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MASTERTHESIS

Liner Shipping Service Network Dynamics

presented by

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Abstract

Liner shipping is one of the most important industries in the world characterized by a mix of structural layers of complexities, challenges and opportunities in liner shipping alliances globally. Strategic alliances, in the business of sea transport across the globe, have been of paramount significance concerning the efficiency of service, operating economics, and network alignment in the liner shipping sector. This paper employs game-theoretic concepts to explore strategic interrelations between shipping carriers functioning in an alliance environment. The analysis considers factors such as market dynamics, external influences such as horizontal and vertical cooperation, as well as technological, environmental and regulatory factors. The developed framework will be complemented with a case study on the 2M Alliance. By investigating the intricate dynamics of liner shipping networks through the lens of game theory, this study aims to build a foundation through game theory toward making decisions in an industry characterized by complexity and rapid changes.

List of Contents

List of Figures

List of Tables

1 Introduction

1.1 Background

Maritime shipping greatly contributes to the modern day global economy, connecting countries and facilitating the movement of goods across the world. This can be explained by the fact that approximately 90% of global trade directly comes from maritime shipping (ICS, 2021). Similar to the widespread impact experienced by numerous industries during the 2008 global financial crisis, the recent COVID-19 pandemic also exerted extensive effects (Chen and Yeh, 2021), leading to a 3.8% contraction in the maritime transportation sector during the initial six months of 2020 (UNCTAD, 2021). This decline was attributed to issues such as new shipping regulations, a significant drop in freight rates, port congestion, and the closure of many ports around the world. In the second half of 2020, carriers began to move toward meeting the growing demand for seaborne trade cargo transport along the Far East-North America trade route, although the capacity effect was limited by existing realities and alterations which involved the reallocation of a capacity-to-priority transpacific routes within a change in scheduled port rotations, including savings in callings or skipping, reducing direct connections, among others were made within the services (Teodoro and Garratt, 2023). Subsequently, the global maritime trade rebounded by as much as 3.2% within the next year (UNCTAD, 2022).

Maritime shipping is divided into three major sectors: liner shipping, industrial shipping, and tramp shipping (Shi, 2011), (ITF, 2018). In the liner shipping business, carriers offer liner shipping services commercially to shippers through the operation at regular service schedules between ports along established trade routes (Tang and wan Sun, 2017). (Haralambides, 2019) stresses that liner shipping is supposed to deliver scheduled services between nominated ports, with timetables and tariffs announced beforehand, while (Notteboom, 2004) suggests that liner shipping is modeled as a hub-and-spoke network, where main feeder vessels ply major ports, and smaller feeder vessels link smaller ports to the main arteries. Further, (Koza, 2017) suggests that in bigger liner shipping structures, thousands of shipping routes are controlled by various container vessels. These routes are connected through the ports, which have a function of loading and unloading not only as nodes but also as transshipment hubs for transiting containers from a given route to another. Interlinking the above automatically gives rise to unalterable complex network systems.

By 2017, the four mega carriers had more than half of global capacity, from 2018, each of them consistently saw a market share above ten per cent (UNCTAD, 2022). In 2022,

Year	Tankers	Major bulk cargo	Other dry cargo	Total
2011	2785	2364	3626	8775
2012	2840	2564	3791	9195
2013	2828	2734	3951	9513
2014	2825	2964	4054	9842
2015	2932	2930	4161	10023
2016	3058	3009	4228	10295
2017	3146	3151	4419	10716
2018	3201	3215	4603	11019
2019	3163	3218	4690	11071
2020	2918	3196	4531	10645
2021	2952	3272	4761	10985

Table 1.1.: International maritime trade from 2011 to 2021 (millions of tons). Based on (UNCTAD, 2022)

the largest carrier was MSC, with a market share of 17.3%. Next was APM-Maersk at 16.5%, the CMA CGM Group at 12.7%, and the COSCO Group at 11.2%. Hapag-Lloyd was the fifth-largest player with a market share of 6.8%. Interestingly, the top five players made up two-thirds of the total capacity. Market concentration has been relatively stable, with the top four carriers growing their market shares among the top 20 carriers (UNCTAD, 2022). As of March 2024, the top 100 Alphaliner carrier ranking is based on 6,838 vessels active worldwide with a unit of 28,985,283 Twenty-foot Equivalent Units (TEUs) and 344,523,295 deadweight tons (DWT) (Alphaliner, 2023).

According to UNCTAD, there has been a general trend toward consolidation and reorganization within the container shipping industry over the past few years. These are in the form of strategic partnerships and alliances between shipping firms, which indeed show evidence of moving toward structures that are more cooperative within the industry. In addition to this, the observed tendency was in horizontal consolidation, where more incentives came from mergers and acquisitions in carriers, thus making markets consolidate and creating driving force on operational efficiencies. A major move toward vertical integration has also been witnessed as shipping firms expand their operations and take over terminal management and various services within the entire scope of logistics, therefore, gaining further influence across the whole supply chain (UNCTAD, 2022). One of the most notable shifts has been the move towards greater reliance on consortia and alliances between carriers (OECD, 2015).
The launching of the first generation of strategic alliances in late 1995 became a turning point in the liner shipping industry and introduced the age of explicit cooperation with worldwide services (Lu et al., 2006). Meanwhile, strategic alliances, also referred to global alliances have become the predominant level of cooperation, characterized by the establishment of major cooperation initiatives among major shipping carriers who were

Rank	Operator	Total TEU	Total ships
1	Mediterranean Shg Co.	5,800,497	812
2	Maersk	4,260,672	696
3	CMA CGM Group	3,658,527	628
4	COSCO Group	3,100,745	490
5	Hapag-Lloyd	2,053,508	281
6	Evergreen Line	1,871,144	235
7	ONE	1,671,007	216
8	HMM Co. Ltd	795,436	73
9	Zim	712,647	132
10	Yang Ming	707,018	94
11	Wan Hai Lines	490,480	117
12	PIL (Pacific Int. Line)	321,751	91
13	SITC	164,384	104
14	X-Press Feeders Group	163,905	85
15	KMTC	149,951	63
16	Sea Lead Shipping	148,032	38
17	IRISL Group	144,292	32
18	UniFeeder	129,011	81
19	Sinokor Merchant Marine	124,176	81
20	Zhonggu Logistics Corp	120,648	86

Table 1.2.: Top 20 shipping operators ranked based on total TEU. Based on (Alphaliner, 2024)

increasingly pursuing new ventures together and/or independently within the liner shipping business with different stakeholders in the liner shipping business (Shi and Voss, 2008). These strategic alliances have come a long way since the beginning and now represent around 90% of container shipping capacity in the world. These are long-term agreements on Vessel Sharing Agreements (VSA), which facilitate joint operation and marketing of vessels to let the member companies use optimal ship deployment and efficient organization of trade route operations (Ghorbani et al., 2022).

The last twenty five years have seen substantial structural changes in the industry of shipping, thereby changing operational and cooperative methods among carriers. This largely has been through regulatory reforms in related jurisdictions, which have redefined the sector's landscape (OECD, 2015). The reform basically intended to engender a competitive and efficient setup and break from practices done in the past that inhibited competition and innovation. This movement to operational collaboration, as opposed to the rate-fixing agreement, marks a dramatic change of the attitude of the carriers in the shipping industry toward competition and collaboration. Carriers agree on rate-fixing—prices or rates that they will charge for freights are determined. Such acts have been widely criticized and regulated against since they are anti-competitive—including policies by the OECD (OECD, 2011) and competition laws used within courts (Tang and wan Sun, 2017). These changes reflect how the industry has adapted to a changing environment in which changes push for more competition and— at the same time—more transparency.

Consortia and alliances mark a step change in shipping, where the benefits are better quality of service, increased levels of operational effectiveness, and improved competitive dynamics. However, these arrangements are subjected to regulatory scrutiny in order to avoid such reduced competition and compromised consumer interest (Shi and Voss, 2007). Hence, the sector's future progression will persistently balance delicately between collaboration among carriers and maintaining a competitive market environment. Larger vessel sizes and, as a result, the necessity for higher capacity utilization, have so far strengthened strategic liner shipping alliances (Koza, 2017). This, therefore, makes companies view the ability to efficiently manage their capacity, balance supply, and find new markets while sharing risks and investments as the way of enhancing the global footprint in operation (Varbanova, 2017). Evidence that attests to the phenomenal rise in the development of strategic alliances is the mega-alliances that have taken place in the last two decades, reshaping the competitive landscape of the industry (GSF, 2016).

Some of the prominent alliances include: 2M Alliance, THE Alliance, and the upcoming Gemini Cooperation—all using VSAs as a means of enhancing operational efficiency and network rationalization.

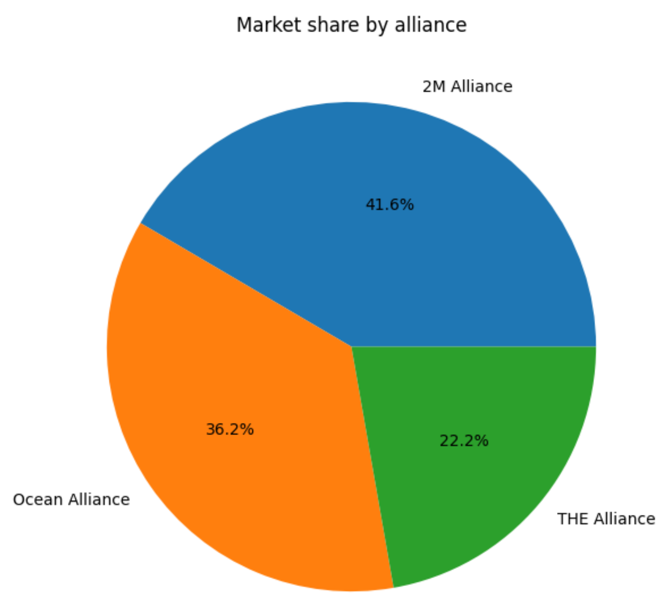

Figure 1.1.: Share of alliance capacity. Based on (Alphaliner, 2024)

Figure 1.1 illustrates that the 2M Alliance has a substantial dominance, where it has a market share of 41.6% of the total shipping capacity market. Then Ocean Alliance follows as the second, having a 36.2% share, THE Alliance takes up 22.2% in rank across the total shipping capacity. Other alliances or standalone shipping companies have relatively less trade volume, reflecting their small size or the extent of impact on liner shipping.

Nevertheless, the vertical integration trend in the industry, particularly in the acquisition of container terminal facilities in Europe, has its own set of potentials and challenges. While, a such strategic move naturally enhances the bargaining power in negotiating with the seaports for carrier alliances, stronger concern is given to how the more convenient accessibility of port facilities owned by integrated carriers will work to the disadvantage of non-integrated competitors (Pallis and Kollia, 2024), (Ghorbani et al., 2022). Furthermore, the global liner shipping industry faces issues involving volatile market dynamics, demand and supply fluctuations, and increasing regulatory pressures on environmental impact (Dierker et al., 2022), (Luman, 2023), (Council, 2024), however strategic alliances and the competitive behavior among shipping carriers form an important part of managing these challenges (Shi and Voss, 2007), therefore understanding the dynamics in the liner shipping industry is an essential step for improving both operational effectiveness and strategic decision-making for the industry.

In this thesis, the main objective of the research is to present a detailed game-theoretic model for capturing the strategic choice processes of liner shipping firms regarding market dynamics, horizontal cooperation, vertical integration, responses to technological and environmental developments, complimented with a case study on the 2M Alliance and its strategic influence on the liner shipping industry. Application of this framework is for the purpose of developing insights into how such strategic partnerships impact the operations and, most importantly, broader implications on the future of liner shipping service network dynamics.

1.2 Outline

The liner shipping industry operates in a highly dynamic and very competitive environment, characterized by complex interactions of carriers and the strategic alliances they form. In such complex landscapes, understanding the strategic behavior of carriers and the impacts of alliances on the service network dynamics emerges as a highly important step for both industry participants and policy makers. Traditional economic models might not be very effective in finding out the nuanced relationships and interdependencies in the liner shipping sector. Therefore, this study proposes the adoption of a game theory approach as an essential framework to comprehend strategic alliance dynamics among liner shipping carriers. Based on the cooperative and non-cooperative game-theoretic frameworks, the research investigates varying alliance scenarios, including competition and cooperation under real-world constraints such as market demand fluctuation, operational costs, regulatory impact,and so on. Sections in this paper are structured as follows:

The first chapter will present an introduction of the liner shipping business, outline the thesis, provide an overview of the evolution of strategic alliances and a discussion on the different forms of cooperative agreements in the liner industry, and lastly provide a problem statement with research questions. In the second chapter, an in-depth examination of the literature on the game theory in the liner shipping is conducted. This section also reviews further existing studies concerning strategic alliances and their contribution to the liner shipping industry. The third chapter of this thesis elaborates on the methodology used in conducting the research. It outlines the sources taken into consideration for the data collection and explains the relevance and reliability of such sources. In addition, the application of game theory as an indispensable strategic analytical framework in understanding the dynamics of the liner shipping industry is discussed. The fourth chapter offers an insightful discussion of market dynamics by exploring supply and demand dynamics. The fifth chapter introduces horizontal cooperation, discusses the current state of alliances, the motivation for liner carriers to join such agreements, and finally analyses the stability of the three global alliances. On the other hand, the sixth chapter thoroughly discusses vertical cooperation in the shipping business by highlighting the key areas of vertical integration and analyzing vessel calls and port usage at the port of Hamburg. Chapter seven addresses technological, environmental, and regulatory aspects that impact liner shipping service networks. Chapter eight covers a case study on the 2M Alliance and its strategic impact on container liner shipping. Finally, the tenth chapter provides a thorough discussion and a summary conclusion providing recommendations for future research directions.

This paper presents an analysis of strategic alliances in liner shipping and, therefore, it adds to the understanding of changing dynamics in this industry. The findings from this research are valuable for companies operating in liner shipping, policy formulators, industrial analysts, and academicians in consideration of policy options and a way forward to navigate the complexity and maximize potential benefits with strategic alliances in a global trading environment that is constantly changing.

1.3 Formation and evolution of strategic alliances

The evolution of strategic or global alliances in liner shipping has been a significant development in the liner shipping industry (Slack et al., 2002).

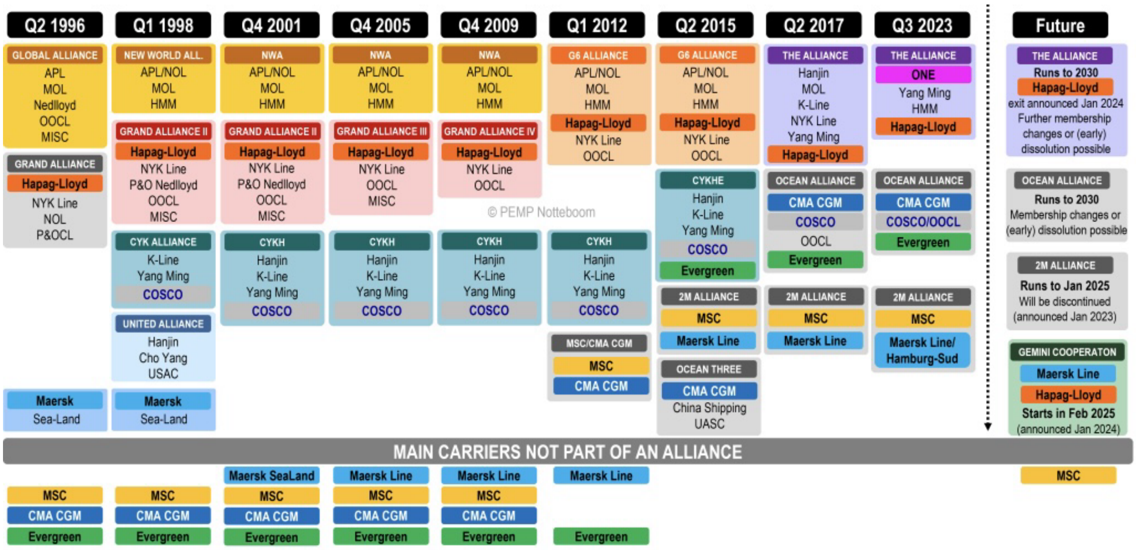

Figure 1.2.: The evolution of strategic alliances in container liner shipping. Based on (Notteboom et al., 2022)

Early alliances (Q2 1996 - Q4 2001)

The early formation of alliances dates back to the 1990s when shipping lines started exploring collaboration beyond traditional conferences. Two of those founding alliances were the Global Alliance and the Grand Alliance both established in 1995 (Notteboom et al., 2022). The Global Alliance included APL, MOL, Nedlloyd, OOCL, and MISC among others. On the other hand, Grand Alliance comprised Hapag-Lloyd, Nippon Yusen Kaisha, Neptune Orient Lines (NOL) and P&OCL (Cullinane and Khanna, 2000). Other consortia, however, such as CYK Alliance and United Alliance, also began to identify their respective main carriers, including Hanjin, Yang Ming, COSCO, among others. This signaled the starting of initial efforts in consolidation among major steamship firms with the objective of leveraging collective strengths and share of the market.

Expansion and Consolidation (Q4 2001 - Q4 2009)

Over time, alliances became larger and more complex (Unit and Hoffmann, 1998). More carriers realized the benefits of cooperating and as the result, the number of alliance members across the board increased. Some of these alliances have invited carrying companies to join them. Some of them carried out consolidation and reorganization to enhance competition ability and operation efficiency (Chen et al., 2022). Entrance by mega-vessels into the industry has been the greatest game-changer causing formation of new global alliances with a further push of the clock consolidation pace in the industry (GSF, 2016). For instance, APL/NOL and MOL merged with HMM then later a year after came together to become the New World Alliance in 1998 whereas the Grand Alliance merged with P&O Nedlloyd, OOCL and MSC (Unit and Hoffmann, 1998).

G6 Alliance and CKYHE Alliance (Q1 2012 - Q2 2015)

The other two major alliances that developed between 2012 and 2015 were the G6 Alliance and the CKYHE Alliance (ITF, 2018). Members of the G6 Alliance were APL, Hapag-Lloyd, Hyundai Merchant Marine, MOL, NYK Line and OOCL. The members of CKYHE Alliance included Cosco, K Line, Yang Ming, Hanjin Shipping and Evergreen. Both alliances worked on strengthening their services in major East-West trade routes including the north-south services (Panayides and Wiedmer, 2011).

2M Alliance, Ocean Alliance and THE Alliance (Q2 2017 - Q3 2023)

The formation of 2M Alliance, Ocean Alliance and THE Alliance brought together the industry's largest players. The 2M Alliance was formed in 2015 as a strategic partnership between Maersk Line and the Mediterranean Shipping Company (MSC). There was realization that for an alliance to work effectively and efficiently, scale was imperative if they were to provide their customers an extensive global coverage that would be of a flexible initiative for meeting the customer requirements with the shared assets (Maersk, 2024). It therefore became one of the world largest alliances (ITF, 2018) to collaborate on the main trade lanes across all continents. Both formed in 2017, Ocean Alliance comprises CMA CGM, Cosco Shipping Lines, Evergreen Line, and OOCL, while THE Alliance was established between the other four major carriers—namely Hapag-Lloyd, ONE (Ocean Network Express), HMM, and Yang Ming. By 2017, three major alliances were officially operational in the liner shipping business (ITF, 2018) (Notteboom et al., 2022). However, in early 2023, 2M Alliance announced that it would be dissolving and the effect would take place in February 2025 (Notteboom et al., 2022). Similarly, at the start of 2024, Hapag-Lloyd announced that it would exit THE Alliance to enter a strategic cooperation with Maersk, the largest Danish container carrier (Hapag-Lloyd, 2024) (Maersk, 2024).

Gemini Cooperation (Q3 2023 - Future)

From February 2025, the new alliance of the two world-leading shipping companies, Hapag-Llyod and Maersk, will come into effect. Both carriers noted in a joint comment that they are going to solve a series of issues related with the transition to climate neutral, while at the same time improving delivery efficiency. The Gemini Cooperation will cover a range of trade routes, including Asia to the US West Coast, Asia to the US East Coast, Asia to the Middle East, Asia to the Mediterranean, Asia to North Europe, Middle East to India to Europe, and Transatlantic routes. As part of this partnership arrangement, both carriers would dissolve existing alliances with other shipping companies in early 2025 (Hapag-Lloyd, 2024) (Maersk, 2024).

Continuous evolution and change

The strategies adopted by mega alliances in liner shipping continue to evolve and adapt continuously in light of market dynamics, customer needs and regulatory considerations. These are relatively common tasks for the members of liner mega-alliance in search of their next degree of freedom. The changing strategies and tactics of mega-alliances in liner shipping assure that they persist through continued competitiveness and respond to market conditions.

1.4 Forms of cooperative agreements

Many researchers in the shipping industry have debated various forms of cooperative agreements within the sector. For instance, the International Transport Forum discusses common types of collaboration in liner shipping as follows.

1. Vessel Sharing Agreements (VSA): This is one of the most common agreements in liner shipping. VSA means an agreement between multiple shipping companies for the joint operation of an agreed number of particular liner services. In a VSA, basically carriers share vessel space, costs, and revenues on a particular route or set of routes. Such rationalization of capacity improvement leads to better service frequency (ITF, 2018).

2. Joint ventures: A joint venture is a complex cooperative arrangement in which carriers share equipment and pool vessels, contributing ships and other resources to create a new brand that offers more frequent services than they could provide individually. On the other hand, a joint-venture is organized more like a merger, presenting a common brand to customers and operating with a higher level of integration (Yang et al., 2011).

3. Consortia: Consortia are agreements between sea carriers to combine their operational, technical, or commercial activities on specific trade routes (Shi and Voss, 2007). Consortia agreements are believed to benefit the shipping companies participating by realizing cost reductions through increasing utilization of capacity and economies of scale (Tiemann, 1994). This form of cooperation optimizes savings since deals between the partners in a consortium are concerned with only a single maritime service (ITF, 2018).

4. Strategic or global alliances: A liner shipping alliance is a cooperative partnership of financial independent companies in the shipping business. These partners cooperate for mutual gain while maintaining individual financial independence, which helps them to provide the desired benefits, such as increased service frequency, broader geographic coverage, and cost savings from shared resources (Shi and Voss, 2008). Among the most frequent types of agreements for collaboration between shipping lines to offer worldwide maritime container transport services are strategic alliances (Ghorbani et al., 2022).

5. Mergers and acquisitions: More than any other form of collaboration, consolidation through mergers and acquisitions could be viewed upon as the fullest, since it results in integration in full or near entirety of business ventures (ITF, 2018).

6. Conferences: Conference means a group of two or more liner shipping companies which provide international services to/from the same geographical area under published tariff rates and mutually agreed upon through rates and charges, and which operate under an agreement or association authorized or permitted to be filed with FMC. A conference may also fix trade shares enabling the adjustment of capacity to demand (Tiemann, 1994).

Actors	Shipping companies	Terminal operating companies	Port authorities	Hinterland operators	Hinterland terminal operators
Shipping companies	* Vessel sharing agreements * Joint-ventures * Consortia * Alliances * Mergers/acquisitions * Conferences	* Joint-ventures * Dedicated terminals * Share * Management contracts		* Carrier haulage * Shuttle trains * Block trains	* Inland terminal share
Terminal operating companies	* Ship repair * Container manufacturing & leasing	* Mergers/acquisitions * Joint-venture	* Total port operation * Pilotage * Towage	* Rail transport operation * Rail construction	* Inland terminal share
Port authorities		* Joint-ventures	* Alliances	* Rail transport operation	* Inland terminal share
Hinterland operators	* Block trains and capacity sharing * Acquisitions	* Joint-ventures		* Alliance	* Inland terminal share
Hinterland terminal operators		* Share			

Figure 1.3.: Cooperative agreements in liner shipping. Based on (OECD, 2011)

1.5 Problem definition and research questions

Liner shipping is one of the key features of world trade, as it provides regular services for transporting large volumes of goods. In recent years, the structure of the liner shipping business has undergone a tremendous evolution with the appearance of strategic alliances between large shipping operators. These may be integrated agreements concerning the operation together in which all members involved in such an alliance pool their resources, align vessel capacity, and work out routes as well as schedules (Liu, 2015).

Even though one of the motives for implementing alliances is to gain efficiency at the operation level, reduce costs, and offer more services to customers (Liu, 2015), their potential effects on competition, market dynamics, and service quality are still under scrutiny and debate. The great question is whether alliances, specifically those including most of the major carriers, generally cause competition to decrease (Cariou and Guillotreau, 2022) and eventually form an oligopolistic (Lee et al., 2012) or even monopolistic market structures (ITF, 2018). Increased freight rates, lack of alternatives for customers, and diminishing service quality are the possible impacts of reduced competition. The other factor that needs to be analyzed is how alliances affect the behavior of the market. This is coupled with trying to find impacts of the alliances on market stability, volatility, and the carrier adoptability relative to the shifts in the market.

Much research is critically needed for examining the impact of strategic alliances on market dynamics and competition, and how and why liner shipping companies form strategic alliances (horizontal cooperation), and eventually, how vertical integration contributes to the optimization of service networks and enhances value chain efficiencies. By investigating these aspects, this research will provide very important insights into the impacts of alliances on liner the shipping service network dynamics, therefore, industry players, policymakers, and other stakeholders will be better placed to make informed decisions, design effective regulatory frameworks, and operational strategies toward a sustainable and competitive industry that serves the growing needs of global trade. Hence, the following are the research questions that this thesis poses:

- RQ1: To what extent do market conditions, i.e., demand fluctuations and price competition, influence the stability and structure of the liner shipping service network and how do carriers navigate such complex market dynamics?
- RQ2: What are the main drivers behind strategic alliances' formation, sustainability, and dissolution in liner shipping, and how could these be explained by cooperative game theory?
- RQ3: What are the operational efficiencies and inefficiencies associated with ver-

tical cooperation within liner shipping alliances, especially in terms of port operations and vessel utilization?

- RQ4: How do developments in technology, environmental regulations, and international trade policies affect the strategic choices of companies in liner shipping alliances?
- RQ5: How might the dissolution of the 2M Alliance affect the competitive dynamics and market positioning of participating carriers?

2 Literature review

2.1 Preliminary research regarding the application of game theory in the liner shipping business

The available literature does not offer general evaluations with a special focus on the application of game theory in the liner shipping industry. This gap identifies a very important opportunity for academic research and growth. Building on the base laid by previous studies, this research further tries to fill that gap using game theory and brings forth a better understanding of the intricate relationships and strategies of shipping companies and their alliances.Some of the earlier published work include (Panayides and Cullinane, 2002) tracking the dynamics of cooperation between participants in liner shipping strategic alliances over time using cooperative game theory. Their work is based on three central objectives: First, they attempted to provide a systematic and comprehensive study of liner shipping strategic alliances with respect to the nature and form, on the basis upon which further studies might be conducted. The second objective was that they gave a brief history of game theory, focusing on the theory and the application of cooperative game theory. They have thus proposed a theoretical framework using cooperative game theory to gain insight into the details of strategic alliances in liner shipping. And (Imai et al., 2004) who tested the economic feasibility of container mega-ships in competitive frameworks by using a game theory basic model named non-zero sum two persons' game. Two different service network configurations are compared based on this theoretical model that is adapted to two different ship sizes, i.e., an optimized hub-and-spoke configuration for mega ships and a multi-port calling strategy for conventional ship sizes. More importantly, into the creation and possible development of liner shipping strategic alliances under market uncertainties, were works of (Shi and Voss, 2008). They found out that with this type of alliance, the strategy has been made and adjusted against market uncertainties. The current analysis reveals that these strategic alliances are formed and developed in different conditions in the market, hence shedding some light on strategic decision-making within the shipping industry. Besides, (Shi and Voss, 2011a) worked towards the application of game theory to the shipping industry, giving a multi-dimensional view in the analysis of such an industry. They introduced a classification system containing three games: the link game, the node game, and the network game. Thus, such a system helps to perceive the strategic interaction within the industry. They, on the other hand, had to do with the interdependence that exists among shipping carriers, ports, and consolidation/distribution operators while framing these relationships as different interdependent components inside network games.

With the above in place, (Shi, 2011) introduced a game theoretic approach to evaluate the impact of strategic alliances on container terminal operators considering both vertical and horizontal cooperations. (Sjostrom, 2009) employed the game theory models explaining cooperation and completion in strategic alliances within the liner shipping business. (Aymelek, 2016) worked on competitive outcomes of liner container shipping activities using a non-cooperative game theory setup with four rational players employing both complete information and incomplete information frameworks. Thus, one is able to understand strategic interactions based on both Cournot-Nash and Bayesian-Nash equilibrium concepts and the implications that these have for the shipping industry. According to (Savunen, 2009), the principles of cooperative game theory offer a potential search mechanism for viable methodologies that can be used in modeling strategic alliances within different settings. Theirs was a study on the various theoretical concepts lying in cooperative game theory and how such frameworks can be adapted to effectively analyze and come up with models capturing the dynamics of strategic alliances. (Yang et al., 2011) were the first to holistically incorporate both mega containerships and alliance strategies by applying core theory in order to investigate how increasing ship size affected the stability of shipping alliances. They further observe that the shipping market at the international level is intrinsically turbulent and, therefore, there is an emerging trend for survival by many of the carriers through the formation of shipping alliances. Furthermore, this strategic move is aimed at optimizing operation efficiency and increasing the level of market share. This strategy becomes particularly important in situations with larger vessel sizes, whereby alliances may be benefices to features such as guaranteed loading capacities and lower levels of transportation costs. However, designing participation in alliances or the commitment of larger vessels must take note that even though it decreases market uncertainty, it continues to remain only a partial solution and may not always be the optimal answer to the volatile dynamics that continue to govern the shipping industry.

In the context of liner shipping, (Luo et al., 2009) applied game theory to study the strategic behavior related to shipping companies. It has been shown that companies very often launch price wars and capacity adjustments in order to outcompete their rivals. Likewise,(Cariou and Wolff, 2011)'s contribution added an analysis on how alliances may impact shipping competition, putting an emphasis on how strategic partnership impacts market outcomes and shipping rates. In their paper, (Wang et al., 2014) put forward three game-theoretical models in order to explore competition between two shipping liner carriers. They used optimization models for every carrier to maximize profit, which included optimal freight rates and deployment strategies, to be developed upon service frequency as well as size of the ship. The market shares were calculated with a basic Logit-based choice model. The paper then followed up with an analysis of three strategic competitive interactions, namely, the Nash game, the Stackelberg game, and deterrence, of each route considering economies of scale in the capacity of the ship. The models were designed in a way to incorporate practical realities of shipping deployment and step-wise pricing adjustments and thus provide a structured approach towards the analysis of strategic competition in shipping. (Lee et al., 2012) developed a multi-level hierarchical approach to model oligopolistic competition and collaborative dynamics among a group of carriers within a maritime freight transportation network. The model treated ocean carriers as the stars in an ocean shipping market, port terminal operators as playing the role of the subservient to the ocean carriers and a superior to the land carriers-the principle players. The researchers applied the principles of Nash equilibrium during their analysis to determine the best strategy to adopt for profit maximization by each of the carriers types. A three-tier model was developed to depict the intricate inter-relations between carriers. A numerical example is given to illustrate the effectiveness of the model in representing accurately the strategic dynamics within the shipping industry. (Shi and Voss, 2011b) developed a game-theoretical model to show that under a typical slot-chartering contract, the overall performance experiences a minimal loss in efficiency or profitability compared to a centralized system. However, they also found that depending on cost parameters and demand uncertainty, the actual loss can exceed this minimum threshold significantly, indicating the importance of these factors in the contract's effectiveness. Indeed, the game-theoretic modeling of this issue by (Shi and Voss, 2011b) provided a proof of general view that under a typical slot-chartering contract, overall performance experiences the minimal loss in effectiveness and/or money making compared to centralized booking. Still, in concert with that they found that depending on cost parameters and uncertainty in demand the actual loss often significantly exceeds this threshold for minimum losses, which gives evidence to high importance of these factors to the contract's effectiveness. Later, (Shi et al., 2008) delved more into the stages of negotiation among liner carriers and created, for a start, an appropriate mechanism for balancing requirements of slots with the right price equilibriums under various scenarios. The study applied and articulated the pricing and negotiation model to give a practical approach to understanding and managing the dynamics within the negotiations.

(Song et al., 2021) explored service competition dynamics between two liner shipping companies, particularly the circumstances by which the two could ally on the core route. Initially, using two liner companies that competed independently and not in alliances, a benchmark game model constitution was created. Subsequently, the construction of game model introductions for three different types of alliances then laid down the foundation for comparisons. In this setting, the quality decision-making process of the two liner companies was modeled as a Nash game. Oligopolistic competition remains one of the core areas of drama within liner shipping markets, and (Cariou and Guillotreau, 2022) were not left behind in the effort to investigate these dynamics. A serious game—or interactive simulation—has been designed so as to closely mirror the competitive environment characterizing the global container market, labeled as TRALIN. During this simulation, four to five global liner shipping alliances will be competing to dominate a network of 12 routes connecting four ports of call over a number of sequential voyages.

More recently, (Meng and Wang, 2021) considered the problem of analytical pricing strategies of shipping alliances with the main tools from game theory models. The findings suggest that alliances are charging higher rates on those routes where they have overwhelming market power but are more aggressive in competing for those routes where there is stimulating competition. This two-pronged strategy enables the alliances to maximize their overall profitability.

2.2 Research on shipping alliances

The dynamics of liner shipping service networks are significantly shaped by numerous factors, particularly the influence of strategic alliances. Since the inception of global or strategic alliances in the mid 1990's, there have been several studies focusing on the various topics of interest in the liner shipping industry, however a minority of researchers have tackled the implication of strategic alliances on the industry. (Slack et al., 2002) conducted one of the first studies on how strategic alliances impact liner shipping. They investigate aspects that are key to alliances and that affect container shipping, including the range and scope of services provided by container shipping companies, the magnitude of their container fleets, and the number of port calls made by vessels. This study conducted a detailed analysis worldwide for the years 1989, 1994 and 1999. Results came showing an elevation in the range of services and the intensity of services over the last ten years. It was also summarized that the number of vessels has increased overtime, but the real difference was the rise in the vessel sizes. In addition, single carriers now serve more ports as compared to before. However, (Slack et al., 2002) qualified that this has not increased the total number of ports it is serving. (Slack et al., 2002) further examined the effect of strategic alliances on freight rates and concluded that, overall, alliances result in more stable and predictable rates. This stability will benefit shippers because uncertainty about the cost of shipping will be reduced. However, the authors have also pointed out that alliances may result in higher rates in markets with limited competition. (Shi and Voss, 2007) examined how the impacts of such rigorous strategic liner shipping alliances extend down to the container terminal operators in aspects of operations and terminal strategies. Another interesting study on the effects of shipping alliances on port competition, but also on European shipping, is that by (Heaver et al., 2010), which gave a snapshot of the different line shipping agreements and undertook to investigate the implications arising from the evolution of market structures within which ports and shipping companies operate. The paper has been particularly focused on appraising the competitive stance of ports in the changing landscape. Likewise, according to (Notteboom et al., 2017), research on the changed organizational practice of the shipping industry as a function of strategic alliances and vertical integration in container terminal operations, the impacts that such trends will have on liner service network decisions regarding the selection of ports of call worldwide. (Panayides and Wiedmer, 2011) debated the fact that liner shipping engaged with cooperation agreements and strategic alliances should have proper characteristics, scrutinized data provided from the first 20 liner carriers in terms of TEU as well as number of vessels each companies has, calculated their market share based on the number of vessels that were deployed in corresponding geographic areas and finally he looked at three principal alliances in the liner shipping industry. (Panayides and Wiedmer, 2011) says that strategic alliances gained a lot of success after the termination of the conference system, and after liner shipping carriers realized how cooperation agreements can make them achieve more success while improving their performance. (Savunen, 2009) investigated major global strategic alliances, answering important questions about the initiation of such alliances and how they are sustained over time. (Hirata, 2017) researched how demand capacity, fuel consumption costs and market share were variable to determine their impact on the freight rates of the shipping companies using datasets sourced from six distinct shipping routes within the East-West services. The findings by (Hirata, 2017) are that liner freight rates do not have a clear influence of market share; what this means is that the rates charged for shipping services are not significantly interfered with by the companies being present in the market. (Rau and Spinler, 2017) discusses and compares three investment frameworks that include the real options analysis, individual, and collective discount cash flow using an integrated alliance formation and investment model. Their outcomes showed that investment framework under the real options analysis does better than the other two in contexts with high competitive pressure and freight rate volatility. Midoro even went deeper into the point of competition that existed between global carriers, e.g., Maersk, Evergreen, or MSC, and global terminal operators in a bid for supply chain control. It considered features like financial power, technical and managerial capabilities, and the study of the evolving role of dedicated terminals, representing one of the central challenges in the liner shipping market. (Rau and Spinler, 2017)investigated and compared three models of investment: real options analysis, individual, and collective discounted cash flows in a model of integrated alliance formation and investments. The results demonstrate that the investment model based on real options analysis is appropriate in comparison to the other two, especially in cases when competitive intensity and freight rates volatility are experienced at high levels. (Notteboom and Rodrigue, 2005) did a study on the development of liner shipping networks between 1990 and 2003. He argues that during this period, these networks became more sophisticated and went global. The networks are characterized by greater numbers of hub-and-spoke systems than ever before and the appearance of mega-alliances. Building on the same work, (Ducruet and Notteboom, 2012) analyzed the evolution of liner shipping network structures from 1996 to 2009. The investigation found that liner shipping networks are following a concentrated path in which the number of shipping companies is decreasing while courting an ever-increasing number of alliances.

(Liu, 2015) are the first to check the efficiency of 2M and CKYHE by means of subjecting a mathematical model which analyzes the supply and demand dynamics to determine the best capacity allocation across ports of Asian and Europe. Results of comparison indicate that existing shipping networks of both alliances do not efficiently lead towards revenue maximization at alliance level. In addition, conflict of interest can also exist between the overall alliance objectives and the individual companies' objectives: the optimal shipping network at the level of individual companies could be very different from the optimal shipping network at the level of alliances. In particular, it has been proven that the 2M shipping network is consistent with revenue maximizing by individual companies, while the CKYHE alliance is not. Varbanova and Brooks (Varbanova, 2017) analyzed the current state of container liner shipping and its market concentration. They came to a conclusion that the setup of strategic alliances is expected to do exercise a rising market concentration. As a result, one may count on increasing stability in shipping markets with reduced competition. (Charłampowicz, 2018) As empirical evidence, he analyzed participant competition in the maritime container shipping market, with services being constantly present on both the Atlantic and Pacific regions, but at the same time not being part of the strategic alliances. In a systematic review, (Chen et al., 2022) evaluated available research that examines the management of strategic alliances in liner shipping at three levels of decision-making, particularly: strategic, tactical, and management policies. Another area of critical research is the dynamism within liner shipping networks and their effects on port efficiency. This is so because, as posited by (Notteboom et al., 2017), the role of strategic alliances is crucial in the formation of port and terminal operations. The argument advanced by (Cullinane et al., 2012) lays a perspective on changing nature in liner shipping network structure and its impact on throughput at container ports. From the work conducted by these authors, changes to such networks have a greater impact on port throughput, especially hub ports. The study underlined the connectivity level between the port and the hinterland, with a concern for its possible adjustment to variation in the liner shipping network.

In their paper, (Óscar Álvarez SanJaime et al., 2013) presented an oligopoly model with vertical relationships that was more directed to capturing some significant attributes of the maritime freight mode. First outlined and then examined the competitive transformations that were encountered by the port and maritime industries, respectively. Then, the strategic conduct of a few key market protagonists – shipowners, terminal operating companies, port authorities, and logistics service providers – was surveyed. Deep in their analysis they thrust their intentions forward. Finally, framing their expected future scenarios, they evaluated the outcomes these same players had realized of the strategies undertaken. Subject areas studied by (Fremont et al., 2007) included the dynamic coopetitive landscape of ports, contractual and equity-based relationships between shipping lines, and terminal operators. (Satta et al., 2014) introduced a deep longitudinal network analysis that aimed at evolving the dynamics of interfirms' relationships over time. (Peng,

2020) conducted a trend analysis of container ship development and identified the driving forces and constraints with a brief introduction to a model for cost calculation of container ships and a comparative analysis of unit costs associated with ships of dissimilar sizes. The follow-on parts of the paper will address the economic impact of the sulfur cap implementation on container ships, providing a detailed analysis and suggestions for finding the best cost-effective solution for vessels of various sizes. (Heaver et al., 2010) provided a concise overview of various types of agreements within the shipping industry and explore the implications of evolving market structures on the operational landscape of ports and shipping companies. Their paper specifically focuses on analyzing how these changes affect the competitive standing of ports in the newly emerging market environment. The study extracted and aligned the consensus views of the stakeholders from four shipping companies that are members of the CKYH alliance. The Delphi technique is a tool that is used to find consensus views among the stakeholders. Nowadays, strategic alliances are treated as a fundamental mechanism of large carriers because this helps greatly in expanding their service spectrum within the global marketplace (Lu et al., 2006). (Kim et al., 2006) used factor analysis, reliability testing, and regression method to examine how the success factors of alliances will relate to performance. Agreements in the shipping world have been briefly described by (Heaver et al., 2010), and the changing market structures have been analyzed with regard to the operations of ports and shipping companies. The focus is on how such change affects the competitive position of ports in a relatively new market context. (Mitsuhashi and Greve, 2009) applied matching theory to explore the process of forming organizational alliances. Recently, (Chen et al., 2022) systematically reviewed studies on the management of liner shipping alliances and found that there are three levels of decision-making: strategic decisions, tactical operations, and management policy. Another recent contribution is by (Ghorbani et al., 2022), in which authors developed a thorough critical review of the literature, considering more than 25 years of research on the subject of strategic alliances within this area. Their review encompasses 85 peer-reviewed journal publications from 1994 to 2019 and is thus categorized into three primary areas of interest: formation, management, and optimization of strategic alliances.

3 Research methodology

This chapter of the research discusses methods that have been used to obtain the outlined objectives. The study begins by looking into the current structure of liner shipping companies within the network market. Particular emphasis was placed on how firms competing against one another may cooperate in certain aspects with each other. Thereafter, it discusses a comprehensive literature review based on game theoretical models and studies of strategic alliances. In this review, two research gaps identified are as follows: careful detailed application of the game theory approach within the liner shipping context and quantitative assessment of horizontal alliances in that context. The study will, in particular, seek to address the following main questions: (1) To what extent do market conditions, i.e., demand fluctuations and price competition, influence the stability and structure of the liner shipping service network and how do carriers navigate such complex market dynamics?, (2) What are the main drivers behind strategic alliances' formation, sustainability, and dissolution in liner shipping, and how could these be explained by cooperative game theory?, (3) What are the operational efficiencies and inefficiencies associated with vertical cooperation within liner shipping alliances, especially in terms of port operations and vessel utilization?, (4) How do developments in technology, environmental regulations, and international trade policies affect the strategic choices of companies in liner shipping alliances?, (5) How might the dissolution of the 2M Alliance affect the competitive dynamics and market positioning of participating carriers?.

3.1 Theoretical framework

The theoretical framework of this thesis is grounded on the use of a game theory approach, which is a very powerful tool to use in analyzing situations in which the outcome of any participant's play depends on the play of others. The model is conceptualized as shown in Figure 3.1, and it is developed to examine the multi-faceted dynamics of liner shipping service networks. The study is organized around four critical dimensions that are essential for the understanding of complexities and strategic behaviors within liner shipping networks. These dimensions include:

1. Market dynamics (Non-cooperative game theory aspects)
2. Horizontal collaboration (Cooperative game theory aspects)
3. Vertical collaboration (Cooperative game theory aspects)
4. Technological, environmental, and regional factors (Non-cooperative game theory aspects)

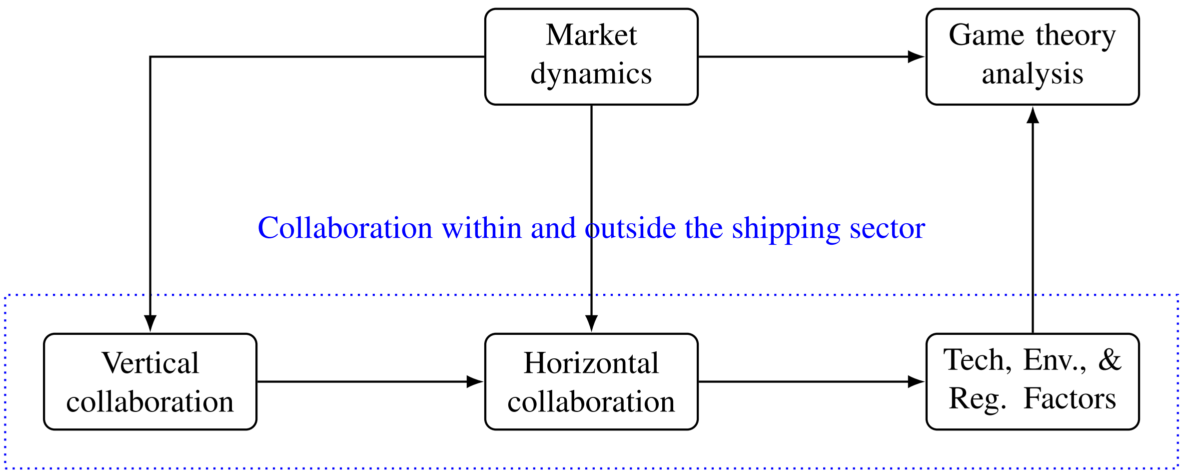

Figure 3.1.: Theoretical framework

The comprehensive synthesis of these dimensions presents a very strong platform in the analysis of strategic decision-making processes among liner shipping firms.

Market dynamics and competition: This segment captures changes in the global shipping market and synthesizes demand and supply fluctuations, rates of freight and prices, competition, economic forces that liner companies face in their strategic and operational decision making. It also examines a possible scenario of how shipping giants Maersk and Hapag-Llyod navigate the complexity of liner shipping service network dynamics.

Horizontal cooperation: At the core of the framework, this segment addresses how and why shipping lines enter into alliance agreements, where horizontal collaboration between companies allows for higher efficiency in operations, expanding market reach, and competitive advantage. The intention will be to review these game-theoretic models summing up the strategic underpinnings within alliances and focusing on critical factors that influence their formation and operational success.

Vertical cooperation: Apart from horizontal alliances, the other form of collaboration explained in this framework is vertical integration. This dimension focuses on the collaboration between liner shipping firms and other players in the logistics value chain, which includes players such as ports, logistics companies, and infrastructure operators.

Technological, Environmental and Regional factors: Finally, the framework takes into consideration the major impacts that developments in technology and regulatory management of the environment may have on the container shipping industry. To what extent will businesses respond to, and adopt new technologies? How are firms responsive to environmental law and regulation with regard to sustainability? This tackles strategic responses to these external pressures on liner shipping networks and the implications thereof on both operational and strategic decision making.

3.2 Data collection

This study employs several data sets, each of which gives another perspective on the market dynamics of the liner shipping industry. The datasets employed were selected in a way that they provide a comprehensive insight into strategic behavior of carriers and the impacts of alliances on the service network dynamics. These datasets were sourced from credible industry databases. For example, for the primary data collection, the operational data, the market data, and regulatory policies insights were sourced from alphaliner.com, unctad.org, oecd.org, and statista.com, to ensure the analysis of liner shipping metrics in a more comprehensive way. The other sources included reports from companies, company disclosures, and regulatory bodies. Official statistics and trends extracted from industry websites reinforced the primarly data collection. Lastly, specialized shipping journals were collected to provide the qualitative comprehensions and industry perspectives.

The data followed a sequence of cleaning and preprocessing processes to ensure its credibility and coherence and involved the following: - The identification and replacement of missing values when required and deletion when they formed significant anomalies or an atypical case. - The identification of any outliers which would potentially distort the study findings through application of available statistical methods. - Data that relates to the financial figures and measures was mapped into common scales so that the comparison between the entities can be made. - Data from different sources was aligned wherever identifiers in the data could be matched, be it a company name or a timestamp, into one generalized form of meta-information.

This thesis uses available data that is in line with the standards of research ethics and ensures the confidentiality of the data. Analyses are performed according to the regulations of data protection and privacy. While the datasets are comprehensive, there are limitations related to the granularity and updates of data. Some datasets may not capture real-time market dynamics or the latest shifts in strategic alliances, which could affect the timeliness of the analysis.

While the datasets are comprehensive, there are limitations related to the granularity and updates of data. Some datasets may not capture real-time market dynamics or the latest shifts in strategic alliances, which could affect the timeliness of the analysis.

3.3 Game theory application

3.3.1 Overview

Game theory (GT) is a study of mathematical models describing strategic interactions among rational decision-makers (Shi, 2011). It predicts and explains the choices individuals or entities make in situations where the outcome depends not only on their actions but also on those of others. Stemming from the realms of economics and mathematics, game theory has worked its way to be of value in a variety of applications, this reaches as far as political science and biology and, obviously, business strategy. For example, "Game theory: Analysis of conflict" by (Myerson, 1991) allows a detailed introduction to game theory and thus carries many examples related to economics and political science. Also, "The art of strategy: A game theorist's guide to success in business and life" by (Dixit and Nalebuff, 2008) provides a guide on 'how to' apply game theory into practice using the backward reasoning method in a game tree.

The pioneers in this field among others include the nobel prize winner (Nash, 1944), (Harsanyi, 1994), and (Neumann and Morgenstern, 1947) who also has greatly contributed to the developments of the game theory models. One of the most common concepts in game theory is the Nash equilibrium (NE), which regarded as the state of the game where no player can increase their payoff by unilaterally changing their strategy, given the strategies of the other players. Another key concept of equilibrium is the dominant strategy, which implies the strategy that results in the highest payoff for a player no matter what the other players do (Rufai et al., 2022).

(Shi, 2011) implies that the game theory model looks at behaviors of carriers in liner maritime shipping. In the liner maritime shipping industry, market conditions are such that companies continuously enter into strategic agreements with the aim of optimizing operational efficiencies for better service provision within a highly competitive global landscape. When applied to these alliances, cooperation game theory provides a suitable base of analysis that allows one to assess and structure collaborations, it negotiates how benefits resulting from mutually beneficial outcomes will be shared between involved parties. Nonetheless, non-cooperative game theory has been applied in the examination of competitive strategies in a number of industries, not excluding the shipping industry. Critical work by Nash (Nash, 1944) introduced equilibrium into non-cooperative games, prompting players who face maximizing respective payoffs without cooperation to make decisions independently and hence formulating the theory. This provides quite a strong framework for interpreting strategic interactions among shipping companies.

Therefore, the game theory model of this thesis, can be analyzed either cooperatively

Solution concept	Proposed by	Application	Represented by	Method	Information set
Nash Equilibrium	John F. Nash	Non-cooperatives games	Normal & Extensive form	Fixed point theorem, Best response analysis	Complete information
Subgame Perfect Equilibrium	Reinhard Selten	Dynamic games	Extensive form	Backward induction	Complete information
Bayesian Nash Equilibrium	John C. Harsanyi	Static games	Normal & Extensive form	Bayes' Theorem	Incomplete information
Perfect Bayesian Equilibrium	N/A	Dynamic games	Extensive form	Bayesian updating, Sequential rationality	Imperfect information
Sequential Equilibrium	David M. Kreps and Robert Wilson	Sequential games	Extensive form	Forward induction, Belief formation	Sequential information

Figure 3.2.: Game theory's solution concepts. Based on (Shi and Voss, 2011b)

or non-cooperatively and hence the use of both cooperative and non-cooperative game theory approaches. The model aims to help identifying stable payoffs (equilibria) for the participants to engage in a mutually beneficial arrangement, analyze the dynamics of alliance formation/dissolution and assess the change in regulations to assess its effect on strategic choices by players. The equilibrias are referred to as the payoff of player actions by game theorists (Daskalakis et al., 2009).

For instance, horizontal and vertical cooperation scenarios might be modeled as cooperative games in which various players (shipping companies) get together for enhancing their collective payoffs and in which shipping companies pool resources in order to obtain collective benefits while keeping their individual competitiveness or interest. Shapley value theory can then be applied to analyze the stability of the three global alliances formed by some of the major players in the liner shipping business. In contrast, a non-cooperative game approach might be used to analyze market dynamics and competition between the shipping companies/alliances. Here, the Cournot competition model can help to understand the supply and demand dynamics between players. Lastly, non-cooperative games may further provide the opportunity to investigate issues relating to the adherence to ecological policies, as the firms weigh the options between an early adoption of a new technology and a wait-and-see strategy.

3.3.2 Components of game theory

The basic elements of a game in game theory are players, strategies, and payoffs (Hotz, 2006).

Players

In this study, players in a liner shipping service network can be referred to as shipping companies, shipping alliances, port authorities, terminal operators, regulatory bodies, freight forwarders, container leasing firms, and cargo owners.

Shipping companies: The necessity of shipping companies makes them deal with almost all other players directly. As already noted in this paper, these companies basically decide on routes, pricing, and other services after interacting with ports, freight forwarders, cargo owners, and regulatory bodies. They also lease containers as needed.

Shipping alliances: This involves shipping companies coming together to pool their resources in aspects that affect the forces of competition and cooperation operating within the industry, and also the negotiations with ports and service providers.

Port authorities and terminal operators: These interrelate directly with shipping companies to provide necessary discharge or loading infrastructure. The performance and tariffs of port authorities and terminal operators directly influence the selection of shipping companies and, in turn, the selections of freight forwarders and owners of the cargo.

Freight forwarders: These are people who act as intermediaries between cargo owners and shipping companies. They make arrangements for the transportation of goods and, therefore, associate with the cargo owners and shipping companies.

Regulating bodies and international organizations: They set operational practices, environmental standards, safety protocols, and regulations that are supposed to be followed by all players in the industry.

Container leasing firms: They lease containers to shipping companies and directly contribute toward the physical handling capacity of the shipping industry.

Cargo owners: They are the customers who demand shipping services that determine the pattern of shipping company activities and thus indirectly of the activities of port operators. They are also those who deal with freight forwarders on how to ship the goods.

Strategies

A player's strategy describes the actions at all possible decision points that they might face in a game (Aguirre, 2009). It is further defined as her selection of actions within the game (Gottlo et al., 2005). Within this thesis framework, competitive strategies in terms of market dynamics could be with respect to pricing, service differentiation, and capacity management. With horizontal cooperation, strategies could be forming or dissolution of alliances, sharing vessels, slot exchanges, joint service agreements, etc, whereas for vertical cooperation, strategies would be collaborative agreements on port operations, negotiating terms with terminals, joint investments in infrastructure, etc.

Payoffs

The payoff designated to a subject in a game is the subjective value that the player gets from participating in the game (Algaba et al., 2020). The payoffs to market dynamics and competition can be defined through market share, profit margins, long-term sustainability, and many others. Examples of results that derive from horizontal collaboration would be reduced operational cost, efficiency gains in an operation, or increased market reach. Some of the pay-offs for vertical collaboration include better port efficiency, reduced turnaround times, and enabling better integration into the supply chain.

3.3.3 Cooperative vs non-cooperative game theory

Cooperative game theory considers the behavior of players as possibly making binding commitments (Algaba et al., 2020). It is based on the possibility that players can discuss and establish agreements that enable the association of plans to be made by such players and the division of the outcomes among themselves (Algaba et al., 2020). In most cases, it deals with the formation of coalitions, actions to be taken, and the fair sharing of the payoffs among the participants (Fogarassy, 2024). Among the most important such solution concepts are coalitions, the Shapley Value which provides some estimate of the value of a player in terms to the success of a coalition, and the Core which provides no disjoint groups of players will break off into their own coalitions. Cooperative game theories can be applied in areas like economic applications for coalitional games, political alliance dynamics, and cooperative strategies in logistics and supply chain management.

In contrast, non-cooperative game theory focuses on strategies for the single, independent players who do not have the possibility to make binding agreements (Algaba et al., 2020). The key concern involves strategic decisions that optimize individual payoffs, considering the decisions of others (Aguirre, 2009). Nash Equilibrium is one of the basic concepts in game theory with dominant strategies and the prisoner's dilemma to show how rational actions might end in universally suboptimal outcomes once nobody decides to deviate from their strategy. Non-cooperative game theory applies to the field where competitive markets are analyzed, conflict resolution of negotiation of Political Science, and strategic interaction between species of evolutionary biology.

The only difference between these cooperative and non-cooperative game theory lies in the way agreements are treated and its principal focus of analysis. Cooperative game theory assumes that binding agreements are possible and deals with collective action and how the payoffs will be distributed among groups. On the other hand, the non-cooperative game theory assumes that these agreements cannot occur, rather, these aspects consider individual strategies and finally, the outcomes of those strategies (Fogarassy, 2024). Nevertheless, this does not downgrade the value of either branch since they both offer profound insights regarding the processes of strategic decision-making either in situations where cooperation is required and coalitions should be formed or in those where competition is the subject and it is all about optimizing individual strategies.

3.3.4 Decision tree

First introduced by Neumann and Morgenstern, decision trees help to visualize the sequence of decision scenarios and their possible consequences, showing different choices and their potential outcomes, including chance events (Shenoy, 1996). A decision tree format is valuable as it offers a clear, documentable, and discussable model, illustrating either the process by which a decision was made or how it will be made (Eriksen et al., 2016). According to (Tadelis, 2013), in a decision tree, the point where a player must choose between different actions is known as a decision node. The endpoints of the tree, where the outcomes and payoffs are assigned, are called terminal nodes. In the context of this thesis, concepts such as decision trees can help explain strategic interactions between players (shipping companies).

3.3.5 Nash equilibrium

The Nash equilibrium is unarguably the central concept in game theory and perhaps the most fundamental concept in non-cooperative games. It is no wonder, therefore, that the Nash equilibrium has a broad application in implementation theory (Maskin, 1983). It prescribes a situation in a game where no player can do better with the set of strategies of the other players held fixed at any point (Kreps, 1989). That is to say, it is a state in which every player is doing everything in their power to make the best decision on the assumption that others are doing likewise (Holt and Roth, 2004).

The Nash equilibrium refers to a game between two or more players, where the decision of each player is common knowledge (Holt and Roth, 2004). In a Nash equilibrium, a strategy of each player at that point, yields them attainable payoffs in the highest form, given none of the parties chooses to deviate from the respective strategies (Aumann and Brandenburger, 1995). This concept is because it predicts the payoffs strategic interactions in competitive environments in terms of economics and politics, which are characterized by social constructs, just to mention a few.

In the mathematical sense, the Nash equilibrium, is when the strategy of each player involved is optimal with respect to all strategy profiles comprising the rest of the players (Daskalakis et al., 2009). The strategy for a player is optimal, at a point of optimality, where he may not fare better by deviating from his strategy, assuming that the strategies of others do not change.

The Nash Equilibrium is not necessarily the solution that maximizes the sum of payoffs but, rather, it is that no individual player may improve his own payoff by switching strategies after observing the choices made by his opponents (Holt and Roth, 2004). This has sometimes been interpreted to mean that results from equilibrium do not match social optimality, an academic argument frequently heard in papers dealing with the Prisoners Dilemma (Aguirre, 2009). In the Prisoner's Dilemma, each of the two prisoners had either to betray the other or remain silent. The Nash equilibrium in that game was for each of them to betray the other, but in fact they both would have been better off had they remained silent. This shows that the Nash Equilibrium will sometimes lead to bad outcomes for the players.

The Nash equilibrium is applied in most fields to show real importance, instead of just game theory on paper (Damme, 2002), (Facchinei and Kanzow, 2007). It relates to purpose or logic in the economics field by helping to understand market mechanisms as well as firm behavior in competitive industries. In political science, it might explain the stability in some political systems or outcomes. The concept extends even further to evolutionary biology in explaining stable strategies that emerge from competing populations.

3.3.6 Cournot competition model

The Cournot competition model is one of the simple models constructed in the arena of economics to describe how much the firms in a single market produce of a homogeneous product, and not to determine price strategies (Abolhassani et al., 2014). In the classic

Cournot model, firms producing a single product determine their production levels. This model is static, analyzing one specific point in time without consideration for temporal changes. Every firm must make a key decision: how much to sell of its product, given that its product is just like its competitor's product (Daughety, 2006). In the overview of Nash equilibrium in the first volume of New Palgrave, David M. Kreps mentioned how Cournot's idea had set the stage for the ideas further refined by Nash in his seminal paper. Briefly, this idea of firms independently setting a level of output in a manner that considers and responds to the levels chosen by others that was introduced by Cournot, and through that, Nash developed his equilibrium theory that serves as a cornerstone in the study of imperfect competition (Daughety, 2006). In this respect, the Cournot equilibrium provides a structured approach for analyzing competition among the shipping companies or alliances with respect to strategic choices in service levels to be provided that would maximize profits. This model highlights how the players behave and perform in the shipping business and the implications for pricing and service offerings.

Core assumptions of the Cournot competition model

1. Quantity competition: This is a situation in which firms compete in quantity choice rather than price. The individual firm decides the amount of quantity they will produce and the market price is determined by adding the total quantity supplied in the market.

2. Non-cooperative behavior: Each firm regards the outputs of other firms as exogenous and independently chooses an output level.

3. Rational players: It is assumed that each supplier is rational and knows the kind of market structure as well as the inverse demand function, but does not collude with any other supplier.

4. Market demand: The demand curve is downward-sloping, whereby the price decreases as the total quantity in the market goes up. This is due to the nature of consumer behavior, which typically experiences a price drop as supply increases.

5. Profit maximization: All firms aim to maximize their profits, which is the difference between total revenue and total cost.

3.3.7 Shapley value concept

The Shapley value, introduced by Lloyd Shapley in 1953, is a concept from cooperative game theory which was developed to address evaluation difficulties found in the "essential" games within the finite theory of von Neumann and Morgenstern, specifically up to their introduction of characteristic functions. It represents a fair distribution of the total gains (or costs) generated by a coalition of players (or agents) who contribute to the overall outcome of the game (Algaba et al., 2020). The Shapley value is particularly relevant in situations where the contribution of each participant is not directly observable or easily quantifiable, making it difficult to determine how the total gains should be divided among them (Roth, 1988).

The Shapley value is required to adhere to four axioms: efficiency, symmetry, dummy players, and additivity (Algaba et al., 2020). Although, only the first three axioms serve as particular criteria that are widely acknowledged in various applications (Roth, 1988), (Algaba et al., 2020). The efficiency axiom implies that the total gain (or cost) is fully distributed among the players, the symmetry axiom implies that players who contribute equally receive the same share, the dummy player axiom implies that players who do not contribute to any coalition receive nothing, and lastly the additivity axiom implies that the Shapley value of a combined game equals the sum of the Shapley values of the separate games. The Shapley value for each player is calculated by considering all possible coalitions that can be formed and how the total value of the game changes when a player joins a coalition. It is the weighted average of the marginal contributions of a player across all possible coalitions.

3 axioms of the Shapley value according to (Roth, 1988):

1. **Efficiency:** The sum of the Shapley values for all players equals the total value that the grand coalition N can achieve, $\sum_{i \in N} \phi_i(v) = v(N)$.
2. **Symmetry:** If any two players are interchangeable in that they contribute equally to any coalition, they receive the same payoff.
3. **Additivity:** If two cooperative games are combined, the Shapley value for each player in the combined game is the sum of the Shapley values for each player in the separate games.

4 Market dynamics and competition (Non-cooperative game theory aspects)

4.1 Overview

Non-cooperative game theory is critically relevant to the understanding of market dynamics and competition in the liner shipping industry. In this chapter, we discuss how strategic alliances impact freight rates from which we can get insights into how shipping companies alter their strategy in an effort to remain competitive. We analyze historical freight rate data for patterns and trends that give us insight into competitive behavior by shipping companies. In this chapter we also apply non-cooperative game theory to explore the dynamics in the liner shipping industry by showing how industry giants such as Maersk and Hapag-Lloyd keep changing their operational strategies continuously under different market conditions and in view of actions by competitors. This approach aims to illustrate the practical use of the Cournot competition model to analyze the competitive interactions between Maersk and Hapag-Lloyd and give an insight into strategic behaviors within the liner shipping market. In addition, in this section we provide a decision tree analysis of Maersk's strategic options between owning and chartering vessels, given uncertain market demand. The methodology follows the taught by Noah Gans in the Coursera course *Operations Analytics*.

4.2 Freight rates trends and insights analysis

The impact of strategic alliances on freight rates can be illustrated by analyzing historical data and identifying periods when alliances were formed or restructured. We should compare how freight rates moved before and after such periods to tell how alliances influence the market dynamics. In this case, the dataset considered for the analysis covers the years 2012 to 2024, with a total count of 512 records. The key variables are Year, Month, Container Size, Origin, Destination, Rate, and Date. To sum up, the freight rates analysis allows us to realize drivers of economic nature within the liner shipping market and strategic choices by companies. Figure 4.1 Figure 4.2 Figure 4.3 Within 2012-2024, the freight rates have widely fluctuated, reflecting quite visible peaks and troughs (Figure 4.1). These could be particularly marked out by events driven from outside such as global economic conditions, alternately changing trade policies, and geopolitical events. Effectively, some of these tendencies are very informative with regard to market dynamics, on the other hand, changes in rates directly impact the competitive nature of the shipping companies.

Furthermore, annual trends show the long-term behavior of freight rates, while yearly fluctuations are rather very pronounced. The monthly analysis would be driven by seasonal variation and probably peak shipping seasons/holidays (Figure 4.2). Understanding these phenomena better involves realizing how companies improve strategies relative to predictable seasonal changes, hence, a non-cooperative game theory company would reconsider actions by competitors. In terms of the average rates of 20 and 40-foot containers, it is revealed that 40-foot containers generally command higher rates (Figure 4.3). This price difference usually affects strategic decisions in companies since they would prefer to use container sizes that ensure profitability for the business. Non-cooperative game theory tries to explain how firms compete with others by providing quotes for various container sizes so that buyers may get a market advantage. It adjusts the strategy with regard to opponents' pricing, thereby keeping prices competitive and orderly.

Interestingly, on special routes from the U.S. West Coast to Central China, Northern Europe to South Asia, and South America to North America, there are very important differences in rate trends brought out through analysis (Figure 4.4). These are strategic routes where companies fight hard to domesticate profitable routes. The non-cooperative game theory will go a long way in explaining the fight among the companies for market share in such vital routes. Over the last decade, freight rates tended to have ups and downs periodically, dramatically peaking in both 2021 and 2022 (Figure 4.5), which could be founded on disruptions related to the COVID-19 pandemic and increased demand. This might manifest how strategic alliances and market dynamics between companies have evolved in this period. Companies change their strategy with certain changing conditions, hence, they work along the principle of non-cooperative game theory.

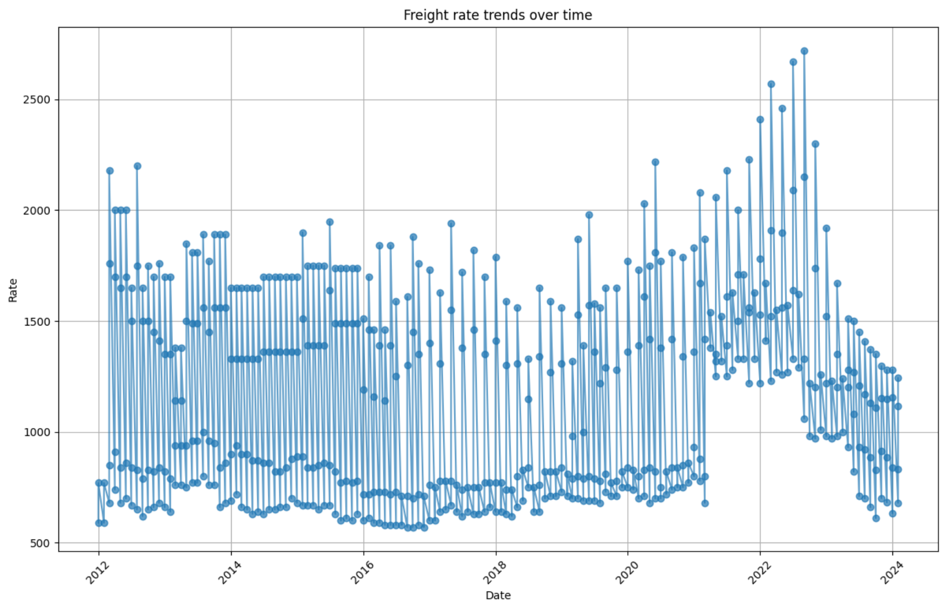

Figure 4.1.: Trend of freight rates over time. Based on (Alphaliner, 2023)

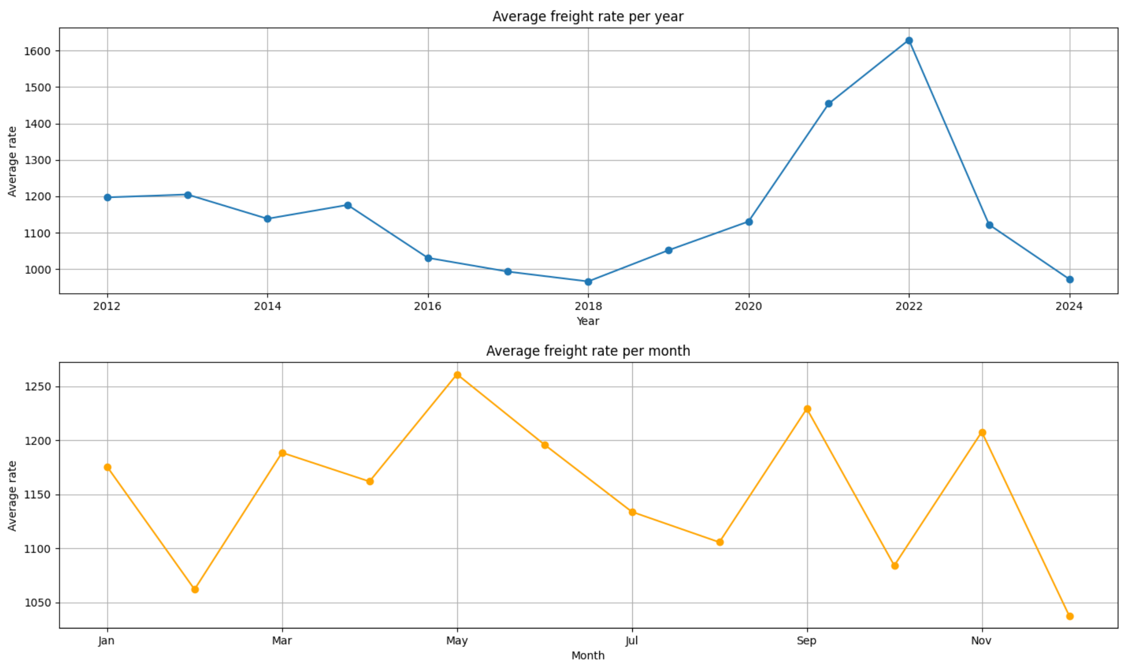

Figure 4.2.: Average freight rate per year/month. Based on (Alphaliner, 2023)

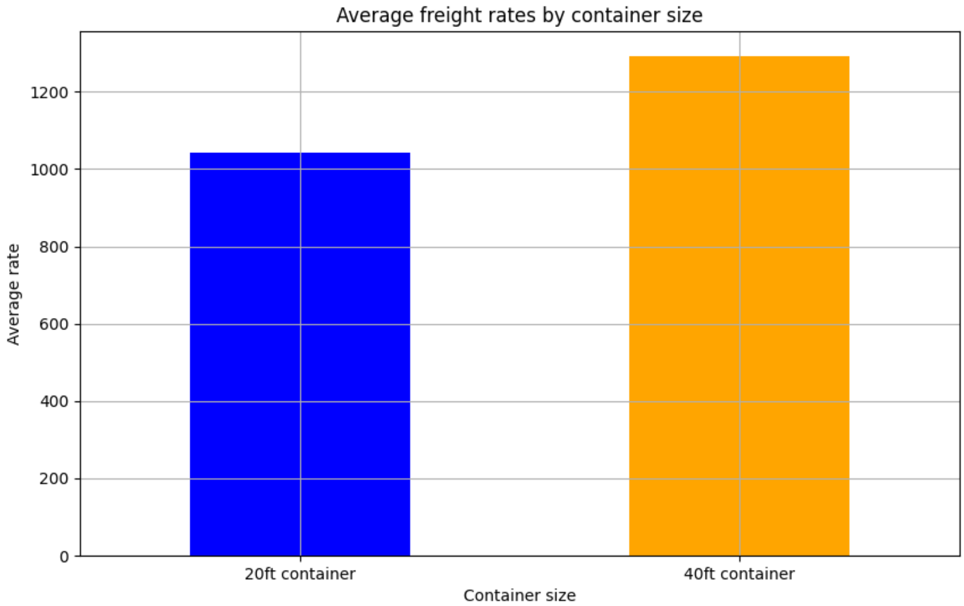

Figure 4.3.: Average freight rates by container size. Based on (Alphaliner, 2023)

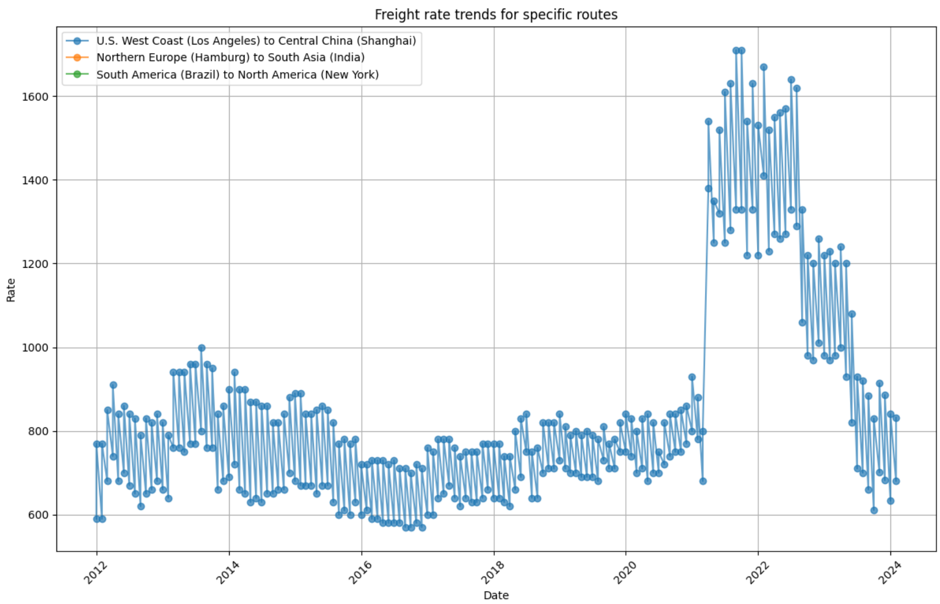

Figure 4.4.: Freight rate trends for specific routes. Based on (Alphaliner, 2023)

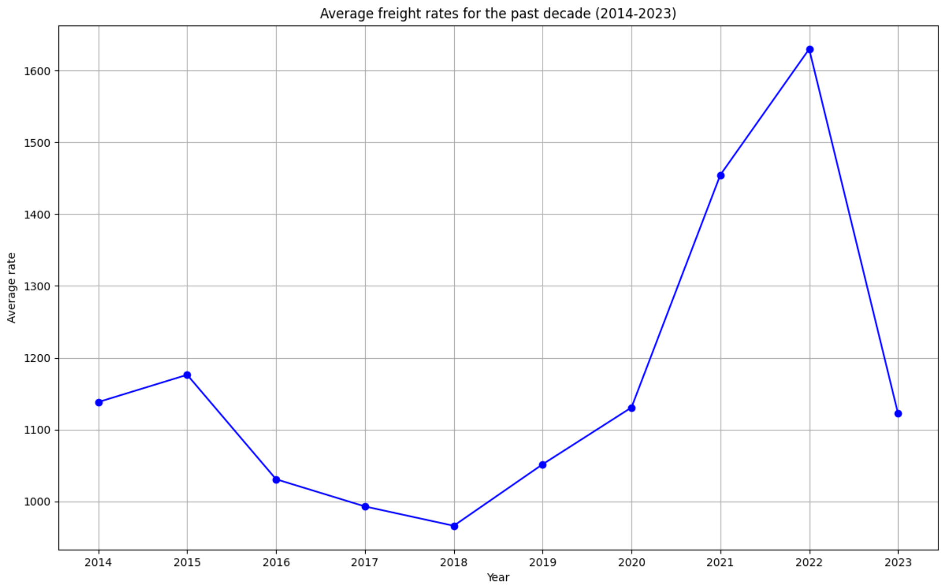

Figure 4.5.: Average freight rates for the past decade (2014-2023). Based on (Alphaliner, 2023)

UNCTAD implies that, while reduced competition has traditionally contributed to higher freight rates, the deeper factors for the supply chain crisis and congestion are diverse. One prominent casualty in this trend is the COVID-19 pandemic, which has disrupted world logistics by causing various complications such as unprecedented freight rates, overloaded ports, delays, and unreliable services. Moreover, the surge in consumer demand—boosted by e-commerce and goods—has flooded this sector to full capacity, thus causing impediments that have overextended the supply chain. UNCTAD further reports that during the COVID-19 pandemic, many developing countries were hit hard by rising freight rates and reduced shipping connectivity, although there is not that much evidence that without carrier alliances or coordinated scheduling, the condition would have been improved (UNCTAD, 2022).

4.3 Containership deployment and supply-side analysis

Container ship deployment describes the best share that can be accorded and managed by a shipping company to its fleet vessels. It includes the decision made on which vessels would be assigned to specific routes, how often the sailings would be, and the capacity that would be deployed on individual routes. Good deployment would secure operational efficiency and market demand as well as a good market share.

The dataset considered for this analysis includes containerships from 1996 to date, with variables such as Total Fleet Number, Total Fleet TEU, Total Fleet DWT, Charter Owner Fleet, Operator Owner Fleet, and Yearly Fleet Growth. Such variables, once analyzed, clarifies how the structure of the fleet did change and what drove these changes.

Since 1996, the global fleet has continued to grow at a constant number of vessels. Specifically, strong growth in fleet numbers is observed in the early 2000s and after 2016. The smooth increasing trend in fleet size would likely be resultant of diversified growing demand for shipping services on a global scale, but periods of more profound growth would likely correspond with economic booms and hence the increase in global trade (Figure 4.6). This upward trend is a very important indicator of how capacity in the industry expanded over all these years. On the other hand, both the vessel TEU total and the overall DWT total have significantly increased, signaling that large-sized vessels, especially the efficient ones, have swollen in higher numbers (Figure 4.7). This upward lift in TEU capacity simply reflects a zeal in the market to enjoy better operational efficiency by deploying larger vessels as this has the aggregate effect of reducing per-unit shipping cost with increasing global trade volumes. It reflects a response to demand for cheaper, high-capacity shipping solutions.

While this was the case, the charter-owned vessels grew at a rate higher than the operator-owned vessels in the initial period. The fleet numbers stabilized in the recent past. The fleet numbers for operator-owned vessels have rather appreciated steadily over time, mainly from 2012. This stabilization of the charter-owned fleet numbers arguably indicates strategic changes by operators, having more of their fleet ownership in their name to reduce dependence on charters and build up their control on operations and costs (Figure 4.8 and 4.9). This trend of operator-owned TEU, the same trend towards self-owned, larger, and more efficient vessels, is a general wave that is responsive to the need to become more competitive and acquire greater operational control. It is strategic for avoiding any risks associated with chartered-in vessels and for acquiring fleet economies via ownership.

Moreover, the fleet growth rate by itself has had sudden surges and declines throughout. The major spikes are observed around the peak years of interest, performed for the years 2000 and 2007, with an observed decline beyond 2016 (Figure 4.10). The yearly fleet growth rate jumps, indicating industry sensitivity toward economic cycles and global trade demands. The troughs can either be low demand due to economic downturns or strategic realignments. Knowing this will give insight into how external economic conditions are related with fleet expansion decisions.

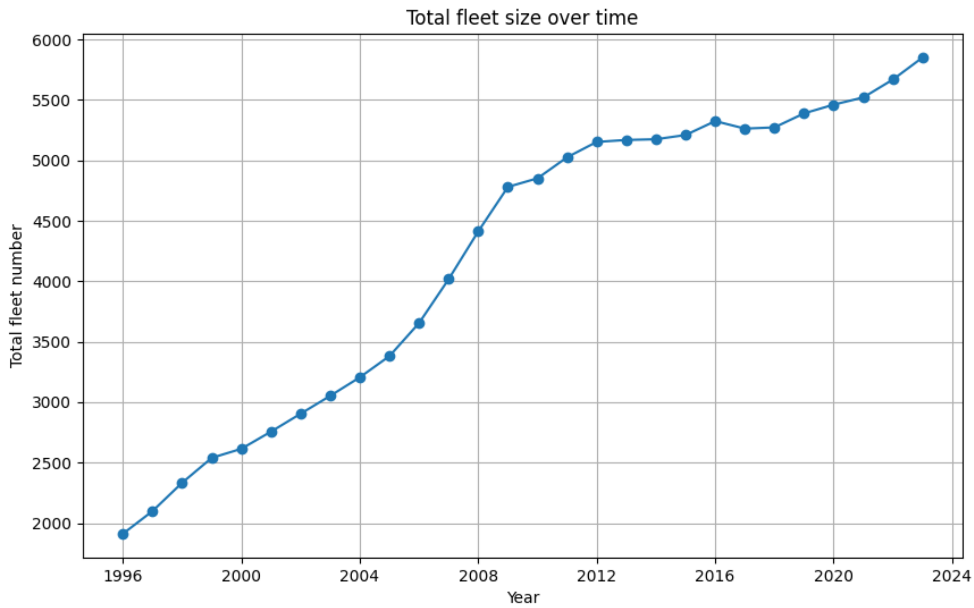

Figure 4.6.: Total feet size over time. Based on (Alphaliner, 2023)

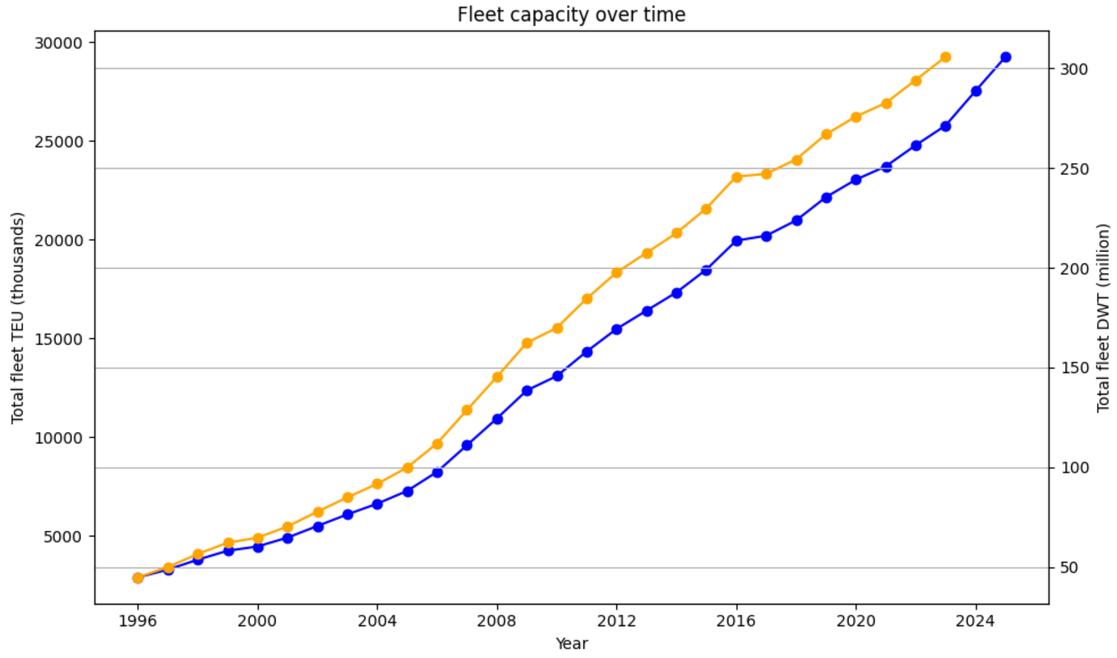

Figure 4.7.: Fleet capacity over time. Based on (Alphaliner, 2023)

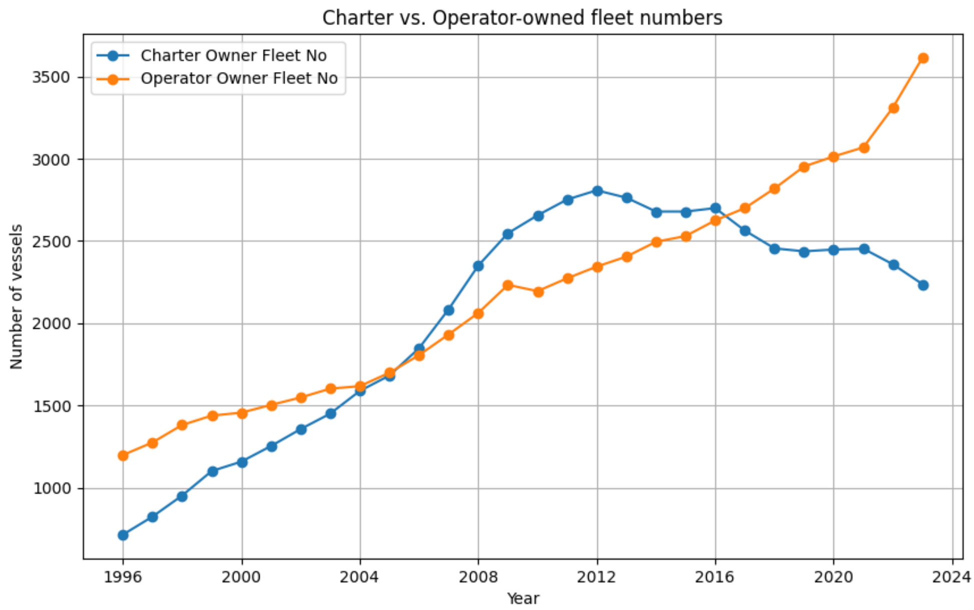

Figure 4.8.: Chartered vs. owned fleet numbers. Based on (Alphaliner, 2023)

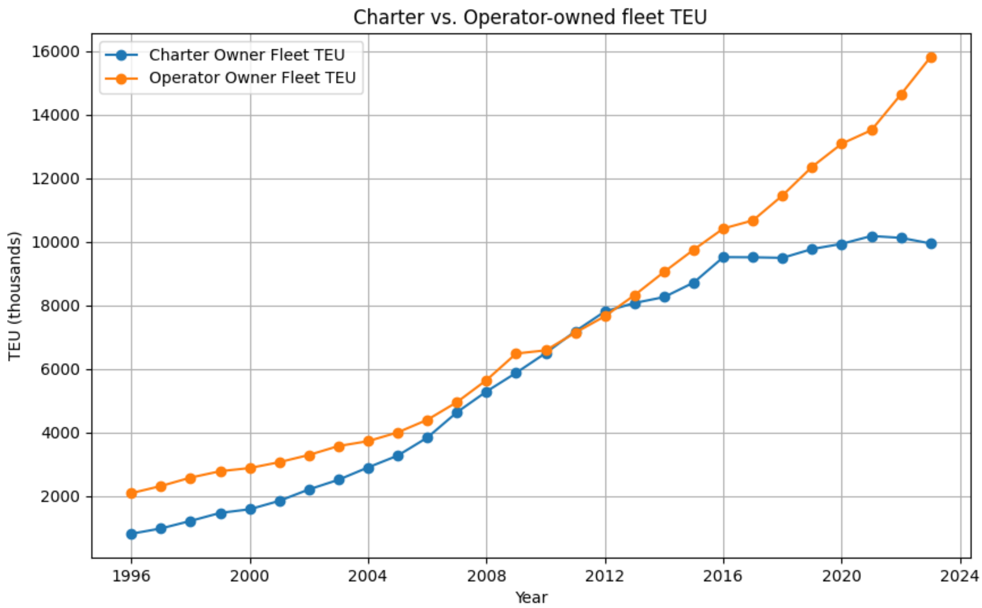

Figure 4.9.: Chartered vs. owned fleet TEU. Based on (Alphaliner, 2023)

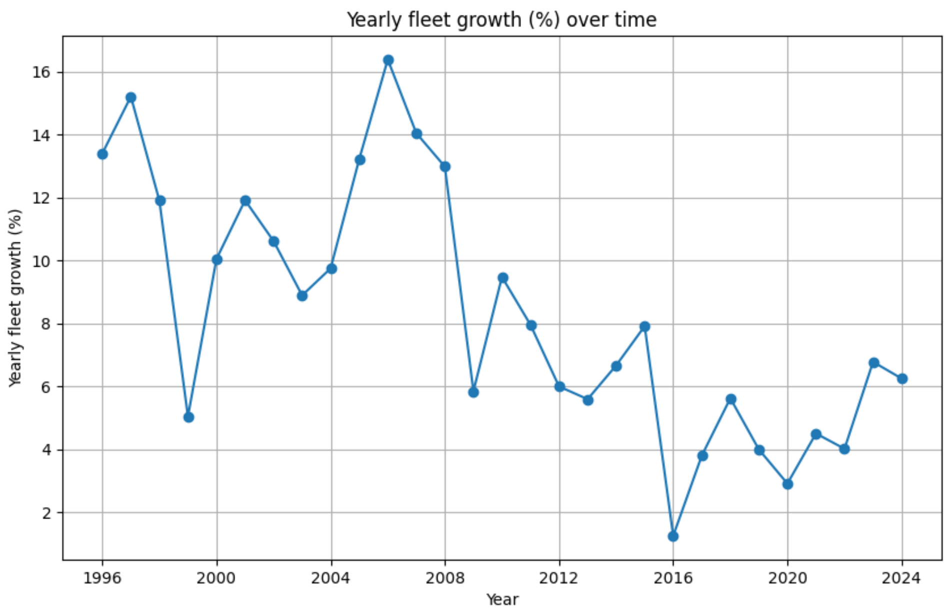

Figure 4.10.: Yearly fleet growth. Based on (Alphaliner, 2023)

Fleet utilization rates are one of the critical measures of operational efficiency within the liner shipping industry. A high rate of utilization of the fleet would tend to indicate that a vessel, or group of vessels owned or operated by an individual, was solely being utilized to maximize revenue potential by having extended sailing times and minimal idle time. Low rates of fleet utilization may indeed indicate overcapacity and inefficiency. Over the past few years, several shipping companies have been able to post higher fleet utilization rates for a variety of reasons. Broadly, increasing global trade demand and proper deployment of vessels contributed to such improvements. Shipping companies have adapted their operations in a more efficient way to better match fluctuating demand, as was hastened by disruptions initially caused by the COVID-19 pandemic. In the early phase of the pandemic, fleet utilization rates dropped because of a reduction in global trade and disrupted supply chains, but now, with rebounding global trade, those fleet utilization rates have increased significantly—a clear indication that this industry is resilient and can bounce back (Ilin et al., 2022), (D'agostini et al., 2024). It can also be seen that effective capacity management strategies have links with higher rates of fleet utilization, such as the formation of alliances and deploying larger vessels. Alliances help shipping companies pool their available resources to optimize routes and share capacity, generally ensuring more efficient operations and better fleet utilization. Deploying larger vessels requires huge investment but provides economies of scale, mitigates the per-unit cost of transportation, and enhances overall efficiency (Ilin et al., 2022). The integration of digital technologies further raised fleet utilization. Advanced data analytics, combined with real-time monitoring, allows shipping companies to make better decisions related to the deployment, routing, and scheduling of vessels—thereby improving operational performance and reducing inefficiencies (Ilin et al., 2022), (D'agostini et al., 2024).

Moreover, it has been recognized from research that integrating tactical-level decisions relating to port service frequency, fleet deployment, sailing speed optimization, and vessel schedule design into a holistic optimization model can capture well-improved fleet utilization and operational efficiency. In this regard, one study on tactical-level planning in liner shipping emphasized that coordinated decision-making in multiple dimensions maximizes profit and efficiency while minimizing costs and emissions (Pasha et al., 2020). For example, in 2023 Hapag-Lloyd introduced into service the "Berlin Express," the first of 12 new vessels of the "Hamburg Express" type. Hapag-Lloyd stresses that at almost 400 meters long and with a container capacity of 23,664 TEU, the Berlin Express is the largest vessel ever to sail under the German flag. Its innovative dual-fuel propulsion technology reduces the emission of $CO2$ and other pollutants on a large scale. At the same time, Hapag-Lloyd is gearing up the existing fleet for the future by increasing the number of TEUs while at the same time reducing fuel consumption (Hapag-Lloyd, 2024). Comparably, on 9 February 2024, Maersk's 18 large methanol-enabled vessels were released into service on the AE7 string via Asia and Europe, with various port calls. According to Maersk, the container vessel, the South Korean-built HHI class, is designed for a nominal capacity of 16,000 containers (TEU) and is powered by a dual-fuel engine running on methanol, biodiesel, and conventional bunker fuel. Similarly, Maersk has committed to a 2040 target of zero greenhouse gas emissions for the entire business and has also established tangible and ambitious short-term goals by 2030 to ensure significant growth. Furthermore, Maersk has put emphasis on active capacity adjustments to meet short-cycle customer requests while securing flexible access to customers and outstanding and reliable products (Maersk, 2024). (Notteboom et al., 2022) state that driven by economies of scale and continuous demand from international trade, the deployed capacity of containerships has doubled between 2006 and 2016. This growth is demonstrated by the increased size of the largest containerships, which has grown much, given the increase in global trade volumes. This has been an underlying trend in the shipping industry toward greater efficiency and, accordingly more significant cost savings, which could accumulated from larger vessels carrying more than one cargo per trip.

In light of this, strategic vessel deployment, capacity management, alliance formation, and the very character of digital technologies involved drive high fleet utilization rates in the liner shipping industry. All these factors combine to help shipping companies achieve optimum operational efficiency and respond quickly to changes in global trade dynamics. Strategic alliances are central to route efficiency in the liner shipping industry. Essentially, such scheduling, vessel sharing, and rationalization of routes may lead to a greatly enhanced scale and operational efficiency in terms of distance and speed as already discussed by (Ghorbani et al., 2022). Alliances have given member companies the possibility of operating shared vessels. Under this, the alliances assure better utilization of the vessels' capacity by cutting down on the partially loaded ships as well as maximizing available capacity. The 2M Alliance, through which Maersk and MSC got the opportunity to optimize their vessel deployments, has definitely bettered the route efficiency.

Such issues of strategic alliance administration by the deployment of the container fleet or analyzing the fleet utilization rate all exhibit how strategic alliances, therefore, scrutinize the container fleet deployment, fleet utilization rate analysis, and other influences that depict market dynamics and competition among the liner shipping companies. Therefore, strategic alliances have a high impact on factors of enhancing operational efficiency, optimization of route efficiency, and a strong role in molding competitive behavior.

4.4 Applying the Cournot competition model

In the Cournot model of competition, firms compete on quantity instead price. Every firm will decide on a quantity of goods produced in view of what it perceives may be the production decisions of its competitor. Therefore, the market price is determined by the total output produced by all firms within a particular market. The model used in this analysis is based on the work from (Cournot, 1838), (Shi and Voss, 2008), (Tirole, 1988), (Grimm, 2008), (Wolfstetter, 1996), (Zhou, 2010), and (Guha, 2016).

In this case, Maersk and Hapag-Lloyd are major competitors in the liner shipping market. The following notations are used:

- q_M: Quantity produced by Maersk (in FFE)
- q_H: Quantity produced by Hapag-Lloyd (in TEU)
- P: Market price per unit (FFE or TEU)
- $C_M(q_M)$: Total cost for Maersk
- $C_H(q_H)$: Total cost for Hapag-Lloyd
- $R_M(q_M)$: Revenue for Maersk
- $R_H(q_H)$: Revenue for Hapag-Lloyd

4.4.1 Data and assumptions

The data used for analysis includes financial and operational performance of Maersk and Hapag-Lloyd from the year 2018 to 2023 (Table 4.1 and Table 4.2). In addition, it envelops important variables that include revenues, handling costs of containers, bunker costs, total vessels, transported volume, and freight rate.

Year	Revenue (M USD)	Container handling costs (M USD)	Bunker costs (M USD)	Total vessels	Transport volume (FFE)	Freight rate (USD/FFE)
2018	28,366	9,481	5,042	710	13,306	1,879
2019	28,782	8,988	4,566	708	13,296	1,853
2020	29,175	8,474	3,835	706	12,634	2,000
2021	48,232	9,775	5,369	738	13,089	3,318
2022	64,299	10,214	8,077	707	11,924	4,628
2023	33,653	9,233	6,064	672	11,904	2,313

Table 4.1.: Maersk's financial and operational data (2018-2023). Based on Maersk's annual reports

Given the differences in metrics for transport volume, with FFE applied to Maersk and TEU to Hapag-Lloyd, not to mention freight rates, the following conversions and assumptions have been done:

Year	Revenue (M USD)	Container handling costs (M USD)	Bunker costs (M USD)	Total vessels	Transport volume (TEU)	Freight rate (USD/TEU)
2018	13,726	472.1	157.8	227	11,874	1,044
2019	14,115	457.8	151.2	239	12,037	1,072
2020	14,577	5,383.2	1,606.2	237	11,838	1,115
2021	26,356	6,376.8	1,985.8	253	11,872	2,003
2022	36,380	6,973.3	3,145.2	251	11,843	2,863
2023	19,210	6,089	2,437.6	266	11,907	1,500

Table 4.2.: Hapag-Lloyd's financial and operational data (2018-2023). Based on Hapag-Lloyd's investor reports

- 1 FFE (Forty-Foot Equivalent Unit) is equivalent to 2 TEUs (Twenty-Foot Equivalent Units).

Cost functions

Container handling and bunker costs are both included by both Maersk and Hapag-Lloyd in their cost functions. Particularly, these costs vary linearly with the amount produced.

For Maersk

$$C_M(q_M) = a_M q_M + b_M$$

where a_M is the per unit container handling and bunker costs, and b_M is a fixed cost component.

For Hapag-Lloyd,

$$C_H(q_H) = a_H q_H + b_H$$

where a_H is the per unit container handling and bunker cost element, and b_H is a fixed cost element.

As a practical example, let us take data obtained in 2023.

Revenue functions

There are revenue functions for both CMG and MSC and these functions depend on the market price and quantity produced. For CMGk For MSC:

Considering the data from the year 2023 as a practical example:

$$\begin{aligned} a_M &= \frac{\text{Container handling costs} + \text{Bunker costs}}{\text{Transport volume}} \\ &= \frac{9,233 + 6,064}{11,904} \\ &= 1,283.17 \text{ USD/FFE} \end{aligned}$$

$$\begin{aligned} a_H &= \frac{\text{Container handling costs} + \text{Bunker costs}}{\text{Transport volume}} \\ &= \frac{6,089 + 2,437.6}{11,907} \\ &= 713.65 \text{ USD/TEU} \end{aligned}$$

Revenue functions

The revenue functions for both Maersk and Hapag-Lloyd will be a function of the market price and the quantity produced.

$$R_M(q_M) = P \cdot q_M$$

where P is the market price per FFE.

For Hapag-Lloyd:

$$R_H(q_H) = P \cdot q_H$$

where P is the market price per TEU.

Profit functions

The profit functions of the firms, Maersk and Hapag-Lloyd, are defined to be that difference between revenues and costs.

For Maersk:

$$\Pi_M(q_M, q_H) = R_M(q_M) - C_M(q_M)$$

$$\Pi_M(q_M, q_H) = P \cdot q_M - (a_M q_M + b_M)$$

For Hapag-Lloyd:

$$\Pi_H(q_H, q_M) = R_H(q_H) - C_H(q_H)$$

$$\Pi_H(q_H, q_M) = P \cdot q_H - (a_H q_H + b_H)$$

Reaction functions and equilibrium

Each firm's reaction function displays the profit maximizing level of output that firm should produce given the level of output its competitor produces. The equilibrium quantities are where each firm's reaction function is at the same point.

For Maersk:

$$q_M^* = \frac{1}{2}\left(\frac{P - b_M}{a_M} - q_H\right)$$

For Hapag-Lloyd:

$$q_H^* = \frac{1}{2}\left(\frac{P - b_H}{a_H} - q_M\right)$$

The Cournot-Nash equilibrium occurs at the intersection of these reaction functions. Solving these equations simultaneously provides the equilibrium quantities q_M^* and q_H^*.

The solution to these reaction functions generates the equilibrium quantities, q_M^* and q_H^*. These equilibrium outcomes can be used to draw interesting insights about the nature of strategic interactions between Maersk and Hapag-Lloyd in the liner shipping market. More specifically, this analysis shows how a change in the conditions of the market, costs, or competitive strategies affects the outcome of the equilibrium.

Additional scenario demonstration using actual data

The following are detailed steps for calculating reaction functions and equilibrium quantities using metrics from 2023.

1. Calculate the cost per unit of Maersk and Hapag-Lloyd:

$$a_M = \frac{9,233 + 6,064}{11,904} = 1,283.17 \text{ USD/FFE}$$
$$a_H = \frac{6,089 + 2,437.6}{11,907} = 713.65 \text{ USD/TEU}$$

2. Establish a market price, P. The following is purely for illustrative purposes; assume the market price to be the average freight rate of the two companies:

$$P = \frac{2,313 + 1,500}{2} = 1,906.50 \text{ USD/TEU}$$

3. Determine the value for the fixed costs b_M and b_H, either these values can be small compared to other costs, or just taken as incorporated in a_M and a_H for simplicity: The fixed costs are often complicated to evaluate without detailed financial separations. This will already be an oversimplification, but we are going to assume $b_M \approx 0$ and $b_H \approx 0$.

4. Solve the reaction functions:

$$q_M^* = \frac{1}{2}\left(\frac{1,906.50 - 0}{1,283.17} - q_H\right) = \frac{1}{2}(1.486 - q_H)$$
$$q_H^* = \frac{1}{2}\left(\frac{1,906.50 - 0}{713.65} - q_M\right) = \frac{1}{2}(2.672 - q_M)$$

5. Solve the following equations simultaneously for q_M^* and q_H^*: Using the scipy optimization library, the equilibrium quantities were calculated as follows:

- Equilibrium quantity for Maersk: 101.64 FFE
- Equilibrium quantity for Hapag-Lloyd: 1280.35 TEU

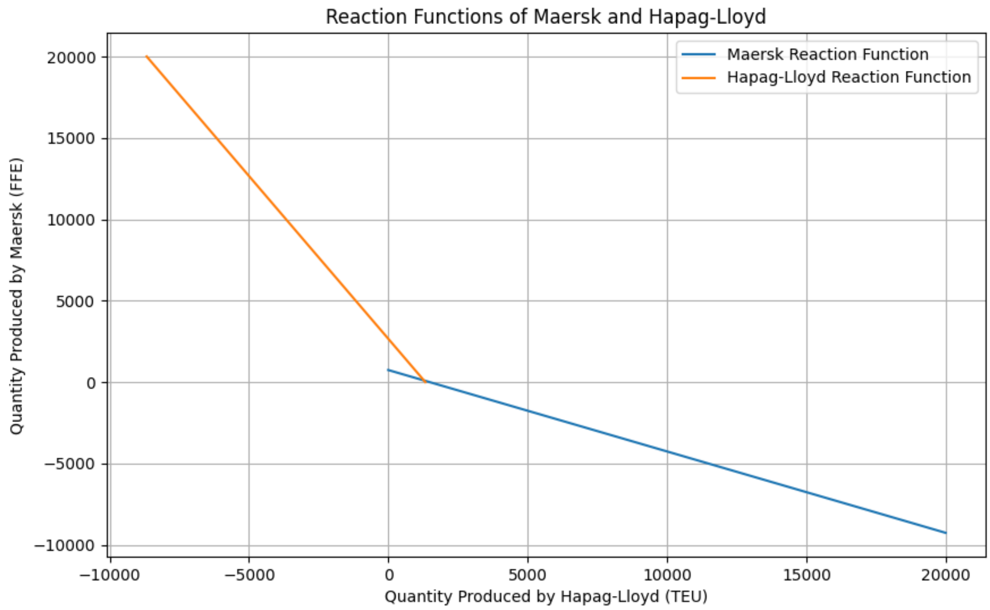

Figure 4.11.: Reaction functions

Illustrative calculations of equilibrium quantities for Maersk and Hapag-Lloyd offers perceptions about how firms such as these two prepare their production decisions with strategic production in a Cournot model framework. Calculated equilibrium quantities suggest that there is a significant difference in the production strategies between Maersk and Hapag-Lloyd. At a higher cost per unit of 1,283.17 USD/FFE, Maersk produces less at 101.64 FFE. Conversely, with a lower cost per unit of 713.65 USD/TEU, Hapag-Lloyd produces more at 1280.35 TEU. This difference may be explained by their cost structures and operational efficiencies. The results indicate that Hapag-Lloyd is better placed to compete through the production of more at lower costs, probably as a result of enhanced operational efficiency or a benefit pertaining to economies of scale. Maersk may instead be more focused on finding ways to modify their pricing strategy or lower costs as a means to remain competitive. These results further portray how strategic alliances, cost management, and capacity optimization are most critical to the carrier aiming to improve its market position.

4.5 Decision tree analysis for Maersk's strategic options

This section provides a decision tree analysis of Maersk's strategic options between owning and chartering vessels, given uncertain market demand. The methodology follows the taught by Noah Gans in the Coursera course *Operations Analytics*. This approach is much more consistent with the strategic impact of major shipping carriers such as Maersk on liner shipping, especially when considering issues of supply and demand.

4.5.1 Demand scenarios

Based on Maersk's financial and operational data from 2018 to 2023. See Table 4.1, we define the three market demand scenarios as follows:

- Low demand (2019): $1,853 per FFE
- Average demand (2023): $2,313 per FFE
- High demand (2022): $4,628 per FFE

The analysis uses the following data for each scenario as provided in Maersk's financial and operational data from 2018 to 2023:

Low demand (2019):

- Transport volume: 13,296,000 FFE
- Container handling costs: $8,988 million
- Bunker costs: $4,566 million

Average demand (2023):

- Transport volume: 11,904,000 FFE
- Container handling costs: $9,233 million
- Bunker costs: $6,064 million

High demand (2022):

- Transport volume: 11,924,000 FFE
- Container handling costs: $10,214 million
- Bunker costs: $8,077 million

4.5.2 Cost structure for owning and chartering vessels

- Owned vessels:

4. *Market dynamics and competition (Non-cooperative game theory aspects)*

   – Fixed costs: Container handling costs + Bunker costs

- Chartered vessels:
  – Fixed Costs: Assumed $0 (costs are treated as variable)
  – Variable Costs: Container handling costs + Bunker costs + Charter fees (based on historical data)

4.5.3 Revenue and cost calculations

The revenue calculation for each scenario is based on the freight rate and transport volume specific to that year. This will enable one to project the financial outcomes under varying market conditions.

Owned vessels

Revenue calculation:

$$\text{Revenue} = \text{Freight rate} \times \text{Transport volume}$$

- Low demand (2019):

$$1,853\,\text{USD/FFE} \times 13,296,000\,\text{FFE} = 24,629.8\,\text{million USD}$$

- Average demand (2023):

$$2,313\,\text{USD/FFE} \times 11,904,000\,\text{FFE} = 27,545.7\,\text{million USD}$$

- High demand (2022):

$$4,628\,\text{USD/FFE} \times 11,924,000\,\text{FFE} = 55,176.9\,\text{million USD}$$

Net revenue calculation:

$$\text{Net revenue} = \text{Revenue} - \text{Fixed costs}$$

- Low demand (2019):

$$24,629.8 - (8,988 + 4,566) = 11,075.8\,\text{million USD}$$

4. Market dynamics and competition (Non-cooperative game theory aspects)

- Average demand (2023):

$$27,545.7 - (9,233 + 6,064) = 12,248.7\,\text{million USD}$$

- High demand (2022):

$$55,176.9 - (10,214 + 8,077) = 36,885.9\,\text{million USD}$$

Chartered vessels

Revenue calculation:

$$\text{Revenue} = \text{Freight rate} \times \text{Transport volume}$$

- Low demand (2019):

$$1,853\,\text{USD/FFE} \times 13,296,000\,\text{FFE} = 24,629.8\,\text{million USD}$$

- Average demand (2023):

$$2,313\,\text{USD/FFE} \times 11,904,000\,\text{FFE} = 27,545.7\,\text{million USD}$$

- High demand (2022):

$$4,628\,\text{USD/FFE} \times 11,924,000\,\text{FFE} = 55,176.9\,\text{million USD}$$

Net revenue calculation:

$$\text{Net revenue} = \text{Revenue} - \text{Variable costs}$$

- Low demand (2019):

$$24,629.8 - (8,988 + 4,566) = 11,075.8\,\text{million USD}$$

- Average demand (2023):

$$27,545.7 - (9,233 + 6,064) = 12,248.7\,\text{million USD}$$

- High demand (2022):

$$55,176.9 - (10,214 + 8,077) = 36,885.9 \text{ million USD}$$

4.5.4 Expected values calculation

Based on these data, and also based on the market conditions and expert judgment, the probabilities for these different demand scenarios are assigned. Indeed, given the historical data, it is known that average market conditions dominate the extreme conditions of either low or high demand. Thus, probabilities are assigned in this way:

- Low demand: 30% Reflects the probability of low demand in case of below average market conditions based on historical occurrences.
- Average demand: 50% - This is the most likely scenario, where market conditions are assumed to be average, as supported by historical data.
- High demand: 20% - This shows the probability that high market demand opposite to that of average market conditions, though possible, it is less frequent.

Expected net revenue for owned vessels:

$$\text{Expected net revenue} = (0.3 \times 11{,}075.8) + (0.5 \times 12{,}248.7) + (0.2 \times 36{,}885.9)$$
$$\text{Expected net revenue} = 3{,}322.74 + 6{,}124.35 + 7{,}377.18$$
$$\text{Expected net revenue} = 16{,}824.27 \text{ million USD}$$

Expected net revenue for chartered vessels:

$$\text{Expected net revenue} = (0.3 \times 11{,}075.8) + (0.5 \times 12{,}248.7) + (0.2 \times 36{,}885.9)$$
$$\text{Expected net revenue} = 3{,}322.74 + 6{,}124.35 + 7{,}377.18$$
$$\text{Expected net revenue} = 16{,}824.27 \text{ million USD}$$

The analysis indicates that for this basic model, having vessels and chartering will yield the identical expected net revenues. However, the strategic implication actually becomes quite different: By owning the vessel, more control over operations and capacity aspects is acquired, yet at higher fixed costs and with associated maintenance responsibilities. On the other hand, chartering vessels provides operational flexibility and reduces fixed costs. This way, it allows Maersk to adjust its capacity according to market conditions but raises its variable costs.

5 Horizontal cooperation (Cooperative game theory aspects)

5.1 Overview

Horizontal integration involves acquiring or merging with competitors within the same industry to gain the competitive benefits of increased scale and operational scope. An acquisition occurs when a company utilizes some of its financial resources to buy another company (Dragomir, 2011). Nevertheless, liner shipping companies have always regarded strategic alliances as a means of operational efficiencies and adjusting of service offerings in the face of an increasingly competitive shipping environment worldwide (Ghorbani et al., 2022). Introducing the cooperative game theory approach to horizontal cooperation offers a great analytical tool to evaluate and structure collaborations where participating entities achieve mutual benefits. Cooperative game theory helps to determine how effective, formed, and stable alliances are in the liner container shipping industry. Two central concepts often considered in theory are the core and the Shapley value, both of essence in defining liner shipping alliances. The core concept involves allocations where no subgroup of players (shipping companies) would benefit from leaving the established coalition (Roth, 1988). An allocation within the core is stable because it ensures that all subsets of the coalition have no incentive to form a different coalition that would improve their situation. The Shapley value on the other hand, provides an answer regarding how to distribute total gains fairly among players according to their marginal contribution to the coalition (Roth, 1988). In liner shipping, it would reflect the relative contribution of each company in terms of capacity share, fleet size, level of technological sophistication, or geographical coverage. In this chapter, we first take a look into the current state of global alliances in the liner shipping business, followed by a discussion regarding the motivation for carriers to join such strategic partnerships, and finally apply the Shapley value concept from cooperative game theory to analyze the stability and contributions of individual shipping companies within strategic alliances.

5.2 Current dynamics of alliances in liner shipping

Strategic alliances among shipping lines have increasingly characterized the dynamics of service networks in the liner shipping industry over the last few years. Strategic partnerships are formed by shipping lines as a result of collaborative efforts aimed at operational efficiency, expanding service coverage, and increased competitiveness (Ghorbani et al., 2022), (Cariou, 2002). The liner shipping strategic alliance landscape is dynamic and strongly influenced by market demand, the regulatory environment, and technological advancement. Before discussing the application of the concept of the Shapley value, it is essential to give a glimpse of the prevailing landscape created by three principal alliances: 2M Alliance encompasses Mediterranean Shipping Co. and Maersk. This alliance benefits from economies of scale and network fortifications occurring from service networks of an enormous scope and scale and vessel-sharing agreements.

Three global alliances — 2M Alliance, Ocean Alliance, and THE Alliance are the liner shipping industry's leading key players. These Alliances allow member lines to share vessels, port calls, and scheduling information to boost their ability to provide extensive and very low-cost operations.

- **2M Alliance:** Consisting of Maersk Line and MSC, the 2M Alliance controls a good share of the capacity in global container shipping. Specifically, it focuses its services across the major East-West trade routes by bringing economies of scale and high service reliability.
- **Ocean Alliance:** With members being carriers CMA CGM, COSCO Shipping, Evergreen Line, and OOCL, Ocean Alliance is positioned on extreme flexibility and comprehensive network coverage. The Ocean Alliance covers various trades on the Trans-Pacific, Asia-Europe, and Asia-Mediterranean routes.
- **THE Alliance:** THE Alliance comprises Hapag-Lloyd, Yang Ming, Ocean Network Express (ONE), and Hyundai Merchant Marine (HMM). This alliance ensures operational efficiency and customer service under one umbrella. It serves the critical commercial routes worldwide, guaranteeing competitive connection times and access to key ports.
- **Gemini Cooperation:** This will be a strategic partnership between Hapag-Lloyd and Maersk, which is scheduled to start in February 2025 as both Maersk and Hapag-Lloyd announced. This alliance will operate on seven trade routes, offering 26 services across 12 key hub ports.

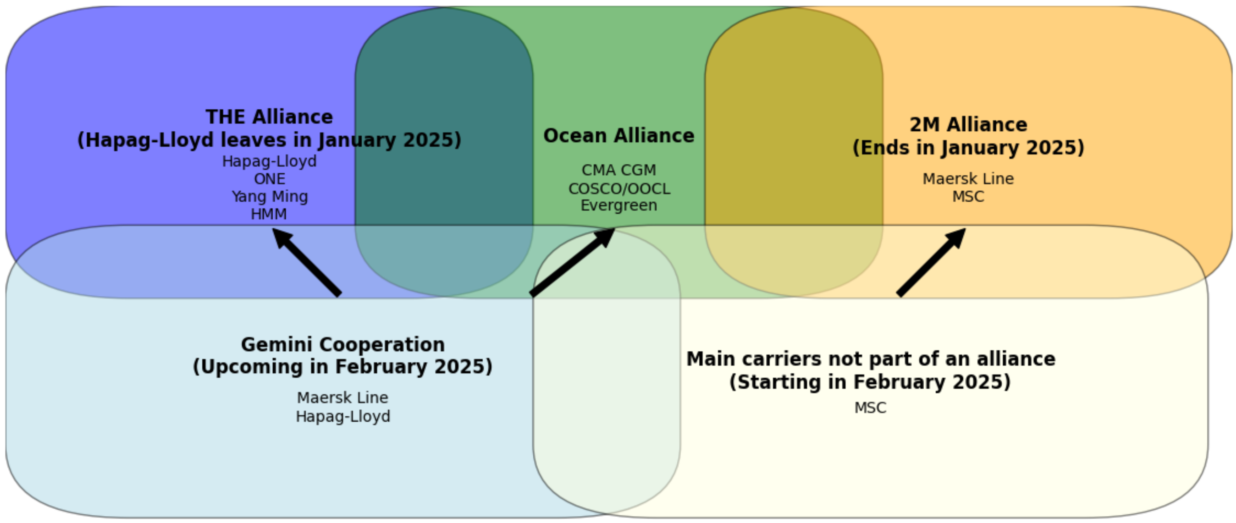

Figure 5.1.: Future perspectives of alliances in liner shipping. Based on (Notteboom et al., 2022)

5.3 Motivation for joining strategic alliances

Strategic alliances have notably influenced the landscape of competition (Shi and Voss, 2007) and market dynamics (Li, 2019) in the liner shipping industry reshaping the competitive landscape and influencing various aspects of the industry. The aim of strategic alliances, as a type of horizontal integration, is to facilitate cooperation in utilizing ship capacity on specific routes (Varbanova, 2017). The primary motivations for forming alliances include reaching a critical operational scale, penetrating new markets, expanding global presence, optimizing fleet deployment, and distributing the risks tied to investing in large container vessels (Notteboom et al., 2022). Shipping companies join alliances with the aim of achieving operational efficiency, cost savings, and enhanced service quality (Zuwei, 2015). Similarly, (Dragomir, 2011) state that by integrating their operations, shipping companies can realize cost savings through the utilization of larger vessels, optimized routes, and shared resources (Dragomir, 2011). The purpose of strategic alliances, being a form of horizontal integration, is to achieve cooperation for the ships' capacity utilization on certain routes. Strategic alliances often involve multiple shipping companies pooling their vessels, networks, and resources, which can lead to increased benefits for each individual player in the alliance, and thus likely reduce competition among shipping companies by reducing the number of independent players in the industry (Cariou and Guillotreau, 2022). According to (Vanelslander and de Voorde, 2008) reasons for forming alliances have been shaped within a context of rising globalization and competitive standards. Through vessel-sharing agreements, alliances can use larger vessels more efficiently, resulting in cost savings per container transported. (Vanelslander and de Voorde, 2008) further debate that carriers have formed alliances primarily to enhance the quality and efficiency of their transportation, products, and services. Their main goals also include reducing costs and sharing risks. (Ghorbani et al., 2022) argue that alliances allow shipping lines to provide extensive network coverage and frequent sailings, handle larger volumes, offer competitive pricing and achieve better profitability. Moreover, (Zuwei, 2015) argue that strategic alliances offer shipping companies the possibility to rationalize their service networks by consolidating routes and reducing duplicate services (Zuwei, 2015), which can lead to more efficient operations, improved transit times, and enhanced service quality. Findings from (Cariou and Guillotreau, 2022) indicate that a coordinated decrease in excess capacity is more probable when there is a limited number of competitors. This underscores the importance of cooperation among liner carriers, where a discernible learning effect between participants in strategic alliances is observed over time. Additionally, alliances allow shipping lines to achieve economies of scale by optimizing vessel deployment and reducing operating costs (Cariou and Guillotreau, 2022), (Imai et al., 2004). By forming alliances, shipping companies can achieve economies of scale by consolidating their operations (Haralambides, 2019). The discussion of the motivations for forming alliances has primarily centered on reducing risk and achieving economies of scale (Sjostrom, 2009).

While a strategic alliance in the liner shipping sector have had many advantages, such as an economy of scale, cost savings through the use of larger vessels, minimization in port calls, and shared resources, among others, these very benefits can be the barrier to entry for some minor players who cannot match the scale. The consolidation in liner shipping is one of the building blocks of the 'fourth generation ' of shipping alliances (ITF, 2018). This wave of consolidation, mainly brought on by the acquisition of smaller carriers, has made the previous alliance structure unsustainable, and the market become highly concentrated with a small number of more prominent players. According to (UNCTAD, 2022) ,(Cariou and Guillotreau, 2022), alliances made it possible for the shipping lines to be established in buyers' markets with a few buyers, leading to the typifying of the formation of oligopsonies. (Haralambides, 2019) argued that within the freight consolidation framework, sea shipping undoubtedly provided economies of scale in addition to meeting storage and distribution needs. It was also in a way that has established the regional hubs and dictated the new image of global logistics to this day. However, the entrenchment of mega-ships and the international shipping alliances built within it are under constraints which, while not anything detrimental, do hurt the efficiency and longevity of the hub-and-spoke system in container movements. The rationalization of the shipping service networks may lead to weakened service options for some of the ports or regions, and this may affect competition in these areas significantly (Shi, 2011). In addition, since all decisions regarding capacity and pricing are coordinated in successive groups of alliances, the price can be constrained by alliances and mutual agreements, and the rate and the rate volatility even increase. The most significant difficulties that liners have faced in price management are inflation and the rapid growth of crude oil prices, among others, over the past few decades (Yue, 2008). The liner shipping business, dynamic by all indications, considers that market dynamics keep shifting in relation to the change in alliances, the formation of new ones, and the market forces that further craft the makeup of the industry. Although alliances brought benefits in terms of operational efficiency and improved service quality, a proper balance between cooperation and competition remains a challenge within the liner shipping industry (Shi, 2011).

5.4 Shapley value analysis of liner shipping alliances

The Shapley value provides a fair distribution of the total gains (or costs) generated by the coalition of players. In the context of liner shipping alliances, we calculate Shapley values with respect to two fundamental characteristics: total TEU capacity and the total number of ships. These metrics are critical in understanding how each of the shipping companies contributes to the overall capacity and fleet size of the alliances. The analysis of Shapley values for the three major alliances — 2M Alliance, Ocean Alliance, and THE Alliance points to the basics of cooperative game theory, which essentially advocates a distribution of payoffs from a coalition or a joint venture in proportion to the individual input provided. It is precisely here that the critical decisions, under the umbrellas of some physical or intangible investments and in the form of cost or revenue sharing among the members of the alliance, are made based on equitable evaluations of inputs, increasing from this point the stability and sustainability of collaboration among members. The model formulation used in this analysis is adapted from (Shapley, 1952), (Roth, 1988), and (Hart, 1989).

5.4.1 Shapley value concept and further analysis

The Shapley value is a solution concept in cooperative game theory designed to distribute the total gains produced by a coalition of players proportionally among those players based on their contribution (Roth, 1988). The Shapley value of any player in a coalition would be an average of his marginal contribution across all possible coalitions. Mathematically, the Shapley value ϕ_i for player i in a game with n players is given by:

$$\phi_i = \sum_{S \subseteq N \setminus \{i\}} \frac{|S|!(n-|S|-1)!}{n!} [v(S \cup \{i\}) - v(S)]$$

where N is the set of all players, S is a subset of N not containing player i, and $v(S)$ is the value of coalition S.

The dataset used for this analysis, contained data from different shipping lines along with their corresponding alliances (Table A.1). The data includes metrics such as Total TEUs and the total number of ships each company has in alliances. To compute the Shapley values, we evaluated coalition value for each possible subset that can be formed with shipping companies involved in each alliance. The coalition value of any subset would be the summation of the number of metric values, either Total TEU or the total number of ships, for the companies involved in the subset. We initialized all subsets that can be made with the shipping companies involved in each alliance to ensure all possibilities were considered. The Shapley value of every shipping company in alliances was calculated based on the initialized coalition values.

The Shapley values for TEU for the shipping companies in each alliance are presented in Figure 5.2. These values represent the average contribution of each company to the total TEU capacity within the alliance. Similarly, the Shapley values for the total number of ships for the shipping companies in each alliance are presented in Figure 5.3. These values represent the average contribution of each company to the total fleet size within the alliance.

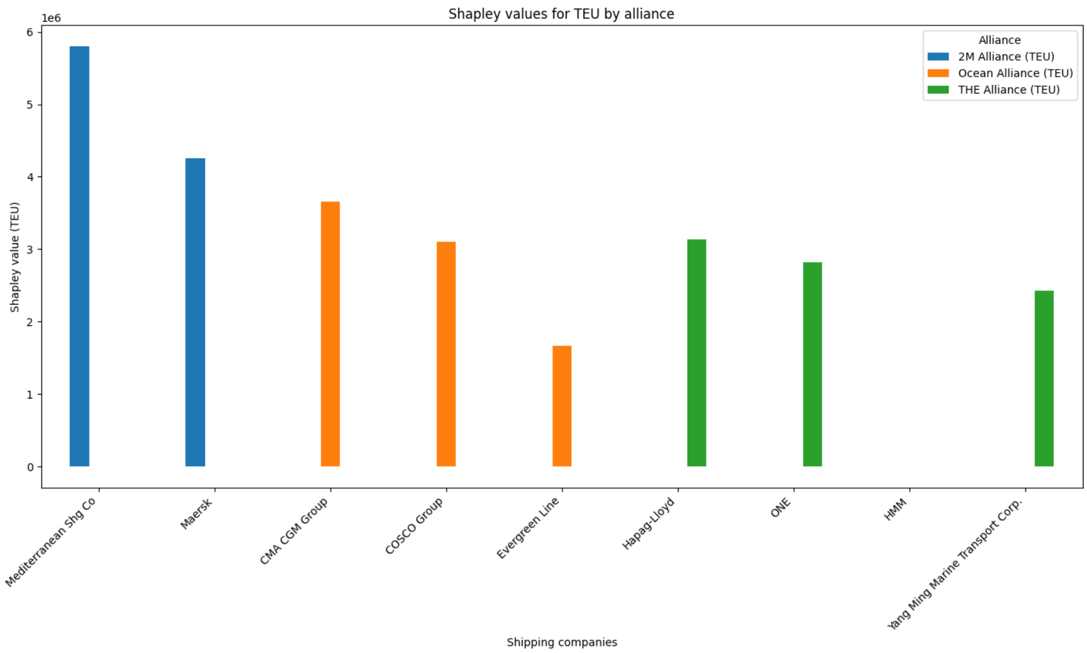

Figure 5.2.: Shapley values for TEU by alliance. Based on (Alphaliner, 2024)

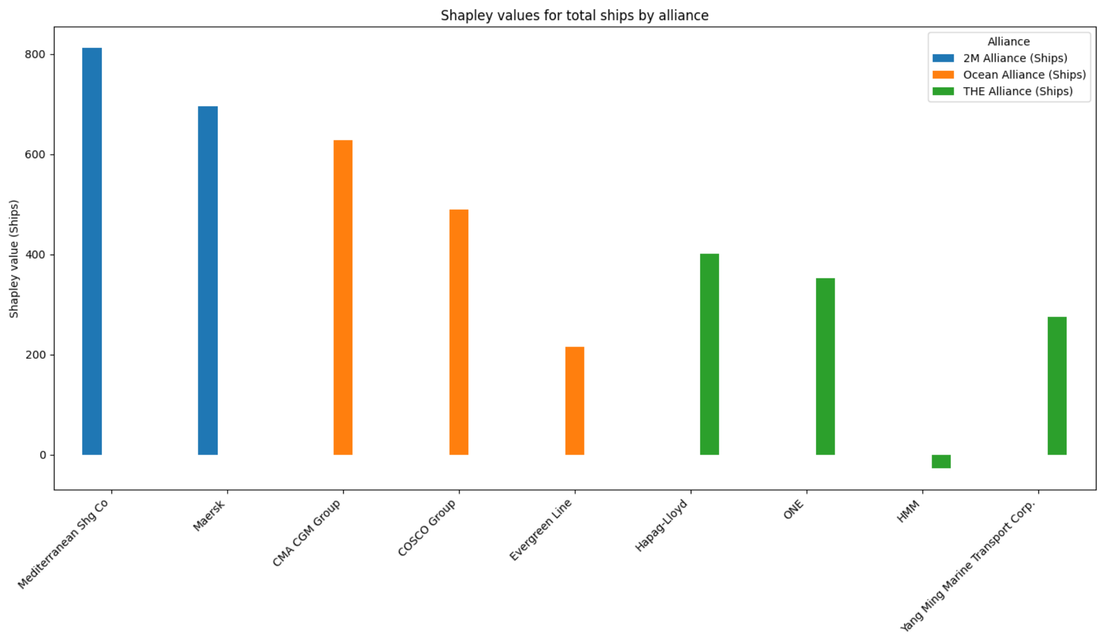

Figure 5.3.: Shapley values for total ships by alliance. Based on (Alphaliner, 2024)

The Shapley value analysis gives the insights into the relative contributions that individual shipping companies make within every alliance. High Shapley values mean larger contributions to the total capacity or fleet size of an alliance. Results can also be used for strategic decision-making within alliances, such as resource allocation and partnership management.

For example, considering the 2M Alliance, it is observed that Mediterranean Shg co (MSC) has a higher Shapley value for TEU compared to Maersk, hence their contribution to alliance capacity is very imperative. In the case of Ocean Alliance, CMA CGM Group also has a high Shapley value with respect to total number of ships and therefore its importance to fleet size is immanent. Such insights might help alliances in optimizing their operations and making informed decisions in terms of future collaborations and expansions.

6 Vertical cooperation (Cooperative game theory aspects)

6.1 Overview

Vertical integration is a strategic approach in which companies extend their operations within their supply chain by acquiring or forming partnerships with other companies that operate at different stages of the supply chain (Vanelslander and de Voorde, 2008). Vertical cooperation refers to partnerships with other players within the same supply chain, such as shippers, liner shipping carriers, freight forwarders, vessel maintenance providers, and similar participants (Shi and Voss, 2008). The most significant case of vertical integration in the shipping industry is that of Maersk (Dragomir, 2011), where the company expanded its operations beyond traditional shipping to include several key stages of the supply chain, moving into port terminal management with APM Terminals, logistics under Maersk Logistics, and even inland transportation. In the context of shipping alliances, vertical integration can involve several key areas such as ports, terminal operations, inland transportation services, and so on. This integration can lead to increased control over the supply chain, cost reductions, and improved service efficiency. These interactions within the liner shipping sector involve some of the most critical issues for the development and dynamics of the service network. Nevertheless, the latest complications to competition regulation in the container shipping industry stem from vertical integration. Shipping lines exploit competition law exemptions existing in most countries to use carrier advantages in deriving competitive advantages for the same markets where they are now directly competing with freight forwarders, port service providers, and logistics operators—businesses that are not exempt. Protection of strong competition among land-side port and logistics markets in which maritime container carriers increasingly participate is required by regulators (ITF, 2022). The concept of vertical cooperation, often modeled through cooperative game theory, provides a window through which the collaborative strategies of operators that can be either "competing" or "collaborating" depending on different levels of the supply chain is examined. This chapter analyzes the influence of these interactions on operational efficiency, especially with respect to the time that the vessel spends in a port.

6.2 Key areas of vertical integration in shipping alliances

6.2.1 Ports and terminal operations

- Acquisitions and partnerships: The major shipping companies that are members of strategic alliances often invest to have stakes in port terminals to secure berthing rights and influence over terminal operations (Notteboom et al., 2017). For example, a shipping company might purchase a significant stake in a major terminal to ensure priority access and customized services.

- Operational synergies: One of the main arguments for strategic alliances is the ability to achieve operational synergies, which allow shipping lines to optimize the allocation of vessels across a larger fleet. This flexibility can mitigate constraints related to the number and size of vessels available to individual shipping lines. However, the effectiveness of these synergies heavily relies on the responsiveness of ports (Cariou, 2002).

6.2.2 Inland transportation services

- Rail and truck services: Carriers associated with shipping alliances can voluntarily acquire or build associations with railways and trucking companies to become responsible for inland services related to the door-to-door services (Notteboom and Rodrigue, 2005). This integration helps to control the inland leg of the shipping journey, crucial for door-to-door delivery services.

- Intermodal operations: There has to be a blend between sea, rail, and road transports in the intermodal operations to boost efficiency in cargo movement, particularly for hinterland connectivity (Notteboom and Rodrigue, 2005).

6.2.3 Logistics and warehousing

- Logistics firms: Acquiring logistics firms allows shipping alliances to offer comprehensive logistics solutions (Notteboom and Rodrigue, 2005) that include not only transport but also warehousing, inventory management, and order fulfillment.

Warehousing: By directly managing the warehouses or by getting into a warehousing arrangement, shipping companies can make available extended services, which include storage, consolidation, and distribution, to embed the client's shipper into its client's supply chain.

6.2.4 Benefits of vertical integration

- Cost efficiency: Reducing the number of intermediaries reduces transaction costs and operating expenses for the company (Dragomir, 2011).

- Enhanced control: Ownership or control of additional levels of the supply chain allows companies to have better control over risks and therefore improves the quality of service and the response to market variations (Rodrigue, 2010).

- Enhanced service offering: Offering a wide range of services through vertical integration significantly increases customers' satisfaction and loyalty to the shipping companies (Dragomir, 2011).

- Strategic asset control: Ownership or control over strategic assets like ports and terminals can provide competitive advantages, particularly in congested or high-demand regions (Rodrigue, 2010).

6.2.5 Challenges of vertical integration

- Capital intensity: Vertical integration requires significant capital investment, which can be a barrier, especially for smaller operators (OECD, 2011).

- Regulatory hurdles: Acquisitions and mergers often face regulatory scrutiny, especially in the strategic sectors of ports and transportation (OECD, 2011).

- Management complexity: The integration of operations across different supply chain segments adds layers of management complexity and requires advanced operational capabilities (Dragomir, 2011).

Carrier	Shipping, Short-sea	Terminal	Logistics	Equipment	Towage	Rail	Barge	Truck
Maersk	✓	✓	✓	✓	✓	✓	✓	✓
MSC	✓	✓	✓			✓	✓	✓
CMA CGM	✓	✓	✓	✓		✓	✓	✓
Cosco	✓	✓	✓			✓		
Evergreen	✓	✓	✓	✓		✓		✓
Hapag-Lloyd	✓	✓	✓	✓				
ONE[8]	✓	✓	✓	✓	✓		✓	✓
Yang Ming	✓	✓	✓					✓
HMM	✓	✓	✓			✓		✓

Figure 6.1.: Vertical cooperation of the top 10 carriers in liner shipping. Based on (ITF, 2018)

6.3 Analyzing vessel calls and port usage at the port of Hamburg

6.3.1 Data and further analysis

The analysis is based on the data of vessel calls at the port of Hamburg, detailing the company names, the number of calls, the Twenty-foot Equivalent Units (TEUs), and the duration of each call. Carriers were classified and assigned to their alliance. Moreover, data were preprocessed to convert 'Duration' from string format (e.g., '1824h') to an integer with the total number of hours spent in port.

A hypothesis was tested to independently determine the impact strategic alliances, i.e., carriers that are members of strategic alliances versus non-alliance members, had on port call durations by applying an independent samples t-test. The mean duration of vessels belonging to carriers within alliances was compared with those who did not belong to any alliance, with the aim to identify significant operational differences.

The t-test gives a T-Statistic of -0.80036 with a P-value of 0.438, which therefore means that there are no statistical grounds for the null hypothesis of difference within the average period of port stay for reasons of alliance members and non- alliance members.

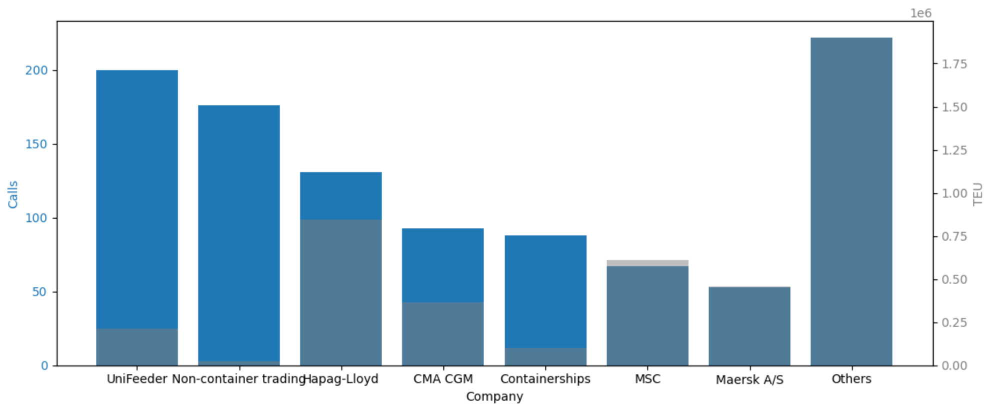

Figure 6.2.: Calls and TEUs by company. Based on (Alphaliner, 2023)

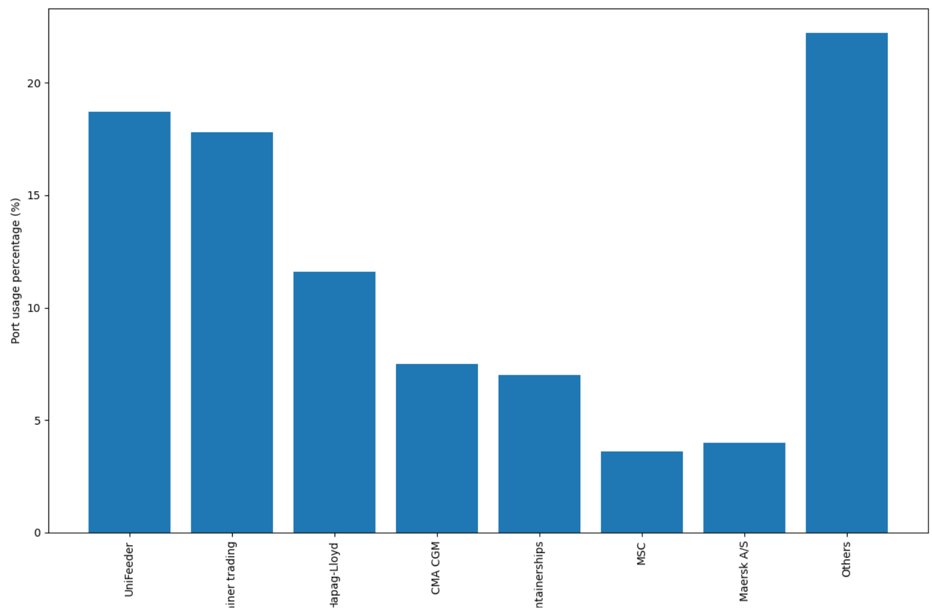

Figure 6.3.: Port usage percentage by company. Based on (Alphaliner, 2023)

The results indicate that being member of an alliance has no significant influence on the time the vessel stays in the port, which goes against the presumed operational efficiencies that many people associate with alliances: more giant cranes, and better scheduling that leads to quicker loading and unloading times.

7 Technological, environmental, and regulatory factors (Non-cooperative games)

7.1 Overview

The dynamics of liner shipping service networks are profoundly influenced by technological, environmental, and regulatory factors. Strict environmental regulations mean enormous compliance costs that might further discourage new entries leading to a high market present concentration (ITF, 2018), (UNCTAD, 2022). On the other hand, technological progress can reduce operational costs for companies (Raza et al., 2023), making the market more appealing to new contestants. Such responses often include strategic alliances and partnerships. A shipping company in an alliance can be able to share technological investment burdens, regulate its performance more effectively, and better meet trade policies through mutual cooperation. From this respect, the alliances act at the spectrum of cooperative and non-cooperative behaviours since companies are acting collaboratively to solve common problems but still are competing against each other at large. This chapter explores the strategic decision-making processes of liner shipping companies in regard to technological, environmental, and regulatory factors. Each of these elements plays a critical role in shaping strategic decisions and competitive behaviors within the industry. Non-cooperative game theory provides a framework to analyze these dynamics, where each company independently makes decisions that might affect their competitiveness and compliance with regulations.

7.2 Technological factors

Digitalization in maritime shipping implies that players in the maritime business will in some way or another adopt new digital technologies to enhance the efficiency, safety, and sustainability of maritime operations (Raza et al., 2023). Essentially, the technology-driven digital era, characterized by various new technologies, including the Internet of Things, Big Data Analytics, Artificial Intelligence, Blockchain, and Cloud Computing, has fundamentally transformed the contemporary shipping operations. Innovations such as blockchain, automation, and artificial intelligence are having significant impacts. For example, blockchain ensures increased transparency and efficiency in logistics toward more secure and faster documentation of the processes (Farah et al., 2024). Better efficiencies in system and ship automation can enhance operations with reduced costs and errors because of human interventions. Enterprises adopting such technologies will find an early market entry with a superior competitive advantage toward reduced operational expenses, enhanced customer servicing, and a better ability to manage complex supply chains (Raza et al., 2023).

A shipping liner can achieve sustainable growth by adopting a multifaceted strategy that includes strong geographic expansion, innovation, and cost leadership. By extending its network into new markets, the liner can tap into emerging opportunities and diversify its revenue sources. Innovation, both in terms of technology and service delivery, enables the company to stay competitive and meet evolving customer needs. Meanwhile, maintaining strict cost leadership ensures operational efficiency and profitability, which are crucial for long-term sustainability (Shi, 2011). Together, these strategic pillars support the liner in building a resilient business model capable of thriving in a dynamic global market.

Basically, a shipping liner can achieve sustainable growth by adopting a multifaceted strategy that includes strong geographic expansion, innovation, and cost leadership. In expanding the reach of the liner into new markets, the liner opens up emerging opportunities and diversifies its sources of revenue. The various innovations, whether in technical or in the delivery of the service, only keep a company afloat in the respective areas where customer needs develop over time. Meanwhile, the strict cost leadership ensures that operational efficiency and profit levels are maintained at satisfactory levels for the liner business in the long run (Shi, 2011). Both strategic pillars make the liner resilient in business models, which can stand in the current global market.

To a certain extent, the strategic decision to adopt new technologies, such as investing in fuel-efficient engines, digital navigation systems, and automation by companies, is a rather complicated situation (Grubler et al., 2002). These decisions can be influenced by the cost of technology, its expected benefits, and the actions of competitors.

In the light of non-cooperative game theory, technological adoption can be seen as a strategic decision where firms individually decide on investments to acquire a competitive advantage. The choice of adopting new technology involves an analysis of costs and benefits where businesses compare the initial expenses incurred with the potential future gains in efficiency and market presence. For example, if one of the rivals adopts a new fuel-efficient engine, all the rest of the firms would copy it so that they do not fall behind concerning operating costs. This is an example of the typically non-collaborative game since the strategies of each firm allow the rest of the firms to achieve the dynamic state of equilibrium of technology adoption.

7.3 Environmental factors

For liner shipping, environmental considerations are becoming increasingly important due to regulatory pressure and the growing public demand regarding such issues, regulation of the sulfur cap by the International Maritime Organization (IMO) forces shipping lines into cleaner technologies (Chen et al., 2022). At the same time, companies have to make critical investment decisions related to whether they invest in the retrofitting of older vessels with sulfur scrubbers, move to cleaner fuels such as liquefied natural gas (LNG), or in the next generation of green ships (Chen et al., 2018), (Zisi et al., 2021). These changes are likely to have multiple implications on operational costs and competitive positioning. In many cases, shipping firms must balance their compliance requirements against their environmental performance and cost efficiency.

It is an important transformation that the maritime industry is undergoing in terms of environmental considerations, wherein the sector is now seeking to integrate new technologies into these considerations to reduce the industry's carbon footprint (Chen et al., 2018). Tugs and ships with zero emissions are the latest frontiers in this regard in the move toward sustainability (Kim et al., 2023).

In response to environmental compliance regulations, such as the IMO 2020 sulfur cap, shipping companies will need to decide on investments in cleaner fuels and technologies to help cut emissions, besides operational optimization. Since there is an element of strategy in adopting green technologies and environmental compliance by firms, they may be seen to correspond to strategic moves in a non-cooperative game under the framework of game theory. The firms have to balance their compliance and innovation costs against potential market advantages. For example, firms that adopt LNG propulsion early may win a niche in environmentally sensitive markets. It is the strategic decision-making process that will better position it in an evolving market landscape by looking forward to competitor actions and regulatory changes.

7.4 Regulatory factors

The regulations landscape in liner shipping is complex and multi-dimensional, with both global and regional regulations that deal with the routes of shipping, port operations, and trade policies (ITF, 2018). International regulations—of which the IMO is one—and regional policy frameworks, such as the European Union's Emission Trading System, shape operational strategies. These regulations need compliance with environmental standards and operational protocols for impact on service networks, together with cost structures (Tiemann, 1994).

Trade policies and tariffs further complicate the regulatory environment (ITF, 2022). International trade agreement changes, such as Brexit or the US-China trade war, are relevant to established shipping routes and demand patterns. Thus, these shifts call for adaptive strategies from shipping companies in their bid to navigate the uncertainties of trade policy and its effect on global shipping dynamics.

During the establishment of agreements such as alliances, competing shipping companies have to comply with a regulatory structure, as in the case of the European Union, by the EU Consortia Block Exemption Regulation. Through this regulation, it is possible for shipping firms to cooperate around specified activities such as joint scheduling and capacity sharing without any breach of antitrust laws. However, to fall under the cover of exemption, firms have to ensure that the arrangements they get into undoubtedly avoid anti-competitive practices like price-fixing or market sharing. Failure to obey these regulations means huge sanctions, such as fines and legal penalties, are enforced against companies that bend or break the rules to ensure a level playing field and integrity in the markets (UNCTAD, 2022).

From the game theory's perspective, shipping firms' interaction with regulators can be conceived as a strategic game where companies have to anticipate regulation changes and change their strategies accordingly. That is, in addition to simply adhering to the current rules, they will have to establish lobbying efforts that assist in changing future policies. In this respect, the strategic decisions getting developed reflect essentially a non-cooperative game wherein the actions of any firm happen according to the foreseen actions of competitors or regulators.

8 Case study: The 2M Alliance and its strategic impact on liner shipping

8.1 Introduction to 2M Alliance

The 2M Alliance is a partnership between two of the largest companies in the liner shipping business which came into effect in 2015 as a response to several key structural challenges that confronted the liner shipping industry, including overcapacity, fluctuating demand, and an upward spiral of operational cost. In respect to this, the purpose of this alliance was to enhance competitiveness and cost efficiency in its operations, which include the Asia-Europe, Transatlantic, and Transpacific trades (Maersk, 2023). During its ten year agreement, the 2M Alliance held a large share in international container shipping capacity, making it arguably one of the most important strategic alliances in liner shipping today (Akman, 2023), most definitely with repercussions for trade routes and schedules, but also on efficiency, sustainability, and standards related to competitiveness.

2M Alliance is a prime example of horizontal cooperation. Through the collaboration between the two largest container shipping companies in the world, both partners were able to reap the benefits of an optimized operation and service network, as well as competing with THE Alliance and Ocean alliance (Akman, 2023). This is illustrative of how collaborative strategies by shipping giants yield significant operational benefits. The members of this alliance not only share the vessels but also the port facilities and other resources that create scale economies, cost savings, service enlargement, and, again, a formidable competitive advantage over other players in the market.

The approach followed by the 2M Alliance in this regard was to create a fine balance between strong market presence and refraining from over-dominance. Instead of leading the market, the alliance was strategically designed to capture a significant share, particularly in the high-value transatlantic routes. This approach made it possible for both companies to afford competitive pricing and reliable services by securing a substantial portion of the market share without overstretching (Yap and Zahraei, 2018), (Bruno, 2023).

The 2M Alliance has had a huge impact on Southeast Asian ports, if not the likes of Singapore, Port Klang, and Tanjung Pelepas. Network connectivity and service reliability are really very important in these instances to the prominence enjoyed by these hubs within the global shipping network. Strategic port calls can enable optimization of trade routes (Yap and Zahraei, 2018).

To sum up, the 2M Alliance played an important role not only in the freight rates and, eventually, service quality but also in the competitiveness of global shipping. The massive share in market control by the 2M Alliance impacted liner trade routes, decisions related to logistics operations, and other aspects worldwide makes it a very critical subject for learning the nature of market dynamics under liner shipping.

8.2 Operational strategies of 2M Alliance

During its 10-year collaboration, the 2M Alliance has implemented a range of operational strategies to optimize their service offerings, enhance efficiency, and maintain a competitive edge in the global shipping industry. Some of the key operational strategies include Vessel Sharing Agreements (VSAs), route optimization, capacity management, digitalization and technological integration, and environmental sustainability among others.

Vessel sharing agreements (VSAs)

Sharing vessels is one of the main motives for joining alliances in liner shipping as statated by (Cariou and Guillotreau, 2022). This explains why the VSAs secure the 2M Alliance an optimal utilization of its fleet: larger load factors and fewer empty slots make for a more appropriate and profitable service. The sharing of vessels allows the alliance to offer services more frequently with reduced transit times. In addition, enhanced sailing flexibility and more dependable schedules boost customer satisfaction. In fact, Maersk announced the starting of a 10-year VSA with MSC in July 2014 (Maersk, 2024).

Service network design and route optimization

As the largest alliance in the container shipping industry, the 2M Alliance strategically selects ports that offer the best connectivity and efficiency. This includes using major hub ports with advanced infrastructure that can handle large volumes and facilitate swift turnaround times.

Based on Figure 8.2. which illustrates the analysis of the minimum-maximum range of TEU capacities for each service provided by both Maersk and MSC under the 2M agreement along with major Asian ports included in each service rotation, services Asia-Europe (AE-6 / Lion) and Asia-Med-N. Europe (AE-55 / Griffin) have the highest maximum capacities, 24,346 and 24,116 TEUs, which means they can accommodate larger cargo loads that should realize economies of scale. The lowest maximum capacity, 18,340 TEUs, is contributed by Asia-Europe (AE-7 / Condor), perhaps because it might have a strategy oriented toward serving markets that require more frequent but smaller shipments. The

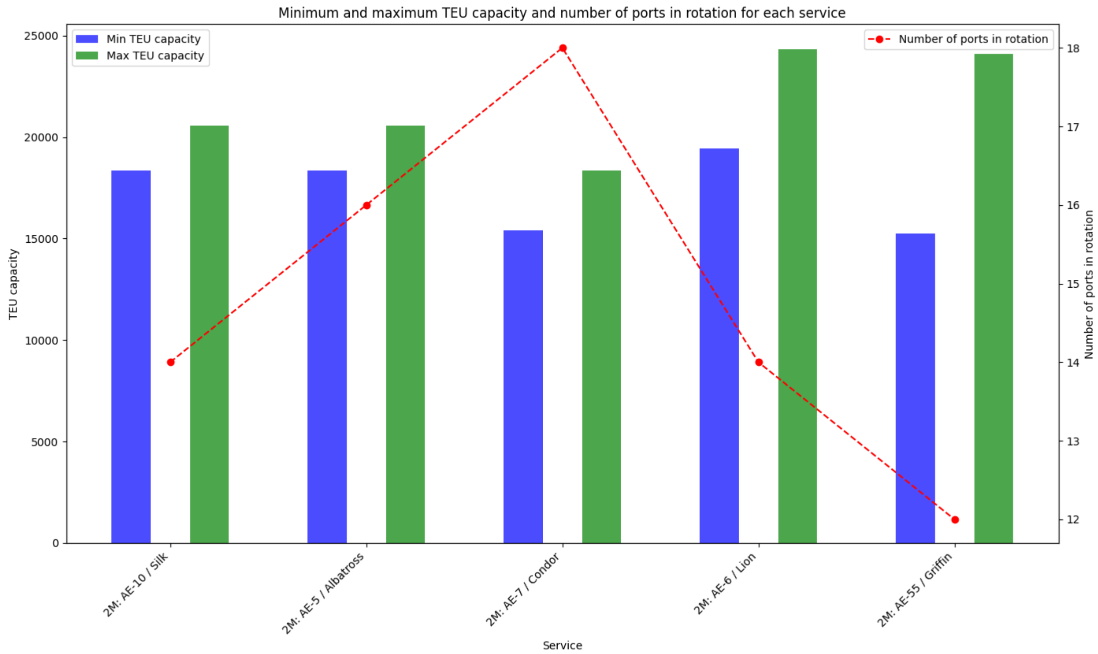

Figure 8.1.: Maersk's minimum-maximum range of TEU capacities for every service and the number of ports under the 2M agreement. Based on (Alphaliner, 2023)

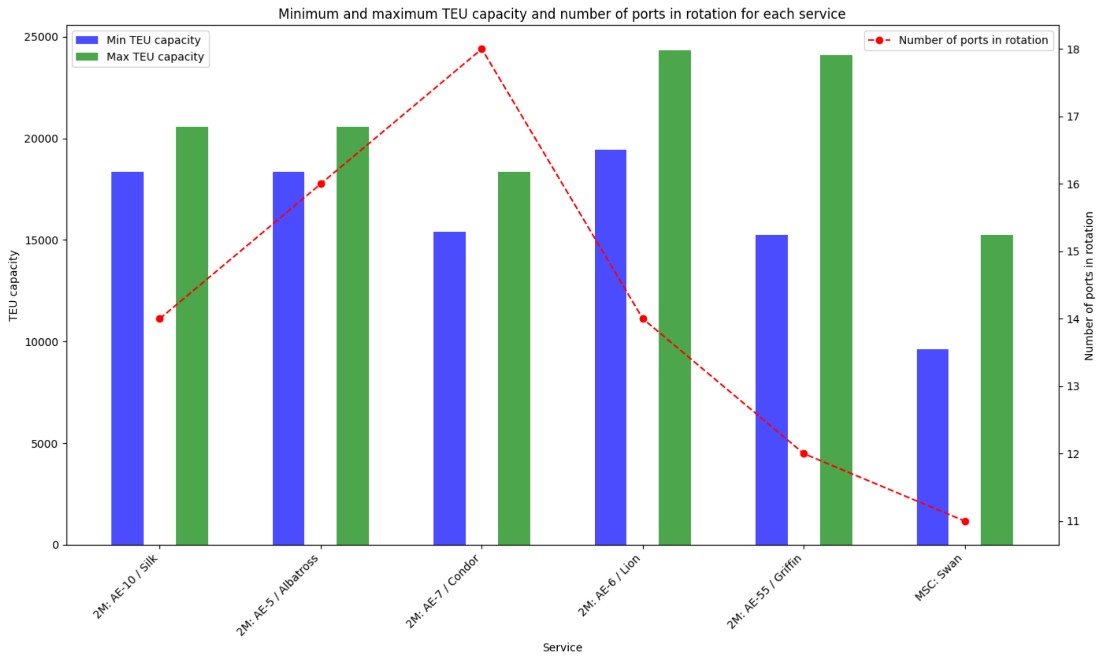

Figure 8.2.: MSC's minimum-maximum range of TEU capacities for every service and the number of ports under the 2M agreement. Based on (Alphaliner, 2023)

number of ports that each service visits differs quite significantly. Asia-Europe (AE-7 / Condor) and Asia-Europe (AE-10 / Silk), calling at the greatest number of ports with

14 in total, suggest higher levels of complexity regarding logistical operations and longer transit times. In contrast, Asia-Med-N. Europe (AE-55 / Griffin) covers the fewest ports, 12, thus implying a more streamlined route with shorter turnaround times and probably less operational complexity.

Services with higher TEU capacity, such as Asia-Europe service (AE-6 / Lion) and Asia-Med-N. Europe (AE-55 / Griffin), must have been designed to maximize cargo volume and operational efficiency. However, this would result in many ports of call in their rotations, thus risking schedule reliability and transit time. Again, there is a strategic difference in network design among the service offerings: some emphasizing broader market coverage, others improving route efficiency. The 2M alliance would likely help Maersk and MSC decode the full potential of combined fleet capacity and service network to provide added value in market reach and increased service frequency. Observed TEU capacities and port rotations give evidence that, due to shared resources, the load is balanced between partners concerning distribution and network coverage, hence leading to a more resilient and flexible service network.

The Asia-Europe (AE-10 / Silk) and Asia-Europe (AE-5 / Albatross) services have similar TEU capacities yet differ in terms of their port rotation. The latter would offer faster voyages with fewer ports, while the former provides pervasive market coverage. The smaller capacity of the Asia-Europe (AE-7 / Condor) service is combined with a significantly higher number of port calls, presenting a clear niche strategy by serving markets where more frequent stops are required to meet specific regional demands. These insights inform strategic decisions concerning how fleets could be deployed in an alliance and with regard to route optimization. Shippers and logistics providers can select services according to exceptional capacity and coverage needs, increasing operational flexibility and customer satisfaction. Because the alliance is better positioned to offer a varied portfolio of services, the resource pooling and coordinated network planning come out as a distinct strategic advantage. While this analysis was built on the base of static data, further research may consider real-time data to trace dynamic changes in market conditions and adjustments in operation.

Capacity management

Shipping lines are able to strategically use their fleet capacities in creating economies of scale that may then allow large cargo volumes to be handled in a very low-cost mode, thus reducing unit costs of operation. (Lam, 2013) provides insights into how better integration can help shipping lines coordinate with their partners in terms of vessel utilization and minimizing empty container movements for better capacity management. Consequently, this could lead to cost reductions while innovating service levels to retain competitive advantage within the liner shipping industry. (Cariou and Guillotreau, 2022) observed that with a clear benefit of continuous interaction over time, carriers would consequently be able to handle excess capacity wisely. Whether on their own or as part of shipping alliances, the respective carriers are in a position to put their respective activities in alignment with the meeting of the appropriate fleet size demand and schedules. This gives flexibility for conducting supply and demand balances in the pursuit towards taking the most minor possible risks in terms of overcapacity and a significant cause in terms of maintaining overall market stability. Through such strategic measures, the carriers can gain effectiveness and efficiency in their operations. For instance, the 2M Alliance provides customers with sufficient volumes while limiting deployed capacity and maintaining high utilization. This flexibility allows it to scale operations up or down, ensuring that it can meet customer needs without incurring unnecessary costs.

Digitalization and technological integration

Digital transformation is among the most vastly explored topics in information systems and organizational science (Mikalef and Parmiggiani, 2022). Integration of digital technologies helps an organization to deal with this complex modern business environment and welcomes new opportunities for growth and success (Mikalef and Parmiggiani, 2022). Therefore, it would not come as a surprise that two of the largest carriers collaborating under the 2M Alliance rollout digital solutions, such as the use of advanced tracking systems and real-time monitoring develop visibility beyond the line of sight within the supply chain. It makes efficient management of shipments possible and quick response to all the issues that can arise. Besides, blockchain technology and the Internet of Things make documentation and tracking more transparent and secure. In its turn, it decreases the possibility of fraud and increases the level of efficiency of logistic operations. For example, from 2019 until 2022, the 2M Alliance collaborated with TradeLens, which is an open and neutral supply chain platform that is based online and uses blockchain technology (Maersk, 2022). TradeLens works towards breaking down traditional silos of its data and process among these trading partners and is making it similar to a streamlined flow of documentation with every shipment.

8.3 Impact on competition and market dynamics

Market concentration and competitive pressure

The more significant market share of the 2M Alliance, particularly in the Far East and Atlantic trades, is likely to raise the concentration ratio of market power. This may cut down whatever little room for competition remains for the smaller carriers and independent operators since the alliance can take advantage of economies of scale and pricing power. Also, with such operational efficiencies and cost management, as the alliance is in a position to offer competitive pricing, it puts pressure on other alliances and also on those independent carriers that compete directly with alliance members to match or improve their cost structure and service offer. Such pressure can trigger price wars that will pressure the profitability of the smaller players (ITF, 2018).

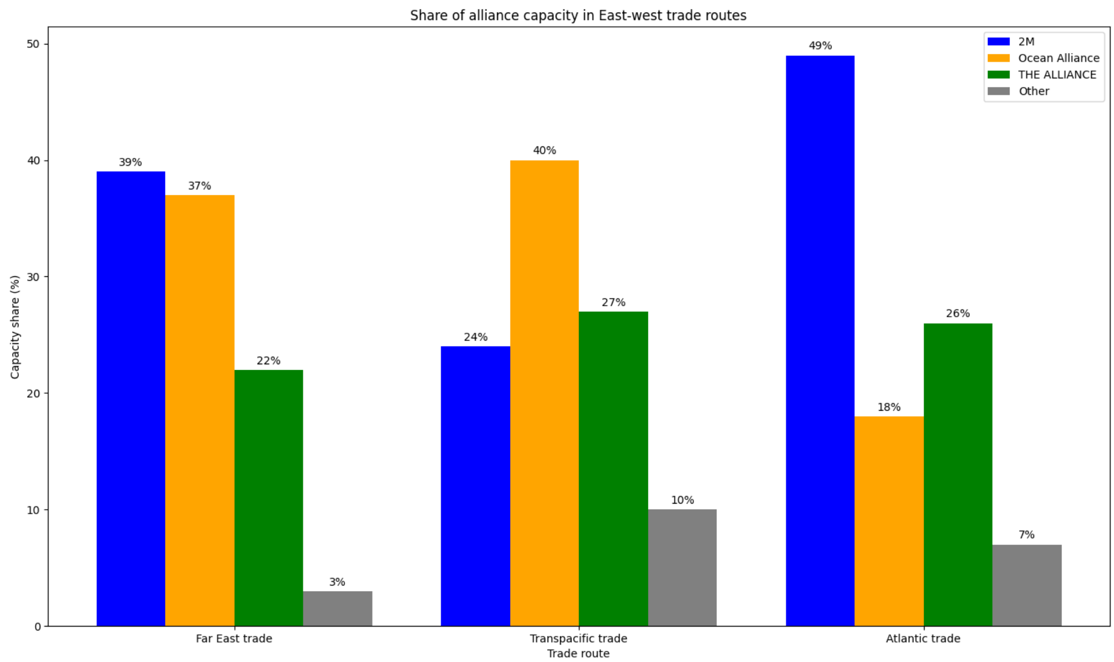

Figure 8.3.: Share of alliance capacity in East-West trade routes in 2022 - Comparative analysis of the 2M Alliance with other alliances. Based on (Hapag-Lloyd, 2022)

In 2022, in the Far East trade trade, the 2M Alliance seemed to be the leader with a 39% market share. Such a high share indicates that the alliance had established a solid form and gained a competitive advantage in one of the most significant international shipping routes in the world. Since, the Far East trade is an essential hub of global commerce, being a leader in this trade route made 2M an essential intermediary between Asia and the rest of the world. Not far behind, the Ocean Alliance also enjoyed a significant share of

37%. This tight competition between the 2M Alliance and the Ocean Alliance puts into perspective a competitive environment in which these two alliances fight with difficult efforts to override each other. THE Alliance occupied 22%, and the other players 3%. The nature of this distribution is therefore more towards a consolidated market dominated by major alliances.

In the Transpacific service, the Ocean Alliance had a majority share volume of 40%. This was the most substantial presence, bridging Asia to North America, the most important trade corridor. The 2M Alliance held a small share of 24%, although its presence was significant enough to remain a relevant player. Summing up, THE Alliance held 27%, while the remaining 10% was shared by other players. The Transpacific trade showed less concentration, with the market share more evenly distributed among different players.

Again, in the Atlantic trade, the 2M Alliance dominated with 49%, and its strategic positioning is seen more clearly. Despite the high percentage, it has retained much of its focus on the transatlantic routes, which provide the most critical link between Europe and North America. The alliance, with 26%, was the second most significant player in this route and shows that the alliance has also played an essential role in this trade corridor. The Ocean Alliance also enjoyed 18% share with the other players, forming 7%, a more fragmented market unlike Far East and Transpacific trades.

The near-leadership position of the 2M Alliance in recent years indicates a strategic Asian focus to leverage economies of scale and network connectivity for pricing and service reliability in the competitive marketplace. It advocates for maintaining a balance between remaining strong and avoiding being weakened, aiming not to lead but to secure a significant portion- decisively opting for the transatlantic routes of higher value, thus improving service and capturing a substantial market share (Yap and Zahraei, 2018).

Service quality and reliability

Service quality seems to have deteriorated since the new alliances were established in 2017, according to (ITF, 2018). Freight forwarders have been affected first and foremost by a decline in schedule reliability and service quality caused by rationalization measures of carriers and alliances. Some small carriers believe that several customers will finally choose reliability and service quality instead of low rates and try to market their added value by providing highly personalized services, complete visibility, and a level of liability that larger carriers are often incapable of guaranteeing for their customers (Baker, 2018). Furthermore, (ITF, 2018) states that since the creation of the 2M alliance, the reliability scores of the carriers have converged-which is the result of a declining reliability of Maersk and increasing reliability of MSC.

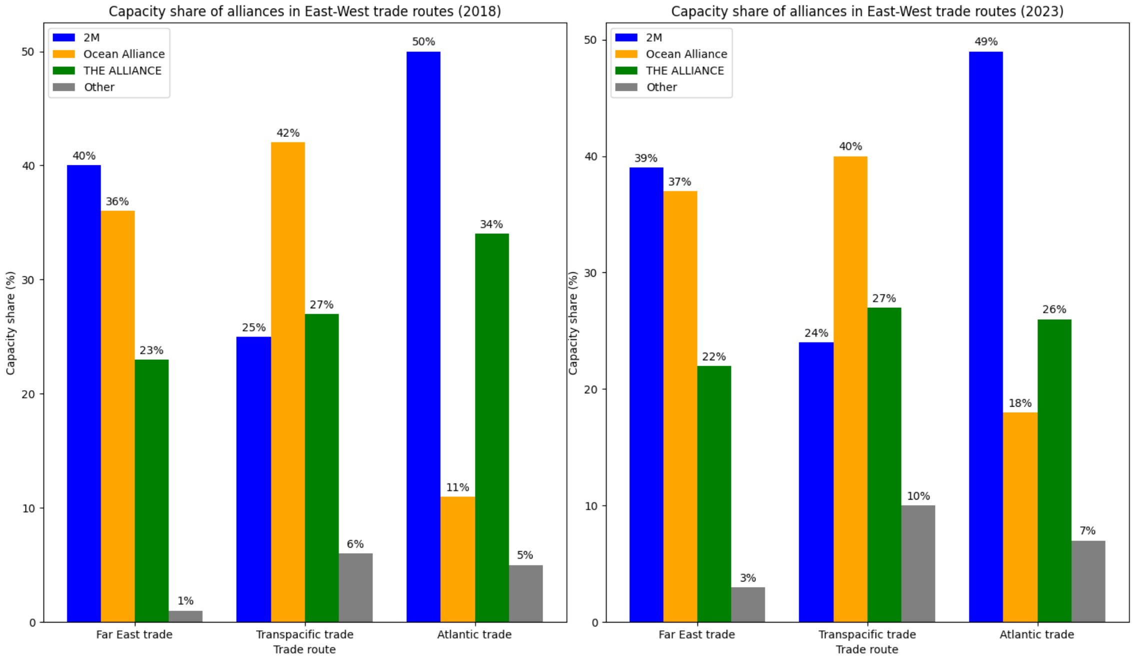

Figure 8.4.: Share of alliance capacity in East-West trade routes 2018 vs 2023 - Comparative analysis of the 2M Alliance with other alliances. Based on (Hapag-Lloyd, 2022)

Impact on smaller players

The high capital requirements and intense competition within container shipping have resulted in market dominance by only a few major shipping lines (Chao, 2017) The operational scale and extent of the market reach of big alliances such as 2M Alliance may make entry into the market by newer players or more minor players consideration difficult as they would confront considerable difficulties in competing with the cost efficiency or reliability of service of the alliance (ITF, 2018). However, smaller players could focus on specific niche markets and specialized services the big alliances might not target. This itself would bring in new segments within the industry to focus services on a small set of customer needs.

8.4 Implications of the discontinuation of the 2M Alliance and the beginning of "Gemini Cooperation": Reshaping competitive landscapes

The partnership between two shipping industry giants has come to an end. With the readjustment of global alliances starting in January 2025, Maersk and MSC will go their separate ways from the 2M Alliance to individually execute their strategies (Maersk, 2023).

At the same time, Hapag-Lloyd is set to leave THE Alliance so as to form the new alliance called "Gemini Cooperation" with Maersk. This change can be regarded as a strategic refocusing of the shipping industry against impending market challenges and opportunities arising from factors such as shifting trading patterns, digital transformation, and growing environmental regulation.

In a joint press release, both Maersk and MSC stated the following: *"MSC and Maersk recognize that much has changed since the two companies signed the 10-year agreement in 2015. Discontinuing the 2M alliance paves the way for both companies to continue to pursue their individual strategies. We have very much appreciated the partnership and look forward to a continued strong collaboration throughout the remainder of the agreement period. We remain fully committed to delivering on the 2M alliance's services to customers of MSC and Maersk"* (MSC, 2024).

This announcement represents a landmark change in the history of liner shipping that might shape the future strategies of either Maersk or MSC and those of their competitors. This implies, therefore, that in the liner shipping industry industry, strategic alliances are rather dynamic, with realignments evaluated whenever market conditions and company strategies change. In the past four years, all nine largest container liner carriers were members of three global alliances, with the latest South Korea's HMM joining THE Alliance in 2020. Maersk has already announced that following the dissolution of the 2M Alliance, it will be forming a new alliance with Germany's Hapag-Lloyd, to begin operating by February 2025. In contrast, the world's largest carrier, MSC, has not indicated wishing to form or join a new alliance within the sector. Indeed, MSC declared that it would revive its cooperation with Israel's ZIM through a vessel-sharing agreement for the Northern Europe to Eastern Mediterranean route. The new joint service replaces MSC's former standalone "Israel Express" service and the Northern Europe-East Med segment of ZIM's "ZIM Mediterranean ISC" service (Hamburg, 2024). Hence, what is more relevant is whether MSC will also decide to form another strategic alliance, join another existing coalition, or continue to operate independently.

At the moment, much is not known regarding the new alliance called "Gemini Cooperation" between Maersk and Hapag-Lloyd set to begin in February 2025. However, Maersk has already announced the desire for forming the new alliance with the following statement: *"In Ocean, normalisation on the back of COVID-19 was felt in the industry and in A.P. Moller - Maersk already in the second half of 2022, which continued throughout 2023 until the emergence of another supply chain crisis centred around the Red Sea. Customers' business needs are evolving, and the need for supply chain resilience and stability has never been greater. The Red Sea crisis is another proof point, following the supply chain disruptions experienced during COVID-19. In 2023, as the Ocean indus-*

try entered into a new chapter characterised by a deteriorating supply-demand balance, managing operations and improving EBIT margins became a sharp focus for the company. This required frequent and active adjustments of deployed capacity, while ensuring adequate and flexible access for customers to high-quality and reliable Ocean products. That is why the company is designing a best-in-class ocean network that will offer an industry-leading combination of reliability, speed to market and geographical reach, all while continuing to support decarbonisation and the company's goal of being net-zero in the future. To deliver this network, A.P. Moller - Maersk has entered a long- term operational collaboration with Hapag-Lloyd, the 'Gemini Cooperation', to be implemented from February 2025, immediately after the conclusion of the current 2M Alliance. The new network design in combination with the launch of Gemini Coorporation represents an innovation that allow A.P. Moller - Maersk to continuously evolve to meet customer needs, while maintaining a disciplined approach to CAPEX and keeping the company's fleet around 4.3 million TEU" (Maersk, 2024).

9 Discussion, conclusions and recommendations for future research directions

9.1 Answering the posed research questions

This thesis has critically examined the market dynamics competition as well as the role of horizontal and vertical cooperation within the framework of cooperative game theory in the liner shipping business with a focus on strategic alliances. Chapter 1 included the introduction to liner shipping, chapter 2 provided a comprehensive review of the relevant literature for this thesis and chapter 3 included the employed research methodology. Chapter 4, chapter 5, chapter 6, chapter 7 and chapter 8 tried to answer the main objectives of the research.

1. Influence of market conditions on liner shipping service networks and carrier strategies (RQ1)

To what extent do market conditions, i.e., demand fluctuations and price competition, influence the stability and structure of the liner shipping service network and how do carriers navigate such complex market dynamics?

Chapter 4 applied the Cournot competition model to two major liner carriers Maersk and Hapag-Lloyd, thereby elaborating on the dynamics of market competition in the liner shipping industry. The results indicate that for both companies to fuel and improve their market position, strategic alliances, cost management, and capacity optimization are even more crucial. These insights could be of use in deciding appropriate fleet expansion, cost-reduction strategies, and strategic cooperative arrangements. In addition, both freight rate and containership deployment analysis assume that shipping firms may try to position themselves properly when making strategic responses to the changes in market conditions; strategic alliance is one of the most important aspects in shaping these dynamics.

2. Formation, sustainability, and dissolution of strategic alliances (RQ2)

What are the main drivers behind strategic alliances' formation, sustainability, and dissolution in liner shipping, and how could these be explained by cooperative game theory?

Chapter 5 elaborated on the role of horizontal cooperation by discussing the motivations for shipping companies to participate in strategic alliances. Besides that, the concept of the Shapley value was applied to evaluate shipping companies' contributions within strategic alliances. Shapley values were computed with respect to total TEU and the total number of ships, giving a fair share for the total gain obtained by the coalition. The application of Shapley values across global shipping alliances explains the complex landscape of cooperation and competition. Although alliances distribute some operational benefits, disparities in contributions can result in uneven distributions of power and influence, possibly destabilizing such cooperative arrangements. What can be considered as the biggest value of strategic alliances is probably not the actualization of some efficiencies, but the intangible benefits that give enhanced reach of markets, shared technological advancement, and collective bargaining power.

3. Operational efficiencies and inefficiencies of vertical cooperation (RQ3)

What are the operational efficiencies and inefficiencies associated with vertical cooperation within liner shipping alliances?

Chapter 6 evaluated the vertical cooperation in liner shipping alliances and observed that, contrary to expectations, time spent in port by a vessel is not influenced much by its membership in an alliance. This finding goes against the presumed operational efficiencies often associated with strategic alliances, such as the use of even larger cranes, better scheduling, and other factors that should result in quicker loading and unloading times. Further, this lack of impact on port time challenges successfully the conventional wisdom that alliances inherently bring faster operations through improved coordination and resource sharing. These results underline the complexity of the impacts of alliances in liner shipping and introduce more sophistication into the understanding of how theoretical alliances perform in practice. They will also guide future strategic decisions in the industry, especially with regard to the reassessment of expected benefits from vertical cooperation within these alliances.

4. Impact of technological, environmental, and regulatory factors (RQ4)

How do developments in technology, environmental regulations, and international trade policies affect the strategic choices of companies in liner shipping alliances?

Chapter 7 discusses the technological, environmental, and regulation factors influencing the liner shipping service network. It is clear that forming alliances might help shipping companies share the burden of technological investments, be more efficient in complying with regulations, and implement trade policies jointly. Specifically, such factors are key drivers of liner shipping service network dynamics and support the strategic decision-making process—from the non-cooperative game theory—where firms self-dependently navigate highly complex challenges with an effort to optimize their position. The broader implications for the industry put emphasis on continuous adaptation and strategic planning by liners in response to the evolving technological, environmental, and regulatory landscapes.

5. Implications of the 2M Alliance's discontinuation (RQ5)

How might the dissolution of the 2M Alliance affect the competitive dynamics and market positioning of participating carriers?

Finally, chapter 8 is a case study of the 2M Alliance, highlighting the influence it has had on the container shipping industry. This section in particular reviewed operational strategies for the 2M Alliance, its effect on competition and market dynamics, and, most importantly, possible implications regarding its discontinuation in early 2025. Official announcements from Maersk and MSC provide further clues on the reasons behind the alliance's ending. Future researchers may be interested in focusing on the strategic decision-making process of both forming and dissolving alliances, with the 2M alliance, in particular, which can often be driven by the influence of emerging technologies, international regulatory frameworks, and environmental standards. Understanding such influences is very instrumental in making out the broader context for the strategic decision-making process within the shipping industry.

Future researchers may be interested in focusing on the strategic decision-making process of both forming and dissolving an alliance since this can often be driven by influence of emerging technologies, international regulatory frameworks and environmental standards. Understanding such influences is very instrumental in making out the broader context for the strategic decision-making process within the shipping industry.

9.2 Mapping content to research questions

Chapter	Main content	Addressed research questions
Chapter 4: Market dynamics and competition	Analysis of Cournot competition model for Maersk and Hapag-Lloyd, including Maersk's decision tree analysis for strategic options	RQ1: Influence of market conditions on liner shipping service networks and carrier strategies
Chapter 5: Horizontal cooperation	Evaluation of contributions within strategic alliances using Shapley values, exploring the formation, sustainability, and dissolution of alliances	RQ2: Formation, sustainability, and dissolution of strategic alliances
Chapter 6: Vertical cooperation	Analysis of vertical cooperation, focusing on operational efficiencies and inefficiencies in terms of port operations and vessel utilization	RQ3: Operational efficiencies and inefficiencies of vertical cooperation
Chapter 7: Technological and environmental factors	Influence of technological advancements, environmental regulations, and international trade policies on strategic decision-making in liner shipping alliances	RQ4: Impact of technological, environmental, and regulatory factors
Chapter 8: 2M Alliance case study	Strategic impact and implications of the 2M Alliance's discontinuation	RQ5: Implications of the 2M Alliance's discontinuation

Table 9.1.: Mapping thesis content to research questions

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For this reason, I am highly indebted to the collective effort and support that this thesis has received.

A Appendices

A.1 Appendix A: Abbreviations

AE	Asian-Europe
GT	Game Theory
EBITDA	Earnings Before Interest, Taxes, Depreciation, and Amortization
ECLAC	Economic Commission for Latin America and the Caribbean
TEU	Twenty Feet Equivalent
IMO	International Maritime Organization
IoT	Internet of Things
UNCTAD	UN Trade and Development
VSAs	Vessel Sharing Agreements

Table A.1.: Shipping carriers and their alliances as of April 2024. Based on (Alphaliner, 2024)

Alliance	Company	Total TEU	Total Ships	Owned TEU	Owned Ships	Chartered TEU	Chartered Ships
2M Alliance	Mediterranean Shg Co.	5,800,497	812	2,843,119	516	2,957,378	296
	Maersk	4,260,497	696	2,536,955	339	1,723,717	357
	Total	10,060,994	1,508	5,380,074	855	4,681,095	653
THE Alliance	Hapag-Lloyd	2,053,508	281	1,232,576	124	820,932	157
	ONE	1,871,144	235	783,644	92	1,087,500	143
	HMM Co Ltd	786,131	71	382,087	38	221,087	13
	Yang Ming	795,436	73	585,632	40	209,804	33
	Total	5,506,219	660	2,983,939	294	2,339,323	346
Ocean Alliance	CMA CGM Group	3,658,527	628	1,857,677	259	1,800,850	369
	COSCO Group	3,100,745	490	1,783,430	187	1,317,315	303
	Evergreen Line	1,671,007	216	987,773	131	683,234	85
	Total	8,430,279	1,334	4,628,880	577	3,801,399	757

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