Master's degree thesis

LOG954 Logistics

The empty container repositioning cycle and the container freight rates during the COVID-19 pandemic. A study of the Shanghai - Rotterdam shipping route.

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Number of pages including this page: 67

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TEU – Twenty-foot equivalent unit

FEU – Forty-foot equivalent unit

SIGP – Shanghai International Port Group

DWU – Deadweight utilization

ECR – Empty container repositioning

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Acknowledgement

I would like to give a big thanks to my supervisor Eivind Tveter, Associate Professor at Molde University College. Through Teams-meetings and e-mails we have discussed the project continuously, which have been very helpful for me! Especially it's been of great value to discuss the scope and the research objective, and how to narrow it down as much as possible. In addition, I have received many good tips on how to structure the thesis, what to focus more on, and which material that should be adjusted or dropped.

Summary

This is written as a research paper-based thesis, where specific information and data are independently collected from already existing reliable scientific sources to answer the research question/objective (Gerlach, u.d.).

The thesis will study the empty container repositioning cycle (ECR) in the COVID-era (2020-2021), and its effect on the freight rates on the shipping route Shanghai – Rotterdam. The problem that developed from 2020 have been called "the container crisis" or "a supply chain crisis" (Logimarex, u.d.). ECR is basically the logistics regarding empty containers and the process of placing them where they are needed. The freight rates, as we will see in this thesis, did in some cases increase by 700 % during the COVID-era, from 2020 – 2021. My analysis looks at some of the different factors that influenced the increased freight rates, and I argue that a self-reinforcing effect took place and created a historical situation on sea freight.

The findings of this thesis will hopefully be useful for some shippers, freight forwarders, and other businesses that rely on shipping as a mode of transportation. I will in this thesis try to explain why the freight rates rose and study the important factors that caused the container crisis. Mitigation of future risks caused by "unknown unknowns" will always be of interest for companies depending on import. However, a shock like the COVID-19 pandemic is not easy to plan for, but to study what happened from 2020 – 2021 could be of importance to some. Steve Saxon in MacKinsey said in an online presentation in 2021 that "*boom and bust are good for nobody*". When rates change by up to 700 % in a short time period it makes planning almost impossible. It could of course be beneficial for some players in the short run, but in the long run it can lead to a change in the industry, for instance longer contracts, moving of production facilities or changed use of raw materials.

1. Introduction

1.1 My interest for studying freight rates

The thesis will study the empty container repositioning cycle during the COVID-19 pandemic (2020-2021), and its effect on the freight rates on the shipping route Shanghai – Rotterdam.

When discussing the term "global supply chains" I mean the worldwide system that businesses use to produce and deliver products. In the shipping industry, this will involve producers, factories, shippers, buyers, container ports, truck drivers, warehouses and financial systems.

This master's thesis focuses on analyzing one of the reasons for change in freight rates from Shanghai to Rotterdam, by looking at the empty container repositioning cycle (ECR) and the container crisis that took place in the COVID-era. Other reasons that can have contributed to the increasing freight rates, as the war in Ukraine and trade wars, will not be part of this thesis.

Shanghai and Rotterdam are two major container ports that serve as gateways for trade between China and Europe, and east to west in general. Specifically, I want to study the container crisis importance of the rise in freight rates from 2020 to 2021, a period that saw significant changes in the global economy due to the COVID-19 pandemic. Overall, the COVID-19 pandemic has had a significant impact on the global economy and container transport, with disruptions to supply chains, decreased workforce (Arda, Umut, & Gani, 2022), imbalance of global trade between supply and demand for goods, increased costs, shifts in consumer behavior, and government interventions all contributing to the challenges faced by the industry.

The main objective of this thesis is to provide a comprehensive analysis of the factors I have found to be the most important and significant. By looking at the factors that have contributed to the container crisis, I have tried to find out what influenced the freight rates in 2020 and 2021. This thesis will try to analyze the empty container cycles importance in the formation of freight rates. I will support my findings on reports, articles, and academic books, especially "Maritime Economics" by Martin Stopford.

1.2 Personal background

I work as a senior supply chain manager in Equinor and have previously been a consultant within the area procurement and negotiations. I have assisted several Norwegian and international customers with major procurements and negotiations of products and materials, as well as ordering transport solutions from Asia to Europe. Specifically, I have spent some time working with the shipping route Shanghai to Rotterdam, trying to achieve the best possible freight rates for my customers product. In connection with this, we experienced the pandemic's tremendous effect on freight rates (Horowitz, 2021). In some cases, in 2021, we experienced that the cost of shipping a 40-foot container (FEU) was far greater than the financial value of the products inside the container, and this raised strategical business questions regarding delaying the operation, sourcing of similar products elsewhere or to move the production back to Europe. However, all transport does not stop even if the freight rates are high; Prices to the end customers can be raised, or it can simply be business critical to have the goods delivered for an ongoing project with a deadline. This will be explained in more detail in Chapter 4 and show why the demand curve used in Stopfords model are quite steep (inelastic).

We are all purchasing food, materials, equipment and services and inflation affect us all. Global Supply Chain and inflation has really become center of attention and is now something we can read about every day in the news. It also affects everyone's wallet, both businesses and end customers. Therefore, I have found interest in the topic of freight rates, which I believe are one of many drivers of global inflation. When studying data from 143 countries the past 30 years, IMF have found that shipping costs are in fact an important driver of global inflation. When freight rates double, inflation picks up around 0.7 % (IMF Blog, 2022).

I am as everybody else also experiencing the rising costs of many products in my personal life. After four decades of low U.S. and western inflation, high inflation has emerged as a central economic problem of the COVID-era (Ball, Leigh, & Mishra, 2022). To write about inflation in general will be a too large scope in a master thesis. Therefore I have narrowed the scope down to one specific trade route (Shanghai - Rotterdam) with one specific asset (40 foot containers). However, this thesis will not try to asses the freight rates impact on general inflation on for instance food or consumer products.

1.3 Data and methods

Data used in this thesis are publicly used indices in the shipping industry. Freight rates (Drewry and Freightos) and reports, such as gross domestic products (GDP). I have also used reports from United Nations Conference on Trade and Development (UNCTAD), United States International Trade Commission (USITC), International Monetary Fund (IMF) and the European Union (EU), and data from the ports of Shanghai (SIP) and Rotterdam. I also use data from the COVID-19 pandemic published by WHO.

Key numbers

Here are some key numbers, to serve as a framework in this thesis. All data are found in UNCTADs yearly "Review of Maritime Transport" 2020, 2021 and 2022.

- *Number of steel containers in the world: Approx 20 million**
- *Container trips per year: Around 200 million (both with cargo and empty)*
- *Global Container port throughput 2019 (TEU): 805 334 972*
- *Global Container port throughput 2020 (TEU): 795 534 166*
- *Global Container port throughput 2021 (TEU): 851 111 853*
- *The total value of global seaborne trade 2019: USD 14 trillion*

**Numbers will vary. One reason can be that shipping lines are holding back information on the amount of steel containers in their ownership, and the industry are known for lack of transparency.*

This thesis is written as a literature thesis. In short, this means that in my work I will use specific data and information collected from already existing reliable scientific sources (secondary sources), books and indices to answer my scientific question (scope). In order to add value to the reader, my focus has been to connect all findings to an academic model, namely the supply and demand model by Stopford. I have also drawn my own visualization to present the self-reinforcing effect of the container crisis in an understandable way and build this around facts and data from the research I have read on the topic.

I have noticed when working on this thesis, that it is very important to be open for the information and data presented to me in articles and indices. I have experienced in a few cases that my own biases and believes, does not match the data that I find. I was under the

believe that all freight rates increased in the period. This is not at all the case, so that the freight rates from west to east remained quite normal during the pandemic was new to me and have been something that I have needed to study a lot to understand deeply enough to write about.

1.4 The increase in freight rates 2020 - 2021

As we see in Figure 1 from Freightos there was a substantial increase in the cost of shipping a 40-foot container (FEU) after the COVID-outbreak in 2020. This thesis will try to analyze why and what factors caused the freight rates to increase with more than 700 % from Shanghai to Rotterdam in the year 2020-2021. It is important to be aware of the following: Freight rates have generally only accounted for a small proportion of material costs, and therefore this have been a historical event in the sea transport industry (Exception: Oil tankers) (Stopford, 2009, s. 163).

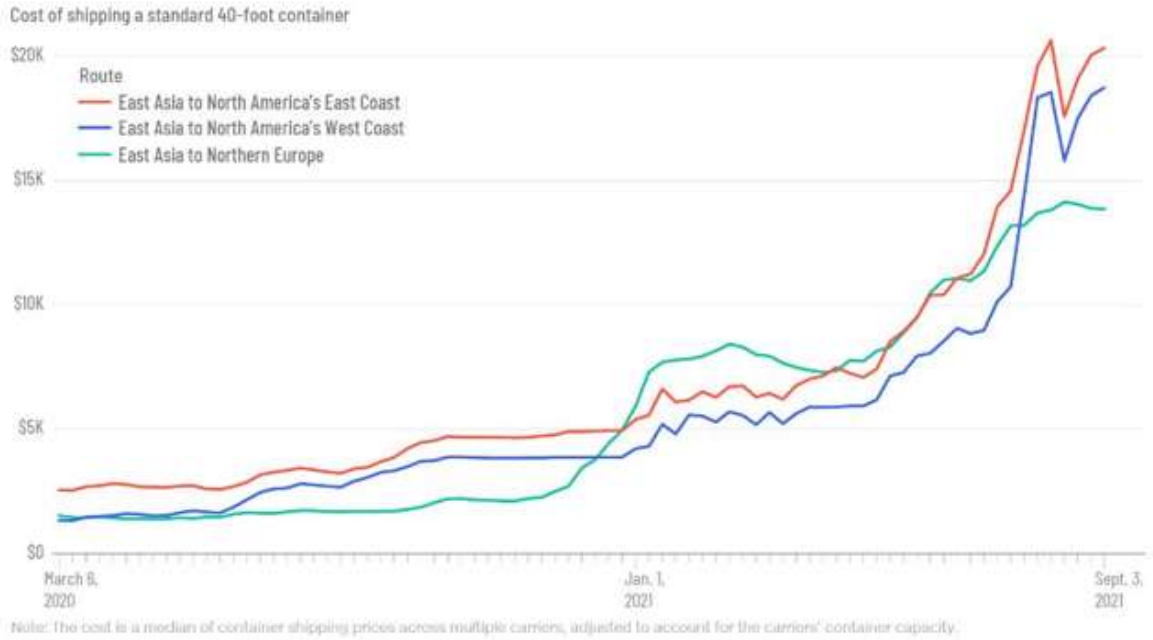


Figure 1 Freightos FEU Index.

If we look at the typical shipping route which I will focus on in this thesis, Shanghai – Rotterdam (both ways), a FEU before the pandemic costed well below $2,000. This multiplied in a very short period, and in the spot market (2021 and 2022) the price rose to above USD 14 000. Note: As shown in Figure 2 the freights rates from Rotterdam to

Shanghai remained relatively normal, due to demand patterns and container crisis (Drewry, 2023). I will go into more details of this in the analysis. It has been of great importance to me trying to understand why the difference in rates from East-West and West-East happened, and it seems clear that the empty container repositioning has been central.

Figure 2 Drewry World Container Index Shanghai to Rotterdam/ Rotterdam to Shanghai

As shown in Figure 2 from Drewry the freight rates remained relatively normal until the second half of 2020 and peaked late in 2021. The steep shift upwards was followed by a steep shift downwards. I will in this thesis focus only on why the rates reached record heights, and not analyze the decline towards normalization from the peak in 2021 through 2022.

1.5 COVID-19

Globally, As of January 19th, 2023, there have been 663 001 898 confirmed cases of COVID-19, including 6 707 959 deaths received by WHO from national authorities (WHO, 2023). It goes without saying that the pandemic has had enormous effect on the very way people have been able to live their lives, and of course also caused big challenges in global supply chains.

Kwon claims the COVID-19 Pandemic can be classified as an unknown-unknown risk whereby the probability of occurrence and the possible consequences of a risk event cannot be foreseen (Kwon, 2020). This is therefore the most dangerous type of risk, because we don't know what we don't know, and have small chances of mitigating the risk in due time. This pandemic differentiates itself in terms of the geographic scope of impact, and the supply and demand-side impacts. Previous shocks or natural disasters have mainly affected the supply side, while for instance the financial crisis in 2008 largely affected the demand side. COVID-19 disrupted both the supply and demand (Kwon, 2020).

Today's world are closely connected via high speed internet and high speed transportation, and the globalization allows people and goods to move faster and more freely than in any previous era. (Kwon, 2020) Global economy has been driven up by the help of globalization, and world trade and prosperity for many have been the result. The globalization however, also caused the COVID-19 pandemic to quickly spread, nationally and international.

Figure 3 shows the brutal economic effect of the pandemic in the first half of 2020. After many years of global GDP-growth, the world went into recession in 2020. We also see that economic activity recovered with a "V-shape", which indicates that the pandemic was a shock, and not driven by "slower" macroeconomic factors such as high unemployment etc.

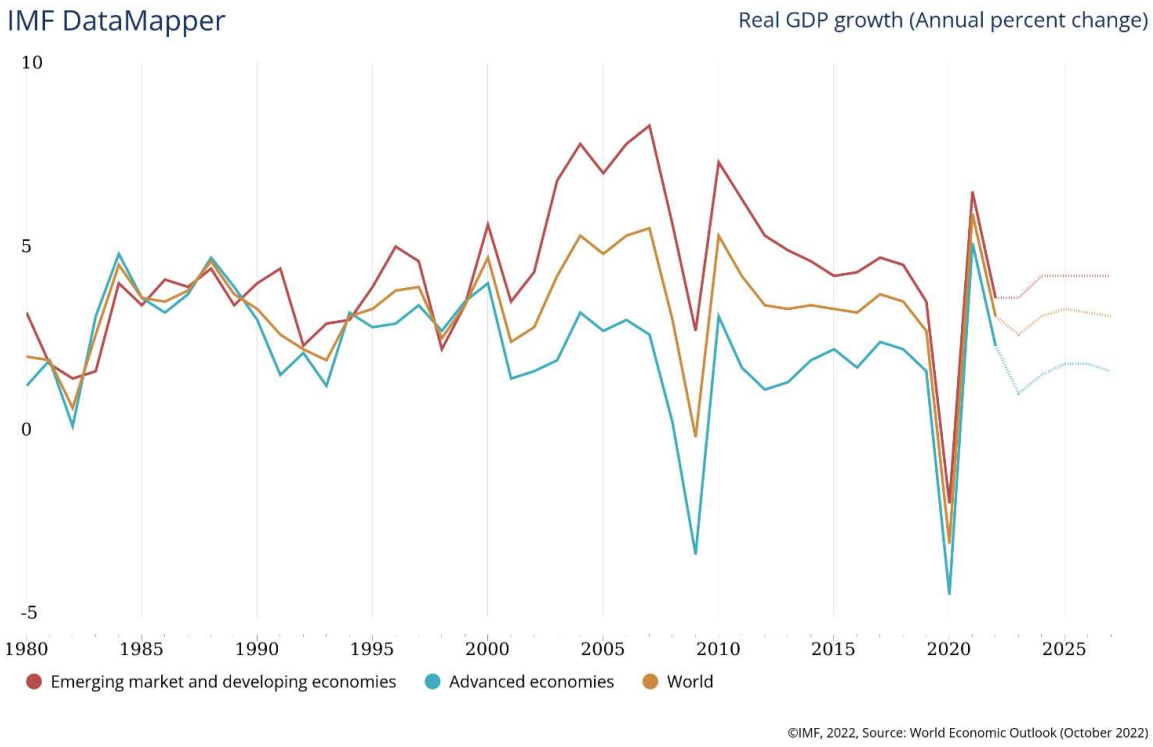


Figure 3 IMF «Real GDP Growth 1980-2023"

2. COVID-19 and its effect on Global Supply Chains, logistics and transportation

I will in this thesis define the Covid-Era as January 1st, 2020, to December 31st, 2021, although the pandemic itself have lasted well into 2023.

When the pandemic hit in the beginning of 2020, virtually the entire world went into lockdown, and global demand and international activity was dramatically reduced, very quickly. A lockdown can be defined as an emergency protocol implemented by the authorities, in order to restrict people's movement and activity level, in order to reduce the spreading of the virus (Business Insider India, 2023). When countries gradually lifted restrictions again in the second half of 2020, demand for certain product categories skyrocketed, and this created a huge shock and imbalances started to form in international supply chains. International supply chains and global trade are a tightly interwoven system, and major shocks like this can quickly produce violent ripple effects that take time to rebalance before a new normalization.

It's difficult to make a generalization about when the reopening of Asia and Europe after COVID-19 happened, because different countries within those regions had varying approaches to COVID-19 restrictions and reopening. Some countries in Asia, such as China and South Korea, implemented strict measures early on and were able to control the spread of the virus relatively quickly, allowing them to reopen earlier than some European countries that had more widespread outbreaks. However, other countries in Asia, such as India and Indonesia, have had prolonged outbreaks and have had to maintain stricter restrictions. Similarly, some European countries, such as Denmark and Norway, were able to reopen earlier due to their successful management of the pandemic, while others, such as the UK and Italy, had more prolonged outbreaks and delayed reopening (WHO, 2023). The data are quite clear that by the spring of 2020, China gladly started to fulfilling export needs, at the time when western countries went in to their first phase of lockdowns and a "work from home"-lifestyle.

In 2021, international sea freight was in the midst of a unique and highly unusual situation. It is estimated that there are around 20 million steel containers in the world and that these annually account for around approximately 200 million container trips (UNCTAD, 2022). These figures say something about the size of global trade and that maritime transport is the

artery that makes it all possible. *(The shipping companies and container carriers are known for restricting data of the amount of containers they have available due to competition and strategies, but 20 million containers are a much used estimate in articles and statistical sites)*. The COVID-19 pandemic led to a series of events which contributed greatly to the sky-high freight rates we experienced between 2020 – 2022. The COVID-19 pandemic itself should be classified as a "unknown-unknown" risk, whereby the probability of occurrence and the possible consequences of a risk event cannot be foreseen (Kwon, 2020).

China was as we know the first country into lockdown, and thus one of the first to start reopening its factories. As they started their reopening and went back to work, a high percentage of Western consumers went in lockdown at their home offices. Instead of spending money on restaurants, services and travels, consumption shifted to products. Demand in the West was rapidly shifting to furniture, clothing, audio equipment, screens, electronics, and home exercise equipment, which, of course, is mainly produced in China. On top of this, large quantities of personal protective equipment (face masks etc.) was imported from Asia. Another effect of recession caused by the pandemic in the West was also that consumers were seeking to buy even cheaper goods, thereby further increasing Western imports from Asia. China, of course, continued production and shipped the products towards their destination. Often by sea, in 20- and 40-feet steel containers. Exports quickly exceeded pre-pandemic levels and were driven by the abrupt demand growth in the West (Researcher, 2021).

In Europe and the US, container ships were met with very delayed port activity due to outbreaks of infection and quarantine of dock workers, truck drivers, seafarers, crane operators and others. In addition, exports from Europe and the US were significantly reduced in the period, when production was simply lower, also due to the shutdown. Many containers were thus stuck in the West and were not transported back to Asia in time, and the imbalance went quicker and quicker. When empty containers didn't return to China fast enough, the imbalance took place, and the situation was then named "the container crisis" (Logimarex, u.d.). Thus, the container shortage occurred, and the demand for container freight from East to West was much greater than the supply of empty and available containers. As the rates than went higher, the shipping companies did not wait in the western ports to be fully loaded, to bring the empty containers back. Instead, they returned to Asia not fully loaded, to take part in the soaring freight rates. In addition, there were also restrictions and congestions in many ports, that caused ships to leave before they were fully loaded. So, this seems to be a

self-reinforcing negative effect, and the container crisis will be very central in chapter 5 “Analysis of the factors that changed the freight rates in the COVID-era”.

The freight rates from east to west started to increase in the mid-2020. A perfectly balanced system will in this case be that every container shipped from the east to the west, also are shipped back (1:1). As this thesis will show, that was not at all the case, and the empty container repositioning process was suffering due to several factors.

2.1 Container Shipping and Liner Operation in general

Wall Street Journal have called the container “A steel box that changed the world”, and the impact on the world trade and globalization have been enormous.

Seaborne container shipping is the transportation of goods using standardized containers that can be easily loaded and unloaded from ships, trucks, and trains. This method of shipping has revolutionized the global economy by allowing goods to be transported quickly and efficiently across long distances.

Liners are a relatively new addition to the shipping business. The improving steamship technology in the 1870s made it possible for shipowners to offer scheduled services. Before this shipping were done by sails ships (Stopford, 2009, s. 506). Container shipping is even newer, and actually a quite young industry. The history of standardized container shipping can be traced back to the 1950s when the American businessman Malcom McLean came up with the idea of using standardized containers for transportation. McLean’s company, Sea-Land Service, started using containers to transport goods on a small scale, and by the 1960s, container shipping had become a major industry (Stopford, 2009, ss. 508-510). In 1956 McLean stacked 58 metal boxes on a ship going from New Jersey to Houston, and this idea completely revolutionized the industry (WALL STREET JOURNAL, u.d.). The development of container shipping was aided by the standardization of container sizes and shapes, as well as the creation of container ports and specialized container ships. Today, the TEU and FEU are the main workhorses of international container shipping, even though many other sizes also exist. By 2004 94 % of all containers were TEU and FEU (Stopford, 2009, s. 510). The introduction of computer technology also helped to streamline the process of container tracking and logistics. The overall system of cargo handling has developed into a very efficient operation, and Stopford highlights the container terminals when combined with larger and larger ships to be central in this. The specialized cranes and forklifts in the

terminals have increased handling speeds multiple times over the years. As shown in Figure 4 Transport costs have considerably declined during the 20th century, with the development of

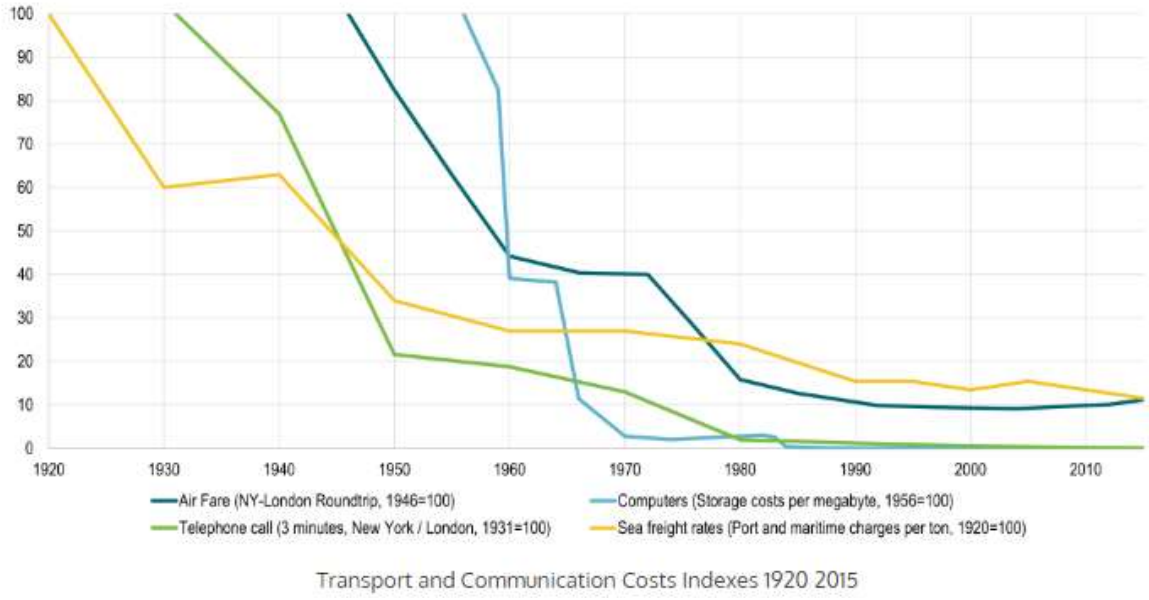


Figure 4 Transport and Communication Costs Indexes 1920 2015

transportation infrastructure and economies of scale. A single TEU can hold 10 000 IPADS, and the unit costs have been slashed multiple times over time (Rodrigue, 2020). In Figure 4 from "Transportgeography" the development in different transportation and communication cost indices are shown.

Globally, 90 % of consumer goods are moved by sea. Furniture, clothes, sneakers, fruit, rice, electronics and practically everything is transported in 20 or 40-ft containers. A 20-foot (TEU) container typically can take in 22 tons of cargo, and a large ship can carry around 24 000 containers (Researcher, 2021). Containers are used to transport a wide variety of goods, including raw materials, intermediate goods and finished products. In recent years, there has been a significant development in container shipping, particularly in the transportation of consumer goods. This has been driven by the growth of e-commerce, which has increased the demand for fast and reliable shipping of small and medium-sized packages. This development further accelerated during the COVID-era and will be discussed in my analysis in Chapter 5.

Container shipping has also been increasingly used for the transportation of perishable goods such as food and pharmaceuticals, which require special handling and temperature-controlled storage. This has been made possible by the development of specialized container types, such

as refrigerated containers, that can maintain a specific temperature range during transportation. Another development in container shipping is the use of larger and more efficient container ships, which can carry more cargo and reduce transportation costs. Additionally, container tracking technologies and digitalization of the supply chain have improved visibility and efficiency in container shipping.

Today, container shipping is a massive industry, with millions of containers being transported by ships each year. The largest container ships can carry tens of thousands of containers at once, making global trade faster and more efficient than ever before. However, the industry also faces challenges, including environmental concerns and ongoing issues with cargo theft and piracy. This will not be addressed in this thesis.

According to data from the United Nations Conference on Trade and Development (UNCTAD), the total value of global seaborne trade was estimated to be around USD 14 trillion in 2019. However, it's important to note that this figure includes not just the cost of transporting goods by sea, but also the value of the goods themselves.

As for the total value of the global shipping industry, that is a bit harder to estimate. According to a report by the International Chamber of Shipping (ICS), the total value of the global shipping industry was estimated to be around USD 571 billion in 2019, based on a combination of factors such as the value of the ships themselves, the cost of operating and maintaining them, and the revenues generated from freight rates and other services. It's worth noting that these figures are subject to a lot of variability and can change significantly from year to year, depending on factors such as global trade volumes, fuel prices, and other economic conditions.

2.2 The empty container repositioning problem

The empty container repositioning problem (ECR) are essentially the moving around of a empty container to a place where there is demand for a container. It is a classic logistical problem, that requires good planning and balancing to solve. There are roughly 170 million containers with cargo moved around every year. This is bringing manufacturing goods to customers, semi-ready goods or raw materials to factories and so on. On top of this, there is approximately another 50 million containers being moved empty, with no cargo (Container XChange, u.d.). Relocating empty containers have always been a major cost element for

shipping lines. It is estimated that it accounts for 5 – 8% of the total cost of operations. If cost of storing and maintaining the empty containers are included, the cost could reach 12 % (Salah El Din , Reason, & Ncube, 2021).

The empty container repositioning cycle is a critical process in the global supply chain of containerized goods. It involves the movement of empty containers from regions of surplus to regions of deficit to ensure that the right number of containers are available in the right locations to meet demand. As we will see in this thesis the amount of goods exported from China are far greater than the import to China, and the empty container repositioning are central for shippers and shipping lines.

The process begins with the initial placement of containers at a shipping port or terminal, where they are loaded with cargo and shipped to their destination. Once the cargo is unloaded, the containers become empty and must be repositioned to another location where they can be used for another shipment.

This repositioning is necessary because shipping routes are not always symmetrical, and demand for containers in different regions can vary significantly. For example, many containers are imported to Europe and the United States from Asia, but there may not be enough demand for exports from the west to Asia to balance the flow of containers. As a result, empty containers must be transported back to Asia to be used for the next round of shipments.

The process of repositioning empty containers can be complex and involves coordination between shipping companies, trucking companies, railroads, and other logistics providers. The goal is to minimize the cost and time required to move empty containers while ensuring that there are enough containers available in the right locations to meet demand.

In Figure 5 The container transport chain are illustrated: solid-lines indicate laden container flows and dashed-lines indicate empty container flows (Song & Dong, 2015). The figure visualizes all the different logistic “stretches” a container typically needs to do in one cycle.

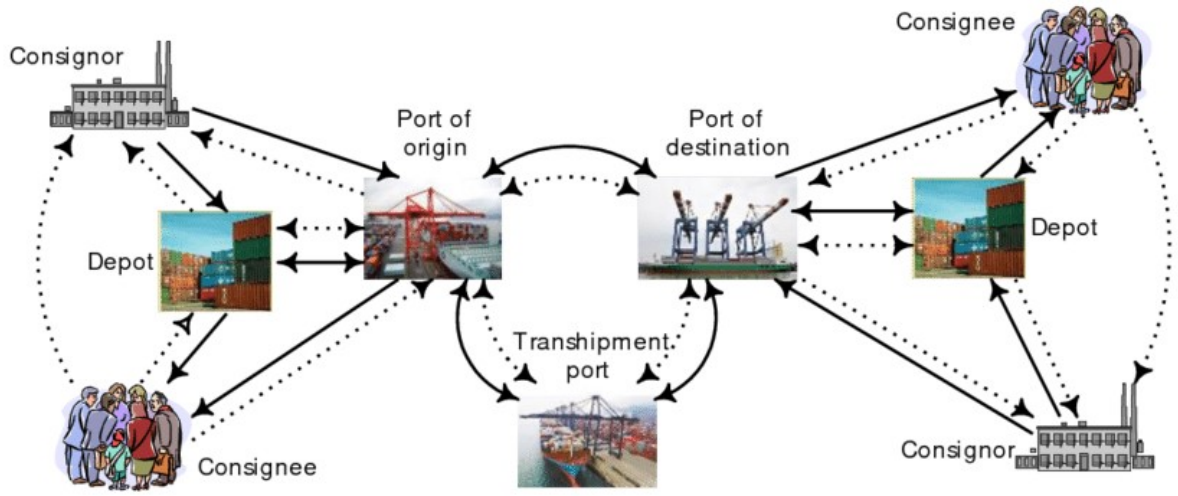


Figure 5 The container transport chain

Another ripple effect wort mentioning following the COVID-19 pandemic and the container crisis, are the rising costs elsewhere in the supply chain: When there are not enough empty containers where needed, it forces manufacturers of goods to store finished goods for longer time periods, while waiting for available containers. It gives them higher inventory cost and injures the cash flow. This effect will not be part of the analysis this thesis, as I am only focusing on the freight rates.

2.3 Shanghai – Rotterdam

This is one of the key trade routes from East to West, and West to East, and are in Stopfords book called "The Europe Far East Trade Route" (Stopford, 2009, s. 512).

According to the World Shipping Council, the Port of Shanghai in China was the world's busiest container port in 2020, with a total container throughput of approximately 43.5 million TEUs handled throughout the year. Rotterdam are one of the largest European ports, and therefore I find it interesting to study these hubs, which can be seen as the main artery for Europe to buy and import Asian products. If a change in freight rates happen on this route it will therefore affect large parts of the world and global trade.

The distance between the two ports is approximately 10 700 nautical miles. The shipping time varies depending on multiple factors such as the shipping company, type of vessel, weather conditions, fuel price and any potential stops or delays. Generally, the shipping time

can range from around 20 to 35 days, with an average of approximately 25 days. However, it is important to note that these estimates are subject to variation depending on the specific circumstances of each voyage. In Figure 6 a heatmap of global shipping lanes are presented, and the Asia – Europe lanes are clearly visible going through the Suez Canal.

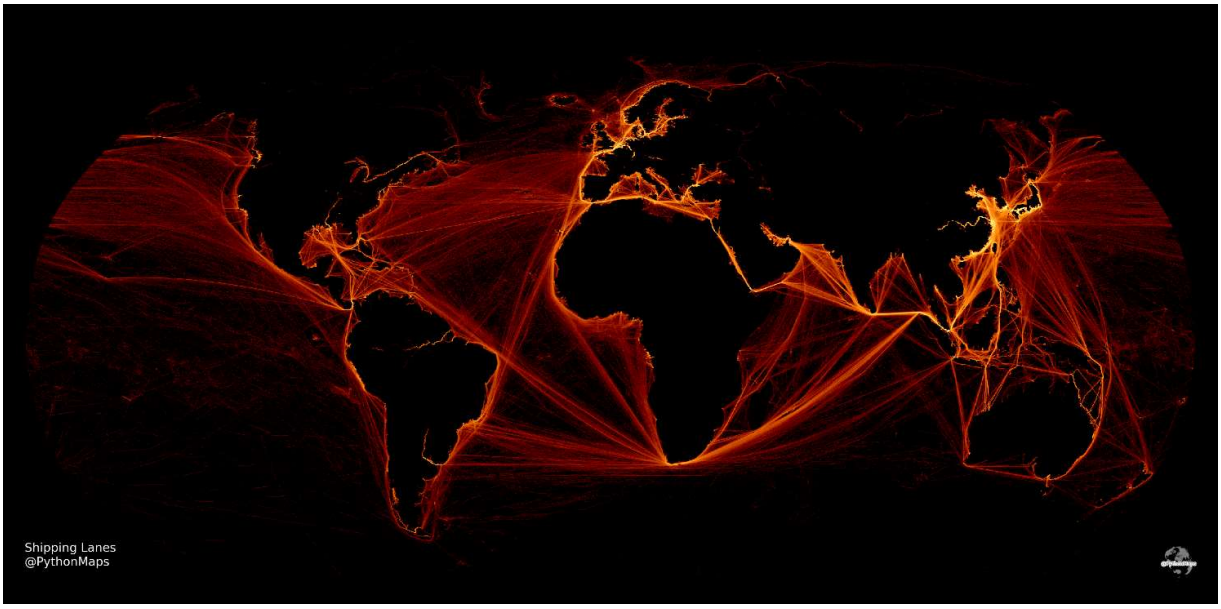


Figure 6 Global Shipping Lanes Heatmap 2015-2021 (PythonMaps)

Shanghai and Rotterdam are two of the busiest container ports in the world. Many gateway ports, also Rotterdam (-7 %) and Shanghai (-6.8%), saw reduction in their container throughput in the first half of 2020 (Cullinane & Haralambides, 2021). For ports this size, a 7 % change are severe, when thinking of the number of containers handled each year. Shanghai for instance, handled around 43.5 million TEU in 2020. The sharp fall in container throughput was equally quick reversed in the second half of 2020. It is very challenging for big systems like this to adjust to new levels of demand, and things started to "break" and imbalances started to form. It should be stressed that the economic hardships induced by COVID-19 were not systemic, but rather the result of an unforeseen external shock (Cullinane & Haralambides, 2021).

Shanghai:

In 2014, the port of Shanghai handled 35.2 million twenty-foot equivalent units (TEUs) of containers, making it the busiest container port in the world. Since then, the port's container

volume has continued to grow steadily, reaching a record high of 43.5 million TEUs in 2020. The port is relatively new, and a latecomer in the container business. Its first container terminal was opened in 1983. But from that time, the growth has been enormous, and it is now the world's largest port measured in container throughput for 13 consecutive years (Port Economics, 2017) (Shanghai International Port Group, 2023).

The port is divided in three main areas: Yangshan, Waigaoqiao and Wusong and are operated by the Shanghai International Port Group (SIGP).

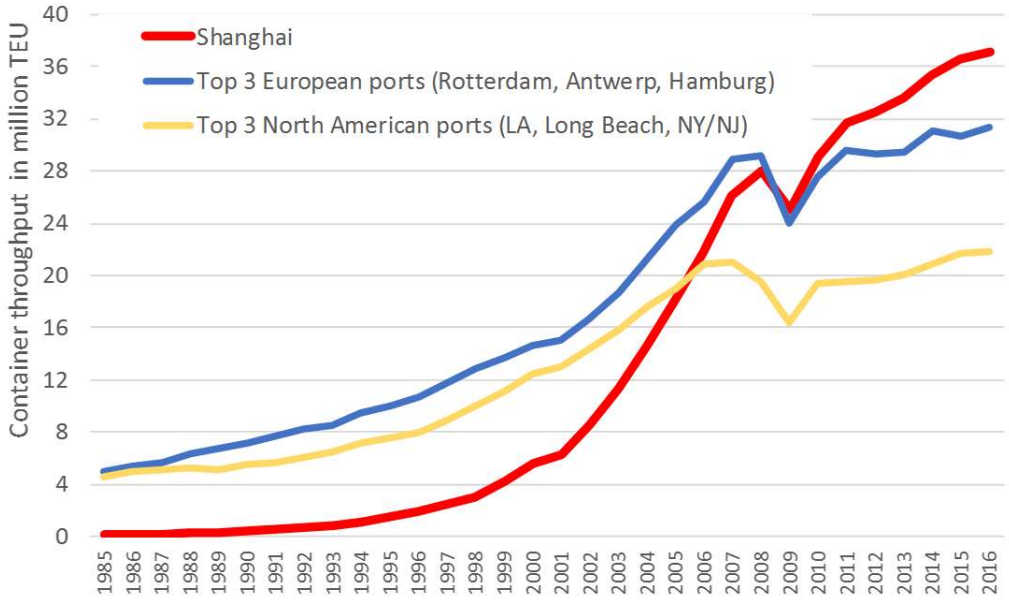


Figure 7 Port of Shanghai Container Throughput 1985-2016 Source: Porteconomics

Seven of the world's 10 largest container ports are located in China, and more than 50 % of the global container shipping volume are handled in Chinese ports (Arda, Umut, & Gani, 2022). China is not only the biggest exporter, but also the second largest importer of goods. This global structure of exports and imports necessitates the formation of a China-oriented container positioning cycle in container transportation (Arda, Umut, & Gani, 2022).

Rotterdam:

In 2014, the port of Rotterdam handled 12.3 million TEUs of containers, making it the eighth busiest container port in the world (Rotterdam, 2023). The port's container volume has also grown steadily over the years, reaching a record high of 15.2 million TEUs in 2019

(Rotterdam, 2023). Rotterdam is Europe's largest port by container volume and has seen a significant increase in the size of container ships calling at the port in recent years. Overall, both Shanghai and Rotterdam have seen steady growth in their container volumes and ship traffic over the past eight years, cementing their positions as major players in the global shipping industry.

3. Research objectives and constraints

The thesis objective is divided into two categories: general and specific objectives as presented below.

3.1 The general objective

The ultimate objective of this study is to assess the empty container repositioning cycle and the container freight rates during the COVID-19 pandemic.

3.2 The specific objectives

The specific objective is to study how the empty container repositioning cycle affected the freight rates on the shipping route Shanghai – Rotterdam, in the years 2020 through 2021.

3.3 Scope

- **20- and 40-foot containers. Abbreviated TEU and FEU.**
    - When discussing freight rates, I will only use the price of TEU and FEU.
    - This means that for instance crude oil, coal or other bulk materials will not be looked at in this thesis. To avoid that the material, research, and data are to complex, I have chosen to focus the thesis on 20 and 40-foot containers. I will rather study this in greater detail, than to spend a "little time on many things."
- **Shipping route *Shanghai – Rotterdam* and *Rotterdam – Shanghai*.** Please note that I will look into freight rates both East-West, and West-East, as these were behaving in very different ways. However, I will focus on the Shanghai – Rotterdam (East- West) as this was the route that saw the biggest changes in freight rates.
- **Time period 2020 – 2021**. Start of COVID-19 outbreak in the beginning of 2020, until peak in freight rates late 2021. This period has been chosen to make sure that I cover the steep rise in freight rates starting in 2020 with a peak in the end of 2021.

The scope has been narrowed down as much as possible to provide deeper answers on fewer things. I considered including 2022 in this thesis, which also saw very interesting movements in the freight rates. The shift downwards from the peak in late 2021 was almost as steep as the shift upwards in 2020 and would have been equally interesting to study. However, during my work I have experienced the need to narrow the scope as much as possible, in order to say something meaningful on "fewer things".

3.4 Structure of the thesis

In this thesis I will use recently published articles, reports, webinars and price indices (2020 – 2021) to describe the situation that occurred during the COVID-era. I will than connect this to the model "The Shipping Market Supply and Demand Model" from the book Maritime Economics (Stopford, 2009). I want to describe the different supply and demand factors and affected the shipping market, and specifically the central variables that was important in the COVID-era regarding the empty container repositioning process.

The thesis is structured as follows: Chapter 1 and 2 gives an introduction and context to the research objectives. Chapter 3 presents the research objectives and scope. Chapter 4 presents the literature review and the theoretical framework. In Chapter 5 I present my analysis (Findings) of the factors that contributed to the increased freight rates. In Chapter 6 I present my discussion and in Chapter 7 I sum up the thesis with conclusions.

4. Literature review and theoretical framework

4.1 Literature review

In this thesis the goal has been to describe how and why the changes in freight rates happened in the container shipping industry in the COVID-era. So, to properly analyze the situation, a good theoretic model has been beneficial. I will describe "The Shipping market supply and demand model" (Stopford, 2009) in greater detail later in this chapter.

I have used only secondary data and have not conducted any gathering of primary data in this thesis.

In my work I have also used Google Scholar and Science Direct to perform my literature search for this thesis. Luckily there are a lot of relevant material published, so the challenge has not been to find literature, but to choose and prioritize. Since Shanghai – Rotterdam shipping route are one of the large global routes, the information and public interest for it have been massive.

From my supervisor Eivind Tveter I was recommended the book Maritime Economic Third Edition by Martin Stopford. This have been central in my work, and especially the shipping market model. I am in no way a shipping expert, so to use the highly acclaimed book to learn the fundamentals of shipping have been important. The history of shipping in general have been interesting to read, although my main focus has been on one specific route and model.

To "connect the dots" in the real world it is useful to use a model as a framework going forward. Scientific models are used to explain and predict the behavior of real objects or systems and are used in a variety of scientific disciplines (Rogers, 2011). When using models, I believe it is of great importance to understand it deeply, and by doing that also get awareness of the limitations in the model.

I have used reports from EU, UNCTAD, IMF and WHO when working. I have to say that the quality and amount of relevant data have been very good and have been used extensively. Above all have been UNCTADs yearly "Review of maritime transport" – reports. This have given me the facts and data needed to describe and answer my research question.

Lastly, I have also seen some useful webinars, for instance by McKinsey & Company, made by their shipping analysts.

In some cases, I have experienced to find varying data, such as container volumes. I have than gone through different sources and found that in some cases there has been an unprecise use of terminology by different sources. Yearly container throughput has been mixed up with container trips, and so forth.

4.2 Theoretical Framework

The main academic model used to answer the research question have been Martin Stopfords shipping market model. In this chapter I will provide an overview of his theory, and in the analysis in Chapter 5, I will look to the model when discussing the different factors that contributed to the rising freight rates.

Martin Stopford's shipping market model is a widely used framework for understanding the dynamics of the shipping industry. The model is based on the principles of supply and demand and how they interact to determine the level of freight rates in the market and have therefore been a natural choice for me when working on this thesis.

According to Stopford's model, the shipping industry is made up of two main components: **shipping supply and shipping demand.** Shipping supply refers to the amount of available shipping capacity, which is determined by the number of ships in the fleet and their carrying capacity. So, the model will also in my view be valid when describing the container crisis and its effect on shipping supply. Shipping demand, on the other hand, is determined by the amount of cargo that needs to be transported from one location to another.

The interaction between shipping supply and demand determines the level of freight rates in the market. When shipping supply exceeds shipping demand, there is an oversupply of shipping capacity, which leads to lower freight rates. Conversely, when shipping demand exceeds shipping supply, there is a shortage of shipping capacity, which leads to higher freight rates.

Stopford's model also considers several factors that can influence shipping supply and demand, including technological advancements, regulatory changes, and economic conditions. For example, advances in ship design and propulsion can increase the efficiency of the shipping industry, while changes in regulations can increase the cost of operating ships.

Economic conditions, such as fluctuations in global trade and commodity prices, can also have a significant impact on shipping demand.

Overall, Stopford's shipping market model provides a useful framework for understanding the complex dynamics of the shipping industry. By considering the interplay between shipping supply and demand, as well as other key factors, the model can help industry participants make informed decisions about fleet expansion, route planning, and other strategic initiatives. In Figure 8 (Jugovic, Komadina, & Hadzic, 2015) the complete model is visualized. However, I will in this chapter focus on Stopfords different supply and demand factors in the model, and eventually how the demand and supply functions look like and behave.

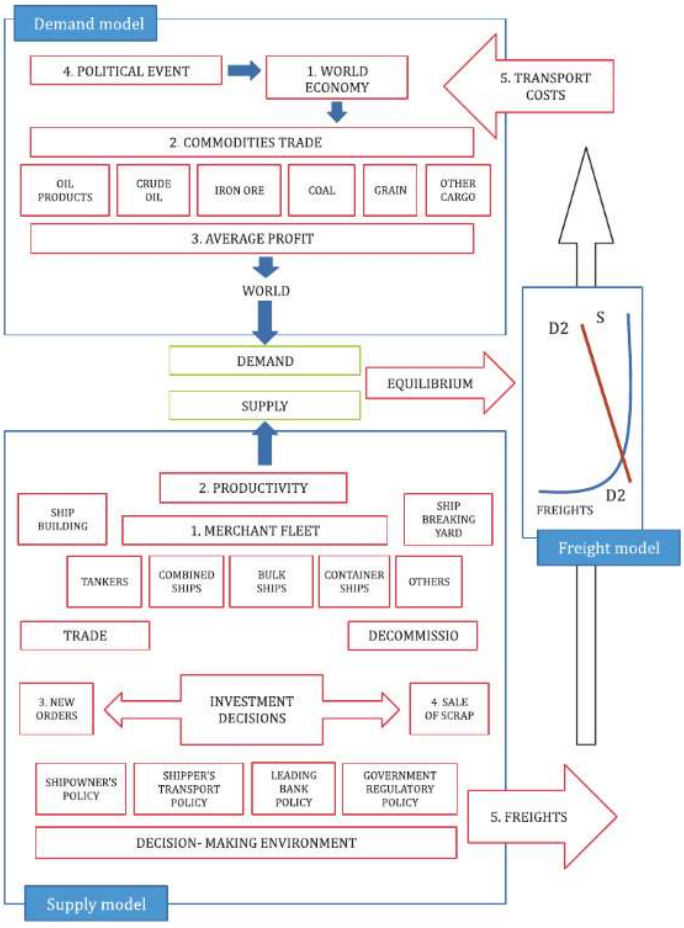


Figure 4 The Shipping Market Model by Martin Stopford, Illustrated by Jugovic, Komadina and Hadzic,

4.2.1 Factors influencing the demand for sea transport

The world economy is the most important single influence on demand for shipping (Stopford, 2009, s. 140). Shipping transports around 90 % of all global trade, including raw materials which are the input factors for all companies that produce something (Jugovic, Komadina, & Hadzic, 2015). As we saw in Figure 3 from IMF the global GDP was reduced in 2020, and this will be of importance when looking at the formation of freight rates. Stopford shows that the growth of sea trade correlates to the global GDP when examining world GDP cycles and sea trade from 1966 to 2006. As Stopford shows in Figure 9, with data from World Bank, the cycles of the world economy greatly correlate with the demand for sea trade (Stopford, 2009).

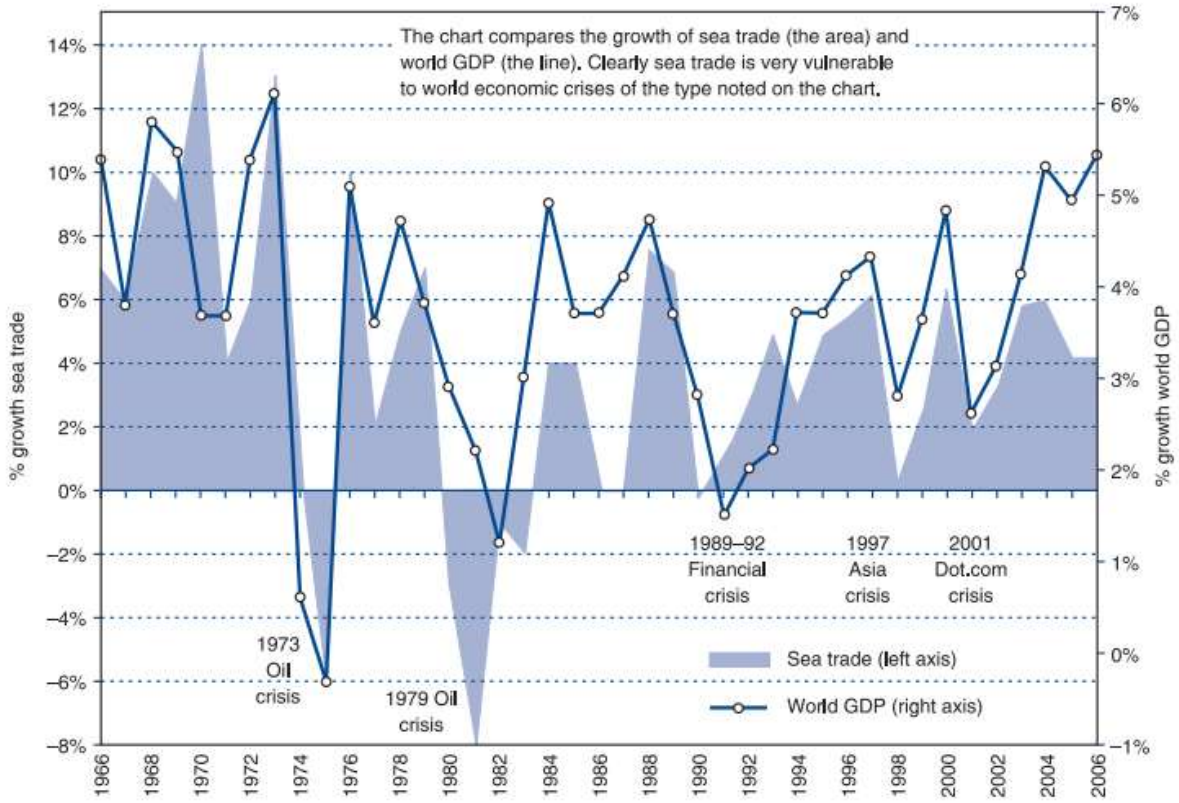


Figure 5 World GDP cycles and sea trade (Stopford)

Seaborne commodities trade, both long term and short term, are the second demand variable in Stopfords model. One important cause of short-term volatility is the seasonality of some trades (Stopford, 2009, s. 143) Agricultural commodities are subject to seasonal variations caused by for instance harvests. This can be fruits, grains, sugar etc. The transportation of commodities like this can be difficult to plan, and therefore shippers often rely on spot market to meet their transport requirements. As a result, seasonality actually has a quite substantial effect on the freight market pricing.

Average haul, or "average profit" as it is called In Figure 8, are the third factor influencing demand in Stopfords model. It is usual to measure sea transport demand in terms of "ton miles", which can be defined as the tonnage of cargo shipped, multiplied with the average distance over which it is transported (Stopford, 2009, s. 146). A clear picture of this has been illustrated several times by the closure of the Suez Canal, which is a key gateway between east and west trade; When the canal closes, it increases the distance by sea from the Arabian Gulf to Europe from 6000 miles to 11 000 miles. This leads to a sudden increase in ship demand, and there have been a freight market boom on all occasions. A severe traffic jam also occurred in March 2021, when "Ever Given" was stuck in the Suez Canal, on its path from Malaysia to Netherlands. It was carrying 20 000 TEUs. 30 % off all containers pass through the canal each year and makes it one of the world's most critical bottlenecks. Each day 51 ship passes the canal, loaded with goods between 3 and 9 billion USD. It has been calculated that the 6 days "Ever Given" was stuck, it halted 10 % of all world trade (University of Maryland, 2021) . In the Findings-chapter I will look further into the traffic jam when discussing the container crisis.

[1] *Ever Given in the Suez Canal 2021*

Random shocks, or "political event" as it is called in the illustration in Figure 8, are also a factor on the demand side of the formation of freight rates. An external shock can turn the shipping market upside down (Jugovic, Komadina, & Hadzic, 2015). I have previously stated that the COVID-19 pandemic should be looked at as a "unknown-unknown", which is the worst form of shock or risk. "Political events" can be revolutions, strikes, local regulations or wars.

Transport cost are the last main factor influencing the demand side in Stopfords model. Raw materials and finished products will only be transported if the cost of transport is acceptable. So, if the transport cost is so high that it makes the business model unsustainable, demand

[1] Photo 26/03/2021 by WorldView-2 © 2021

will fall, and businesses will look elsewhere for sourcing of the products or try to change their input factors. However, in the last century larger ships and improved effectiveness in maritime operations have led to a steady reduction of transport cost. Affordable overseas transport has had a huge effect on world trade and globalization (Jugovic, Komadina, & Hadzic, 2015, s. 26).

4.2.2 Factors influencing the supply of sea transport

The supply of shipping services can be characterized as slow in its response to changes in demand. The reason is that merchant ships take about one year to build, and delivery may take 2-3 years if the shipyards are busy. So, if the demand increases the market will need some time to adjust to this. On the other hand, once built, a ship has a physical life of 15-30 years, which means that adjusting to lower demand can also be a lengthy business (Stopford, 2009, s. 150).

The shipping supply are controlled by four groups of decision-makers: shipowners, charterers, bankers, and regulatory authorities (Jugovic, Komadina, & Hadzic, 2015, s. 26). I will in this thesis look at the supply of shipping capacity in the COVID-era, given that there was a high share of blank sailings in 2020. I will also look at the supply of available containers (TEU & FEU) and see if this influenced the overall supply for sea transport.

The Merchant fleet size are in the long run determined by shipbreaking and newbuilding. We know that the average economic life of a ship is 25 years, and this means that only a small portion of the fleet will be scrapped each year (Stopford, 2009, s. 153). In this thesis I will focus on cellular container ships. From 1980 to 2007 there was a 10 % growth per annum in deadweight ton of this ship class. This have not happened only by building more ships than decommissioned ships, but by increasing the size of the ships.

Productivity of the merchant fleet, (P) are measured in ton miles per deadweight**,** depends on four main variables**:** Speed, the time spent in ports, deadweight utilization (DWU) and the time a ship spent at sea loaded with cargo. Speed determines the time a vessel will use on a voyage. The speed can be affected by oil-prices, freight rates, maintenance of the ship, hull fouling and aging of the fleet. Port time are also important when discussing productivity; the upper limit is set by the physical performance of the ships and the terminals. In this thesis, port congestion, strikes, lockdowns and traffic jams will be discussed in the Findings-chapter, and will be relevant when trying to answer why freight rates behaved as they did. DWU refers to

the cargo capacity that are lost, when for instance space onboard are used for bunkers, stores etc., which will prevent a full load from being carried. Lastly, a vessels time is divided between “loaded days at sea” and “unproductive” days. If one of these increases the other one decreases, naturally (Stopford, 2009, s. 156).

Shipbuilding is an industry that plays an active role in the process of adjustments in the shipping market. When trying to assess the future demand for shipping services**,** one will have to rely on estimates. The combined building and delivery time will range from 1-4 years and makes estimation of future demand difficult.

Scrapping and losses are the last main supply factor described in Stopfords model. The growth rate of the merchant fleet depends on the shipbuilding and of the deletions from the fleet in form of scrapping or ships lost at sea. Scrapping is decided based on age, technical obsolescence, scrap prices current earnings and future expectations. Overall, when influenced by that number of variables, this is a very complex matter (Stopford, 2009, s. 158).

Freight rates are the ultimate regulator that influence the supply of sea transport. The rates are a key input factor when deciding to order new ships or to send some fore scrapping.

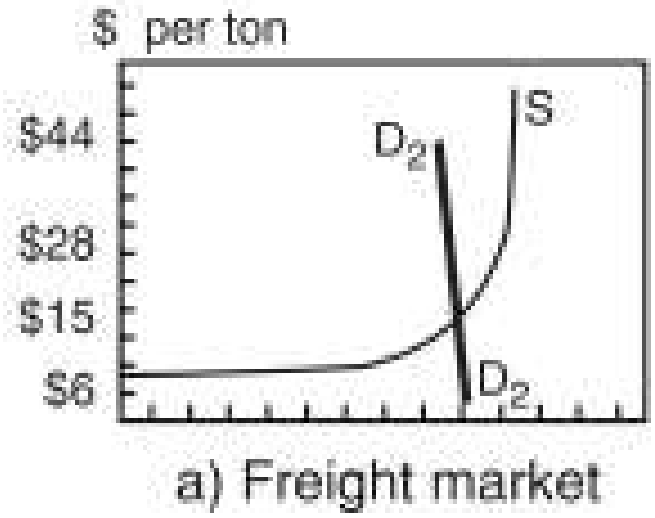
4.2.3 The freight rate mechanism

The third part of the shipping market model is the freight market. This is where supply and demand are connected. This is normal economic theory, where the result will be

lower demand than supply = lower price

higher demand than supply = higher price

When a price is established, shippers and shipowners adjust to it, and this will eventually bring the market towards balance (Stopford, 2009, ss. 160-161).



The relationship between supply and demand have always been a key economic matric in many economic models. In short, prices go up if the demand are greater than the supply. This will be a central aspect in this thesis, and specifically what caused the demand of container freight and transport from Shanghai to Rotterdam to be much greater than the supply of possible containers. If there is a skew somewhere, the system starts to shake, and the supply and demand curves to move. In this thesis I will here investigate this aspect, and especially the imbalance of containers between the east and the west.

4.2.4 The supply and demand functions

The supply function for an individual ship is a J-shaped curve and the equation looks as follows:

$$S = \sqrt{\frac{R}{3pkd}}$$

S = Optimum speed (miles per day)

R = The voyage freight rate

p = the price of fuel

d = distance

This equation defines the J-shape and takes into account the optimum speed (cost of fuel as a result of speed).

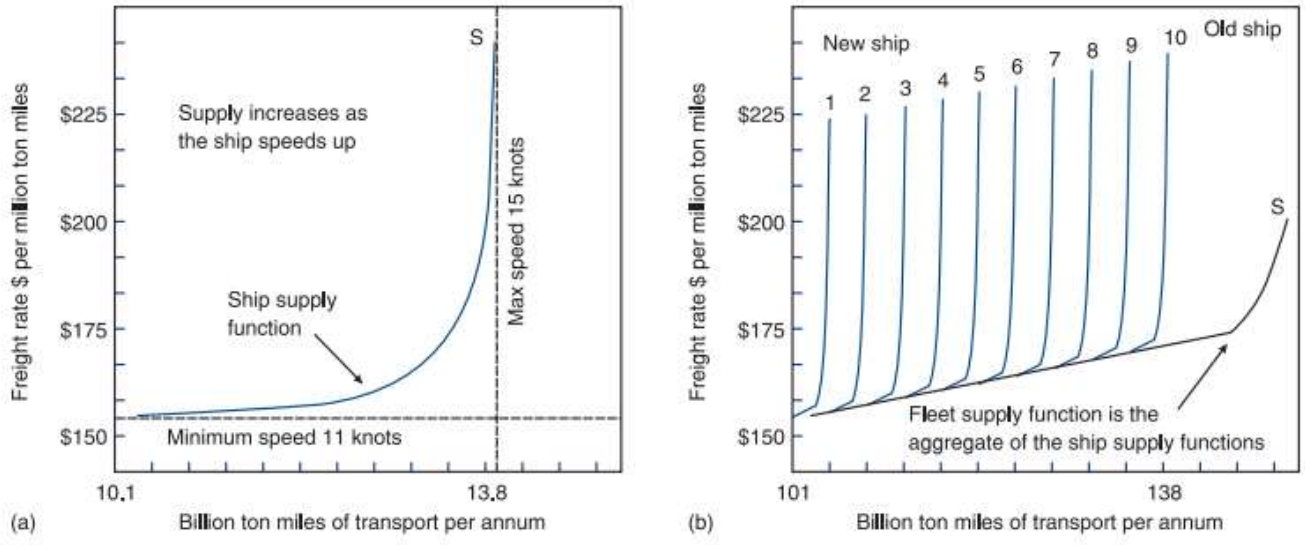


Figure 6 a) The Ship Supply function b) The fleet supply function

Providing the market is perfectly competitive, the shipowner will maximize his profit by operating the ship where the speed at which marginal cost equals the freight rate. So, by increasing the speed, supply increases.

The fleet supply function is the aggregate of the ship supply function. In the model Ship 1 are the newest, and Ship 10 are the oldest, and therefore will be the one with the highest operating cost. The fleet supply will be adjusted by moving the oldest ship in and out of service (lay-up).

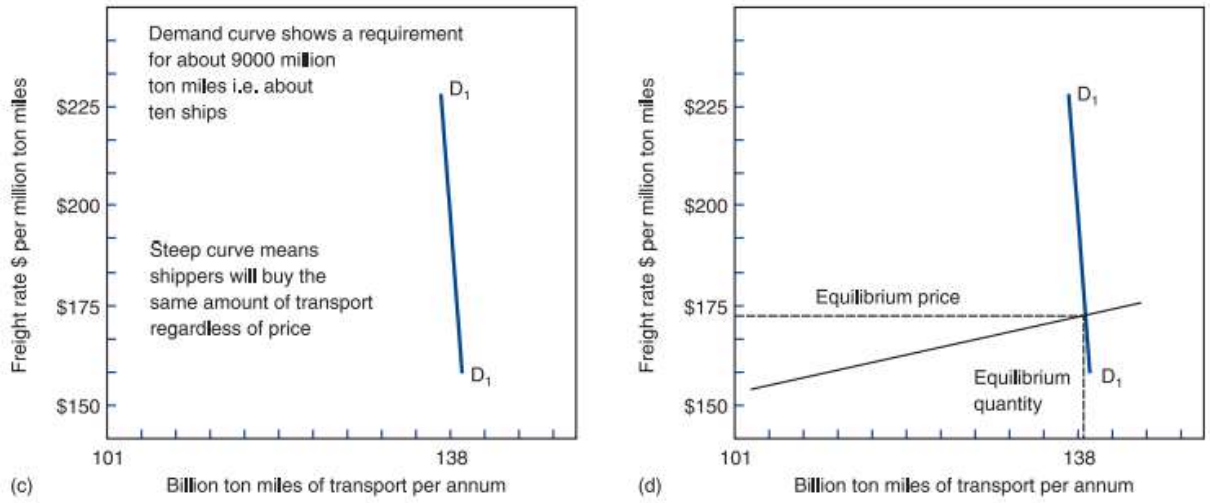


Figure 7 c) The demand function (for oil transport) d) supply-demand equilibrium

As we see in the model the demand function/curve are very steep (inelastic). Stopford have made the model like this to illustrate that demand for sea transport are quite inelastic due to the lack of alternatives. Shippers need the cargo, until they have time to make alternative arrangements, almost regardless of cost (Stopford, 2009, s. 163). In shipping it often takes time to make alternative arrangements. It also works opposite: Low rates will not tempt shippers to increase demand.

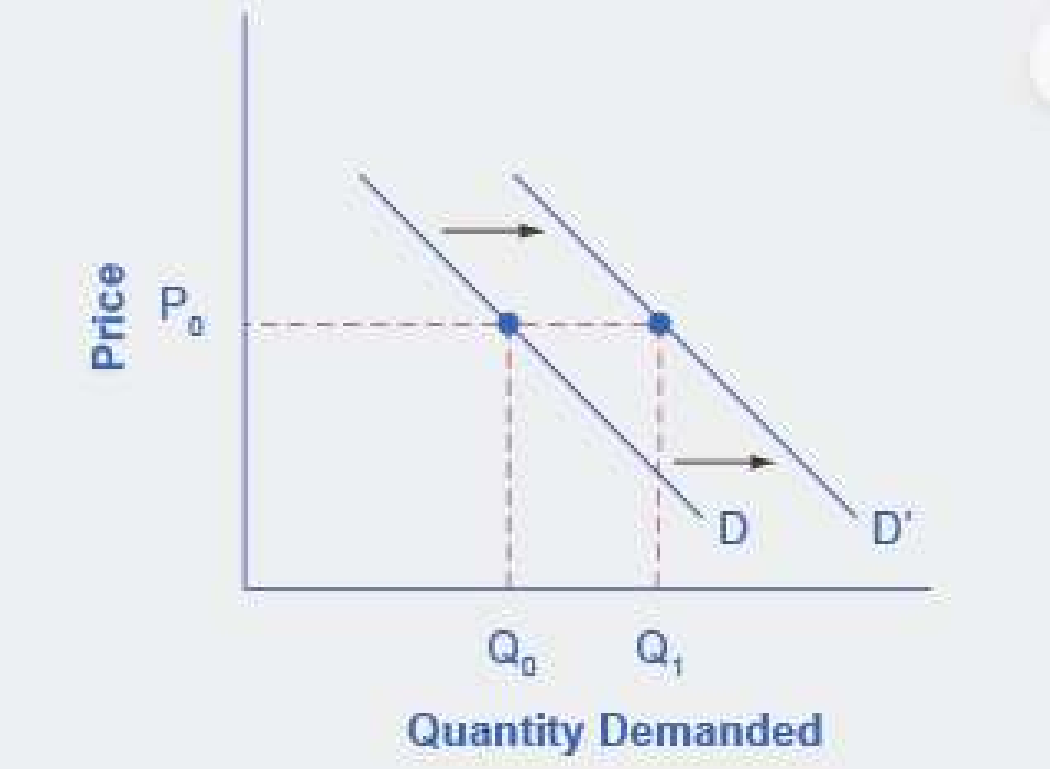
The demand curve can shift inwards and outwards. When the demand curve shifts inward, it means that consumers are willing to buy less of the goods or service at any given price level. This can happen, for example, if there is a decrease in consumer income or if there is a substitute product that becomes more attractive to consumers.

Conversely, when the demand curve shifts outward, it means that consumers are willing to buy more of the good or service at any given price level. This can happen, for example, if there is an increase in consumer income or if the goods or service becomes more popular.

Changes in the demand curve can affect the supply curve and price in different ways. If the demand curve shifts inward, it means that producers will have to lower the price in order to sell the same amount of the good or service. This can result in a decrease in the quantity of the good or service supplied.

Conversely, if the demand curve shifts outward, it means that producers can charge a higher price and sell more of the good or service. This can result in an increase in the quantity of the good or service supplied.

In summary, the demand curve can shift inward or outward due to various factors, and these changes can affect the supply curve and price of the good or service. Understanding these relationships is important for analyzing market dynamics and predicting market outcomes.



[2]

The demand curve used in the model is steep (inelastic) because shippers need cargo almost regardless of cost, and it takes time to make new arrangements if the prices get too high (See figure 11c).

[2] Worked Example: Shift in Demand | Microeconomics (lumenlearning.com)

4.2.5 Equilibrium and the importance of time

In the model the supply and demand curve intersect at the equilibrium price. Stopford claims that prices are a blend of the present and future expectations, and have divided the timeframe in three:

- *Momentary equilibrium*
- *The short run*
- *The long run*

Momentary Equilibrium

This type of equilibrium describes the freight rate negotiated for prompt ships and cargoes (Stopford, 2009, s. 163). It is also called the sport marked. The ships are ready and the cargo are waiting for transport, and a deal needs to be made. This should be looked at as an auction in a very short-term situation.

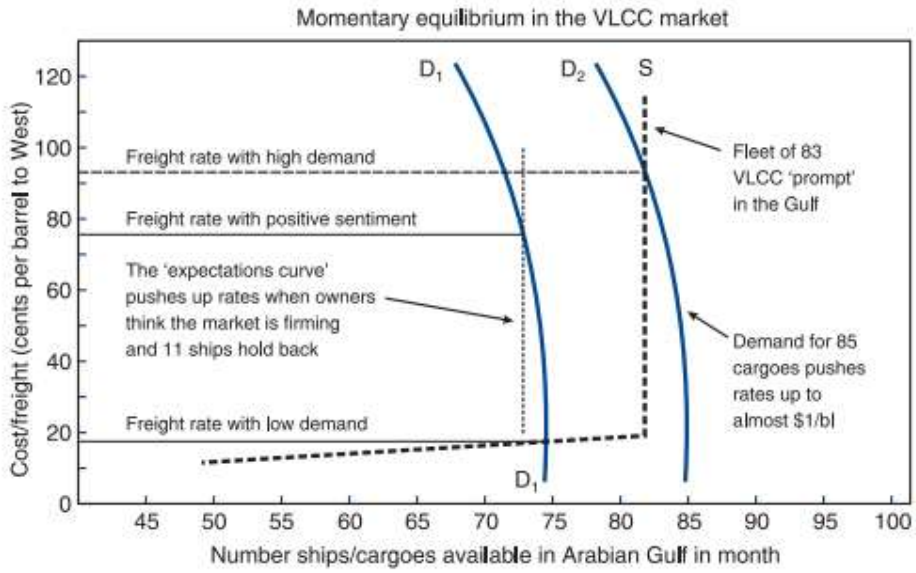


Figure 12 Momentary Equilibrium in the VLCC market

In Stopfords example there are 83 ships available to load and the supply curve S slopes gently from 15 cents a barrel to 21 cents a barrel until all 83 ships are loaded. Than the S-curve goes vertical. In the example the demand for only 75 ships are shown, and there are more ships than cargo. In that case rates fall to operating cost, which in the example are 20 cents.

The short run equilibrium

In the short there are more time to make arrangements and respond to price changes. The market settles at the freight rate where supply equals demand. A small increase in demand (Point A to Point B in Figure 13b) will only create a small increase in freight rates. The reason for this is that available ships in lay up immediately can come out of lay-up to meet increasing demand. But then, if demand keeps increasing to point C, the market rate will now be determined by the oldest and least efficient ships, which need very high rates to be tempted to go into service.

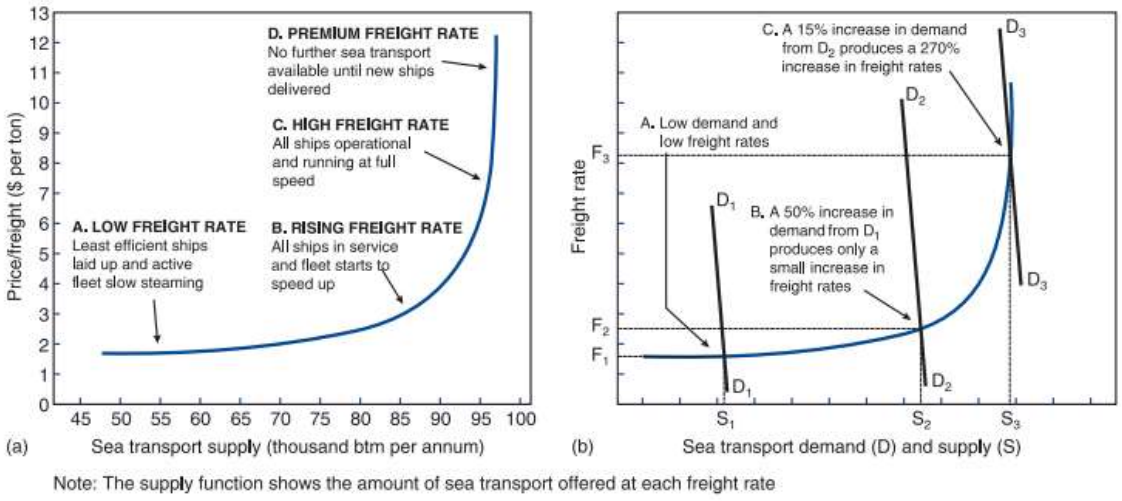


Figure 13 Sea transport supply and demand in the short run equilibrium (Stopford, 2009, s. 165)

The long run equilibrium

In the long run fleet size can be adjusted by ordering new ships and scrapping old ones. If fright rates fall during a recession the profitability of ships, and therefore the secondhand value of the least effective ship, falls to scrap price. When a ship is scrapped, it is permanently removed from the market and the supply surplus are reduced. When there is a shortage of ships the freight rates are pushed up, and shippers may decide to expand their operations. With more buyers than sellers, second-hand prices rise until used ships gets more expensive than new buildings.

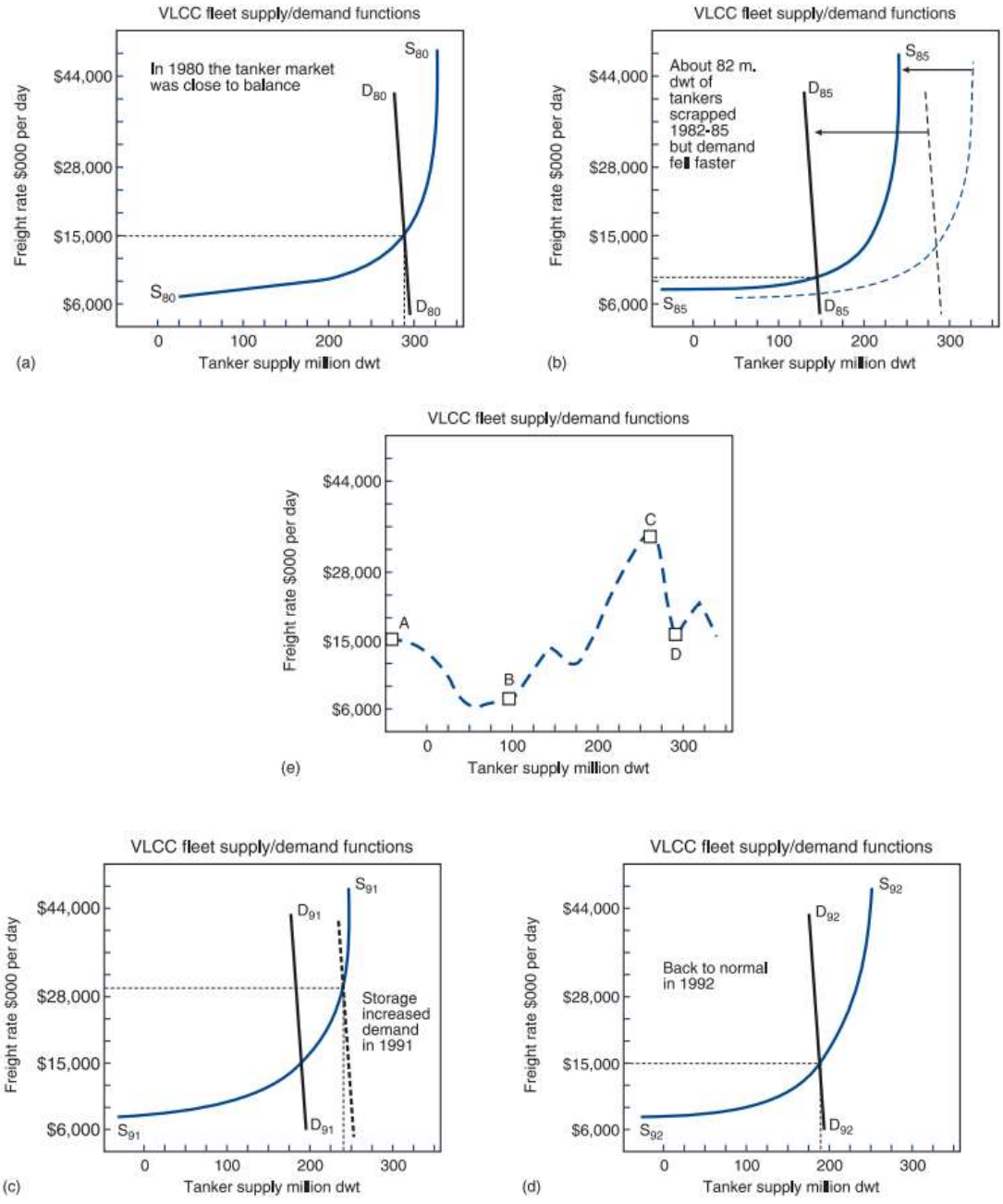


Figure 14 Sea transport supply and demand in the long run equilibrium (Stopford, 2009, s. 165)

5. Analysis of the factors that changed the freight rates in the COVID-era

First, on major finding for myself have been that the freight rates from East to West greatly differs from the freight rates from West to East, as shown in Figure 2. For me, this clearly indicates that the global container situation has played a vital part and will be central in my analysis. The question of interest for me have been to find out why the freight rates increased so much. In my view the container crisis and the container repositioning cycle are to blame, and I will in this chapter make my arguments for this. I will make my arguments based on some of the factors listed in Stopford's model, and look at supply factors, demand factors and time dimensions.

I will discuss the factors which I have identified and make arguments for why I believe these are the most central when explaining increasing freight rates. This means that some are not included, for instance the war in Ukraine.

Overall, I will in this chapter argue that the following factors did contribute to the container crisis that developed from 2020 to 2022 and caused the drastic increase in freight rates:

Demand factors:

a) *Increase of e-commerce and demand patterns*
b) *Government response*
c) *Increased demand for consumer products*

Supply factors:

a) *Bottlenecks and overload*
b) *A consolidated and powerful market of shipping lines.*
c) *Cancelled sailings*

Supply and demand interactions

a) *The container repositioning cycle and the self-reinforcing effect.*
b) *Lack of new containers*

In the table below I have summed up the different factors that will be discussed in this chapter, and tried to give an overview of the type, importance, and time dimension. I would argue that it is the sum of all factors that have caused the container crisis, and then the increased freight rates. However, I believe that some factors are more influential than others.

Factor	Type	Importance	Time dimension
E-commerce	Demand	High	Short/medium term
Government response	Demand	Medium	Short term
Consumer Products	Demand	High	Short term
Bottlenecks and overload	Supply	High	Short/medium term
Shipping market concentration	Supply	Low/medium	Long term
Cancelled sailings	Supply	Medium	Short term
Lack of new containers	Supply	High	Short/medium term
Container repositioning cycle	Supply	High	Short/medium term

5.1. Demand for sea transport in the COVID-era

a) Increase in e-commerce and demand patterns

McKinsey stated in August 2021 that the overall global demand for sea transport by containers increased by 5 % compared to 2019 volumes (McKinsey, 2021). They claim that 5 % should be relatively easy for the container lines to handle, so to investigate the spike in freight rates the supply side are very central. Although there was an overall global demand increase of "only" 5 %, there was a clear spike in North American and European imports. As we know, some of the biggest shipping routes are from China to North America, and China to Europe, where the main import ports from Asia could see container volumes up to 40 % higher than in 2019. Such an increase in volumes causes the ports and the hinterland infrastructure, such as rails, trucking and container yards to congest and to slow down. So according to McKinsey`s analysts, there have been a moderate increase in demand but a significant drop in supply.

To be able to deliver a container loaded with cargo, the first thing you need are an empty container. A practical example of the demand of empty containers during the COVID-era are from a container vessel on the route Dubai- Mumbai – Dubai; The shipper/exporter claims that before the pandemic it used to take 1 month to get hold of an empty container, but in

2021 it took 3 months. This led to the willingness of exporters to pay higher rates for empty containers (Salah El Din , Reason, & Ncube, 2021).

In the initial phase of the pandemic outbreak, both global production and international trade declined (Cullinane & Haralambides, 2021). This had to do with the lockdown in China and its closure of many production facilities. It was followed by lockdowns in Europe and North America, which initially (Q1 2020) led to reduced demand for Chinese imports. As shown in Figure 7 from IMF, the world went into recession. However, the contraction of global overall demand did not get as dramatic as many analysts feared; the contraction of demand in some sectors was compensated by an increase in others (Cullinane & Haralambides, 2021).

Overall, the demand curve, after an initial shift left, did shift right in the years 2020 to 2022.

The demand for online retail, or e-commerce, have been in a upward trend for some years, but in 2020 there was a noticeable spike in online retail sales, and it went well above the trendline shown in Figure 15. 2020 started with a decline, but then the shift is very steep upwards. As shown in Figure 15 from IMF we see the clear spike in e-commerce vs the trend line (Alcedo, Cavallo, Dwyer, Prachi, & Spilimbergo, 2022). *(The graph describes data from USA, which are quite similar to Europe and can be used in this thesis.)* I notice the steep shift upwards in 2020, very similar to the spike in freight rates in the same period. We also know that retail goods (electronics, clothes, furniture etc) are produced mainly in China, and that goods must be shipped to the customer. So, in my view there is good reason to say that the spike in e-commerce for retail goods produced in China contributed to the increased freight rates. It is also noticeable that the graph returns to the trendline during 2021, also with quite steep changes.

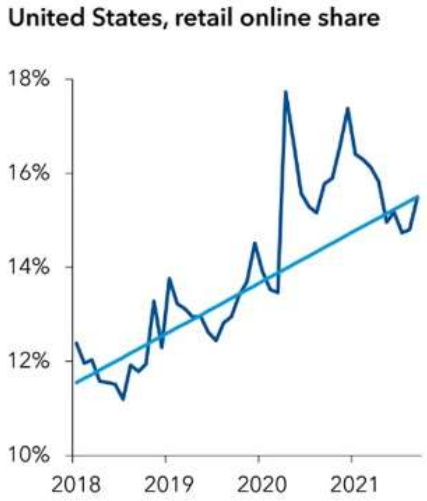


Figure 15 Retail online share vs Pre-Pandemic trend (IMF)

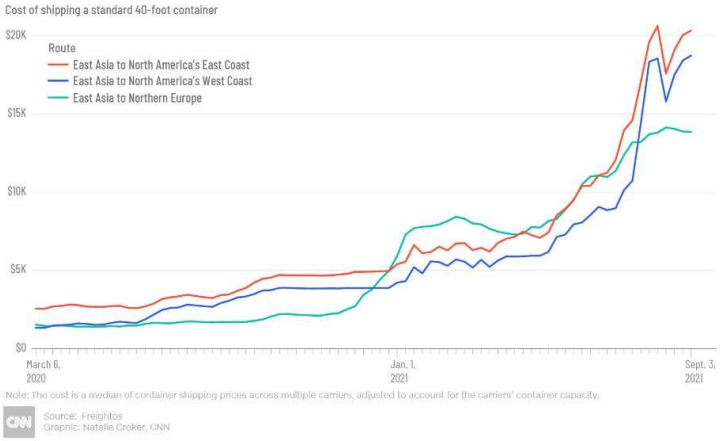


Figure 1 Freightos FEU Index

In Figure 16 below, McKinsey compares US consumers spending between Q1 2019 and Q1 2021. The data shows clearly that there was a significant shift in demand from services to goods in the period. Again, China is the main producer of these product-types, and Shanghai are one of the biggest hubs where these are shipped from.

Figure 16 McKinsey Spending Q1 2019 vs Q1 2021

According to the UNCTAD`s "Review of Maritime Transport 2021" the percentage of online retail sales increased from 16 % (2019) to 19 % (2020). The report estimated the overall global e-commerce market at $27 trillion, equivalent of 30 percent of GDP (UNCTAD, 2021).

b) Sustained demand through government response

Many governments were quick to roll out many different stimulus packages during the pandemic and demand was sustained in many areas.

In the United States, the Coronavirus Aid, Relief, and Economic Security (CARES) Act, which was signed into law in March 2020, provided direct payments to individuals and families, expanded unemployment benefits, and provided loans to small businesses. The 2 trillion dollars CARES Act helped to support consumer spending and prevent a deeper contraction in the economy (Anoushiravani, O`Connor, DiCaprio, & Iorio, 2020).

Similarly, in Europe, the European Union (EU) implemented a 750 billion EUR stimulus package, which included grants and loans to member states, to support the recovery from the pandemic. The package aimed to sustain demand by providing funding for investments in healthcare, education, and digital infrastructure (European Commision, 2020).

In China, the government implemented a range of measures to support the economy, including fiscal stimulus packages and monetary policy measures. For example, the government provided tax relief to businesses, increased spending on infrastructure projects, and implemented monetary policy measures to support liquidity in the financial system (IMF, 2020). Overall, the government response and stimulus packages were critical in sustaining demand during the COVID-19 pandemic. By providing direct support to individuals and businesses, governments helped to prevent a deeper contraction in the economy and mitigate the Impact of the pandemic on households and businesses. When knowing that around 90 % of global trade are transported by sea, this naturally had effect on the demand for shipping. In the initial phase of the pandemic shipping supply was reduced by using “blank sailings”, so the stimulus packages might came as a surprise for the suppliers of sea transport, and also contributed to the increased freight rates.

c) Increased demand for consumer products

Stockbuilding produces sudden bursts of demand as industries adjust their stocks during the business cycle (Stopford, 2009, s. 141). During the global lockdowns in the first half of 2020, inventories were run down, as evidenced by the substantial restocking that took place in the second half of 2020 (Cullinane & Haralambides, 2021). According to McKinsey it is also quite normal with a peak in demand in the months August, September and October where

many importers are building their stocks in time for Christmas (McKinsey, 2021). The sum of these events increased the demand for consumer products.

5.2 Supply for sea transport in the COVID-era

In this section I will look at the network that supply containers, which in turn of course affects the overall supply of sea transport.

In his article from 2020 where AIS Big Data was used, Jishuang Zhu concludes that the COVID 19-pandemic did not significantly affect the number of ships arriving at Chinas Ports. However, it has caused a significant reduction in berth time, indicating that the number of containers loaded and unloaded are reduced under the influence of the pandemic (Zhu, Qiu, & Jian, 2020). This could also indicate the container crisis effect (lack of containers caused by the imbalance).

a) Bottlenecks

According to reports United States International Trade Commission (USITC) COVID-19 have also impacted transportation personnel and port operations. High infection rates among workers led to reduced activity and bottlenecks, which decreased the amount of cargo that could move to and from ships. Shipping container backlogs were forming, and further delayed loading and offloading. Health policies, quarantine and travel regulations also decreased the activity. Labor shortages also affected onshore transportation systems, including rail and trucks) which added to the container repositioning problems. The International Labour Organization estimated that 800 000 seafarers were unable to embark or disembark their vessels in 2020 (USITC, 2020). The same report also estimates that the higher labor-related expenses caused by COVID-19 caused maritime personnel costs to rise 6.2 percent in 2020.

It is a well-known fact that supply chain bottlenecks developed during the COVID-era, and this contributed to lower supply and higher freight rates. Lockdowns and restrictions led to disruptions in the transportation network, including seafarers, dock workers, truck drives among others. The sudden shifts down and then up for sea freight demand during 2020 led to ripple effects throughout the already stressed network. The ports were also facing a shortage of labor due to social distancing protocols, leading to delays in unloading and loading of

containers. This also affected other activities, such as maintenance, repairs and inspections. The slowdown of activity in the ports increased the ships waiting times, as seen in the picture below. Border closures and quarantine measures by various countries further complicated the situation. I have included a photo (below) from Marinetraffic, taken on the date April 19th 2022, that shows the bottleneck outside the port of Shanghai. The amounts of ships waiting to load or discharge are significant larger in 2022 than in the previous years:

[3] Bottlenecks outside Shanghai (Source:Marinetraffic)

The "Ever Given" incident reminded the world just how much we rely on shipping (UNCTAD, 2022). A calculation was done and showed that the 6 days "Ever Given" was stuck, it halted 10 % of all world trade (University of Maryland, 2021).

[3] Ships waiting to load or offload at the ports around Shanghai April 19th 2022 (Source: Marinetraffic) Red= Tankers

b) A consolidated and powerful market of shipping lines

The container shipping lines experienced enormous profitability during the COVID-era. The market power of the biggest players have been growing, which are shown in the Figure 17 from UNCTAD below.

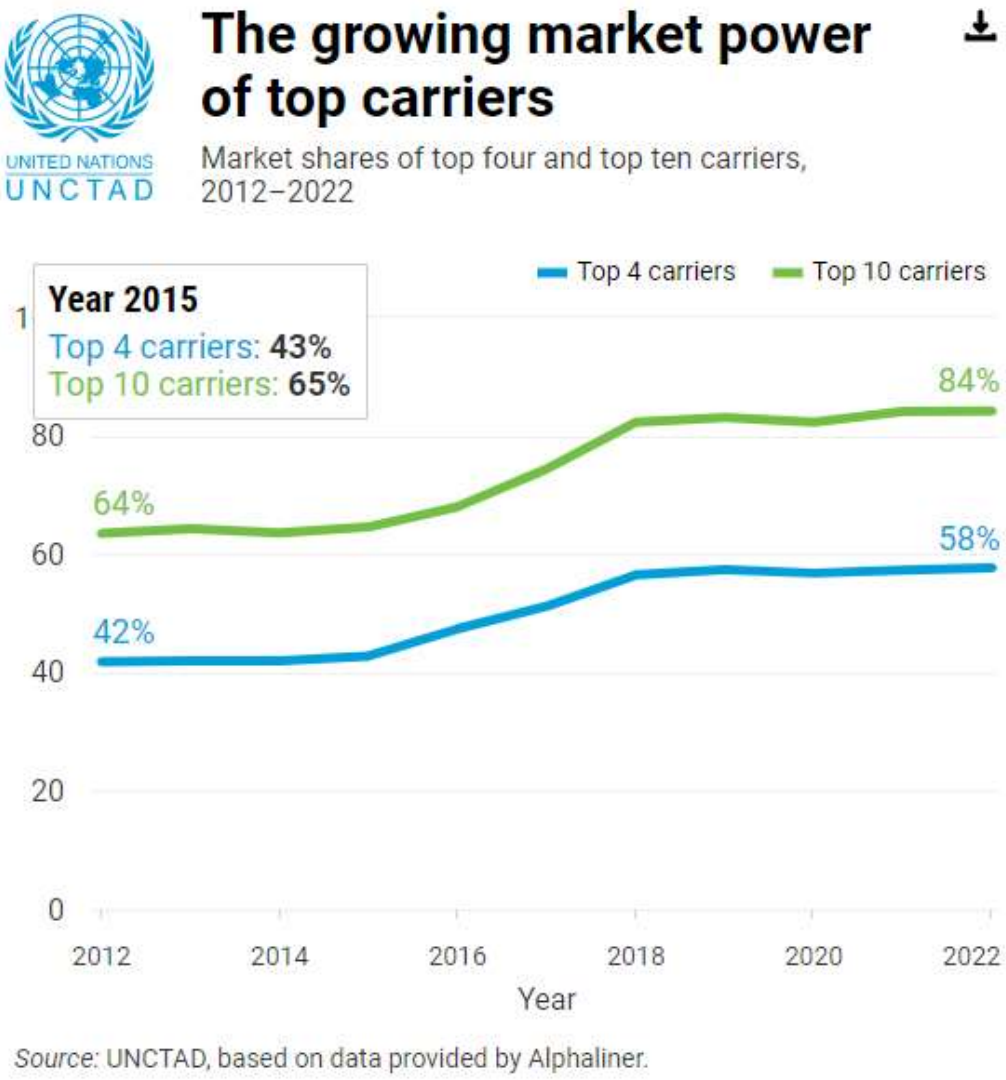


Figure 17 Market Power of top carriers 2012 – 2022 (UNCTAD)

According to UNCTAD container carriers made "astronomical profits" during the COVID-era (UNCTAD, 2022). Especially, the EBIT-margins have changed dramatically (Earnings before interest and taxes); For instance, the Danish A P Moller-Maersk increased its EBIT

from 2020 to 2021 by 370 %. UNCTAD`s data for selected container shipping lines are presented in Figure 18 below.

Carrier	Revenue 2021	Revenue 2020	Change	EBITDA 2021	EBITDA 2020	Change	EBIT 2021	EBIT 2020	Change	Volume 2021	Volume 2020	Change
	Billion ($)		(%)	Billion ($)		(%)	Billion ($)		(%)	Million (TEU)		(%)
A P Moller – Maersk	61.8	39.7	55.7	24	8.2	193	19.7	4.2	369.0	26.2	25.2	3.6
CMA CGM	56	31.5	77.8	23.1	6.1	279	19.6	3.6	444.4	22.0	21.0	5.0
Hapag-Lloyd*	26.4	14.6	80.1	12.8	3.1	313	11.1	1.5	640.0	11.9	11.8	0.3
Hyundai Merchant Marine (HMM)**	12.1	5.4	124.1	N.A.	N.A.		6.4	831	670.2	3.8	3.9	-2.1
Ocean Network Express (ONE)	30.1	14.4	109.0	18.3	4.9	274	17.2	3.8	352.6	12	11.9	0.4
COSCO Shipping***	49.1	24.6	99.6	9.2	1.9	384	19.8	2.1	842.9	26.9	26.3	2.3
Evergreen Marine Corp**	17.7	7.5	136.0	N.A	N.A		10.3	1.3	692.3	N.A	N.A	

Figure 18 EBIT-margins selected carriers (Source: UNCTAD)

The “astronomical” change in EBIT is made on only moderate changes in volume. This clearly indicates that the historical high freight rates have in fact been very good for some, and off course could lead the way for questions regarding their market power and if their incentives to balance the market was reduced. The supply side in container shipping can, according to Stopfords model, be adjusted by the use of newbuilding and scrapping, but I will also mention the use of “blank sailings”, also knowns as “cancelled sailings”.

c) Cancelled sailings to reduce supply in 2020

Blank sailing refers to the cancellation of a scheduled voyage of a container ship. In sea transport, shipping companies sometimes cancel scheduled voyages due to a variety of reasons, such as low demand for cargo, congestion at ports, or adverse weather conditions. Blank sailings are used by shipping companies to balance supply and demand, and to manage their capacity. When demand for cargo is low, shipping companies may cancel a voyage to avoid operating a ship that is only partially filled with cargo. This helps to reduce their costs and maintain profitability. Similarly, during peak demand seasons, shipping companies may add additional voyages to meet the demand. Blank sailings can have an impact on supply chains and logistics, as they can lead to delays and disruptions in cargo transportation. They can also result in higher shipping costs, as the limited capacity can lead to increased competition for available space on ships. Overall, blank sailings are a common practice in sea transport and are used by shipping companies to manage their capacity and balance supply

and demand. In the first half of 2020, ocean freight shippers reduced the number of vessels at sea, in response to the falling demand and manufacturing slowdown. This limited the global shipping capacity, but also led to empty containers stored at ports were no longer picked up in time (Newton, 2022).

Questions have been raised by some if the high freight rates have been "manufactured" by the carriers, by speculating in the use of blank sailings to reduce the supply longer than they should have (Sea-Intelligence, 2021).

5.3 The Container repositioning problem and the self-reinforcing effect, aka "The Container Crisis"

I will in this section discuss what I believe was a self-reinforcing effect in the container crisis.

a) The container crisis

In my opinion, what developed to be called "the container crisis" is a critical factor in comprehensively evaluating what happened to the freight rates in the COVID-era. By container crisis I mean the situation that occurred when containers ended up displaced in the west: The trade balance led to more containers with goods coming to the west, than what was exported from the west to the east. *"Empty boxes were left in places where they were not needed, and repositioning had not been planned for"* according to UNCTADs policy brief from 2021. This is normal but combined with the quick shifts in demand patterns after the first wave of COVID-19 it multiplied this issue. Over time, and quite rapid, this led to an imbalanced (not optimal) placement of containers, which was further compounded by the self-reinforcing effect. The absence of empty containers in regions where they where needed slowed down activity and locked the global supply chains (Arda, Umut, & Gani, 2022).

So, this tells us that to investigate the reasons for this, we will have to look at demand, supply, and time. This aligns seamlessly with the theoretical framework of Martin Stopford which serves as the foundation of this thesis.

The COVID-19 pandemic had a significant impact on the global supply chain and logistics industry, which in turn affected the empty container repositioning cycle. There are several reasons why the situation may have worsened after the pandemic:

1. **Disruption of trade flows:** The pandemic led to disruptions in global trade flows, with many countries implementing lockdowns and travel restrictions. This disrupted

supply chains and led to imbalances in the distribution of empty containers, as some regions had excess containers while others experienced shortages.

2. **Congestion at ports**: The pandemic also led to congestion at many ports around the world, as shipping companies struggled to manage the flow of containers in a rapidly changing environment. This further disrupted the empty container repositioning cycle, as containers were unable to move efficiently between regions.
3. **Reduction in shipping volumes in the first phase of the pandemic**: The pandemic initially led to a reduction in global shipping volumes, as many businesses scaled back operations or shut down altogether. Shipping lines had many blank sailings (cancelled sailings), and challenges when making their plans. This further exacerbated the imbalances in the distribution of empty containers, as there were fewer shipments to balance out the flow of containers. Due to COVID-19 there were also a reduced number of operational vessels. When the world trade slowed down in the beginning of 2020, some vessels went for refurbishment (Kuehne Nagel, u.d.). According to Kuehne+Nagel some vessels even had their voyages interrupted due to on board COVID-19 cases.
4. **Increase in shipping costs**: The pandemic also led to an increase in shipping costs, as shipping companies faced higher costs for fuel and other inputs. This increased the cost of repositioning empty containers, making it more difficult for shipping companies to balance out the flow of containers between regions.

Overall, the COVID-19 pandemic had a significant impact on the global supply chain and logistics industry, which in turn affected the empty container repositioning cycle. While the situation has started to improve as the pandemic recedes, there are still challenges that must be addressed to ensure that the empty container repositioning cycle can operate efficiently and effectively. When a container is offloaded a ship, it goes into a terminal, which during COVID-19 was already filled to the brim. It is than placed on trucks or trains to do the next leg of logistics. In many ports, especially in the west, the trucks that came to pick up containers was waiting in big lines to get into the terminals, and therefore the offloading of the ships took longer and longer time. That led to the trucks getting more delayed and not getting back to the terminals in time with the empty container. The ships ended up spending more time in the terminal doing offloading and loading and got delayed on their backhaul. We also know that ships from the west sailing to the east generally carries more empty

containers, due to the global demand patterns, and this makes the lack of empty containers in Asia more severe for each day. The congestion in the ports have actually led to terminal operators restricting or prohibiting shippers from sending empty containers back to Asia, which leads to shippers in Asia are struggling to find containers to use, which means they have to buy new containers, and this pushes up their shipping cost (Denby, u.d.) .

The global supply chain system seems to be overloaded. 1 % of system overload can lead to more than 1 % delays, according to queuing theory (Gross, Shortle, Thompson, & Harris, 2013). This effect can come from starting and stopping of processes, or resource contention, where different requests start competing for the same resources. In a transportation network, a small traffic jam or accident can cause delays that ripple through the system, causing more traffic jams and accidents in other areas. As these disruptions compound, the system becomes more congested and less efficient, leading to even more delays and disruptions.

All of the above seem to me like a self-reinforcing negative effect, where ripple effects spreads through the transportation network, and are compounding over time. In Figure 19.1 I present a visual representation of the self-reinforcing effect that resulted in an increasing number of containers being displaced in the western regions (caused by demand and then congestions) and consequently led to higher freight rates from the east (caused by lower supply and increasing costs). Furthermore, due to the rising rates from Shanghai, the shippers' incentives for waiting for empty containers to be loaded in the west decreased. We also know that shippers where restricted and prohibited to spend time loading empty containers. The self-reinforcing effect refers to a phenomenon in which the initial imbalance of container placement, caused by trade imbalances, is amplified over time.

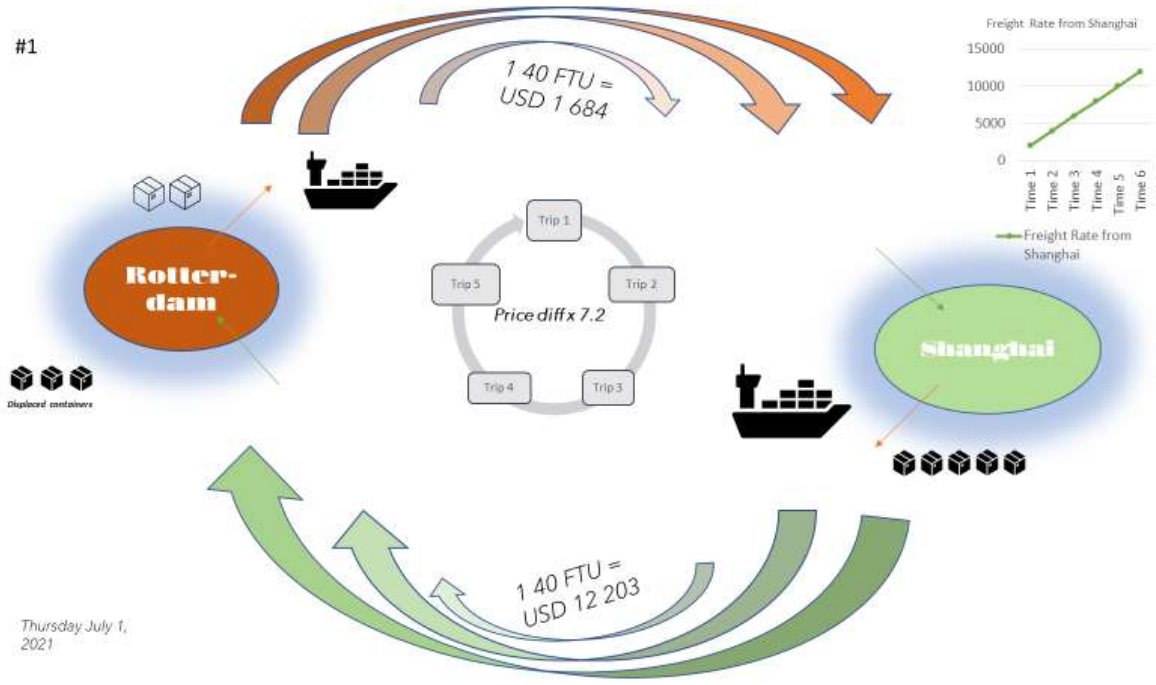


Figure 19.1 The Self reinforcing effect of the container crisis 2020 - 2021

In Figure 19.1 I try to visualize the shipping cycle between Shanghai and Rotterdam, in a given time period. (The model in full page size are also in the Appendices). The model's cycle are clockwise and repeats time after time (Trips). The model is off course a rough simplification, where the goal is to show the container cycle between Shanghai and Rotterdam, leading to more and more displaced containers, and to show how severe the price difference was between East – West and West – East. The price data from Drewry are from July 1st 2021 (Figure 19.2).

The cycle starts with loaded containers being shipped from Shanghai to Rotterdam, where the freight rates reached historical levels in the period. In Rotterdam the containers are offloaded, and because of reasons discussed in this chapter, some containers are displaced, meaning that they remain in Rotterdam, and are not part of the ships backhaul to Shanghai. The ships leaves Rotterdam with some containers loaded with cargo, some empty containers and some spare space not utilized. The freight rate for this leg on this date, had a 720 % price difference between headhaul and backhaul. I believe this does something with the incentives, and the shippers wants to get back to Shanghai as quickly as possible, to take advantage of the historical high freight rates. This incentive seems sub-optimal, as it contributes to the self-

reinforcing effect of the container crisis. As the cycle continuous the effect gets worse; the lack of empty containers affects the supply, and the freight rates gets higher and higher.

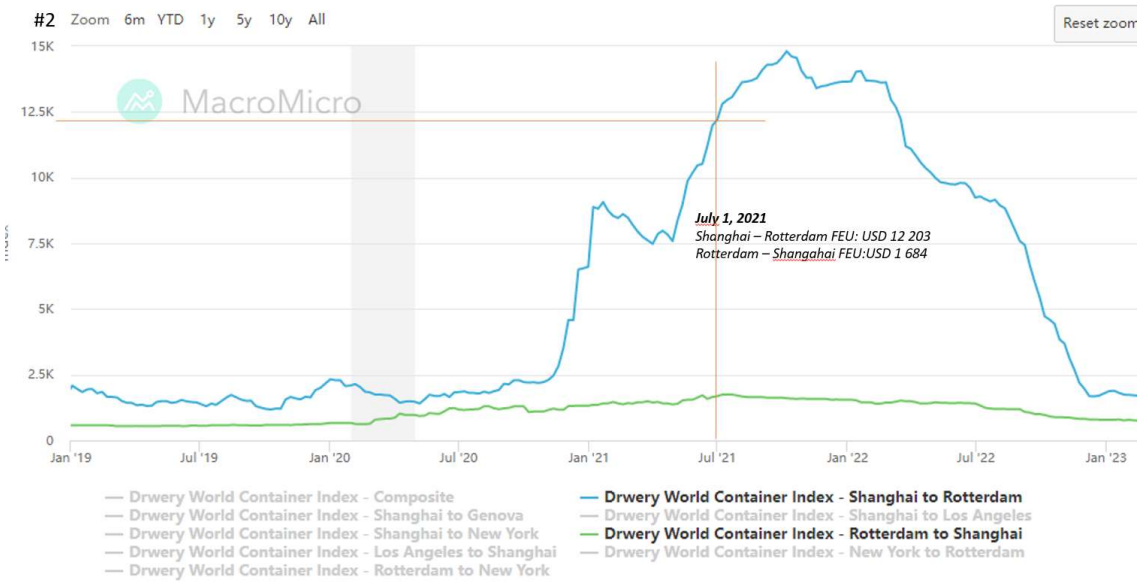


Figure 14 The Self reinforcing effect #2

5.3.1 Lack of new steel containers

b) The lack of new containers

According to Container Xchange the container market is known for its lack of transparency. However, around 85 % of all container manufacturers are based in China. As for other products, low labor cost and affordable steel production makes China a big player (Container Xchange, 2023). The same source also highlights that since China are the biggest producer of goods globally, it is therefore natural that they play a big part in the production of containers, as they can avoid the repositioning cost relative to other countries.

According to The World Steel Association 2020 data, the estimated global production of steel containers was approximately 3.5 million TEU`s, representing an increase from the 2019 production of 3.3 million TEU`s. *(In chapter 1.3 I wrote that the total amount of TEU`s are estimated to be around 20 million).*

When reading reports on the supply of new containers in the COVID-era, it follows the same pattern as discussed other places in this thesis:

1) *Sudden drop in the growth rate of new containers in the first half of 2020, due to port closures, COVID-outbreaks, congestions and restrictions* (Container Xchange, 2023).
2) *Sudden rise in demand for goods in the second half of 2020, and therefore increased demand for containers.*

According to Drewry, there are probably enough containers in the world, but the containers are in the wrong places (Van Marle, 2021).

When containers got harder and harder to get hold of in time, the purchasing price as well as the leasing prices went up in the COVID-era. Price of new containers have been rising in the period, and the average price of a 40ft high cube (HC) in Q1 2021 was USD 6160, approximately 90 % higher than in 2020 (van der Merwe, 2021). Therefore, we can argue that this factor also contributed to the increasing freight rates.

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6. Discussions and Conclusions

6.1 Discussion

In this thesis the focus has been to analyze and explain the empty container repositioning process, and the container crisis that took place from 2020, to say something about its effect on the increasing freight rates in the period.

This means that I have not spent time analyzing the decline (normalization) of the freight rates, which also are interesting, as the decline from the peak late 2021 were quite steep. COVID-19 may be over as a health risk, but it still affects supply chains, macroeconomics, interest rates etc. So, there are many interesting themes that could have been discussed In this thesis, that I have chosen not to go into. When starting out in January this year the plan was to look at the time period 2020 through 2022, which also would have included the normalization of freight rates. My experience was that the scope got to big, and the structure of such a thesis would not have been optimal.

I have used Martin Stopfords shipping market model as a framework. My thesis has looked at the short run freight rates 2020 and 2021. The model focuses a lot on fleet sizes, but my focus have been to study available containers. So, I have adjusted the model in order to answer my research questions and applied the same principals and theory when analyzing the container situation. The model have still served as a good framework for me, and many of Stopfords supply and demand factors are included in my analysis in Chapter 5.

6.2 Conclusions

The aim of this thesis was to examine the impact of the COVID-era on the empty container repositioning cycle (ECR) and its effects on freight rates on the Shanghai-Rotterdam shipping route. In order to achieve this goal, the study examined the most central supply and demand factors, as well as the empty container repositioning process. My conclusion is that the problems with the empty container repositioning process (ECR), was so severe that it was named “the container crisis” and did affect the freight rates in 2020 and 2021.

After a thorough analysis, this study concludes that the empty container repositioning process had a significant impact on the freight rates. The container crisis was triggered by a number of factors that have been discussed in Chapter 5 and briefly summarized in the list below. One of the main factors was the strong demand during the COVID-era, which was preceded by an initial slowdown in the first half of 2020. The supply side was disrupted and chaotic, with bottlenecks and system overload leading to containers ending up in places where they were not needed.

In addition, the study reveals that "unknown unknowns" are the most dangerous form of risk or shock, as their impact is uncertain and difficult to predict. Furthermore, the container shipping lines, which dominated the supply side, made huge profits during this crisis, and the will to rebalance the situation may or may not be very strong, although I have no information to speculate in this.

It is also important to note that global supply chains are highly interconnected, and ripple effects spread through them in a very short time. Consequently, attempting to increase supply by building more vessels or containers would probably not have been helpful in the short or medium term. This is because, firstly, the wrong positioning of empty containers was the most significant issue. Secondly, ordering new ships takes a long time (18-36 months) to deliver, and lastly, injecting more vessels or containers into an already overloaded system could compound the bottleneck problems in ports and increase delays (van der Merwe, 2021).

My conclusion is that the empty container repositioning process had strong effect on the freight rates.

- Demand was strong during the COVID-era, after the initial slowdown in the first half of 2020.
- Supply was disrupted and chaotic.
- “Unknown unknowns” are the most dangerous form of risk or shock, since we don’t know what will happen or how it will affect us.
- The supply side are dominated by big actors (container shipping lines) that made huge profits. The will to rebalance the situation might not be very strong.
- Global supply chains are highly interconnected, and ripple effects spreads through them in a very short time.
- Containers ended up in places where they were not needed, due to bottlenecks and system overload.

- To increase supply by building more vessels, would probably not have helped in the short/medium term. Firstly, it was wrong positioning of empty containers that hurt the most. Secondly, ordering new ships will take years (18-36 months) to deliver. And lastly, injecting more vessels to an overloaded system would compound the bottleneck problems in ports and increase the delays (van der Merwe, 2021).

References

Alcedo, J., Cavallo, L., Dwyer, B., Prachi, M., & Spilimbergo, A. (2022). *E-commerce During Covid: Stylized Facts from 47 Economies.* International Monetary Fund.

Anoushiravani, A., O`Connor, C., DiCaprio, M., & Iorio, R. (2020). Economic Impacts of the COVID-19 Crisis. *The Orthopaedic Forum*.

Arda, T., Umut, Y., & Gani, M. (2022). Investigation of empty container shortage based on SWARA-ARAS methods in the COVID-19 era. *European Transport Research Review*.

Ball, L., Leigh, D., & Mishra, P. (2022). *Understanding U.S Inflation During the Covid Era.* International Monetary Fund.

Business Insider India. (2023, March 11). Retrieved from What is lockdown meaning and what to expect from it: https://www.businessinsider.in/india/news/what-is-lockdown-and-what-to-expect-from-the-lockdown/articleshow/74759615.cms

Container Xchange. (2023, February 19). *Container XChange*. Retrieved from Top 10 container manufacturers globally: https://www.container-xchange.com/blog/container-manufacturers-new-built-and-used-containers/

Container XChange. (n.d.). *SOC Container Masterclass: The Empty Repositioning Problem*. Retrieved from https://www.youtube.com/watch?v=UoDEI5mBpfc

Cullinane, K., & Haralambides, H. (2021). Global trends in maritime and port economics:the COVID-19 pandemic and beyond. *Maritime Economics & Logistics* .

Denby, S. (n.d.). Retrieved from Youtube: https://www.youtube.com/watch?v=8d5d_HXGeMA

Drewry. (2023). Drewry World Container Index. *Drewry World Container Index*. Drewry World Container Index.

European Commision. (2020). *Europe's moment: Repair and prepare for the next generation.* Brussels: European Commision. Retrieved from https://ec.europa.eu/commission/presscorner/detail/en/ip_20_940: https://ec.europa.eu/commission/presscorner/detail/en/ip_20_940

Gerlach, S. (n.d.). *Aristolo Blog*. Retrieved from How do I write a literature thesis as a bachelor or master thesis?: https://blog.aristolo.com/en/how-do-i-write-a-literature-thesis-as-a-bachelor-or-master-thesis/

Gross, D., Shortle, J., Thompson, J., & Harris, C. (2013). *Fundamentals of Queueing Theory.* Wiley.

Horowitz, J. (2021, September 8). *CNN Business*. Retrieved from CNN: https://edition.cnn.com/2021/09/08/business/shipping-containers/index.html

IMF. (2020). *POLICY RESPONSES TO COVID-19.* International Monetary Fund.

IMF Blog. (2022, March 28). Retrieved from International Monetary Fund: https://www.imf.org/en/Blogs/Articles/2022/03/28/how-soaring-shipping-costs-raise-prices-around-the-world

Jugovic, A., Komadina, N., & Hadzic, A. (2015). Factors influencing the formation of freight rates on maritime shipping markets. *Scientific Journal of Maritime Research 29*, pp. 23-29.

Kuehne Nagel. (n.d.). *Why does the current container shortage happen?* Retrieved from https://home.kuehne-nagel.com/-/knowledge/market-insights/container-shortage

Kwon, O. K. (2020). How is the COVID-19 Pandemic affecting Global Supply Chains, Logistics, and Transportation? *Journal of International Logistics and Trade*, 107-111.

Logimarex. (n.d.). *The container crisis and its effects*. Retrieved from Logimarex international: https://logimarex.com/en/the-container-crisis-and-its-effects/

McKinsey. (2021). *What's going on with shipping rates?* Retrieved from McKinsey & Company: https://www.mckinsey.com/industries/travel-logistics-and-infrastructure/our-insights/whats-going-on-with-shipping-rates?cid=-soc----oth---&sid=5356061990&linkId=128716880

Newton, E. (2022, March 18). *Supply Chain Connect*. Retrieved from Why is There a Shipping Container Shortage?: https://www.supplychainconnect.com/supply-chain-technology/article/21236551/why-is-there-a-shipping-container-shortage

Port Economics. (2017, March). Retrieved from Port Economics: https://www.porteconomics.eu/portgraphic-the-spectacular-rise-of-shanghai-as-a-container-port/

Researcher, T. (Director). (2021). *Container Shortage: Why the Prices of Goods Are Rising in 2021* [Motion Picture]. Retrieved from https://www.youtube.com/watch?v=VJH5W0ijdWc

Rodrigue, J.-P. (2020). *The Geography of Transport Systems 5th edition.* London.

Rogers, K. (2011, April 11). *Britannica*. Retrieved from Scientific modelling: https://www.britannica.com/science/scientific-modeling/additional-info#history

Rotterdam, P. o. (2023, 02 28). *Port of Rotterdam*. Retrieved from Port of Rotterdam Facts and Figures: https://www.portofrotterdam.com/sites/default/files/2022-11/facts-and-figures-port-of-rotterdam_0.pdf

Salah El Din , M., Reason, M., & Ncube, M. (2021). The impact of Post-Covid-19 Container Shortage Crisis on Global Supply Chains. IEOM Society International.

Sea-Intelligence. (2021, January 19). *The "myth" of nefarious blank sailings*. Retrieved from Sea-Intelligence: https://www.sea-intelligence.com/press-room/42-blank-sailings-myth

Service, P. L. (n.d.). *The History of Shipping Containers*. Retrieved from PLS Logistics Service: https://www.plslogistics.com/blog/the-history-of-containers/#:~:text=distribution%20of%20supplies.-,The%20Invention%20of%20the%20Standard%20Shipping%20Container,the%20country%20at%20the%20time.

Shanghai International Port Group. (2023). Retrieved from Shanghai International Port Group: https://en.portshanghai.com.cn/FactsFigures/index.jhtml

Song, D.-P., & Dong, J.-X. (2015). *Handbook of Ocean Container Transport Logistics.* Springer.

Stopford, M. (2009). *Maritime Economics Third Edition.* Routledge.

UNCTAD. (2021). *Review of Maritime Transport 2021.* UNCTAD.

UNCTAD. (2022). *United Nations Conference on Trade and Development*. Retrieved from Maritime transport indicators: https://hbs.unctad.org/maritime-transport-indicators/

University of Maryland. (2021, April 15). Retrieved from University of Maryland: https://www.rhsmith.umd.edu/research/ever-given-unstuck-ripple-effects-remain

USITC. (2020). *THE IMPACT OF THE COVID-19 PANDEMIC ON FREIGHT TRANSPORTATION SERVICES AND U.S. MERCHANDISE IMPORTS.*

van der Merwe, B. (2021, September 13). *Investment Monitor*. Retrieved from Weekly data: How Covid-19 disrupted global shipping: https://www.investmentmonitor.ai/features/covid-global-shipping-container-shortage/

Van Marle, G. (2021, April 27). *There are enough containers for global trade – they're just in the wrong places*. Retrieved from The Loadstar: https://theloadstar.com/there-are-enough-containers-for-global-trade-theyre-just-in-the-wrong-places/

WALL STREET JOURNAL. (n.d.). *How a Steel Box Changed the World: A Brief History of Shipping*. Retrieved from Wall Street Journal: https://www.youtube.com/watch?v=0MUkgDIQdcM

WHO. (2023, January 18). *WHO Covid 19 Explorer*. Retrieved from WHO Covid 19 Explorer: https://worldhealthorg.shinyapps.io/covid/

Zhu, J., Qiu, W., & Jian, W. (2020). Evaluating Impacts of the COVID-19 Pandemic on China's Container Ports Based on AIS Big Data. *IOP SCIENCE*, 1-5.

APPENDICES

1. The Self-Reinforcing Effect of the container crisis.

#1
Displacedcontainers
Rotter-
dam
Shanghai
1 40 FTU =
USD 1 684
1 40 FTU =
USD 12 203
Pricediffx 7.2
Trip 1
Trip 2
Trip 3
Trip 4
Trip 5
Freight Rate from Shanghai
15000
10000
5000
0
Time 1
Time 2
Time 3
Time 4
Time 5
Time 6
Freight Rate from Shanghai
Thursday July 1, 2021
4

[4] Appendix 1