Limitation of mega ships in the container shipping industry

An analysis on increasing size of mega ships and its effects on the shipping industry

Bachelor thesis for Shipping and Logistics Program

HAMZA NASIR
FARBOD SAGHATCHIAN

DEPARTMENT OF MECHANICS AND MARITIME SCIENCES

CHALMERS UNIVERSITY OF TECHNOLOGY
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Department of Mechanics and Maritime Sciences
Chalmers University of Technology
SE-412 96 Gothenburg
Sweden
Telephone: + 46 (0)31-772 1000

Cover:
Note. Container ship HMM Algeciras, , first visit to Rotterdam of the largest container ship in the world, VB CHEETAH and Rotterdam from Boluda Towage assisted the ship to the RWG terminal on Maasvlakte 2. (Kees Torn 2020). Wikimedia. CC BY-SA 2.0

Department of Mechanics and Maritime Sciences
Chalmers University of Technology
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PREFACE

This study covers the maritime and logistics bachelor program and scope of the study is limited to Scandinavian region. The authors would like to give a special thanks to Olle Lindmark who was the supervisor for this bachelor thesis report. The authors would also like to give special thanks to the interviewees for taking the time out of their day to partake in this study.

Gothenburg, May 2021

Hamza Nasir and Farbod Saghatchian

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SAMMANDRAG

Efter andra världskriget började efterfrågan att växa för större fartyg inom sjöfartsindustrin för att transportera mer last. 2006 introducerade Maersk det allra första Mega containerfartyget. Efter den händelsen har rederier strävat efter nya storleks standarder för att ytterligare öka sina intäkter. Studien vill undersöka vad de framtida begränsningarna för mega containerfartyg är och hur den ökade storleken på dessa fartyg påverkar de olika aktörerna inom sjöfarten. Studien baseras på rederier och hamnmyndigheten i Skandinavien där intervjuer har genomförts. Intervjufrågor strukturerades för att svara på forskningsfrågorna med ytterligare hjälp av litteraturstudier.

Resultatet som genererades visade sig att, trenden kommer att fortsätta med investeringar i större fartyg men begränsningarna ligger inom djupgående, hamn storlek och sjöfarts vägar. Detta på grund av att de väldigt stora fartygen endast kan användas på rutter mellan Europa och Asien. Den ökade storleken på mega containerfartyg sätter press på hamnarbetarna eftersom ett normalt arbetsschema inte kan integreras då mega containerfartyg skapar en signifikant arbetsbörda för hamnpersonal när de anländer till hamn.

Den ökade storleken skapar också begränsningar för handelsvägarna eftersom andra kontinenter bortsett från Asien och Europa inte kan hantera dessa stora fartyg. När rederier strävar efter större storlek standarder och sedan sätter fartygen i drift kommer de tidigare fartygen som var på de populära handelsvägarna att flyttas runt till andra rutter. Detta innebär att alla hamnar i branschen påverkas av storleken eftersom att de måste investera i hamninfrastruktur samt överbyggnad för att kunna hantera större hamnanlöp. Även mindre hamnar får ta emot anrop från större fartyg beroende på hur rederierna arbetar och planerar sin flotta. Detta går under namnet “Cascading Effect”.

Det diskuterades att den nuvarande trenden för mega containerfartyg är förmodligen inte hållbar. Mega containerfartyg i hamnar kommer att ha stora utsläpp på grund av långvarig lasthantering och väntetider. Hamnar kan också börja introducera avgifter för fartyg med höga utsläpp. Ett visst företag från intervjuerna har investerat i LNG-drivna mega containerfartyg som kan vara en av lösningarna mot en mer hållbar trend inom sjöfarten.

Nyckelord: Container, Mega Ship, begränsningar, Hamnar, Rutter, Fartyg, Sjöfart, Kontinenter, Industrí

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ABSTRACT

After World War II, a growing demand in the shipping industry pushed for larger vessels to be built in order to transport more cargo. In 2006, Maersk introduced the very first mega container ship. Since then shipping companies have been pushing for new size standards to further increase their revenue. The study wants to find out what the future limitations of mega container ships are and how the increasing size of these vessels affect the different actors in the shipping industry. The study is based on shipping companies and port authorities in Scandinavia where interviews have been conducted. Interview questions were structured to answer the research questions with additional help of literature studies.

The result that was generated was that the trend will be to continue to invest into larger vessels but the limitation will be draft restrictions, port size and shipping routes since the large vessel can only be utilized in routes between Europe and Asia. The increasing size of mega container ships puts pressure on the port workers since a normal working schedule cannot be integrated due to the peaks which the mega container ships create when calling a port.

The increase in size also creates limits on the trading routes since other continents except for Asia and Europe cannot handle these large vessels. When shipping companies push for larger size standards and then put them into operation, the previous vessels that were on the popular trading routes will be moved around to other routes. This means that all the ports in the industry are affected by the size since they must invest into port infrastructure as well as superstructure to be able to handle larger port calls. Even smaller ports get to take calls from larger ships depending on how the shipping companies operate and move around their fleet. This is called the cascading effect.

It was discussed that the current trend for mega container ships might not be sustainable. Mega container ships on ports will have high emissions due to long cargo handling operations and waiting times. Ports can also start charging vessels for high emissions. A certain company from the interviews have made investments into LNG fueled mega ships which could be one of the solutions towards a more sustainable trend.

Keywords: Container, Mega Ship, Limits, Ports, Routes, Vessels, Shipping, Continents, Industry

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ACRONYMS AND TERMINOLOGY

Congestion	Inefficient port operations of incoming and outgoing ships leading to longer waiting times for ships on ports.
ETA	Estimated Time of Arrival
HMM	Hyundai Merchant Marine
IMO	International Maritime Organization
MOL	Mitsui O.S.K.Lines
NYK	Nippon Yusen
ONE	Ocean Network
RoRo	Roll-on/Roll-off
TEU	Twenty Foot Equivalent Unit
VLCS	Very Large Container Ship

1. INTRODUCTION

According to Garrido et al. (2020) global trade boomed after the events of World War I and World War II, and the growing demand pushed the shipping industry to build larger vessels in order to carry more cargo. In 2006, Maersk introduced the container vessel Emma Maersk which is known to be the first very large container ship (VLCS). In 2013, a new generation of containerships came into commission that could carry over 20,000 twenty-foot equivalent units (TEU) which marked a new standard for large container vessel volumes (Garrido et al., 2020).

The size of these new containerships was unprecedented in the shipping industry at the time. Definition of the shipping industry in this case means the business of transporting goods and how it will affect its surroundings like the environment and the ports. The term mega ship has been around for a long time and with each new large ship, the standard for what can be considered a mega ship increase (Garrido et al., 2020).

The appearance of mega ships had shook the shipping industry, pushing port infrastructures to expand and grow in order to support larger ships, and while there was a growing demand due to economy of scale, there were other actors in the field who would be negatively affected by the growing sizes (Baik, 2017). Such as how there was an increase in congestion and traffic for several ports, and ports needed larger cranes to support the loading and unloading of mega ships (Baik, 2017).

Now sizes like Maersk's Triple E class ships have become a standard for mega ships but there has been a growing trend and demand for port infrastructures to expand even further so that they can support even larger ships. As the economy of scale grows and more larger vessels are built because of market demand, the situation brings an important dilemma. (Merk et al., 2015).

While Mega Ships have had many positive aspects to the shipping and logistics industry, one must ask, when is it enough and could the overcapacity of cargo have negative effects? In 2018, the International Maritime Organization (IMO) set out a new goal and regulation for the shipping industry which is to reduce the global emissions by 50% in 2050 in relation to the global emission output that was in 2008 (International Maritime Organization [IMO], 2018).

According to a scientific article by Garrido et al. (2020), mega container ships give less emission per TEU compared to smaller container vessels due to the high utilization of the vessel's capacity. However, mega container ships have high emission output at port terminals due to long turnaround times, these long periods lead to high emissions from mega ships because the ships are not being utilized. The ports are not optimized to handle large calls while mega container ships are simply not sustainable for the environment in the long run. This study goes into the issue of how the size can affect various aspects of the maritime industry and how these aspects can be interconnected with each other.

1.1 Aim of the study

The purpose of the study is to research the mega ships and if there are limitations in the future and if so, how it will affect the shipping industry. The report intends to cover areas regarding the size limits of mega ships, whether bigger is better and how larger mega container ships can affect other aspects of the shipping industry such as the port infrastructure and the environment.

1.2 Research questions

For the report, the authors drafted and organized the following questions:

- What are the future limitations of ship volume for mega ships?
- How do the mega ships affect the shipping industry in the present?
- How will the volume of the mega ship affect the ports and its workers?

1.3 Delimitations

The delimitation is narrowed to mega ships in the liner shipping business. One must take into consideration that there are many ports around the world so another delimitation has been set to Scandinavian ports since it will be time consuming to gather data for all ports. Lastly a delimitation is set based on the authors schedule for the report since it is time-limited due to the period when the report was conducted as well as resource limitations. The report will be based on interviews and the scope of the interviews will take place within national levels of the authors location i.e. Sweden, with the port of Gothenburg and shipping companies located in Sweden as the main focus.

2. THEORY & BACKGROUND

In this section the theoretical background will be explained. Information and theory related to the study will be useful for the reader since it will make it easier to understand the results and discussion.

2.1 Container shipping in general and its history

The shipping industry has a long history of its development of ships. Before the invention of container ships, seafaring countries had to depend on nature's forces to sail and trade goods with countries around the world. World shipping council (2021a). states that the loading process was quite demanding and time consuming since the seafarer and port workers had to load and unload the ship with physical labor. The goods were usually loaded in barrels, sacks, or wooden crates which at the time was the most efficient way of transporting goods in general and at sea. Ships still had long dwell times since the method was not very efficient and relied on human strength and speed.

In 1955, Malcolm P. Mclean, who was a trucking entrepreneur from North Carolina, USA, decided to buy a steamship company to put his business idea into action (World shipping council, 2021c). According to World shipping council (2021c) Malcolm wanted to make transportation more efficient by transporting the goods without taking them out of the trailer trucks. Based on his theory it would be significantly quicker to lift the containers and place them on a ship without any major interruption. This idea together with the first container ship being introduced in 1968 would revolutionize the logistic system as well as the transport industry (Haralambides, 2017). Loading and unloading cargo was made more efficient than ever before. The first ever container ship had the capacity of 1,100 TEU and from that point onwards the capacity continued to rise (Haralambides, 2017).

With Malcolm P. Mclean invention of containerization, it would lead to new opportunities for global trade and liner shipping. According to World shipping council (2021b) new common routes were created to connect countries, markets, people, and business. Companies and consumers were now offered a brand-new option to sell and buy goods in a way that was not possible before. Liner shipping made the process of trading more efficient which helped boost the world economy and move it into a direction of globalization (World shipping council 2021d).

2.2 Ports

A port infrastructure can determine if it is viable for mega ships to enter and exit. Proper port logistics, coordination of the port operations and the port infrastructure are required for a mega container vessel to dock.

According to (Baik, 2017), mega ships can impact the port infrastructure in many ways. As a brief example: The berth of a port determines what vessels can dock, larger vessels require larger berths and quays to support the length, weight, and height of the vessels. Large vessels also require larger gantry cranes to support the loading and unloading of cargo in large volumes. The cranes are required to be large and therefore are heavy with longer reach but this then requires the piers to be reinforced and expanded in order to support the weight and size.

Yap & Loh (2019) informs that all these changes are caused by the size and length of a vessel which goes to show the vast amount of investment that is needed to make the port accessible to mega ships. “The bigger the ship is, the larger the risk is”, larger vessels also add a lot of risk regarding port congestion and can have heavy impacts on the environment if an accident were to occur in the port (Baik, 2017). According to Park & Suh (2019), if in the future a mega container ship with a volume capacity of 30,000 TEU is in operation then ports need to dredge and increase the water depth by more than 20 m and that will have to be the new standard for ports and container terminals.

An example of this can be referred to in the article by Meng et al. (2017) where the authors created a simulation of Hong Kong terminal operations to determine whether it will be able to handle larger container vessel operations. The article concluded by stating that smaller vessels are more efficient for the terminal operations due to lower waiting times however, generally the terminal will need to expand its infrastructure to handle mega container vessels in the future.

An article by Kyu (2019) brings up the issues of constraints in port infrastructure, calculates and predicts future container vessel sizes via data collection and analysis; and focuses on constraints by water depth, waiting times and handling of cargo in quay cranes. In all three categories, ports need to heavily alter the infrastructure to avoid congestion and handle the size of the mega container ships. The article concluded by mentioning that the reduction of waiting time requires a change in berthing plans and operations to handle different sizes of ships.

2.2.1 Hinterlands

The hinterlands are the land behind coastal waters or the land around riverbanks. According to Baik (2017), hinterland infrastructure is needed to cover mega container ship operations, hinterland operations have access to container yards and warehousing in addition to road and railways for inland transportation. If the hinterland infrastructure and facilities are not adapted to handle mega ship calls then it will result in port congestion, this is because high traffic in terminal operations are difficult to handle when it comes to larger vessels that require capacity in container yards (Rodrigue, 2016).

Making improvements upon the hinterland infrastructure can make mega ship operations easier and efficient, however the investments will be heavy and can take a lot of time to implement before the hinterland and port can offer high quality service (Baik, 2017).

2.2.2 Port workers and port turnaround

Ports are very large freight hubs and can take on very different types of cargos. The ports are run by manual labor with port workers but can also be run with the help of automatization. In a study made by Li et al. (2016) mention that port workers are a broad term which usually covers several occupations for example stevedore, dispatcher, tallyman, driver and inspection personnel. The main process for port workers is to load and discharge ships with the help of different equipment available at port (Li et al., 2016).

When a ship calls to port, it puts a lot of things in motion depending on the size of the vessel and the type of cargo. Li et al. (2016) mentions that throughout history the working conditions for port workers have not been the most optimal one. There are a significant number of hazards and risks involved when working at a port. Since most of the work is done outdoors one of the hazards that the port workers are exposed to is hot and cold temperatures as well as exposure to loud noises. Another hazard could be working closely with dangerous goods since there is always certain risk involved when working with dangerous cargo.

The struggle for port workers is that port turnaround and activity are different depending on the size of the ship calls. There are days that the container terminal is very busy and then there are days where there is not much to do (Fabba et al., 2016). The labor arrangements, according to Fabba et al. (2016), needs to be flexible due to the volatile ship calls to match the supply of workers to the fluctual demand. According to Fabba et al. (2016) this needs to be done without compromising the turnaround time in ports and scheduled vessels arriving in port. This is so that excessive costs are not produced for the port operator.

2.2.3 Port of Gothenburg

The port of Gothenburg is the largest port in Scandinavia and is one of Sweden's busiest ports when it comes to foreign trade. 30 percent of Sweden's foreign trade runs through the port. The port is strategically placed in a good location at the Swedish west coast and can accept as well as handle port calls from significantly large container vessels (Port of Gothenburg, n.d.). According to Port of Gothenburg (n.d.), in 2016 they operated around 800,000 TEU and handled berthing operations of container vessels as large as 20,000 TEU. The port network and the terminals are operated by APM-Terminals which even operates the import and export of containers at port. Furthermore, they offer other services like container depot, container service as well as warehousing for containers (APM-Terminals, n.d.).

The primary duty for Gothenburg port authority is to reinforce the industry on a national level in conjunction with the local level to further put the Scandinavian industry at a competitive advantage (Port of Gothenburg, n.d.). They do this by maintaining, developing, and marketing the port in addition to creating conditions that support an efficient and sustainable freight hub. The authority is also tasked with the responsibility to inform the opportunities and services available at the port of Gothenburg to encourage more import and export companies to use their services (Port of Gothenburg, n.d.).

The Gothenburg port authority does not receive any financial support from the city of Gothenburg which makes it a completely self-financed port. Their finance is subsidized in form of concession charges, port charges, freight charges, rent and leases (Port of Gothenburg, n.d.).

2.3 Economy of scale in the container shipping industry

According to Kenton (2021), Economy of scale is a business concept which can be applied into any industry. It displays the advantages bigger businesses have over smaller ones especially when it comes to cost-saving and competitive advantages. Larger businesses have bigger cost savings since they can increase their production and lower their costs. This is done by spreading the costs over several goods and spaces. Naturally, this means that the smaller business must charge more for the same product or service that the bigger companies offer. According to Kenton (2021), "the cost per unit depends on how much the company produces".

Take the shipping industry as an example, bigger liner shipping companies can afford to push the construction of bigger container vessels since they have the economy for it. The bigger vessel offers the company more flexibility since it has a lot of space in TEU (Kyu, 2019). This means that they can accept significantly more cargo compared to other competitors that do not have the same option as the bigger companies. According to Kyu (2019), with more space to accept cargo the company can lower its prices to beat its competitors. The smaller companies need to have a high price since the shipping company does not offer enough space compared to larger companies.

According to Rodrigue (2016), the industry that benefits most from economy of scale is maritime shipping. The reason behind this is because the industry has control and direct impact of their own operating cost. Naturally the larger the vessel, the more cargo it can carry which will lead to lower transport cost per unit. Shipping companies have been pushing for construction of larger vessels especially in the container shipping industry since they have significantly high traffic and volume transportation between Asia, Europe and across the pacific (Rodrigue, 2016). An article by Ge et al. (2019), states that the carriers are incentivized to partake in investing larger ships which leads to competition between other companies in building larger capacities for vessels. In recent years, there is a disconnect between the low demand and the high supply of container vessels which is predicted to lead to overcapacity and making the industry unprofitable due to loss in revenue for carriers. This is further strengthened by Cho & Lee (2020) the economy of scale works like a double-edged sword where larger scales in the maritime sector can burden even the largest ports in Asia. Cho & Lee (2020) also informs that mega container ships are a major cause of the lower freights in the industry as well as the competition for supersized vessels is causing a downturn due to oversupply.

2.4 Mega containerships in the industry today

According to Garrido et al. (2020), globalization and the increase in demand has been well documented around the world. This has led to the container shipping industry putting more focus into their cost control and implementing the economy of scale to their business (Garrido et al., 2020). Shipping companies pushed the deployment of new and bigger container ships that could have a carrying capacity of 15,000 TEU (Notteboom, 2021). These are called mega container ships and were introduced in 2006 (Notteboom, 2021). Today the shipping industry

has pushed the carrying capacity to even higher levels. These new container vessels were introduced by Maersk Line in 2013 which paved the way for new upscaled capacity and new models of container vessels called the triple E class (Notteboom, 2021).

Ever since the introduction of these new types of container vessels, shipping companies have been putting in more orders for newer and bigger ships (Garrido et al., 2020). Today there are container vessels that can carry a capacity beyond 20,000 TEU (Garrido et al., 2020). Currently, the biggest mega containership is HMM Algeciras which has the capacity to approximately hold 24,000 TEU (Notteboom, 2021).

The biggest mega container ships in the shipping industry today will be demonstrated below. As mentioned before, the largest ship in the container industry today is HMM Algeciras (see cover page). According to MI News Network (2021), it has a capacity of approximately 24,000 TEU, 399.9 meters long with a draft of 14.7 meters.

The second largest container ship in the industry goes by the name HMM Oslo and is a sistership of the HMM Algeciras. The vessel is 400 meters long, 61.50 meters wide and with a draft of 16 meters and a carrying capacity of 23,792 TEU (MI News Network, 2021).

The third largest container vessel in the world is MSC Gulsun (see figure 1) with the length of 400 meters and 62 meters wide and in addition a carrying capacity of 23,756 TEU (MI News Network, 2021). This vessel is the first of its kind that can carry 24 containers side by side across the breadth of its hull and the reported draft on MSC Gulsun is 16 meters (MI News Network, 2021).

Figure 2 MSC Gulsun

Note. Container ship MSC Gulsun, first visit to Rotterdam of the largest container ship in the world, MSC GÜLSÜN 23,756 TUE, seen from the Nieuwe Maze. (Kees Torn 2019) Wikimedia. CC BY-SA 2.0

2.5 Environmental impact of shipping

According to Cirella et al. (2021), the container shipping industry produces the most emissions in comparison to the rest of the industry. International Maritime Organization (IMO, 2018) sought out to regulate and reduce the emission output in the shipping industry by 40% in 2030 and 50% in 2050 which has put incentives on shipping companies to use sustainable methods.

A common method for reducing emissions is slow steaming. According to Cariou (2011), slow steaming is the practice of slowing down vessel speeds to reduce emissions. As an example, simply lowering vessel speed by 10% reduces the emissions by 10-15%. However, the issue with this method is that it can result in loss of revenue due to operation costs, for this method to be beneficial, bunker prices need to be high.

Most companies utilize alternative fuel sources which produce less emissions compared to fossil fuel. An article by Ellis et al. (2018), discusses the potential for methanol as a renewable fuel for vessels. Methyl alcohol or Methanol is a clean-burning alcohol fuel which can be produced from natural gas and coal but also from renewable feedstock. Methanol has been widely tested as engine fuel and has proven to have reduced emission and less impact on the environment (Ellis et al., 2018). Recently methanol has been a potential renewable fuel source in the shipping industry but the switch in fuel is not simple. A change in fuel source also requires the container vessel to change its engine and fuel system with the purpose to utilize methanol fuel. Also, a wide usage of methanol fuel or other alternative fuels requires an entire supply chain system to allow for easy access and incentive to use alternative fuels (Ellis et al., 2018).

LNG fuel is another promising fuel source for the shipping industry. According to Shell (n.d.), Liquified Natural Gas, or LNG for short, is a natural gas which is converted into liquid forms at a degree of -162 Celsius, the liquid is cleaned out and rid of any carbon dioxide and dust. Because the liquid form of the gas is smaller in volume, it is easier and safer to transport and store while shipping. Once transported to its destination, the LNG is converted back to clean gas which can then be burned for fuel in industrial plantations and factories.

According to Shell (n.d.), in 2017, LNG trade had reached about 300 million tons in comparison to the year 2000 where LNG was only at 100 million tons. Compare this to the first year of LNG trade back in 1964, there was only about 80,000 tons of LNG transported. LNG has been rising as the most predominant fuel resource for its minimal carbon output and clean fuel that can be used not only in industrial purposes but also for transportation by sea or land (Shell, n.d.).

2.6 Shipping company

A shipping company is a company where the main operation is to operate vessels and even offer alternative logistic solutions. According to Tiberg et al. (2015), the definition of a shipping company is a company that operates vessels and keeps them in operation. Depending on the agreement between the shipowner and charter, the shipping company also has the responsibility of hiring a master and a crew to operate the vessels (Tiberg et al., 2015).

The vessels transport different types of cargo depending on what type of shipping company it is. In this study the theory focuses on liner shipping companies. The liner shipping companies have their vessels in a fixed routing to different ports. The custom is that the company has several vessels attached to several fixed routings and each routing goes to different ports. Each route has a different estimated time of arrival (ETA) additionally they have routes to different continents in the world.

The shipping industry is a very competitive industry which forces the competitors in a race of who can offer the lowest rate for cargo transport. Because of this and the economy of scale, the shipping companies in the industry have pushed for bigger vessels to decrease the rate of transport (Rodrigue, 2016). This also forces the competitors to join in on expanding their fleet and vessel sizes since they must match the prices in the market. This can be done by bigger companies but the smaller companies either join alliances with other smaller companies or get bought out by the bigger companies (Ge et al., 2019).

Alliances are not limited to smaller shipping companies but are even beneficial for the bigger ones as well. The benefit lies in the ability to provide shorter ETA, bigger market reach and the ability to transport cargo on allied vessels.

2.6.1 CMA-CGM

CMA CGM is a French liner shipping company which was first founded in 1978. According to CMA CGM (n.d.b.), the company is operating in 160 countries with about 750 offices and 110,000 employees. CMA CGM has about 31.6 billion USD in revenue and they transport about 21 million TEUs of volume annually. The company owns a fleet of about 566 ships and has connections to 420 ports worldwide, the total amount of capacity the fleet has is 2.7 million TEU and they have 750 warehouses (CMA CGM, n.d.b.).

CMA CGM has had many acquisitions as well as partnerships between other companies. The partnerships formed has resulted in an alliance known as CMA CGM group which consist of CMA CGM alongside shipping companies American President Lines LLC (APL), Australian National Line (ANL), CHENG LIE Navigation Company (CNC Line), Containerships Ltd, Comanav and Mercosul line. The company also has a shared partnership with the logistics company CEVA Logistics (CMA CGM, n.d.a).

CMA CGM specializes in container freight transportation. The company offers dry, reefer and specialized cargo container transport and ships across 251 lines. Alongside sea freight, the company offers inland transportation and recently air freight with 4 dedicated airbuses. CMA CGM also specializes in RoRo (Roll-on/Roll-off) transportation (CMA CGM, n.d.b).

2.6.2 Hapag-Lloyd

Hapag-Lloyd is a German liner shipping company as well as one of the leading liner shipping companies around the world. According to Hapag-Lloyd (2020a), the company transports an annual of 11.8 million TEUs per year and since 2006 they are ranked as the fifth largest liner shipping company in the world. They have around 13,100 employees in 395 offices expanding around 129 countries (Hapag-Lloyd, 2020a). They offer a fleet of 237 modern ships with a total capacity of 1.7 million TEU, additionally they have a container stock of 2.7 million TEU (Hapag-Lloyd, 2020a). Furthermore, out of these 237 modern vessels at their disposal 56 of them have a carrying capacity above 10,000 TEU (Hapag-Lloyd, 2020a).

Like many other shipping companies, Hapag-Lloyd has established an alliance with other liner trading companies. The alliance was founded by Hapag-Lloyd, the three Japanese shipping companies by the name of Nippon Yusen (NYK), Mitsui O.S.K.Lines (MOL), K line and a Taiwanese shipping company called Yang Ming (Hapag-Lloyd, 2020). Today the Alliance consists of Hapag-Lloyd, NYK, Yang Ming, ONE which was merged by MOL and K Line to create Ocean Network Express and the South Korean container shipping company Hyundai Merchant Marine (HMM) (Hapag-Lloyd, 2020b).

Hapag-Lloyd offers their customers two brands of services. Carrier haulage is one of them which offers the customer the opportunity to get their cargo picked up and delivered to and from a destination. This is also known as door-to-door service. Merchant haulage is the second service which they provide. This offers the customer the option of picking up the Hapag-Lloyd container from the container terminal and which is loaded by the customer and then delivering it to port for further transportation. Basically, the customer has the option of either getting it received at port and delivered to port or received at door and delivered to door or a mixed option of both depending on how the customer wants to structure the service.

2.7 Cascading effect

Yap & Loh (2019) highlights that the development of larger vessels poses a challenge when it comes to shipping routes and sea traffic. In the shipping industry, ships with high capacity use the best logistical trade routes since there is more revenue gained from ships with high TEU (for example, 8,000 TEU) using those routes compared to ships with lower TEU capacity (4,000 TEU). The cascading effect describes how new vessels with larger capacities (10,000 TEU) are placed on the most popular trade route and the placement of new, large vessels on popular routes leads to cascading older ships onto lesser popular routes (iContainers, 2016).

For example, the vessels with 8,000 TEUs which used to be in the most popular route move down to the 2nd popular trade route. The vessels with 4,000 TEU which were in the 2nd most popular trade route are moved down to the 3rd popular trade route and this continues till all routes are replaced with better capacity vessels. This causes the routes that had smaller capacity ships to rise in capacity which can then affect ports which only take in smaller capacity ships (iContainers, 2016).

This phenomenon is also supported by an article by Merk et al. (2015). The article mentions that one of the largest trade routes is the Far East-Northern Europe trade route and therefore the largest container ships are placed on these trade routes. The average ship size on this route had a significant increase between 2007 & 2014 of about 67%. In the same period between 2007-2014, the Transpacific and Far East-Mediterranean routes also had a significant increase of about 79% in average container vessel size (Merk et al., 2015).

2.8 Suez Canal Incident

According to The Guardian (2021), the Ever Given is a mega container ship that has a capacity of about 20,000 TEU, making it one of the largest container ships in the world. On March 23rd, 2021, the mega ship was crossing the Suez Canal and ran aground near the entrance of the canal. This resulted in an obstruction of passage for all other container vessels who were waiting to cross the canal. The Ever Given was stuck for 6 days and was finally freed on March 29th and the accumulated ships waiting for passage of the canal had gone above 400 (The Guardian, 2021).

The blockage of one of the most vital canals in the shipping industry had resulted in major costs not only for the Ever Given but for other vessels that were waiting outside of the canal as operating costs continued to rise (The Guardian, 2021).

An article by Al Arabiya English (2021), discusses the importance for the Suez Canal to upgrade its infrastructure and discusses the options for extending the second route built in 2015, in order to allow for traffic to continue if vessels were to run aground. As of writing, the cause of this incident can only be speculated as it is still under investigation (The Guardian, 2021).

3. METHODS

In this section the choice of method will be presented including the author's intentions on what to achieve in this study, and how the data was collected and processed.

3.1 Explorative study

Jupp (2006) quoted "Exploratory research is a methodological approach that is primarily concerned with discovery and with generating or building theory. In a pure sense, all research is exploratory." One of the goals of this study is to investigate the effects of the mega container ships on a small scale, which was mentioned as covering the Scandinavian region. This research can be used as the groundwork for future larger scale studies which helps in saving time.

Based on the research questions and the guidance from sage method map (SAGE publication. n.d.), a conclusion was made to use a case study research method (SAGE publication. n.d.). Chalmers library was used to find databases and reliable sources regarding the case study method.

The methodology gives a flexible approach to the research in the sense that it gives the researchers more tools to use. Mills et al. (2010) informs that "It can be seen as a special research strategy and approach that can use either qualitative or quantitative data, or even combinations of them. The studied cases are usually simple ones, and they are studied in their own special environment." The authors can use different methods such as data collection and interviews depending on the questions that are being answered regarding the study. This methodology aligns with what we want to achieve in this study since it does not put pressure on smaller scale research due to its flexibility.

3.2 Literature review

The data collection will be done by using databases from Chalmers library, additionally the use of Google Scholar and other search engines like Lloyd's list and web of science to find scientific articles and magazines for the report. The process of finding academic articles started with the help of keywords related to the research questions. The keywords that were used were "mega ships", "container shipping", "impact on ports", "volume" and "limitations". These keywords were used in different search engines to find articles related to the study (see figure 3, flowchart produced by the authors). The searches were filtered by publication date and language, the publication dates were set in between 2010 and 2021 with the language being set to English. This helped narrow down the relevant articles to the study. The decision on which articles to include in the study were determined by reading the abstract and then using the process of elimination. The process of elimination is done through verifying whether the article relates to the author's research topics and questions (see Figure 2, flowchart produced by the authors).

Figure 3 Process of Elimination

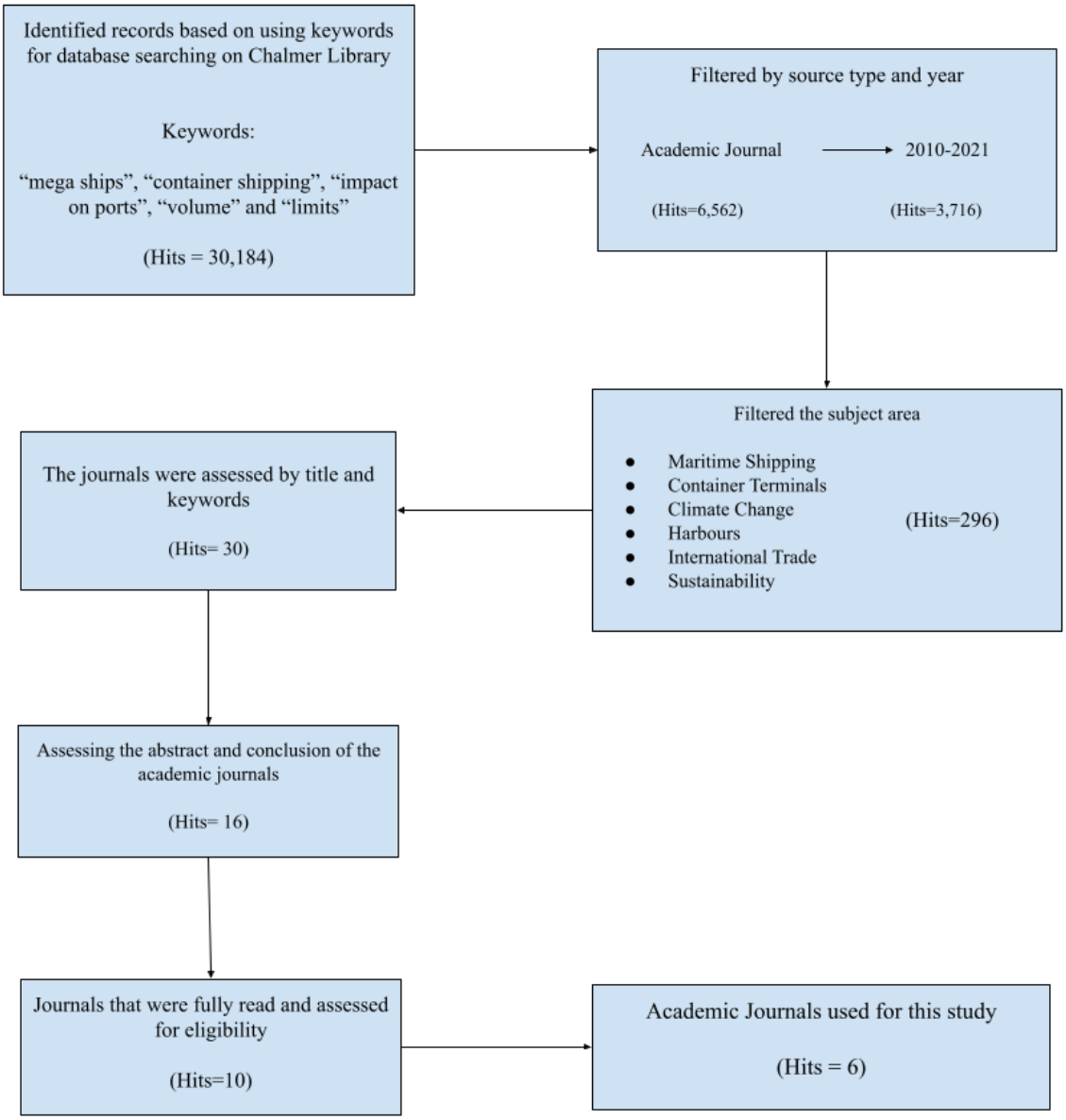
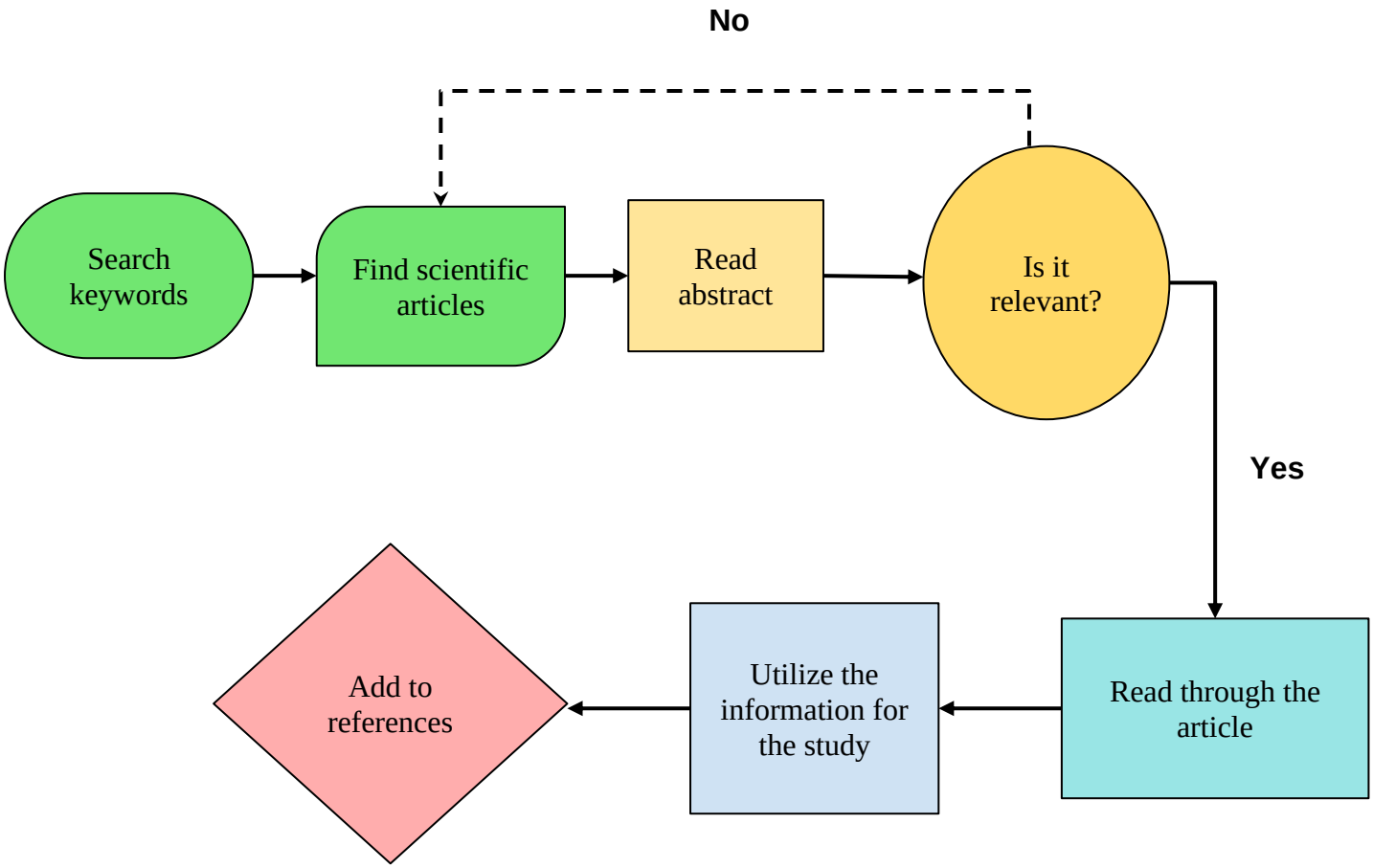


Figure 4 Literature Review Flowchart



3.3 Interview

Mills et al (2010) explains that "the gathered pieces of information constitute qualitative data, which are then interpreted. Qualitative data can be gathered not only as texts but also as pictures or through participatory observation, and a range of other methods. Interviews, for example, especially thematic interviews, are the most common data gathering method for a case study."

Since the interview is the most common type of data collection when it comes to the case study method, it can be applied to the study. The choice of interview is a semi structured interview. The interview process can be applicable but only if the companies that are being contacted are willing to cooperate and agree to their information and statements being published online. The purpose of the interview is to get the company's perspective and their view on limitations of the mega containerships. The companies in question are Hapag-Lloyd and CMA CGM which are two of the biggest shipping companies in the world and Port of Gothenburg which is responsible for Gothenburg port.

3.3.1 Ethical aspects

Before conducting the interviews, ethical aspects had to be considered. When reaching out to the participants and potential candidates it was informed by mail that if one is to participate in the study an agreement must be made between the interviewee and the authors. The agreement was that the information obtained from the interviews would be published online with the participants consent. Additionally, the interviewees would remain confidential in the report due to respect and trust between all parties involved. One aspect that was not informed to the participants was that during any time in this process, the candidates could withdraw from the study even post interview.

Before the interview, the authors would ask the interviewee if it was possible to record the interview with the intent of extracting and analyzing information. If the interviewees declined, then the recording would not take place and instead notes were taken. The recordings and transcripts will be deleted after it has served its purpose which was agreed upon with the participants.

3.3.2 Implementation of the method

The authors implemented the case study method by starting with the literature review. With the help of google scholar, chalmers library and web of science, many articles could be found. To narrow down the article's keywords were used such as mega ships, container shipping, impact on ports, volume, and limits. After this process, the authors read through the abstract of the remaining reports to further narrow down the academic papers to 16 papers. Additional sources were added from websites, magazines, and course literature.
This was done to further enhance the theory.

Before contacting companies, the authors drafted interview questions so that it was relevant to the study and the research questions. Emails were sent to 3 shipping companies and 4 port authorities. From the shipping companies 2 replied and participated in the interview and when it comes to port authorities only 1 replied and participated. The interviews took place in online applications such as zoom and Microsoft teams. Like previously mentioned in 3.2.1 before doing the interviews the participants consented to the interview and that information will be publicly available as well as identities being confidential in the report.

This report is not written with the intent of cooperating with a company. The report will be based on literary sources and the data that will be collected and analyzed from the interviews. The questions will be developed by the authors and try to be as easily defined as possible which will give the interviewer clear and broad answers which the authors can lead up with follow up questions.

The interview was a semi structured interview where it was a more casual and relaxing conversation between 3 people. Before every interview, the authors asked the interviewee for consent of recording the interview so that the authors could look back and perform a thematic analysis. The authors divided the questions so that everyone was involved in the interview. When all the interviews were conducted, the authors transcribed the interviews into written text. This was done to simplify the extraction of data to be used for the results.

3.3.3 The selection of interviewees

The limitation of mega container ships is a very broad research question, and it affects a couple of actors in the shipping industry. The focus was put into finding interviewees that had the most involvement and influence on the size of container vessels. These actors were mainly people from known shipping companies around the world as well as port authorities. The interview was done with one representative from each company in the Gothenburg area (see table 1). The companies that partook in the interview were shipping companies which had their locations in Gothenburg and the Port of Gothenburg. The average length of the interviews were around 30 minutes. The interview questions varied because of the different actors working in different segments of the shipping industry.

Table 1
Interviewees

Interview 1	Representative from Hapag-Lloyd
Interview 2	Representative from CMA CGM
Interview 3	Representative from Gothenburg Port Authority

3.3.4 Thematic analysis and the processing of data

According to Mills et al. (2012) thematic analysis is not a research method, but it is an analytic approach on specifying the meaning of the method being used. One of those methods is the case study research method. In this type of analysis, a wide range of data can be used in a thematic analysis which includes interview transcripts, audio files and video files (Mills et al., 2012). According to Mills et al. (2012) researchers have applied this analysis primarily through textual data which one must then transcribe the audio and video recording to text prior to analyzing the raw data. When that is done then the researchers will proceed with the manual coding.

By coding it is emphasized by Mills et al. (2012) that the researchers should look for repeating patterns in the text in regard to theming, topics and relationships in order to refer to the theory-building and research questions of the report. Mills et al. (2012) further explains that the process of noticing patterns, comparing and revising the data to the theory, processing the data into relevant information, the researcher can construct a case which describes, explores or explains the data collected.

The authors in this study recorded the interviews that were held online with the help of the software OBS studios. When all three interviews were recorded the process of transcribing was initiated. The entire interviews were transcribed from audio to text, this was done to lessen the burden of analyzing and coding the data. The relevant parts from the interview were extracted and processed in the result section of the study.

4. RESULTS

In this chapter the result will be presented regarding limitations of mega ships and what aspects that can affect it. The results are based on interviews conducted and a compilation of scientific articles that the authors have read.

4.1 The limitation in the shipping company

Both Hapag-Lloyd and CMA CGM acknowledged that the common trend for the last decade has been to continually push for an increase in ship size. This has been the case for all the shipping companies since it brings significant benefits to both the company and its customers, these benefits have economic, environmental, and logistic aspects. Because of these benefits it is natural that shipping companies adapt to the current market and trend to stay relevant in the industry. Companies that did not adapt would be left behind the competition since they can't offer the same service as the other companies that adapted to the current trend. This would leave them with few options to stay relevant, either they would get bought out by another shipping company or create alliances to stay relevant. By creating an alliance, they could reach a global market as well as using allied vessels.

All three of the interviewers agreed that the current trend and perhaps the future trend is to continuously invest into larger mega containerships since the cost benefits with economies of scale are too beneficial to pass up on. CMA CGM also explained that there could be limits on size based on depth and certain shipping routes like Malacca Strait. Hapag-Lloyd and CMA CGM emphasized the limit for shipping companies would be the shipping routes.

Furthermore, they bring benefits when considering emissions released in the environment. Even during the pandemic some shipping companies estimated that the demand would decrease but instead it increased. The problem is that investing in these mega container ships takes time to fully utilize them. It takes time to construct them and put them into the market and from the information that was extracted from the interviews from Hapag-Lloyd and CMA CGM the limitation is that they could mostly be utilized in a route between two continents which are Europe and Asia. Ports in the other continents are limited by draft, port size, the infrastructure and the superstructure of the port. The interview that was conducted with the Hapag-Lloyd representative highlighted that naturally it would be of great interest to increase the size of the vessels in the future but there will be a limitation due to the significant number of ports having trouble handling calls from mega containerships.

The CMA CGM interview highlighted that even massive ports like Hamburg, Rotterdam and Antwerp have issues with turnaround time since they cannot handle the calls from every mega container ship which leads to some ships anchoring outside of ports waiting for an open slot in port. The interview with the port of Gothenburg and CMA CGM gave insight on the increasing size of the vessels that made it efficient for the shipping company and its customers to transport goods, but a new problem has risen and is making it difficult on ports and their workers. Increasing the size of mega container ships is the standard in today's trends because of its efficiency but in the future, the increased sizes can prove to be inefficient because of ports not having the time to adapt to the increasing size.

4.2 The limitation in Ports and Hinterlands

An interview was conducted with the Port of Gothenburg which gave insight into the perspective of port authorities regarding mega container ships.
According to the port of Gothenburg, ports in Sweden have always been upgrading the port infrastructure since the 1960s. The Port of Gothenburg views mega container ships as links that connect Sweden with the rest of the continents around the world and acknowledges how beneficial mega container ships can be to the industry. However, the costs to maintain and upgrade the infrastructure are quite steep and there are no financial methods to recoup the losses made.

While ports are making efforts to expand its infrastructure to allow for larger ships, the interviews have shown that the rising trend of mega container ships creates a lot of pressure to force the ports to adapt which can result in heavy costs from the port, port authorities or sometimes even the Swedish maritime administration. (Personal Communication. March 24, 2021).

The port of Gothenburg also gave perspective on how small ports that only accept small feeder ships are not safe from the effects of the mega ships in the industry. In the interview, Port of Gothenburg mentioned the "cascading effect" where larger ships would take over popular trade routes and the next largest ships would replace other trade routes. The cascading effect can reach even the least popular trade routes that have small feeder ships which forces even the smallest ports to upgrade their infrastructure (Personal Communication. March 18, 2021).

Port of Gothenburg quotes regarding the present trends of mega container ships,
"*You could describe it as a race, you're either in it or you're not. You either upgrade to have the facilities for larger vessels or you don't.*"

When asked about how port workers would be affected by the mega ships, Port of Gothenburg explained by using their own port operations as an example. The Port of Gothenburg takes one call per week when it comes to mega container vessels, this is because the vessel creates high peaks in the terminal working hours as all workers are tasked to focus on the berthing, loading and unloading of the mega container vessel. Whenever its small feeder vessels, the dock workers have standard schedules but whenever mega ships are called then peak work hours are created. Because of this, there is no normal schedule for the dock workers but rather that they work on and off depending on the peaks (Personal Communication. March 18, 2021).

In the interview, it was also inquired whether automation would take over and if it would be a solution to the handling of mega container ships in ports. Port of Gothenburg replied that while automated operations would have a stable workflow, they would not be as flexible as physical workers and automation is not yet advanced enough to fully adjust to high or low intensity workflow on terminals (Personal Communication. March 18, 2021).

4.3 How it affects the environment

Hapag-Lloyd and CMA CGM provided similar answers when it comes to the environment and how the mega container ships affect it. It all depends on the perspective and the circumstances. The Hapag-Lloyd interview provided a comparison to other modes of transport where if one would transport a certain type of cargo by truck then the space would be limited and depending on how much the customer wants to transport then it requires several trips or more by trucks which will release more CO2 emissions. But if one were to load cargo in a 40 foot or 20-foot container and be able to load hundreds or ten thousand of these containers on a mega container ship then naturally it would be the more environmentally friendly option. Because all the cargo is transported at once. By looking at each vessel the total amount of emissions is significant but when divided by the amount of cargo loaded on board then the emissions are not that significant if compared to other modes of transport.

CMA CGM provided a similar example, but they compared mega container ships to smaller vessels. Instead of transporting 23,000 TEU of cargo divided into 10 smaller vessels why not transport it all in one large vessel instead. It would be cost efficient for the company since they would not have to put 10 ships into operation. They mentioned the perspective of looking at emissions per TEU transported which in total would be less if the company puts the mega container ship into operation. They also mentioned that the company is trying to start a new trend in the shipping industry by investing into mega container vessels that run on LNG fuel instead of focusing on expanding and pushing for increased size.

5. DISCUSSION

In this chapter the authors will discuss the result and compare it to the theory. What can be done about the limitation? How effective was the choice of methodology used to research? The author's opinion will be taken into consideration in this section.

5.1 What can be done about the limitation

Conducting the interviews has brought in a lot of correlations to research articles referred to in the theory sections of the report. The interviews gave like-minded answers regarding the research questions in the study.

When it comes to what could be done about the limitation depending on what the industry actors desire, i.e., a shipping company and port authority have different values based on what was showcased in the results; the port of Gothenburg remarked that it would cost heavy amounts for a port to build upon its infrastructure and that even the smallest of ports would need to expand due to the cascading effect. One can think that if the mega ships were not an industry trend, the ports would likely not want to expand in order to save costs which was mentioned in Kyu (2019) article regarding constraints of port terminals and predicted future sizes of container vessels.

When dealing with mega container ships, perhaps the solution is not to simply expand but to improve the port operations, invest in technology capable of planning out how to handle peak hours in terminals and help create efficient operations. Continuously investing into introducing a new size standard can be quite problematic without taking the other actors in the shipping industry into consideration. What the shipping companies can do is to further try to invest into finding more sustainable solutions before trying to maximize the profits and utilize the economies of scale. This could give time to port authorities to work out a solution to handle these peaks that the mega container ships create. This will be further discussed in sections 5.1.1, 5.1.2 and 5.1.3.

5.1.1 Shipping companies

The trend for the shipping companies has been to always push for larger vessels which was acknowledged by all three interviewees. The benefits in the three different aspects were economic, environmental, and logistical. In these aspects three actors are related to each other. The liner shipping company, the customer, and the ports. The economical aspect was based on the economy of scale where the shipping companies could increase their loading capacity in exchange for cheaper prices for the customer which benefits both parts. In the result it was mentioned that there would be continued investments into building larger vessels since it continues to give benefits to the shipping companies. The result showed some limitations to ship size according to the shipping companies and the port of Gothenburg.

This theory is further strengthened with academic studies by Garrido et al. (2020) where they expect mega container ships with the capacity of 30,000 TEU to be launched around 2025. Garrido et al. (2020) further explains that it would be the ultimate limit because of the constraint of the Malacca Strait. This was also mentioned in the interview with CMA CGM where they emphasized the limit for shipping companies would be the shipping routes. This means that the economic benefits could be limited when it comes to economies of scale since there seems to be a future limit. This has a connection with what the port of Gothenburg

interview talked about since they mentioned that the liner shipping industry is like a race where they are competitive about pushing the prices down through investing into the size of mega container vessels. The connection is that the shipping companies are in a competition to build larger ships in return for lesser prices, when one company builds a new size standard in the industry, other companies follow suit to try and surpass the new size standard.

The logistical benefits for the shipping company would probably be that several smaller vessels are not needed to be put into operation, this is specially focused on the main routes. Instead, it is more beneficial for one large vessel to handle the cargo because it lowers the capital cost for the company. The issue is that the mega container ships create peaks on ports and other modes of transport which in turn creates complications such as congestion.

The environmental benefits which both shipping companies claimed in the results were that it would be better to have one large vessel in operation instead of several smaller ones. The shipping companies also mentioned that it depends on the circumstances when it comes to emissions. When compared to other modes of transport i.e., rail or air, transporting by sea is more beneficial and sustainable. This is based on the perspective of emissions released by TEU transported. However, a study made by Cirella et al. (2021), mentioned that the container shipping industry is one of the largest producers of emissions when compared to other maritime shipping industries. It may be the most sustainable option when it comes to transporting goods compared to other modes of transport, but the fact remains that the container industry produces the most emissions in the maritime industry. The shipping companies can continuously work to find more sustainable options. CMA CGM mentioned in the interview, where the company is trying to start a trend by moving towards investing into mega container ships that use LNG as fuel which is currently the most environmentally friendly fuel in the industry. By starting this trend, it could be a solution to bypass the limitation of size and the amount of emissions that the large vessels emit.

5.1.2 Trade routes

Trade route aspects had been overlooked when it came to the effects of the trending mega container vessels and the interviews have shown the importance of the trade routes and their effects on the industry and ports. Trade routes have always been affected by the economies of scale since the race for building large ships leads to larger vessels taking over popular trade routes and causing the cascading effect; however, one can speculate that the cascading effect had minimal impact on the unpopular routes prior to the introduction of mega container vessels. With the current trend of mega container vessels, all trade routes including routes connected by small ports are affected due to the cascading effect.

However, while the trend of mega container ships is growing, the size is limited by the trade routes itself. In the results, CMA CGM mentioned that shipping companies would be limited by the trade routes. This aligns with an article by Merk et al (2015) where it was mentioned that the Transpacific trade route between Far East and the West Coast of North America had less significant growth in ship sizes from 2007-2015 due to the constraints of the Panama Canal.

5.1.3 Ports

Getting an interview with the port of Gothenburg helped with understanding the effects of mega container ships on the container terminal perspectives. In the discussion 5.1.2, the authors issued an article mentioning how the Panama Canal can limit the growth of ship sizes, but the results suggest that ports can also affect the growth of the mega container ships.

There is a common correlation between all interviews which is that while mega ships are growing there are not enough ports to support the ship sizes, this could be analyzed as the mega ship trend is moving faster than the industry can keep up. It was insinuated in the interview with the port of Gothenburg that there is not much of a choice besides investing into infrastructures and superstructures of ports because staying behind industry trend would result in a loss on potential revenue. The problem is that there is no equal benefit for the ports, having to invest in their infrastructure is a long-term plan and would require a significant amount of financial costs.

The effect on dock workers is also an issue which was brought up in the interviews. Depending on the size of the port and the number of calls, the mega container ship calls on ports put pressure on the workers because all the resources go into handling cargo operations for mega ships. The peak working hours for dock workers creates high intensity since all of the port resources are being utilized which could lead to higher risk of accidents occurring. Another issue when it comes to dock workers is that the size differs from port call to port call and the amount of work that needs to be done by port workers will be unevenly distributed. This causes the problem of having employed workers in a short time span and when there are smaller ships calling to port large sets of workers are left with nothing to do. This leads to ports having to rely on part time workers since employing the full time would put a strain on personal cost which leads to port workers not having a stable job and must work a different job on the side.

All ports are affected by the mega container ships because of the cascading effect therefore, in the long run every port is forced to invest in the infrastructure otherwise the ports would potentially lose calls from ships if the ports aren't willing to adapt to the ship sizes. Losing calls consecutively would not just result in loss of revenue but also end up affecting the country's trades. It can be deduced that the increasing size of mega container ships will be an issue until the ports have fully built and expanded their infrastructures. The problem might be able to solve itself, as the increasing growth of mega container vessels have been stagnating because of the limited port infrastructures. It would be preferable that most ports with high traffic complete the building and expansion of their infrastructures before larger sized vessels are built since the port industry would be caught up with the trends.

5.2 Moving towards a sustainable future

As previously mentioned in the discussion both shipping companies mentioned how their vessels affect the environment and that larger vessels were superior than having smaller vessels in traffic. The reasoning behind the answers from the interviews and discussion can be backed up by the academic article written by Baik (2017) they mention that mega container vessels are good for the environment since they consume 50% of the fuel per container moved compared to older vessels. Baik (2017) also informs that the newer designs of mega container ships focus more on fuel efficient operations.

An example could be the mega container ships that are triple E classed which stand for "energy, efficiency and environmental improvements", these vessels can carry up to 18,000 TEU.

Garrido et al. (2020) also mentions how they can reduce energy usage per TEU which would reduce the environmental impact mega container ships have. But an additional port perspective was added by Garrido et al. (2020) where they mentioned that bigger vessels produce more air pollution and emissions than smaller ships which could lead to ports charging shipping companies based on the emissions released. This would depend on the regulatory framework of ports which could cause a limitation in size since the shipping companies will have reduced profits if they are charged based on emissions released (Garrido et al., 2020). This can be a limit for the shipping companies since they cannot push for larger vessels. Instead, they have to move towards a sustainable future and find alternative solutions when it comes to reducing the emissions that their vessels are producing. There are already various possibilities for sustainable solutions such as alternative fuel sources like LNG and methanol, to slow steaming methods which reduce speed in order to lower emission output.

5.3 Suez Canal Incident and the trends in the industry

As previously mentioned in the theory, the liner shipping industry has a long history of development when it comes to the size of the ships and the way to transport cargo. With the help of containerization, the liner shipping industry has evolved to put these mega container ships into operation. Ships like HMM Algeciras, HMM Oslo and MSC Gulsun which all have the capacity to take on around 24,000 TEU, are the biggest ones currently in the industry. Compare them to the accident that occurred with Ever Given which had less capacity than the previously mentioned vessels by 4000 TEU, it really shows how it can affect global trade. A vessel that had around 20,000 TEU capacity caused an obstruction at one of the most important routes in the industry and halted global trade for 1 week which cost a significant amount of money for everyone involved. Accidents can occur but what would happen if the vessel was even bigger than the Ever Given? More cargo would have been delayed to their respective destinations, an increased number of resources would have been put into use and overall, it would be costly for every party involved.

The liner shipping companies are aware of the great risks that can occur with these large vessels and the pressure they put on other ports including canals when pushing these new orders of bigger vessels. It is quite straightforward, like previously mentioned in the result, it is a race between the shipping companies. Shipping companies are so dependent on increased earnings with economies of scale (Kyu, 2019) that they are willing to push the size limit to its fullest unless one of the liner shipping companies in the business creates a new trend in the industry. According to the interview with CMA CGM, they were trying to start a new trend by investing into new mega container vessels that run on LNG fuel which allows them to be more sustainable rather than putting a new global size standard on mega container ships. CMA CGM's approach to sustainability is a sign of a possible trend which could compete with the present trend and slowly spread around the shipping industry.

5.4 Technology role in society and sustainable development

Society has never been more dependent on technology than in the present. Different types of customers like a private person or a company can order stuff from mostly anywhere in the world with a few steps. This could be done mostly because of the contribution from the internet and globalization. Vendors can post products online on a webpage and some stores don't even have a physical location where things can be bought instead the entire store is online where the goods are in a warehouse waiting to be shipped. This makes it easier for customers because they can access and buy things within minutes without having to go out to town. Containerization is one of the contributing factors since container shipping is the most common and environmentally friendly transport at the moment when it comes to transporting large volumes of cargo. There could possibly be a correlation between the increasing demand of cargo as well as increase in digitalization and shipping companies' resolution to keep pushing for bigger vessels.

Technology has made it easier for people in society to access the global trade which has benefited the shipping companies as well since they can easily accept shipping requests online on the website. This has made major impacts on the environment since vessels are getting larger which has increased the release of emissions released. That is why the International Maritime Organization (IMO, 2018) informs that the UN has implemented goals for the year 2030 to reduce emissions by 40% and in the year 2050 to further reduce it by 50% to try to steer shipping towards a sustainable direction.

5.5 Method discussion

The method used in this report is based on a case study method that uses qualitative data collection with additional use of semi structured interviews. When collecting the data, the authors had to consider the reliability and the validity of the data that was collected. The definition of reliability in this case is how consistent the method is when collecting the data (Guest et al., 2012). Validity is the confirmation of whether the instruments, data and findings are accurate and trustworthy (Guest et al., 2012).

The key concept for reliability is basically consistency when it comes to repeating and comparing the method of the data collection, furthermore, improving the validity by having different perspectives when it comes to interviews. To further strengthen the reliability of this study it would have been optimal if the study had a larger sample of data. The validity of this study could have been further strengthened by interviewing different representatives from the shipping industry. This would have given a different perspective to the problem for everyone involved.

The substantial flaw of this report lies in the reliability and the validity. Since the amount of data is lacking due to only having a limited set of interviews, additionally the representative from the industry was limited to two shipping companies and one port authority. If more time was available, then the possibility of arranging more interviews could have been done to further strengthen the reliability. When it comes to the validity, another perspective could have been added to further strengthen the answer to the research questions.

The choice of interviewees was based on getting different perspectives from different actors in the shipping industry. A total of three interviews were conducted and was combined with literature research to further strengthen and analyze the result. To further strengthen the study, interviews could have been arranged to conduct with other port authorities in Europe additionally add the perspective of someone that is knowledgeable in sustainability and how the mega container vessels affect the environment. This could have contributed to more material to analyze but delimitations had to be added since the study was limited by time and the size of the report.

The case study method is a good method to use when it comes to educational research, but it has its benefits and drawbacks. According to Mills et al. (2012) it may not always be the best method since there are limitations. Mills et al. (2012) explains that before proceeding with a case study method one major factor needs to be taken into consideration and that is the availability of resources. These resources consist of time, funding, experience and knowledgeable researchers. The benefit of applying the case study method into the study is that fewer researchers can carry out the study during a short period of time.

The drawback would be dependent on the scope of the research since a significant amount of time goes to interviewing and to extensive travel to location of the interviews. This was not the case for this study since all the interviews were done through online applications like zoom and Microsoft teams. Another drawback would be that the researchers need to be experienced. Experienced researchers can plan and budget their time accordingly to maximize the efficiency of the research method.

Alternative methods that could have improved the study would be to combine the usage of qualitative data and questionnaires. Questions could have been structured in the questionnaires and sent out to multiple actors in the shipping industry to further increase the sample size of the data additionally it would provide the same result as the current method.

6. CONCLUSION

The introduction of mega container vessels has proven to shake the industry and while the impact has benefits and drawbacks, there is also room for the trend to steer towards a sustainable future.

The answer lies in recalling the research questions established in the beginning of the report which as follows:

1. What are the future limitations of ship volume for mega ships?
2. How do the mega ships affect the shipping industry in the present?
3. How will the volume of the mega ship affect the ports and its workers?

When relating future limitations for mega ships to the results and what was discussed, it appears that the future limitations may not lie only in the port infrastructure but also in the trade routes with artificial waterways. Small ports affected by mega ships due to cascading effect may not be able to continue expanding in size in comparison to the large ports because smaller ports may not have the financial ability to upgrade infrastructure. For shipping companies, utilizing economies of scale on mega container ships may end up in loss of revenue because port authorities can charge for emissions which can get steadily higher as the bigger the ship gets unless the companies discover ways to reduce emissions such as utilizing LNG fuel.

When it comes to how mega ships affect the industry in the present, the mega container ships are proven to be generally better for the environment. The expansion in size of these ships have been stagnating due to ports still under construction on their infrastructure, mega container ships are already limited by the number of ports that can accept calls. Ports are not the only limits to ship sizes but trade routes as well, with the Ever-Given Suez Canal incident being a relatively recent example at the time of writing.

In the case of ports and its workers, the results and discussion covered how the ports are essentially forced to invest in their infrastructure otherwise there is a risk that they will lose calls which leads to loss in revenue and trade power for the country. Large calls on ports due to mega container ships cause peak work hours as all dock workers focus on the cargo handling of ultra large container vessels. However, this still depends on the size of the ports, when it comes to port of Gothenburg the dock workers do not function under a standard schedule but rather the workers have to adapt depending on the peaks.

6.1 Recommendations for further research

In no way does this cover the entire solution or answer to the research questions, there are various factors that have not been covered which could have been discussed if given more time and if the scope of the research were wider.

Further research can be done on various ports and shipping companies. Research could also be done on optimization of port operations when handling port calls during peak hours when mega container ships call the port. This could give an interesting perspective on how to efficiently find a way to handle large port calls and decrease the turnaround times in ports.

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