Marketing has the utmost developed analytics with the focus on customer demand and behaviour, prices can be improved and consumer approach can be adjusted accordingly. Whilst logistics analytics improved inventory and resources distribution, identify optimal distribution position and decrease transportation costs. Operation analytics measure efficiency and quality in order to improve inventory and maintenance (Sanders 2016).

As more information becomes accessible and companies progressively move towards digitization, a new set of defensive and strategic opportunities arises for companies. Defensive methods consist of security management, process-to-actuate and assimilate-to-analyse (Sanders 2016).

Table 5. Applications of big data analytics in supply chain operations

Delivery	Able to observe routes for delivery, traffic delays, weather forecast and an alternative route for volumes and asset sharing.
Inventory Planning	Complete view of stock keeping unit (SKU) and automatic replenishment process. Additionally, forecasting customer demand trend that minimises insufficiently or overstocking.
Distributing	Real-time maximization of multifaceted webs of distribution centres, plants, and warehouses based on the material flow data
Demand	A precise approximation of demand by evaluating information on sales, market trends, local and global economic issue.
Forecasting	Big data analytics of enterprise resource planning (ERP) system and identifying inventory levels, incorrect delivery, and incoming deliveries.
Warehousing	Improved transparency of demand, inventory quantities, and manufacturing volume thus more precise output and dissemination scheduling.
Scheduling	Able to observe routes for delivery, traffic delays, weather forecast and an alternative route for volumes and asset sharing.

Source: Authors

4.3 Risks and Limitations

Companies face significant risk such as transactional and technological risks when they take digitization systems to coordinate with their partners. By taking into consideration, supply chain digitization is the degree to which a company adopts a digital supply system to engage with customers electronically. Compared to other industries that have been implementing digitization for a long time, supply chain and container shipping companies are concerned about technological, regulation and security risks (Kumar & van Dissel 1996).

4.3.1 Technological

Technological risk refers to the potential for technology failures to disrupt business such as information security incident or service outages (Spacey 2015). The causes of website outages are mainly because of the server overload and are under maintenance. A particular website with heavy traffic or long processing time or even high volume of email can cause issues for another site on the same server when resources are stretched too thinly. Moreover, even a website outage in a short time could bring down the business's revenue.

For instance, Woolworth's online ordering system was disrupted and taken offline forcing them to cancel all orders that were made and leaving customers disgruntled (Powell 2017). In manufacturing, for instance, an interruption in the delivery schedule due to the technological issue could cause serious production problems because technology use has eliminated the inventory buffer (Longstaff, Chittister & Haimes 2000).

Such technological risks can be an unexpected and unfortunate occurrence. Hence, it is important for businesses to be prepared to face risks by updating software regularly, back-up data, understand legal obligation for business and most importantly, train the

employees in technology policies and procedures (Pavlou 2003).

4.3.2 Regulation

To achieve the security objective of the company, regulation plays a significant role to ensure the well mitigation plans for future challenges. According to Fernandez (2016), the regulatory framework in the shipping industry is very strict and having to compete with many competitors that strive under different challenging situations. Current issues can be addressed by a set of regulatory framework that covers security policies and provides training information security and privacy awareness among the entire people in the company. The regulation framework has to continually focus on technological changes, threats, people's view and behavior. Hence, it is important for a company to have a policy for a business to run to demonstrate their commitment towards a company must have a policy to demonstrate their commitment towards the system which they operate daily (Tallon 2013).

4.3.3 Security

Cybersecurity is a common issue and a major factor in general data acquisition on board, a company should be aware that certain data could be jammed or spoofed from cyber-attacks. The slow trend towards digitization is what makes the maritime industry is vulnerable to cyber-attacks. There are several causes from cyber-attacks; attacks have the capabilities to obtain sensitive data information (GPS), so it is important that the correct procedures and processes are in place to stop the worst from happening (Schmahl et al. 2019, Wingrove 2017).

Based on a case study, Maersk was hit by a cyber-attack called Petya ransomware and has brought Maersk's business volumes negatively down for a couple of weeks. According to Maersk CEO, Soren Skou, as a result of the cyber-attack, the total lost revenue is estimated to be between $200m and $300m (Palmer 2017). As a company, it is important to have cybersecurity and defend against potential thievery and other actions that could cause problems. Also, companies tend to face challenges due to limited resources and information regarding data security. Thus, addressing these challenges can be done by having a security awareness lead by the business leaders to protect a company's sensitive information and reduce the loss of productivity due to downtime.

Pertaining to the implementation of digitization to businesses, security is vital in making sure to keep the business run well. Hence, the authors have identified three major impacts of cyber-attack on businesses that the supply chain players may face when the company is attacked. The secondary data are analysed through summarization method.

Table 6. The impacts of cyber-attack on businesses

Financial Loss	• Theft of company's information • Theft of sensitive information (bank & personal details) • Theft of money • Disruption of online money transaction • Loss of business or contact
Reputational Damage	• Loss of customers • Loss of sales • Reduction in profits • Cyber-attacks can damage business' reputation and destroy the trust of customers.
Legal Consequences	• A company may face potential fines for either accidental or intentional breaching of sensitive data and authorities failed to take security action in place

Source: Authors

According to the data in Table 6, the authors have identified the major impacts of cyber-attack on business financial loss, reputational damage, and legal consequences. The findings of this paper show that big data analytics has garnered increased attention due to its complex nature and has been used in industry to enable companies making better decisions. But from the supply chain perspective, it is found that there are many issues such as adaptability and integration to be addressed.

Table 7 shown the challenges that are associated with digitization implementation of big data in the maritime industry.

Table 7. Challenges and the outcomes

Challenges	Outcomes
Data Transaction	Ships have a number of sensors on board and will cause a major of uncertainty from data transfer from sensors. Hence, it is important to have appropriate data communication for them to transmit the information to the database.
Cybersecurity	This will need to be protected from external interventions such as piracy, viruses, etc. It will be the key issue for ship system to prevent disruption in maritime security.
Data Quality	Low-quality data would lead to errors in interpretation. Data should be error free. Hence, quality of data is a big concern for the industry.
Data Ownership	Ownership of data is crucial to the shipping industry and will become challenging for ship operators to distribute the data ownership and the level of authority in the future.
Data Protection	Sensitive data will need to be shared externally making security and privacy priorities for data protection and to maintain the data quality.
Adoption and Standard Management	The industry has to adopt big data analytics to understand the benefits of using it. The shipping industry need to create awareness across the stakeholders to adopt new technologies and to regulate standards.

Source: Authors

The effective information retrieval from big data can build efficiencies in the supply

chain nodes, enhance correlation with supply chain players and be responsive. Based on findings and discussions that have been reviewed, big data is deemed to have a huge impact in enhancing the business innovation and making seamless end-to-end process.

To execute big data analytics in a method that adds innovation to supply chain procedures, supply chain practitioners are required to foster data science abilities and skill sets (KPMG 2017). In fact, competition over the noteworthy values of big data is becoming so extreme that in the forthcoming, hiring and retaining employees with the abilities to analyse big data will be precedence in any industry. In the context of supply chains, data scientists should have the necessary skills to extract value from large volumes of upstream and downstream data to help key stakeholders within the organization make wiser and better decisions regarding demand forecasting, inventory planning, and logistics management.

5. Implications and Conclusions

The findings of this paper provide an insight into the revolution of digital transformation specifically in container trade and supply chain industry. Digitization and big data bring numerous opportunities into daily business operations. However, the challenges of digitization are not given the emphasis, especially, to address the security issue that should be in place to mitigate further loses or cyber-attack. Also, the lack of tools to determine the impact of digitization when the mass adoption of digital technologies and applications is having on companies and economies. Subsequently, insufficient of a data scientist to decipher the large volume of information. Lacking data scientist lead to a disadvantage to a company to fully gain the potential of big data analytics to improve business operation. Nevertheless, digitization leads to many opportunities than a risk to guard against.

The term “big data” in supporting container shipping industry is still relatively new. Accepting and adapting to big data concept or digitization, may pose challenges to shipping companies, many challenges and issues exist which need to be brought up right from the start. Whilst many advantages of implementation of digitization to both supply chain and container shipping industry which have been described in this paper, there are risks and limitations pertaining to it. The case study of Maersk’s cyber-attack has disrupted business around the world and can destroy its entire supply chain. The maritime industry should develop a set best practice of guidelines to improve the situation. Moreover, work on a longer-term plan to initiate cybersecurity standards should be embraced by all shipping companies. The government and business owners must increase cybersecurity awareness and give necessary supports to allow improvement in cybersecurity. Lastly, employees must be well trained for and equipped to overcome any issues on cyber-attacks as part of the risk management in search to threats and vulnerabilities. Simultaneously, by taking these actions will lead the greater cyber-resilience in the maritime industry.

As pertaining to every research, this paper has some limitations. First, this research was unable to collect primary data, with primary data this paper could be more enriching and precise. As primary data analysis is crucial to have fresh, unused data to help determine how or what should make the supply chain nodes to be more customer oriented, agile and effective with the application of digitization. Secondly, the research area is still new to the container trade, hence there are not many scholar articles to be used as a secondary data analysis. Additionally, the revolution of technology in the maritime industry constantly changing according to the pattern of customer demand.

A recommendation for future research can be made by using primary data on a much

larger scale such as conducting an interview and survey to obtain more accurate data based on questionnaires from respective authorities in the maritime industry. Further research on the challenges and opportunities of implementation of digitization is needed to gain better insights. The future research should look at the impact of e-business technologies on supply chain operation performance in regards the role of production information assimilation in creating a seamless integration of entities in a supply chain.

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