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Thesis

Dry – Docking Cost Analysis

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This Diplomatic Thesis was unanimously approved by the Three-member Examination Committee appointed by the EDiE of the Interinstitutional MSc in accordance with the Operating Regulations of the Interinstitutional MSc 'Management in Marine Science and Technology'.

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Abstract

Cost of maintenance of vessels has rarely been a subject of discussion in academic maritime papers. Most of them where either technical or they focused on operating expenses. In this thesis a research and analysis of the Dry – Docking costs will be conducted. The scope of this research is to identify the impact of Covid – 19 in the Dry – Docking costs considering the effect of the pandemic in the global supply chain as well as the shipping industry. In order to avoid country heterogeneity of the sample Dry – Docking invoices from Chinese Shipyards were used. The dataset consists of 16 cases of containership repairs from 2018 to 2023. The method that will be followed is the regression analysis of a repeated cross-sectional dataset. Some analogies can be found by Kruger and Angrist in their attempt to tackle quasi experimental issues that appeared in their dataset.
The results clearly show the impact of Covid – 19 in the Dry – Docking costs and could be used to identify similar shocks in the future. Another important result is the impact of steel prices in the Dry – Docking. Even though it does not seem to have great impact in the costs by themselves it helps the model to show more significant results around the pandemic. Finaly, an interesting finding is that even though the market steel prices fell on the after Covid – 19 pandemic the cost for steel and steelwork in the shipyards keeps rising.

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1. Introduction

Modern shipping activity has a significant impact in the economies it affects. Due to the size of shipping companies, more and more are turning to economies of scale in an attempt to achieve cost minimisation as a measure of growth and increased profitability. In particular, in shipping companies relying on long term charters, cost reduction is key to increasing profitability.

The costs of shipping companies that are usually also of concern to investors are operating costs. However, there is one category of costs that is often overlooked but can be key to the viability of both the ship and the company itself. These are Dry – Docking (DD) costs which can sometimes exceed the annual operating costs of the ship. For this reason, it is recommended that financial planning for the dry docking of a ship should start up to 4 years in advance.

In the context of this thesis, a quantitative study will be carried out by taking a specific sample of tanker tariffs carried out in the past in order to analyse the prices of specific major repairs. The sample will consist of tariffs from different shipyards in China to ensure uniformity and as the prices are likely to be from different sized ships, they will be reduced to a unit of measurement. In addition, Chinese yards are chosen because the price difference from Europe is so large that they always make sure that the last voyage before Dry – Docking is always in that direction. They will also be tested on container ships (containerships) to be studied in the same repairs.

The main hypothesis of this thesis is the impact that Covid – 19 had in the Costs of Dry – Docks in China. The result of the research is to observe and interpret any trends in shipyard prices and to find correlation and causality between prices and events that have affected shipping and China's shipyard prices. This will be done using the time series repeated cross sectional of the grouped DD costs statistical method where short cycle data[1] will be studied.

2. Literature review

[1] Short cycle is considered in shipping as a 5-year period

There are very few academic papers devoted to the Dry – Docking costs. According to Apostolidis[2] (2013) the reason is the scarcity of such data. For this reason, the majority of previous conducted researches are consisting of operating costs that are easier to retrieve and analyse. For better understanding of the Dry – Docking procedure, the following literature will explain the necessity and the serious impact that this process adheres to the shipping company operating expenses.

Dry – Docking as stated above is one of the most important costs that the shipowner should consider when he is planning the vessel's expenses. As stated in the thesis of *Amuntenya* [3](2024), the marine economics on the "supply-side management" framework, should take into consideration Dry – Docking costs. Dry – Docking should be essential if a shipowner wants to achieve the optimum life cycle that a well-maintained and serviced vessels could retain. The procedure of Dry – Docking entails taking a vessel out of the water and putting it on dry land so that any sections that become damaged when submerged in water may be cleaned, repaired, and maintained. These include propulsion systems like engines, rudders, chain lockers, stern tube seals, and propellers, as well as safety equipment, navigational systems, and watertight equipment like hull.

The importance of Dry-Docking is crucial for the performance and integrity of the vessels. The two main reasons for DD, according to *Jack Nial*[4], are the Hull maintenance and the repairs that occur during the usage of the vessel. Rust and marine growth build up on a ship's hull over time can reduce its speed and fuel efficiency. Dry – Docking enables the hull to be thoroughly cleaned, de-scaled, and painted, delivering it to its ideal state. During Dry – Docking, the hull and underwater parts are examined for flaws. One can carry out any required repairs or corrective actions to guarantee the seaworthiness and adherence to safety regulations of the vessel.

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[2] Apostolidis, A., Merikas, A. and Merika, A. (2013) 'The Modelling of Maintenance Cost: The Case of Container-Ships in Dry-Dock', *Journal of Computational Optimization in Economics and Finance*, 5(1), pp. 27–39

[3] AMUTENYA, M.N. (2024) *The Importance of Dry Docking in the Maritime Industry*. thesis

[4] Ramanujan, A.K. (no date) *What is dry dock? necessity of dry docking*, *DieselShip*. Available at: https://dieselship.com/marine-technical-articles/marine-engineering-knowledge-general/drydocking-of-ships/dry-docking-cargo-ships-complete-information

In order to ensure that shipowners follow the proper guidelines and to prevent accidents from lack of maintenance SOLAS has issued regulations for when a vessel should undergo a Dry – Dock. As SOLAS states in RES. A.997 (24)[5] "a minimum of two of the inspections of the outside of the ship's bottom during any five-year period should be conducted in Dry – Dock. In all cases, the maximum interval between two Dry – Dock bottom inspections should not exceed thirty-six (36) months".

The effect of Covid-19 pandemic

An additional goal of this paper is to address the pre and post pandemic Dry – Docking costs. The pandemic caused numerous side effects that hit the maritime industry, which many authors have tried to identify. An example would be D. Gavalas [6] (2022, 157-164) analysed the reaction of the stock markets in shipping industry through the pandemic. Their research concluded that with the exception of the tanker market, dry market and stock markets had a negative first reaction after the WHO announcement on January 30th 2020. After 4-5 days the market came back to its original values but the second time in March 11th, 2020 the shock of the possible country restrictions hit the market harder, as everyone was predicting that these restrictions could lead to a collapse of global trade.

Even though COVID-19 was considered an unpredictable event, shipowners and charterers should always hedge for such events in order to minimise their risks. What is also important and will be discussed later in the Dataset chapter is the cyclicality that the pandemic ignited. After the second market shock (March 11th 2020), the containership market not only recovered but as proven by the indices such as HAX[7] **tripled** in 2021-2022. Michalopoulos (2021[8]) it is further explained that the reopening of the economy following COVID-19 lockdowns in multiple nations had resulted in a surge in demand for goods and raw materials. In addition, the virus kept interfering with international supply lines, clogging

[5] *All SOLAS chapters and their regulations explained* (no date) *nautilus shipping*. Available at: https://www.nautilusshipping.com/solas-chapters (Accessed: 19 August 2024).
[6] Gavalas, D., Syriopoulos, T. and Tsatsaronis, M. (2022) 'Covid–19 impact on the shipping industry: An Event Study Approach', *Transport Policy*, 116, pp. 157–164. doi:10.1016/j.tranpol.2021.11.016
[7] Services, M.D. (no date) *Duyurular*, *Vapur Donatanları ve Acenteleri Derneği*. Available at: https://www.vda.org.tr/
[8] Michalopoulos, K. (2022) 'The Rise of Charter Rates in the Containership Market', *The Danship News*. 22nd edn, January, pp. 7–7

up ports, and holding up vessels, all of which reduce their number that can be used to transport cargo across oceans. The Covid outbreak forced the closure of China's Yantian Port, which is the third-largest port in the world and processes 40.000 TEU every day, for three weeks. All of the main chartering companies, including MAERSK, CMA-CGM, and Hapag-Lloyd, were forced to avoid the port and divert the goods that were piling up due to client delays when the Ningbo-Zhoushan port was closed for two weeks starting on August 11th, 2021. This caused a strain on the supply chains. The scarcity of container ships was the main factor driving up charter fees. Due to numerous variables, the supply of containers and containerships rose slower as the demand for cargo transportation followed the same trajectory. Main culprit was the increase of American product consumption. It was the primary cause of the high demand for imports into the US from Asia, particularly China. As consumers were impacted by rising manufacturing prices and inflation of final goods, the US's high consumer appetite gradually diminished.
All the above led to the shipping circle that our dataset covers. During the research for this literature review, no papers were found to analyse the impact of COVID-19 on the Dry – Docking sector. For this reason and all possible future implications, it is important that one of the major expenses that the shipowner faces is researched accordingly.

3. Dataset (assumptions) target group

To support the above statements, the subject data from 16 dry docking invoices has been collected, processed, and analysed. After careful examination and in order to have a homogenous dataset, it was decided to continue with dry docking from containerships that were completed in Chinese shipyards between 2018 and 2023. The vessels were owned by US listed companies that have medium to large fleets of containerships. The reasoning behind this very narrow pick will be explained in the remaining of this chapter.

The ship companies that were selected are 2 US stock exchange listed companies. The reason for this choice was simple; there was easier access to data due to their need to report every financial change to the SEC through multiple reports. Most of the information on these reports may not be considered as direct input, for this research but can assist at certain conditions to choose data and reduce outliers. Also, it is assumed due to the size of the companies and their respective containership fleets, they have the same owner's negotiation capacity. This way it can be further assumed that the Dry – Docking costs may have the same impact on their yearly expenses.

In the Dry – Docking operation multiple issues are being tackled since the vessel endures a lot of problems because of turbulent situations while on journey (bad sea). In order to have a better understanding and uniformity the containerships were chosen as a category of interest. Specifically, containerships are used mostly in liner shipping which is the practice of using large vessels that travel regular routes to transfer freight and merchandise from one location to another on predetermined schedules. This can be useful because fleets that tend to follow the same route repeatedly might endure common damages of the vessels.

To eliminate geographical heterogeneous effects such as inflation, exchange rate fluctuations, different labor and material costs the dry dockings of the dataset were completed in Chinese shipyards. Chinese shipyards account for around 50% of the world's dry dockings according to *Drewrys*[9] *report (2023*). Considering that the rest of the world amount to the other 50% without any clear competitor in terms of quantity, we can assume that China is the market leader in Dry Dockings, therefore is the most dominant area to analyse. In conclusion, it could project on how the market could perform in the years to come, due to their position as market leaders.

The Dry – Docking invoices span over a 5 year period (2018-2023) and we shall examine whether it corresponds to a short shipping cycle. At this point it is important to identify

[9] *Ship operating costs annual review and forecast 2023/24* (no date) *Drewry*. Available at: https://www.drewry.co.uk/maritime-research-products/maritime-research-products/ship-operating-costs-annual-review-and-forecast-202324

what it a small shipping cycle. According to Cournot[10] (1927, p.25) there are three types of economic cycles: **long term** cycle which spans up to 60 years, **short term** cycle which spans from 3 up to 12 years, and **seasonal cycle** whose span depends on seasonal demand. In this research the type of cycle that matches the dataset is the short-term cycle.
Schumpeter[11] (1954, p. 744) identifies 4 stages of the short term cycle:

- Market trought
- Recovery
- Market Peak
- Collapse

As Stopford[12] stated a short shipping cycle may last from 4 to 7 years depending on how aggressive the investors are. This is explained from the inability of the market to recover after the recession. In this case the market could need the 3 more years. Abortive recoveries are not uncommon in shipping and are frequently the consequence of counter-cyclical vessel ordering. Anticipating a rebound, investors place bulk orders for inexpensive vessels, so impeding the recovery through supply. Following Kirkaldy's[13] (1914) view shipping market cycles have a Darwinian purpose. They establish a climate that drives out weak shipping companies, allowing the strong to endure and grow, and promotes a lean and effective shipping industry. Stopford agrees about the cycles, because supply and shipbuilding capacity undoubtedly have a role in establishing the tone for a decade. There

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[10] *Cournot, A. (2020) 'Researches into the mathematical principles of the theory of wealth', Forerunners of Realizable Values Accounting in Financial Reporting, pp. 3–13. doi:10.4324/9781003051091-2.*

[11] Dorfman, J. (1954) 'History of economic analysis, *by Joseph A. Schumpeter, Elizabeth Boody Schumpeter*', *Political Science Quarterly*, 69(4), pp. 603–605. doi:10.2307/2145638

[12] Stopford, M. (1993) Maritime economics. London: Routledge

[13] Kirkaldy, A.W. (1970) *British shipping; its history, organisation and importance*. New York: A.M. Kelley

is a window for marine economists to contribute in this "supply-side management" framework.

Due to the pandemic of Covid-19 the stages of the short-term cycle could be traced between 2018-2023 when the data are collected. According to the Danish Ship Finance[14] the volatility of the container market has led to the decline of the earnings for the shipping companies of the sector in 2023. On the other hand, port congestion is back to pre-pandemic levels. The average volume of Container capacity caught up in ports rose from 31,6% in 2019 to 34-35% in 2021 and 2022. In 2023 the average number of container vessels caught up in ports has dropped to a 31% increase, due to larger fleet volume. This is also another indication that the data follows a short cyclicality as shown in the graph below.

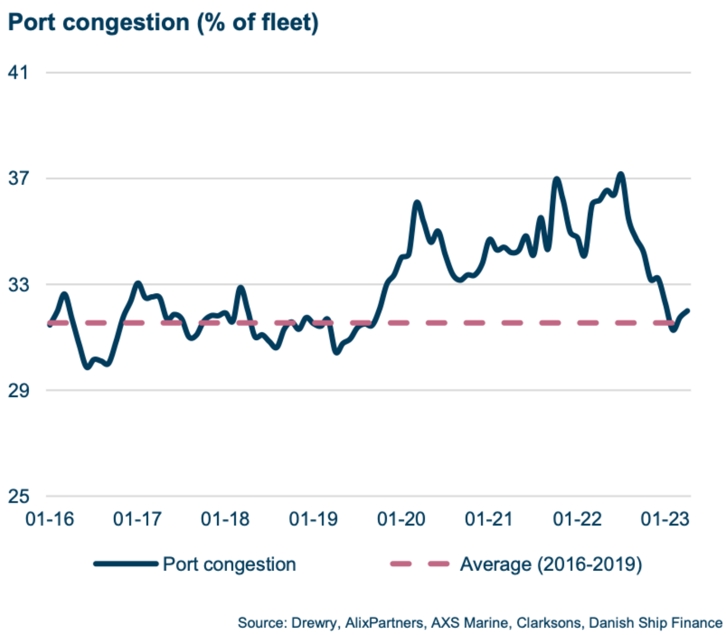

Figure 1 Port Congestion

The graph below depicts the whole course of the short cycle, in the Supply and demand balance (DWT and TEU-miles):

[14] *Shipping market review - May 2023*. Available at: https://www.shipfinance.dk/media/2327/shipping-market-review-may-2023.pdf (Accessed: 18 August 2024).

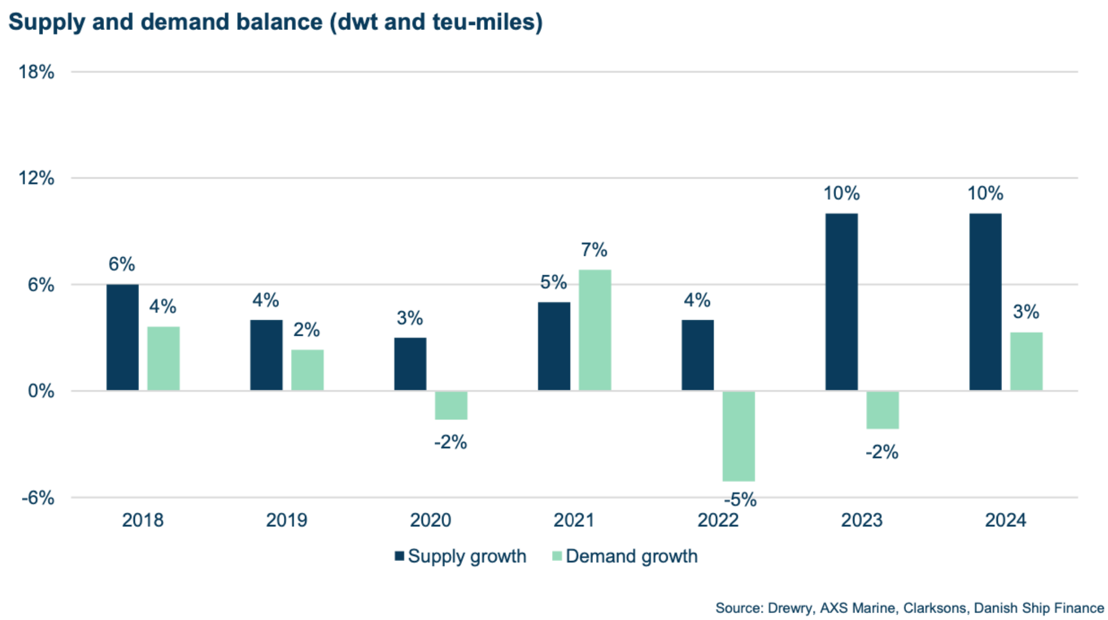

Figure 2 Supply and Demand Balance

As stated by Stopford, a short cycle begins from a peak and ends on a peak. We can clearly see on the second graph above from the Danish Ship Finance that both the containership supply and demand growth begin with a peak in 2018 and end with an even higher peak in 2023/2024. This is also a clear indicator that the dataset of this research may capture a short shipping cycle and especially the costs of Dry – Dock during that period.

Moreover, the past 5 years have been crucial for the shipping industry due to the effects caused by the covid-19 pandemic. As stated in D.Gavalas etc. although COVID-19's origin, course, and desired end, as well as the extent of its impact, are still being determined, it should be regarded as a typical unpredictable event. Since their research only shows how shipping markets reacted to a hygienic external shock, they think it should be helpful to shipping stakeholders. This implies that shipowners and charterers will have enough time to use hedging strategies to reduce their losses, improve their cash management, and steer clear of sharp fluctuations that can immediately jeopardize the viability of shipping companies. Since the Covid-19 epidemic was still going strong at the time of their research, more investigation were required to fully comprehend the ramifications of this unique event. To further analyse the ex-ante and ex-post covid-19 era in the Dry – Docking sector it is important to have 5 years of data that contains pre covid and post covid costs. From the aforementioned research we take the 23th of January 2020 as the date of the Covid-19 outbreak.

After a thorough analysis of all the available invoices, it is evident that there was too much noise in the data. Due to severe conditions in the sea all vessels undertook certain services that were unique for each specific damage occurred. Not only that, but also the vessels during the pandemic, experienced severe mechanical issues. According to technicians these issues could be assigned to the postponed maintenance which by its turn was attributed to the high speed of the vessels while carrying full load. The initial cause of this situation is the sudden increase of the charter rates. It is worth considering that the average age of the vessels that undertook such heavy load was 13,4 in the dataset. Another point that is noteworthy is that during the dry dock the majority of the vessels often had new technological modifications such as the bulbous bow modification and the scrubbers. Those modifications improve the vessels' performance and green transition respectively. The previous costs need to be excluded because they are not in the main list of services that are provided while in dry dock.

For all the aforementioned reasons it was decided that only the following categories[15] will be examined which were common in all the Dry – Docking invoices.
Those categories are: General Services, Paintings, Steel work.

General Services consist of all the services a vessel undertakes from the moment it reaches the port of dry dock until it departs. There are minor and major categories. The most important of all are the docking and undocking, the mooring and tuggage, as well as the stay in the docking area. Included in the General Services are the costs of docking in the port as well as the mooring in the port and move around the port.

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Paintings consist of all the services provided in order to scrape the paint of the vessel and then paint it. In order to have uniformity in the data the painting prices are a mix of the following sub categories:

- Hull H.P.F.W.: The cleaning of the hull of the vessel with High Pressure Fresh Water.
- Vertical Paint: The cost of painting the vessel in vertical surfaces.
- Flat Bottom Paint: The cost of painting the vessel in the flat bottom surfaces.
- Topside Paint: The cost of painting the vessel in the Topside surfaces.

Steel Work is the most important part of the dry docking costs and sometimes amounts up to 50% of the whole operation. Due to the different needs of each vessel and the extension of the damage, the costs may vary. It accounts for all the steel necessary for the dry dock of the vessel and would attempt to draw a picture for the difference of the price of the commodity steel price versus the price that the shipyard charges considering the exchange rate fluctuations.

In order to test the hypotheses of this research around the inflation, exchange rates, and steel prices post and after covid-19 all the costs are unified using the basis of measurement of containerships, the Twenty-foot Equivalent Unit (TEU). TEU is measuring the length of the container (which is 20 feet). Containers where designed and introduced by Ian Mclean in 1956. It was the first unitized way of transporting goods. The actual dimensions of the container are 19'4" xil'8" x7'10" Due to the nature of the dataset it will be easier to unify the data by deriving the costs per TEU and in some cases per TEU per Day (in Dry – Dock).

4. Methodology

Due to the particularities of the dataset, the methodology that will be used for the analysis will be the regression analysis of a repeated cross-sectional dataset of Dry – Docking costs. The reason we used this methodology is because we have an individual vessel for each Dry – Dock every year. We do not have repetition of vessels that underwent Dry – Dock during the period we examine.

Similar method was used by Kruger (1999) in his paper where he analyses the effects on children's performance on smaller classes than larger classes in a kindergarten using data from Project STAR. In this study, data from 11,600 kindergarten through third grade students and their teachers who were randomly allocated to various class sizes are analysed. To account for non-random attrition and class transitions, statistical techniques are applied. The primary findings indicate that: (1) students in small classes perform better on standardised tests on average the first year they attend; (2) students in small classes have an advantage in test scores that grows by approximately one percentile point annually in subsequent years; (3) teacher aides and measured teacher characteristics have little effect; (4) class size has a larger effect for minority students and those receiving free lunch; and (5) Hawthorne effects are unlikely.

The same methodology Angrist (1999) used in order to test Maimonides' rule for the effect of a class size on scholastic achievement. Maimonides, a Jewish scholar from the twelfth century, suggested a class size limit of forty. In Israeli public schools, this same maximum creates a nonlinear and nonmonotonic relationship between grade enrolment and class size. Instrumental variable estimates of the effects of class size on test performance are constructed using Maimonides' rule of forty. They use statistical techniques in order to investigate the effect on the treatment group compared to the control group. The addition of extra covariates and their magnitude will reveal whether there is a linear relation between them and the dummy variable of interest. In this quasi-experimental environment, we will induce the effect of the outcome from the magnitude and significance of the classroom size. Based on estimations, students' test scores rise significantly for fourth and fifth graders, but not for third graders.

For our analysis we will examine the impact of Covid-19 period and the shock that occurred on a number of Dry – Dock costs. As we mentioned previously, our dataset describes the Dry – Docking of 2 market leaders and that created a representative and random sample of the whole population of containerships. This is crucial for our quasi-experimental framework in order to have a valid causal framework. We chose a number of variables to control the final outcome, and we included some of them even if they are insignificant because we want to explain an extra portion of the total variance, and this will drive us to more concrete standard error estimation. In our framework we do not have convenience of using the fixed effect method because out individuals appear only one time. Thus, we are trying to minimize the heterogeneity effect through the existence of these extra controls and through partial out the effect of those variable we can isolate the pure effect of Covid-19 in the Dry – Dock. It is worth mentioning that we chose to group the categories of expenses in General Services, Paintings, and Steel work although we had various other subcategories because we have evidence that they share a great number of common characteristics which produce group heterogeneity.

The regression equation that resulted from the aforementioned papers and our research is the following:

$$\mathbf{Cost}_{i,t} = \boldsymbol{\beta}_0 + \boldsymbol{\beta}_1 \boldsymbol{Vessel}\mathbf{Age}_{i,t} + \boldsymbol{\beta}_2\mathbf{COVID\text{-}19}_t + \boldsymbol{\beta}_3\mathbf{DD\_Days}_t + \boldsymbol{\beta}_4\mathbf{CostType}_{i,\mathrm{Steel}} + \boldsymbol{\beta}_5\left(\mathbf{CostType}_{i,\mathrm{Steel}} \times \mathbf{Steel\ Price}_{i,t}\right) + \boldsymbol{\beta}_6\mathbf{CostType}_{i,\mathrm{Painting}}$$

Where:

$\mathbf{Cost}_{i,t}$ = Represents the Dry-Docking costs in logarithmic terms. It is the amount of cost of each vessel's invoice including all the categories of expenses that occur in the shipyard, General Services, Paintings, Steelwork. The Costs are divided by the Consumer Price Index of China according to the World Bank for the years we examine in order to remove from the dataset the influence of inflation which was very high in this period as shown from the diagram bellow.

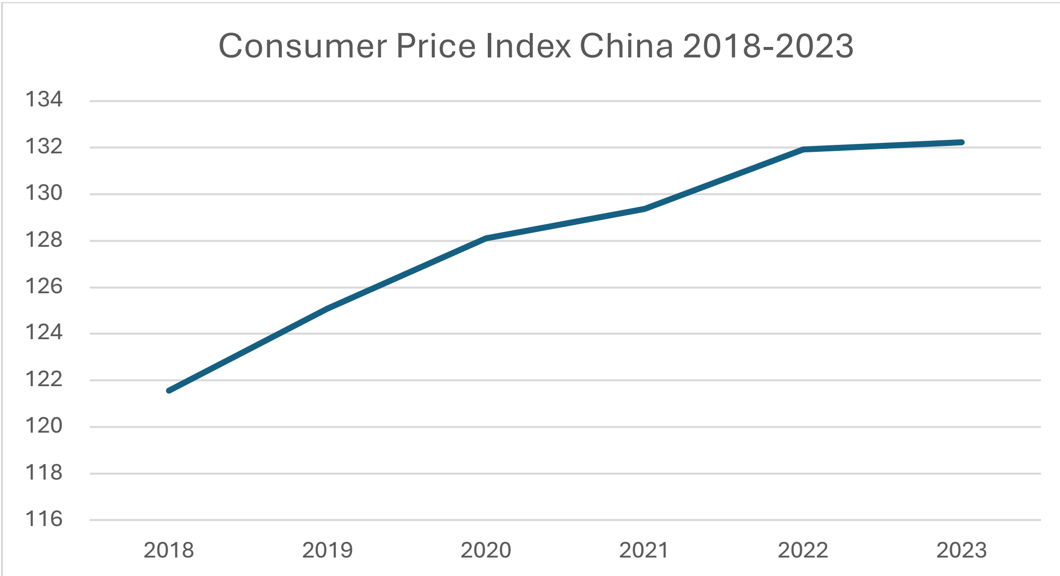

Figure 3 Consumer Price Index in China 2018-2023, World Bank

$\textbf{Age}_{i,t}$ = Represents the age of the vessel. The age of a ship is counted from the delivery date, by the building shipyard to her owners. The age of each vessel is considered the date that it underwent Dry-Docking.

$\textbf{COVID-19}_{t}$ = Is a dummy variable that assumes the years that the Covid-19 pandemic hit the shipping industry. It begins in 2020 where the first quarantine began and ends in 2022. It assumes 1 when there is Covid-19 and 0 where there is not.

$\textbf{DD\_Days}_{t}$= Represents the number of days that the Dry - Docking took place. It begins from the day it enters the shipyard until the day that it is delivered back to the shipowner. We want to partial out the unexpected days of DD due to other damages that are specific to each vessel.

$\textbf{CostType}_{i,\text{Steel}}$ = Is a dummy variable created to minimize the impact of individual steel cost fluctuations to the overall costs of the Dry – Docking. The reference base of this dummy variable in the General Services.

$\textbf{CostType}_{i,\text{Painting}}$ = Is a dummy variable created to minimize the impact of individual painting cost fluctuations to the overall costs of the Dry-Docking. The reference base of this dummy variable in the General Services.

$\textbf{CostType}_{i,\text{Steel}} \times \textbf{Steel Price}_{i,t}$ = Is a dummy variable that controls the market price of steel as a commodity in China, converted from Chinese Yuan to USD. In order to achieve that we multiplied the dummy variable controlling the steel prices with the market price of steel. We used this interaction variable (dummy * continuous variable) in order to isolate the extra effect of the market fluctuation of steel prices on top of the heterogenous effect of market prices.

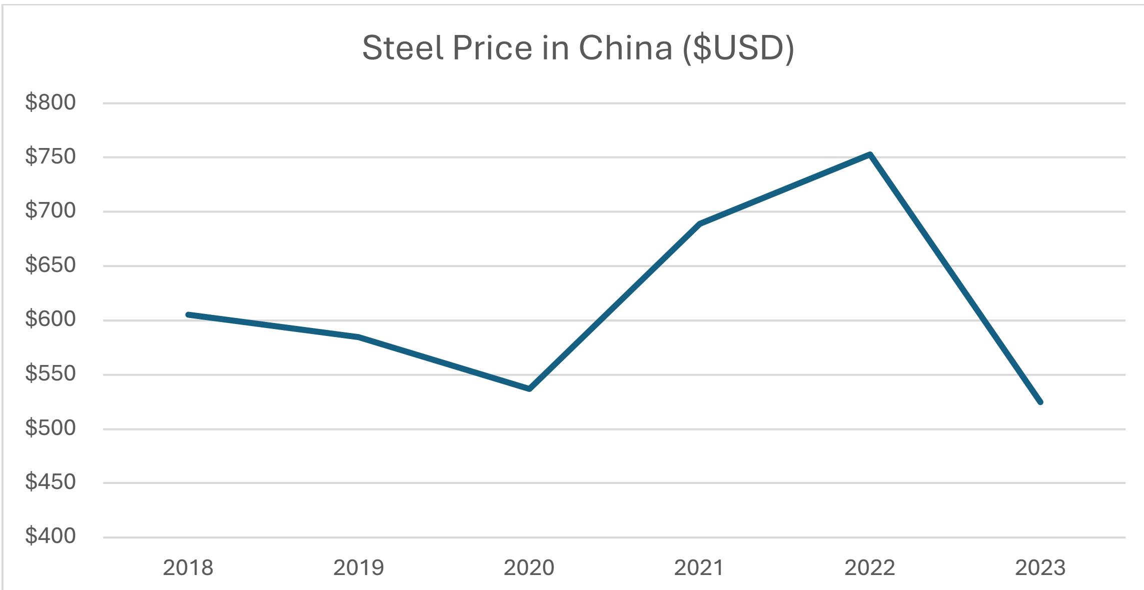

Figure 4 Steel Market Price in China, Trading Economics

It is worth mentioning that in our regression model we did not include the size of the vessel. The reason is the fact that the dataset does not give us a clear picture regarding the cost per size. As shown in the graph below the size has many anomalies appears not to be correlated to the total cost of the vessel.

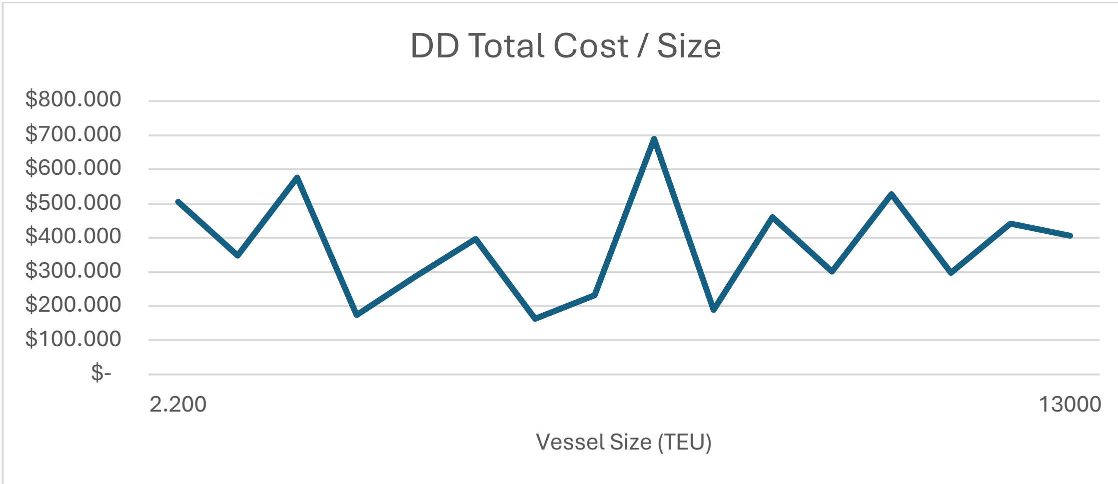

Figure 5 Total Cost of Dry - Dock / Size of vessel (TEU)

5. Descriptive Statistics

In the following chapter we will try to identify patterns and the way costs have been fluctuated through time series analysis of the data. In this graph the overall Dry-docking costs are depicted though the 5 years we are trying to analyse. Due to the difference in the size of the vessels in question in order to unify the dataset we have divided the total cost with the TEU of each vessel. As a result, the graphs present the total cost of the Dry – dock per container capacity. The red dotted line represents the starting point of the pandemic period that occurred in 2020.

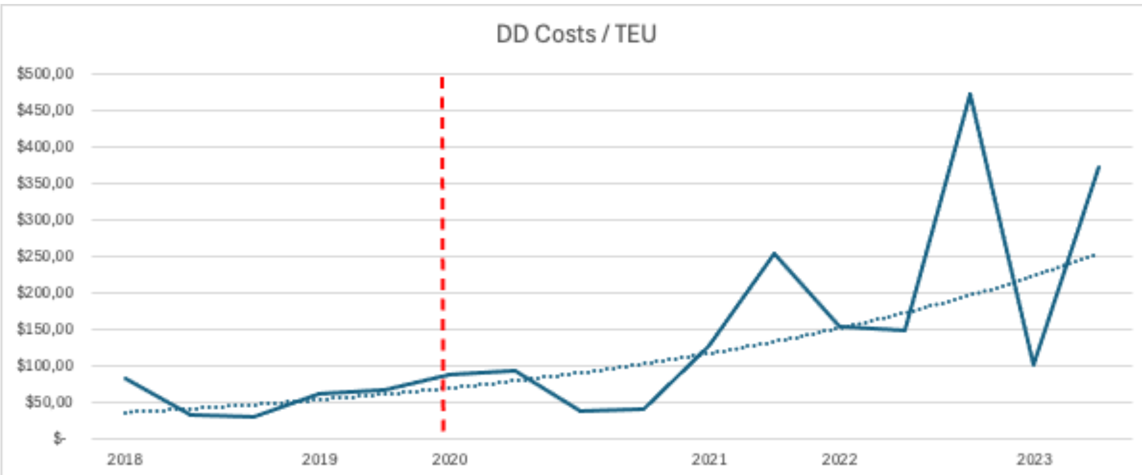

Figure 6 Dry Docking Costs / TEU

The minimum dry - docking cost of the sample is 30,16 $ / TEU in 2018, with a maximum of 374,58 $ / TEU in 2022. It is clear that the data fluctuates over the time period. Though the exponential trendline it is clear that there is a trend of increase of the price of Dry – docking. Even though there is an abnormal cost of 374,58 $ / TEU the upward trend remains. This cost although could be further investigated whether it is an outlier. We can clearly see that after the Covid-19 hit the first reaction of the market was a sudden drop. Moving in 2021 and later 2022 we see a straight escalation nearly 3 or even 4 times the costs compared to pre-pandemic levels with high fluctuation.

In this graph the General Services costs are depicted though the 5 years we are trying to analyse. Due to the difference in the size of the vessels in question in order to unify the dataset we have divided the general cost with the TEU of each vessel. As a result, the graphs present the general services cost of the Dry – dock per container capacity. The red dotted line represents the moment that the pandemic occurred in 2020.

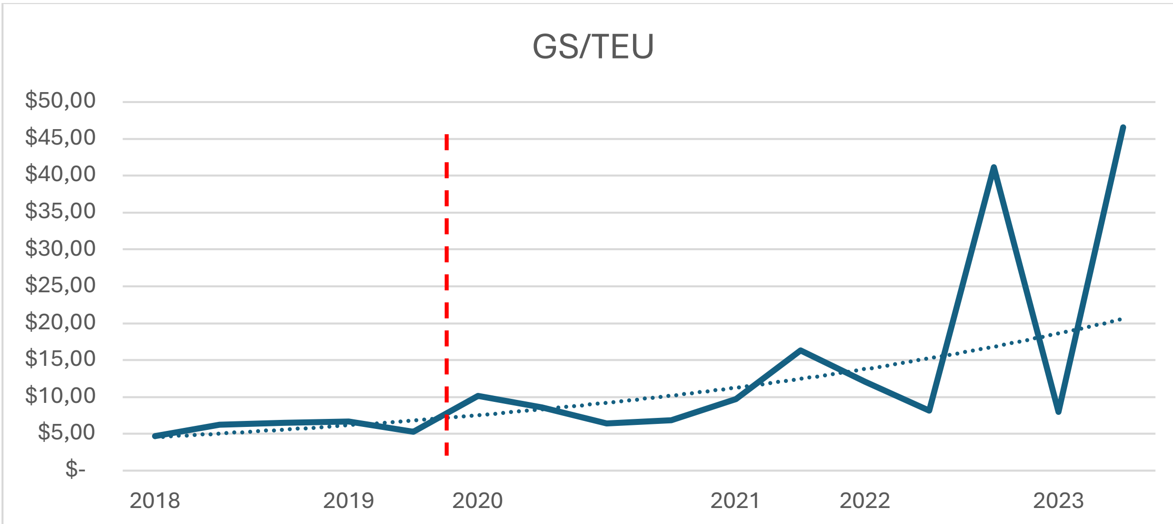

Figure 7 General Services Cost / TEU

The minimum of the general services cost of the sample is 4,68 $ / TEU in 2018, with a maximum of 46,57 $ / TEU in 2023. It is clear that the data fluctuates over the time period. Though the exponential trendline it is clear that there is a trend of increase of the price of Dry – docking . Even though there is an abnormal cost of 46,57 $ / TEU the upward trend remains. This cost although could be further investigated whether it is an outlier. General Services follow the same trend as the Total DD costs above. They seem smoother maybe due to the removal of the other categories of services.

In the graph below the Painting costs are depicted though the 5 years we are trying to analyse. Due to the difference in the size of the vessels in question in order to unify the dataset we have divided the painting cost with the TEU of each vessel. As a result, the graphs present the painting cost of the Dry – dock per container capacity. The red dotted line represents the moment that the pandemic occurred in 2020.

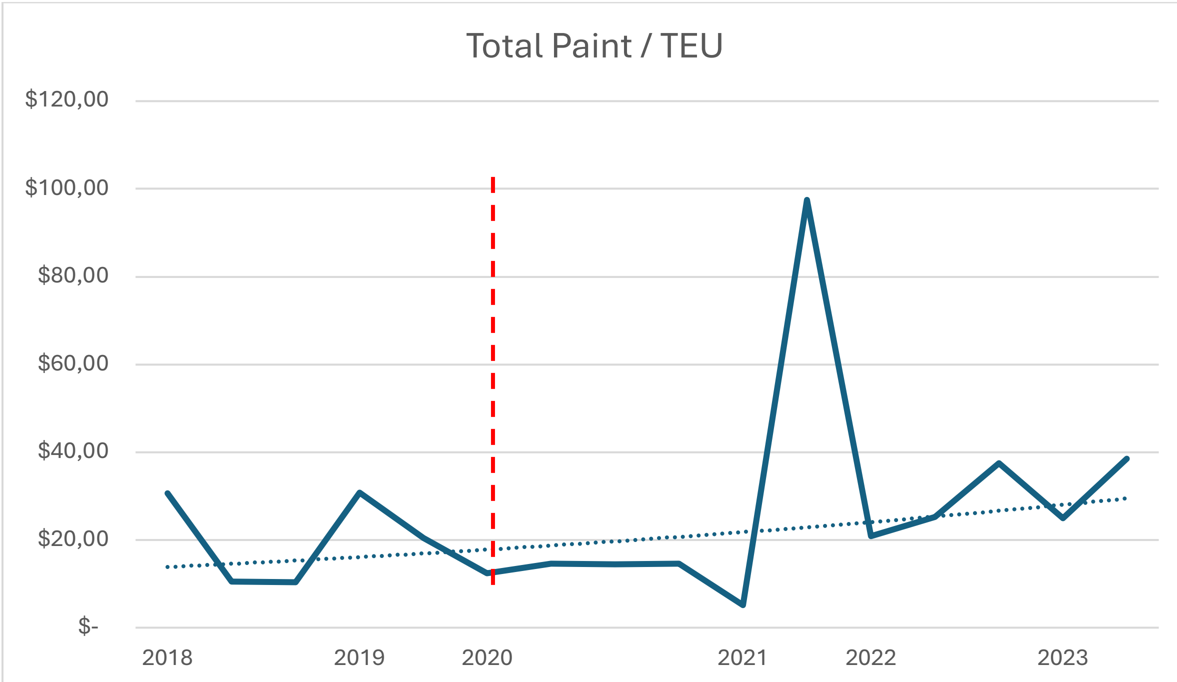

Figure 8 Total Paintings Cost / TEU

The minimum of the paintings cost of the sample is 5,13 $ / TEU in 2021, with a maximum of 97,50 $ / TEU also in 2023. It is clear that the data fluctuates over the time period. Though the exponential trendline it is clear that there is a trend of increase of the price of Dry – docking . Even though there is an abnormal cost of 46,57 $ / TEU the upward trend remains. This cost although could be further investigated whether it is an outlier. Painting costs have smaller volatility compared to other costs. They follow the same spike but the exponential line looks less aggressive.

In the graph below the Steel costs are depicted though the 5 years we are trying to analyse. Due to the difference in the size of the vessels in question in order to unify the dataset we have divided the painting cost with the TEU of each vessel. As a result, the graphs present the Steel cost of the Dry – dock per container capacity. In this graph we have included also the price of steel in China for the years we examine. The reason for this addition is that we are trying to investigate whether the steel prices before and after covid affect the steel costs in the shipyards. Steel prices are presented in USD per Tone. The red dotted line represents the moment that the pandemic occurred in 2020.

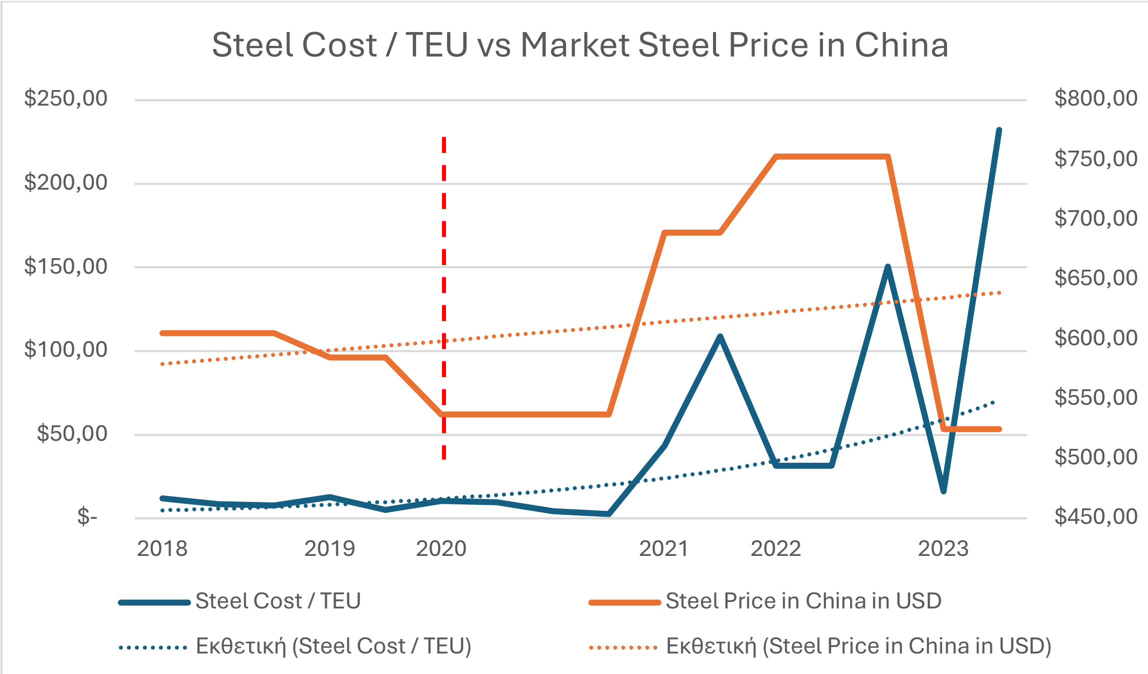

Figure 9 Steel Cost / TEU vs Steel Market Price in China

The minimum of the steel cost of the sample is 2,59 $ / TEU in 2020, with a maximum of 232,25 $ / TEU also in 2023. It is clear that the data fluctuates over the time period. Though the exponential trendline it is clear that there is a trend of increase of the price of Dry – docking . Even though there is an abnormal cost of 232,25 $ / TEU the upward trend remains. This cost although could be further investigated whether it is an outlier. On the steel price we see the fluctuation follows an upwards trend as in the steel cost but somewhat smoother. The minimum price is 524,71 $ / Tone in 2023 and the maximum price is 752,88 $ / Tone in 2022. There seems to be normal fluctuation between the steel prices in China. We can clearly see a potential cause of the price fluctuation of the total cost of DD from the high volatility of steel costs after the pandemic began. It is important to mention that even though both the market steel price and the steel prices of DD exponential curves are inclining the costs are rising higher than the market price. It can also be observed that after the shock, in 2023 market steel prices get back too pre pandemic levels but the steel cost remains in high levels.

6. Empirical Results

Running our model, we reach in the following results for the Dry – Docking costs. There is a pattern that is consistent between the model with the descriptive statistics and the literature. The model shows that during the pandemic of Covid-19, Dry-Docking costs were increased significantly by 33% (at the usual reference significance level α= 0,05). This gives us some evidence that the shock of Covid-19 changed the shipping industry's costs regarding the Dry-Docks. We have some evidence of causal relation between Covid – 19 and DD costs.

Steel Market Price seems also to be a significant factor of the steel category of the DD cost. Even though, most of the other variables do not seem to be significant, they help in the better acceptance of the result regarding Covid – 19. Also the results they gave helped in order to take out other parameters that were not relevant with our hypothesis.

Both aforementioned empirical results seem to prove the assumptions made on the descriptive statistics chapter about the impact of Covid – 19 to the Dry – Docking costs.

7. Conclusion

The scope of this thesis is to examine the impact of Covid – 19 in the cost of Dry – Docking for Containerships. Both the descriptive statistics as well as the empirical results of the analysis propose that there was correlation between costs and the pandemic. Also, a very clear result was the impact of such economic shocks such as Covid – 19 to prices of Dry – Dockings. It is a clear indicator why shipowners should plan out very carefully their Dry-Docks and why it is of utmost importance to be aware of the market shocks. The most efficient counter measure could potentially be a safe projection of the shipping cycles which can be very challenging especially under unexpected circumstances. The shipping companies and shipowners for this reason should be always prepare in advance by keeping stock or even purchasing steel in more competitive prices. Finaly, an interesting finding is that even though the market steel prices fell on the after Covid – 19 pandemic the cost for steel and steelwork in the shipyards keeps rising which is an important issue to be addressed in another paper.

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9. ANEX

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0,78896556
R Square	0,62246666
Adjusted R Square	0,59143652
Standard Error	0,6727403
Observations	80

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	6	54,4726536	9,07877559	20,0600677	1,0462E-13
Residual	73	33,0383042	0,45257951		
Total	79	87,5109578			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	4,98655537	0,32443242	15,3700894	1,3836E-24	4,33996248	5,63314826	4,33996248	5,63314826
Vessel Age (DD year)	0,02167752	0,01462995	1,48172209	0,14271816	-0,0074799	0,05083497	-0,0074799	0,05083497
Covid	0,33091727	0,15943912	2,07550872	0,04146293	0,01315558	0,64867897	0,01315558	0,64867897
Days of DD	-0,0136798	0,02098096	-0,6520079	0,51644378	-0,0554947	0,02813524	-0,0554947	0,02813524
Steel Dummy	-1,182328	1,28860097	-0,9175284	0,36188731	-3,750506	1,38585004	-3,750506	1,38585004
Steel Market Price * dummy	0,00446284	0,00207583	2,14990801	0,0348759	0,00032572	0,00859995	0,00032572	0,00859995
Paint Dummy	1,65275333	0,1942034	8,51042443	1,546E-12	1,26570652	2,03980014	1,26570652	2,03980014