Synergies in Liner Shipping

Integrating Quantitative and Qualitative Analysis in the Partnership Decision

Master Thesis

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TU Delft

Synergies in Liner Shipping

Integrating Quantitative and Qualitative Analysis in the Partnership Decision

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Summary

Liner shipping companies engage in strategic cooperation to deal with the market's overcapacity, capital-intensiveness and volatile freight rates. However, these partnerships do not reach their full potential and have lowered the level of service in the industry. To identify how carriers would be able to realise further synergies, this study has investigated the current performance of liner shipping companies and developed a model to identify and assess potential partnership opportunities. This model supports liner shipping companies in their decision of who to partner with and what kind of partnership to pursue.

The study has been confined to a single transpacific route. On the basis is an overview of vessels that sail this route over a period of several years. This overview includes information on arrival dates, number of containers on board, capacity and operator for each vessel. This is used to examine local demand and deployed capacity, vessel utilisation and competition. The analysis confirms trends found in literature, such as the growing size of vessels that are enabled by strategic cooperation. Most importantly, it indicates flexibility on the side of vessel operators in their decision of which vessels they deploy per route during the year.

A synergy model has been developed based on the findings in literature and the results of this analysis. This model uses the identified flexibility in vessel deployment and builds on the notion that liner shipping companies should pursue more integrated partnerships to realise further synergies.

The model was also applied to the case of CMA CGM's acquisition of APL in 2016. After calculating the costs for sailing each of the available vessels, potential partnerships were identified for the analysed route. This was done by optimising vessel deployment for the cargoes to be transported at minimum cost and with a limited number of partners. A strategic-level assessment was then performed to determine whether a partnership would be feasible among the identified companies and to what extent integration should take place. By including both the companies' motivations (drivers) and factors that facilitate a positive environment (facilitators) for the partnership, this assessment brings multiple perspectives to the table.

The conclusion is that carriers can adjust which vessels they deploy to match transport demand and that they can use this to realise further synergies. By using a model with both a quantitative and a qualitative component, it is possible to identify potential partnerships that result in cost reduction, maintain high vessel utilisation and allow for improvements in the level of service that companies offer to their customers.

It is recommended to extend the coverage of the model to include more routes, ports and vessels for a more comprehensive analysis. Furthermore, using variable transit times in the model to determine when vessels are available would make the model more realistic and would also allow changes in vessel speed to be included in the analysis. It is also advised to explore opportunities for regulatory bodies to apply this model for monitoring and assessment of the effects partnerships have on competition per route.

Preface

This thesis is written as my final project for the degree of MSc. in Marine Technology with the specialisation in Shipping Management at the Delft University of Technology. With this thesis comes an end to my time in Delft, which has brought me many memorable moments and great friends.

Many thanks go out to my university supervisors Koos Frouws and Edwin van Hassel, who have read many versions of this report and have helped me along greatly with their enthusiasm and advice. I would also like to thank my colleagues from EY, who have really made me feel part of the team. Special thanks go to Melissa for stepping up as my mentor and for all the geeky moments we had. I am also very grateful to my parents, Niels, Hans and Wouter for their input and support.

P. T. Janzen
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Introduction

1
Introduction

Liner shipping companies provide a regular service for container transport overseas along predetermined routes. To guarantee fixed and frequent sailing schedules with a broad geographical reach, liner shipping companies require many ships. This, combined with investments in infrastructure and additional assets, makes the liner shipping industry very capital intensive. The industry is also characterised by overcapacity. To be able to respond quickly to a growth in demand, some excess capacity is standard in the industry. However, the vessels must adhere to their fixed schedule and depart even if the vessel is not completely full. As a result, liner operators lower their freight rates to keep the filling rates of their vessels stable, especially in times of low demand (as has been the case since the economic crisis of 2008). At the same time, the companies have also been investing in larger and more fuel-efficient ships. This allows them to reduce costs, but also increases the market's overcapacity even more. What results from this capital intensiveness, overcapacity and volatile freight rates is strategic cooperation among liner shipping companies. By working together in the form of alliances or mergers, they strive for synergies that allow them to keep their operations running at low costs.

However, actually achieving the potential synergies has been proven a complex task. Alliance formations frequently change, mergers do not bring the desired results and the level of service in the industry has been drastically reduced. For that reason, the objective of this research is to develop a general consultancy model that analyses operational synergies resulting from strategic cooperation and that identifies partnership opportunities in terms of cost reduction and improved service levels. It aims to include operational and tactical information from liner shipping companies in the strategic decision of who to cooperate with. The kind of cooperation considered is limited to different levels of horizontal integration, meaning that the focus is on cooperation between companies belonging to the same industry. The consultancy background of this model implies that it must be able to assess many different companies, as opposed to presumably more detailed company specific models.

The structure of this report is as follows. Chapter 2 starts with an overview of existing literature. The report is then split into two parts. The first part concerns an analysis of the performance of liner shipping companies and is spread over Chapters 3-5. The second part focuses on the synergy model that has subsequently been developed and consists of Chapters 6-10.

The investigation into the performance of carriers was based on the main findings from literature and provides better understanding of the behaviour of liner shipping companies. The method used for this analysis is described in Chapter 3, followed by the results in Chapter 4. The conclusion of Part 1 is then given in Chapter 5. The second part of the report begins with the method adopted for the synergy model in Chapter 6. The model that is developed consists of a quantitative, tactical-level part, explained in more detail in Chapter 7, and a qualitative, strategic-level component that is presented in Chapter 8. After this, a case study is used as an illustration and to assess the usability of the model. Chapter 9 presents the results of the case study. The conclusion of Part 2 is provided in Chapter 10. Finally, a discussion of the analysis and conclusion for the entire study are presented in Chapters 11 and 12 respectively.

2

Literature Review

A review of existing literature is performed for further understanding of the liner shipping industry, its market characteristics and the issues that cause challenges for liner shipping companies. As it turns out, strategic cooperation plays an important role in the industry. The reasons for this are explored, as well as how successful previous efforts to achieve synergies have been.

2.1. Liner Shipping Industry

Three different types of shipping can be distinguished: industrial, tramp and liner shipping (Lawrence, 1972). In industrial shipping, cargo owners have their own vessels to transport their goods. For tramp shipping, cargo is negotiated for every journey, resulting in an unstructured sailing pattern (Stopford, 2009). Liner shipping on the other hand, is performed by vessels operating according to a predetermined and fixed schedule with a structured sailing pattern (Christiansen et al., 2004). Reliability is an important factor in the liner shipping industry and the liner shipping companies must adhere to their fixed schedule (Stopford, 2009). This means that liner services promise to depart according to their schedule regardless of whether the ship is full (Agarwal and Ergun, 2010).

Containerisation and globalisation have led to high growth in the shipping industry. In the 1970s, the use of containers to transport cargo reduced shipping costs, decreased the amount of damaged or lost cargo and improved ship utilisation (Christiansen et al., 2013). Furthermore, international trade increased due to globalisation, leading to higher world trade volumes. Development of the economy and how regions interact with each other can be measured in gross domestic product (GDP) (Hübner, 2016). Because of the higher world trade volumes, the industry's growth even exceeded the growth of world GDP (Guerrero and Rodrigue, 2014). In 2015 however, the growth in container demand was lower than world GDP growth, which did not happen before (BCG, 2016).

The market structure under which a firm operates determines its behaviour (Sys, 2010). The liner shipping industry is a challenging market environment because of its irregular market cycles, imbalances in supply and demand, high capital intensity and the high level of consolidation (Rau, 2017). Rapidly changing customer requirements, the increasing size of container vessels, advances in information technology and increasing competition also contribute to a fast-changing and complex competitive environment (Sys, 2010).

2.1.1. Market Cycles

In the shipping industry, supply is made up of the transport capacity offered by the shipping companies (Hübner, 2016). Demand is the amount of cargo to be transported by sea. The shipping cycle can be described as a mechanism to balance supply and demand for ships (Hampton, 1991).

The shipping market shows three types of market cycles: the long cycle (20-30 years), driven by technical, economic or regional change, the short shipping or 'business' cycle and seasonal cycles of yearly occurring fluctuations on the demand side (Stopford, 2009). The long-term cycles are less relevant for shipping investments, because their length exceeds a vessel's economic life and seasonal cycles are less challenging because they occur on a yearly basis and are therefore relatively predictable (Hübner, 2016).

The 'business cycle' is mostly driven by supply and is the most challenging and influential in the shipping business. This cycle displays four stages: market trough, recovery, market peak and collapse (Hübner, 2016;

Stopford, 2009). Despite the periodicity of these stages, their duration is extremely irregular and predictions are difficult to make, which increases the financial risk for liner shipping companies (Stopford, 2009). When the shipping cycle is at a peak, transport demand is greater than supply and freight rates are high. As a result, ship owners invest in extra capacity, driving excess demand and freight rates down. Because freight rates are constantly adjusted in response to changes in the balance of supply and demand, they are extremely volatile (Stopford, 2009). Furthermore, the price of long-distance container shipping demand is inelastic since no substitutes are available at a comparable cost (Rau, 2017).

2.1.2. Overcapacity

Demand changes faster than supply and new ships add large amounts of capacity to the industry (Brooks, 2000; Fusillo, 2003; Stone and Saxon, 2017). This creates a major challenge for the industry. Because of the relatively fixed supply, liner shipping companies operate with almost permanent excess capacity (Fusillo, 2004). Furthermore, building new vessels always takes several years, which causes large capacity delivery in times of low demand from vessels that were ordered when rates were good (Hübner, 2016; Rau, 2017). This results in an even larger overcapacity in the market trough, leading to even lower freight rates.

There has been an overcapacity in the liner shipping market since trade demand declined during the financial crisis of 2008. Currently, supply is 20% greater than demand (**?**). Forecasts suggest that this gap will close in the 2020s at the earliest, though probably even years after that (Drewry, 2018; **?**). Due to the market's overcapacity, the liner shipping industry is characterised by a low profit margin. In an attempt to increase vessel utilisation (and thereby reduce unit cost), Liner shipping companies lower their margins by driving down freight rates (Koza, 2017). Another reaction seen in the industry is the concept of 'slow steaming', where carriers lower the sailing speed of the vessel to save on fuel costs, even though this increases transit times and thus requires more vessels for the same level of service (Cheaitou and Cariou, 2012).

2.2. Strategic Cooperation in Liner Shipping

In these harsh market conditions, it is important for liner shipping companies to optimise their operations for highest efficiency. To achieve this, liner shipping companies apply aggressive growth strategies (Satta et al., 2013). Organic growth through investments in new vessels and chartering arrangements is considered too slow in the volatile market (Brooks, 2000). As a result, many liner shipping companies prefer external growth through mergers and acquisitions (M&A) and strategic alliances (Cariou, 2008; Heaver et al., 1999).

2.2.1. Levels of Decision Making

Decisions on how to move forward with the company are made by management. Management decisions can be divided into three levels: strategic, tactical and operational Lee and Song (2017). On a strategic level, decisions on the types of resources are made. These decisions generally have a long time horizon. Strategic level decisions have a large impact on a company's operations and deviating from strategic decisions or plans is therefore also the most difficult and costly of the three decision levels. In liner shipping, examples of strategic issues are fleet sizing and the design of maritime logistics systems Christiansen et al. (2004). At a tactical level, decisions are made on how to deploy these resources identified in the strategy. For liner shipping companies this is, for example, the task of fleet deployment, where they assign vessels to routes Christiansen et al. (2004). The lowest level of decision-making is the operational level. This level involves decisions on the daily operations of resources and therefore also has a time span of only a few days. An example of this is cargo booking: which cargoes to accept or reject for a given voyage Christiansen et al. (2004). Looking at these levels of decision-making, it can be found that the decision to join an alliance or to partake in M&A activities is also strategic. However, there is always some interdependence between the levels, so the tactical and operational levels can still influence the strategic one. When determining the expected synergies from the cooperation between two potential partners, it can be said that including the day-to-day operations is too detailed. However, the operational data can be used on a tactical level, the results of which can then subsequently serve as input for strategic decisions.

2.2.2. Operational Synergy

In these collaborations, synergies are pursued. Synergy is defined as the additional value that is generated by combining two firms, creating opportunities that would not have been available to these companies operating independently (Damodaran, 2005). Operational synergies focus on the operations of firms specifically, increasing profits from existing assets and/or increasing growth (Damodaran, 2005). Higher profits can be realised by increasing revenues or by reducing costs. Through the ability to offer services on additional routes, a liner shipping company's market position improves and opportunities for extra revenue arise (Alexandridis and Singh, 2016). These are called revenue synergies. Methods to generate higher revenues are in general increasing the price per unit and increasing the number of units sold. In the liner shipping industry, freight rates are extremely volatile due to high competition and the market's overcapacity, so increasing prices is not a feasible strategy. Furthermore, the in-elasticity of shipping demand makes reducing freight rates unlikely to lead to higher cargo volumes (Tran and Haasis, 2015a). Increasing the amount of cargo transported is another way to increase revenues. In the current market, the vessels are sailing with excess capacity. The amount of cargo transported is thus not physically limited by operations, but is more likely the result of firms' commercial decisions (e.g. sales and marketing) (Stopford, 2009).

It is also possible to increase profits from existing assets by reducing operating costs. A large portion of the total cost base is made up of operating costs. Brooks (2000) found operating ratios (operating expenses as a percentage of revenue) for liner shipping companies of 85-100% in 1991-1995. More recent annual reports for 2017 show that operating ratios have improved, but are still high. Maersk has a relatively low value of 55% (Maersk, 2017), but other large operators have their operating ratios around 80% (CMA-CGM, 2017; COSCO Shipping, 2017; Hapag-Lloyd, 2017). These high operating ratios indicate that the carriers have relatively high operational costs. Cost synergies focusing on reducing costs, for example through efficiency gains, economies of scale and sharing resources and overhead costs, are thus important to explore (Alexandridis and Singh, 2016).

2.2.3. Cost Structure of a Liner Shipping Company

As reducing costs seems the most feasible measure for increasing profits, the areas where cost synergy would be possible need to be determined. For this, the structure of costs for carriers is first described, as well as factors influencing the composition of these costs for different vessels. The cost factors that can be used in the synergy model are then identified.

Table 2.1: Types of costs (Stopford, 2009).

1.	Running costs	Manning, stores, maintenance, administration
2.	Voyage costs	Fuel, port charges, canal dues
3.	Cargo-handling costs	Loading, stowing and discharging cargo
4.	Periodic maintenance costs	Major repairs in dry-dock, special survey
5.	Capital costs	Initial purchase, periodic cash payments to banks or equity investors

In liner shipping, operators face five main types of costs, as given in Table 2.1. When looking at these costs and their relation to unit costs, distinguishing between fixed costs (4 & 5) and variable costs (1-3) is important. The variable costs can be further divided into trip-related (1 & 2) and cargo-related costs (3) (Ting and Tzeng, 2003). These costs are often translated to unit costs as a measure of cost efficiency. The aim is to have the lowest possible unit costs, as this leads to the largest profit per container. The main costs influencing the unit costs are the fixed and the trip-related variable costs, which have to be paid regardless of how much cargo is transported during the trip (Stopford, 2009). Furthermore, if a vessel is not actively operated, it is said to be laid-up, In this case, the fixed costs and costs for lay-up of the vessel (often including keeping the ship ready for fast recommissioning) still have to be paid (Heaver, 1985).

Capital costs are relatively high in the liner shipping industry. This capital intensity can be explained by the required investments in expensive assets and the long pay-back time on these investments (Agarwal and Ergun, 2010; Notteboom, 2004; Rau, 2017). The need to offer a regular service with large global reach makes the investment needed even higher, because companies need many assets (Cariou, 2008; Lee and Song, 2017). The number of vessels required per liner service route depends on the frequency of the service. The number of vessels needed to operate a service line can be determined by dividing the duration of sailing the entire route by the sailing frequency (Agarwal and Ergun, 2010). Even though trip duration can take up to multiple weeks, a weekly departure is nowadays the norm for liner services, which means the number of ships needed equals the number of weeks needed to sail the entire line (Koza, 2017).

2.2.4. Cost Reducing Efforts

Several methods in which liner shipping companies are trying to reduce costs can be identified. Most important are the increasing size of vessels and the efforts to reduce fuel consumption. In general, the aim is to reduce unit costs, which are the average costs associated with transporting one Twenty-foot Equivalent Unit (TEU), or the equivalent of a 20-foot long shipping container.

Increasing vessel size Literature widely acknowledges that the average size of containerships has increased significantly over time. Reason for this is the pursuit of economies of scale by liner shipping companies. This entails reduction of unit costs by sailing with larger vessels. The average unit cost decreases as vessel size increases, because the relation between capital, running and maintenance costs and ship size is less than proportional (Agarwal and Ergun, 2010). However, several drawbacks of the increasingly large vessels are also identified in literature. First of all does the cost advantage from newer and fuel-efficient ships only last a short time, until the competition buys similar vessels (Brooks, 2000). Secondly, as all firms in the industry invest in larger ships, this creates even more overcapacity (Stone and Saxon, 2017). Furthermore, without sufficient asset utilisation, the economies of scale will become diseconomies of scale instead (Stopford, 2009; UNCTAD, 2014). Tran and Haasis (2015a) note that the unit cost advantage of a 14,000 TEU ship will become a disadvantage at 60% utilisation compared with a 100% utilised 4000 TEU vessel. They estimate that a 10% decrease of vessel utilisation will drive up unit cost by 5.3%. A solution for higher utilisation would be for liner shipping companies to rearrange their services to consolidate more cargo in major ports, but this means offering less direct routes and thus lowering service quality (Koza, 2017). In addition, research by Ha and Seo (2017) into influences on carriers' profits has indicated that the effects of economies of scale are only minor. Sys (2010) also notes that vessels with a size optimal for one trade may be suboptimal for another, especially in relation with vessel size and cargo-handling restrictions in ports.

Reducing fuel consumption Another reason for liner shipping companies to be investing in new vessels despite the market's overcapacity is to increase their vessels' efficiency (Sanders et al., 2015). More fuel-efficient ships do not lower the capacity on the market when they replace older vessels, but they reduce fuel costs, the most significant element of liner shipping companies' operating costs (Ha and Seo, 2017; Rau, 2017). This reduction can be achieved through advancements in technology that result in more fuel-efficient machinery, but also by designing the vessels for a lower service speed. Lowering the sailing speed of a vessel leads to reductions in fuel consumption, which is caused by the reduction of added water resistance (Stopford, 2009). Figure 2.1 shows the fuel consumption for different speeds for the different vessel sizes. A lower sailing speed is thus already a fuel cost-reducing measure for vessels that were originally designed for higher speeds. This cost reduction is even higher for vessels with their design optimised for these lower speeds, as is the case in the newest generation of vessels. Unfortunately, also the measures for reducing fuel costs are not ideal. For one, the lower sailing speed means that more vessels are required to offer the same level of service to the customers (i.e. to keep the same sailing frequency). The quality of service is further reduced by the cargo's increasing transit time, which results in higher inventory costs for the customer (Kontovas and Psaraftis, 2011). Another point to note is the inability of these newer vessels to speed up in case market conditions improve (Merk et al., 2015).

2.2.5. Forms of Cooperation

As mentioned in the beginning of this chapter, the liner shipping industry's market conditions call for external growth strategies for carriers. This involves both participating in alliances and partaking in M&A, which are discussed subsequently.

Alliances Participating in an alliance is a strategy often adopted by liner shipping companies. Alliances are a form of operational cooperation, as the alliance members remain separate companies with their own management, sales and marketing departments and assets, but integrate their operations (Stopford, 2009; Sys, 2010). Today, the majority of alliances are still based on Vessel Sharing Agreements (VSAs), which focus on optimising members' unit costs and network reach (Sanders et al., 2015). Firms pool a part or all of their assets in the alliance and the alliance members share the capacity on these vessels (Brooks, 2000). Capacity allocation to each member corresponds to the proportional share of capacity it is providing to the alliance (Quartieri, 2017). This allows the members to realise economies of scale, extend their customer base and increase asset utilisation, while also being able to offer more frequent sailings and shorter transit times without large investments (Agarwal and Ergun, 2010; Cariou, 2008). The incentives for carriers to join alliances can differ per company size (Caschili et al., 2014). For these alliances to be sustainable, mechanisms to manage interactions and benefit and loss sharing are important, as well as having an efficient network (Agarwal and Ergun, 2010).

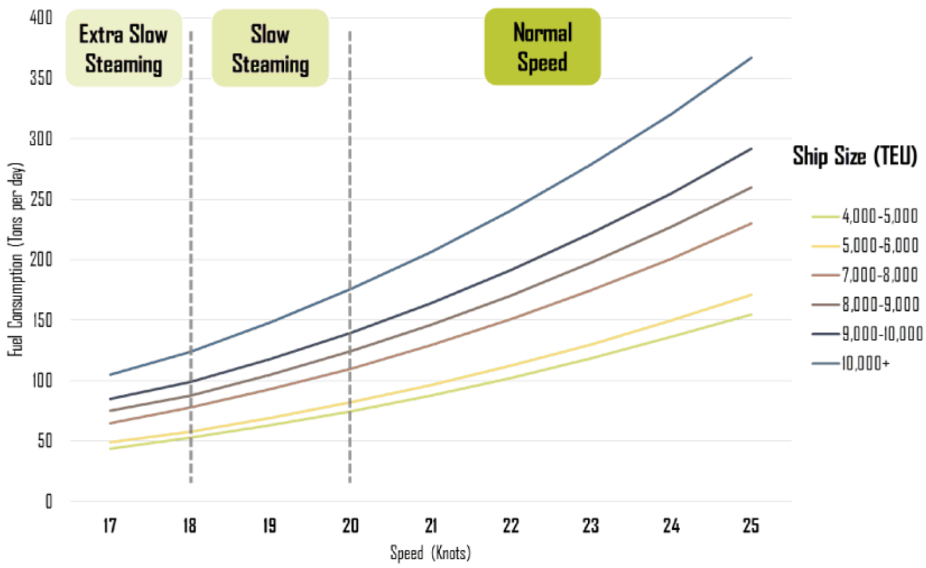

Figure 2.1: Relation between speed and fuel consumption (Rodrigue et al., 2017).

The first alliances were formed in 1994-1996, but instability of the alliances led to reorganisation only a short time afterwards (Song and Panayides, 2010). For example, P&O and Royal Nedlloyd Lines were in competing alliances, but decided to merge in 1997. Today's main alliances are THE Alliance, 2M and Ocean Alliance. The top 8 liner shipping companies of 2018 are all in one of these three alliances (Clarkson Research Services Limited, 2018).

Mergers & Acquisitions Another method of strategic cooperation are M&A, which involve full-scale cooperation (Sys, 2010). A merger is an occasion where two companies join together to make a larger company (Cambridge Dictionary, b). An acquisition is when a company is bought by another company (Cambridge Dictionary, a).

There has been much consolidation in the liner shipping industry, which has also lead to increased concentration and a higher degree of oligopoly of the market (Sys, 2010). Ten of the top 20 carriers in 2013 will soon no longer exist as stand-alone companies, with six having merged with larger peers, one bankrupt and three forming a joint venture together (Saxon, 2018). The global liner shipping market is currently dominated by a few major players: the top 10 liners claim two-thirds, whereas the top 20 liners own nine-tenths of the market (Lee and Song, 2017).

Integration of two companies is considered horizontal if the companies belong to the same industry. This implies that the shipping network becomes broader and more complex because of the growth of company size and interaction between different networks of shipping lines (Tran and Haasis, 2015b). In case the companies are in different parts of the supply chain, it is called vertical integration (Van de Voorde and Vanelsander, 2009). Both types of integration are a means to internalise and reduce the risks and costs associated with the transaction (Brooks, 2000).

On the subject of M&A in liner shipping, literature often focuses on the motives for this form of cooperation: cost reduction, increased revenue opportunities, economies of scale and increased market share (Heaver et al., 1999; Panayides and Cullinane, 2002). In the case of Hanjin, it was found that conflicts of interest, slow decision making and inflexibility were reasons for mergers among alliance members (Thanopoulou et al., 1999). Main advantages of M&A are streamlined organisation structures and far less day-to-day operational complexity (Sanders et al., 2015). Alexandridis and Singh (2016) add to this that acquisition of assets and fleets is often sufficient to realise synergies, removing the need to carry out more complex deals that involve full-scale integration. Besides the risks associated with integration, value misperception and ownership structures make integration difficult (Sanders et al., 2015). The importance of an adequate M&A process is stressed by Alexandridis and Singh (2016) and Saxon (2018).

2.2.6. Success of Strategic Cooperation in Liner Shipping

The possible advantages of alliances and M&A have not been realised in practice (Brooks, 2000; Panayides and Cullinane, 2002). The findings of Sys (2010) in terms of market-share and profits support this. Brooks (2000) lists the focus on the deal instead of the actual integration, rushing the deal and using mergers or alliances as a strategy in itself instead of a means as main reasons for failures. What is more, companies appear to choose the same strategy repeatedly, which may cause them to prefer alliances over mergers (or vice versa), even if circumstances have changed in the other strategy's advantage (Das, 2011).

In alliances, instability of the agreements is often named as a major factor for frequent alliance failures and reorganisations. This instability results from several factors. Firstly, combining operations is a complex task due to the constantly changing market conditions and the large global scale of services (Midoro and Pitto, 2000). Secondly, there are many different parties involved, each with their own culture, processes and strategies (Song and Panayides, 2010). Another reason for alliance instability is that competition between the members still exists within the alliances (Koza, 2017).

Furthermore, analysis indicates that operational motives are more important than strategic motives in a company's decision to partake in an alliance (Panayides and Wiedmer, 2011). Alliances are formed for specific lines based on current market conditions and service agreements and are changed continuously following fluctuations in supply and demand (Panayides and Wiedmer, 2011). These fluctuations are unavoidable in the shipping industry, which implies that it is difficult to achieve a stable shipping alliance in practice (Song and Panayides, 2010).

Success of M&A in liner shipping is also limited. Operational and revenue synergies that result from combining two companies can lead to cost savings of 3-6% of the total cost base. However, this may take a large investment, include unwanted business and regulatory bodies may prevent it. Furthermore, revenue dilution from customer overlap, service failure and customers' spreading their risks lowers the actual profits (Saxon, 2018).

When comparing the two types of strategic cooperation, it is noted that M&A and alliances offer different strategic advantages and that both lead to a competitive advantage (Brooks, 2000). The extent of redundant resources, the nature of these resources and the intensity of competition have been found to be important in the decision between the two, while market uncertainty and the level of synergy are less relevant for the choice between the types of cooperation (Das, 2011).

Most models developed for these analyses of how liner shipping companies cooperate are either based on quantitative or on qualitative methods. Quantitative studies on alliance formation mostly focus on the allocation of benefits and costs (Agarwal and Ergun, 2008; Song and Panayides, 2010) and on fleet deployment and network design (Lin et al., 2017; Zheng et al., 2015). Christiansen et al. (2013) give an overview of existing literature on liner network design and fleet deployment. They observe that most models focus on cost reduction, but also name a few studies that take the level of service into account Alvarez (2012), Meng and Wang (2011) and Wang et al. (2011). (Cariou, 2002) assigns vessels to minimise total cost with the constraint of service frequency and finds that the broader choice in alliances to allocate the most economical and suitable ships creates operational synergies. Another study on quantifying operational synergies has been performed by Gupta and Gerchak (2003). They focus their study on M&A and develop an expected profit function for the merged entity that could also be applied to vessel deployment.

Midoro and Pitto (2000); Slack et al. (2002) and (Thanopoulou et al., 1999) present qualitative studies on alliance formation and indicate the importance of strategic alliances in liner shipping. Midoro and Pitto (2000) also propose a solution for better cooperation. They suggest that differentiation in the contribution of each member could lead to increased synergies and conclude that alliances with fewer partners or led by a dominant partner are more likely to succeed. Very few other studies focus on how companies should find a good partner, despite the numerous studies analysing the factors for failing collaboration. A fuzzy multi-criteria decision model has been developed by Ding and Liang (2005) to select partners of strategic alliances. Furthermore, Douglas et al. (1996) do not focus on any industry in particular and provide a model that can be used to determine whether a partnership is warranted and if that is the case, how close of a partnership is warranted.

2.3. Level of Service

A major effect from the increased cooperation efforts in the liner shipping industry, both in the form of alliances and M&A, is the reduced level of service. The measures taken to reduce costs, increasing vessel size and lowering fuel consumption, both have a negative effect on the level of service. The larger vessels can physically enter fewer ports and cargo handling time increases. In addition, the slower sailing speed increases the cargoes' transit time and the same number of vessels offers a lower service frequency (Murnane et al., 2016). In theory, the results of these cost-cutting measures would be mitigated by strategic cooperation. Having more vessels available would allow lowering speed without reducing the service frequency and the larger vessels can be filled more easily by two parties instead of one. In reality however, liner shipping companies apply the earlier mentioned cost reductions, even when cooperating, to such extent that it leads to an overall lower level of service in the industry. Another consequence of increased cooperation is that container transport has become a commodity, meaning that there is no distinction anymore between the different parties that offer the service (Slack et al., 2002). Merk et al. (2018) mention that as parties cooperate more intensely, their different attitudes (for example towards timeliness) converge. The service level is further influenced by the number of parties involved in the partnership. With the many different partners seen in alliances, the liner shipping companies cannot provide the same amount of information to their clients about the shipments (Murnane et al., 2016). This is because they do not know with certainty on which vessel and to which terminal a cargo will be shipped.

2.4. Key Learnings from Literature

The liner shipping industry offers great challenges to its firms. The high capital intensity in combination with volatile freight rates and overcapacity makes it hard to survive. Increasing vessel sizes and slower sailing speeds are identified as the key measures taken by the industry to deal with the current market conditions. However, these solutions are still far from ideal. The advantage of using a larger vessel strongly depends on its utilisation level. Furthermore, lowering the sailing speed reduces fuel costs for that vessel, but requires more vessels for the same sailing frequency on the route and increases the cargoes transit time. From this perspective, it is clear why strategic cooperation is such an important factor in the liner shipping industry. However, insufficient connections between strategic, tactical and operational decision making lead to unsuccessful cooperation between firms.

II

Investigation in the Performance of Liner Shipping Companies

3

Method for Performance Assessment

3.1. Model Description

The liner shipping industry consists of a network of routes along which vessels transport cargo between ports. These vessels are operated by liner shipping companies, that offer their shining services according to a predetermined and regular schedule. Also, all major carriers are involved in strategic cooperation. To ensure that improvements for strategic cooperation formulated in this research are rooted in reality, an analysis of the current performance of liner shipping companies is carried out. This performance analysis includes how much cargo is transported and by which vessels, but also how companies' strategies may lead to differences among them and how this influences competition. The method used in this analysis is described in the remainder of this chapter.

3.1.1. Performance Indicators

To find out how companies are performing and how they respond to changes in the market, the amount of cargo transported, deployed capacity and freight rates have been analysed. Furthermore, vessel utilisation and market shares were calculated and examined. This was supplemented by information on the sailing frequency and the ports being visited for analysis of service levels.

Transported Cargo The amount of cargo transported is interesting on all levels of the industry. It can serve as a proxy for actual demand and it can be used to determine vessel utilisation levels and market shares.

Deployed Capacity Information considering the deployed capacity is also valuable, especially with the industry's characteristic overcapacity that was identified by literature. On vessel level, the capacity can be used in the calculation of utilisation rates. It can also provide insights on the strategies used by liner shipping companies for vessel deployment and dealing with changes in market conditions.

Freight Rates As described in literature, freight rates are in theory a balancing mechanism for supply and demand. As such, freight rates were studied as an indicator of how well this balance is achieved.

Vessel Utilisation Vessel utilisation is also an important parameter in the liner shipping industry. With fixed schedules and high trip-related costs, high vessel utilisation is important because the more cargo is on

Table 3.1: Information needed per voyage.

Vessel Information	Voyage Information
Name	Arrival Date
Capacity	TEU on board
Age	Ports on Route
Operator	

Table 3.2: Concentration index ranges for loose and tight oligopoly (Shepherd and Shepherd, 2003).

Index	Loose Oligopoly	Tight Oligopoly
CR4	<40%	>60%
HHI	<1000	>1800

a vessel the lower the costs per unit are. The utilisation rates are thus an indication of how well capacity is adapted to transport demand. The formula used for vessel utilisation is presented in Equation (3.1), which divides the total amount of TEU on board by the total TEU-carrying capacity of the vessel.

$$Vessel\ Utilisation = \frac{\#TEU}{Capacity} \tag{3.1}$$

Market Share Where the amount of transported cargo can be used for comparison in absolute terms, this does not represent changes in the market. A company transporting fewer containers may be the result of poor decision-making, but it is also possible that it improved its operations relative to other companies in the market, while total demand in the market declined. To also allow for comparison in relative terms, the market shares can be calculated according to equation (3.2), with TEU_x the total amount of TEU transported by company x and TEU_{total} the sum of all TEU transported by all entities.

$$Market\ Share = \frac{TEU_x}{TEU_{total}} \tag{3.2}$$

Sailing Frequency The frequency at which companies can offer sailing to their customers is an important aspect of the level of service. Counting the number of vessel trips in a certain period can thus be used as a measure of service level and can provide information on how it evolves over time.

Port visits Another factor that indicates the level of service to the customers is the number of port-to-port connections offered. This can be investigated by analysing the number of ports that are visited on a vessel's voyage. If vessels visit many ports during their voyage, this also means that customers' cargo can reach more destinations directly without any transshipments. With fewer ports on the ship's schedule, transit time and risks increase due to the extra transshipments needed to reach other ports.

3.1.2. Competition

The overview of vessel arrivals can also be used to analyse competition. This can lead to valuable insights into what drives certain kinds of behaviour from liner shipping companies. In very concentrated markets, for example, the focus is generally more on maximising profits than on offering a good service or product to the customer. The analysis of competition was done by means of growth rates per company in terms of market share and transported TEU, by calculating the Hirschman-Herfindahl Index (HHI) and by compiling concentration ratios. The formula used to determine the concentration ratios CR-4 and CR-8 is presented in Equation (3.3), with $n = 4$ and $n = 8$ respectively. The HHI is another concentration index that is useful, because it reflects top-firm market dominance (Shepherd and Shepherd, 2003). Its calculation is shown in equation (3.4), where n is the total number of operators. In both equations, s_i is the market share of the ith carrier. The factor $10,000$ in Equation (3.4) gives extra weight to the largest operators. Table 3.2 shows the ranges for the CR-4 and HHI for a '*loose oligopoly*', where collusion is unlikely and competition is effective, and a '*tight oligopoly*', in which collusion is likely and there is no effective competition (Shepherd and Shepherd, 2003).

$$CRn = \sum_{i=1}^{n} s_i \tag{3.3}$$

$$HHI = \sum_{i=1}^{n} s_i^2 * 10,000 \tag{3.4}$$

3.2. Data

The main input in this model is an overview of vessel trips with information on the items listed in Table 3.1. This overview is compiled by combining two sets of data: cargo data and vessel data.

Cargo data The cargo data consists of information from incoming shipments regulated by U.S. Customs and Border Protection's Automated Manifest System (AMS). All vessels carry a *'Bill of Lading'* which contains information on the cargo on board. Every year, a summary of all imported containers is published, including on which vessel and on what date the cargo arrived. For this study, the cargo data covers the years 2014-2017 and the first five months of 2018. Furthermore, because the data set consists of import records, it only includes information on the containers that are loaded, even though vessels may also carry some empty containers.

Vessel data The cargo data includes the name of the vessel on which the containers were transported. By matching these names with the World Fleet Register provided by Clarksons Research Services Ltd, vessel-specific data can be added to the containers. This includes ship types, the total capacity of the vessel, ship age, owner, operator and even former names.

3.3. From Data to Input

The Bill of Lading data from the U.S. import records provides information on container level. This information includes the arrival date, the port of lading, the port of unlading, the unique number of the container in which the cargo was transported and the vessel on which it arrived. This data is arranged in such a way that it becomes possible to say more on the vessels on the route and their operators. The steps taken in the process of translating the raw data into the format of vessel trips needed for the analysis is given in Figure 3.1.

Figure 3.1: Steps taken in translation from data to model input.

Data Cleansing Several data cleansing actions had to be performed on the cargo data set. First of all, the Bill of Lading data contains entries of imports that can be 'New', 'Amended' or 'Deleted'. Only the first two categories were used in the model. Furthermore, some entries in the Bill of Lading data were from vessels that are not container vessels. These vessel names were removed, as this model focuses solely on container vessels. Another difficulty arose for vessels that have been given a new name. For those vessels the old names were replaced by the new names to allow matching the Bill of Lading data with the vessel data. Furthermore, even though it is known on which vessel a container is transported, the Bill of Lading data set contains spelling and punctuation errors in the vessels' names. To minimise errors, the names were cleaned by removing spaces and punctuation and capitalising all letters. Numbers were not removed, for there are several vessels that have the same name with a unique number behind it. Unfortunately, there were still 36 vessels with a duplicate name in the resulting data set. Three different factors can help distinguish between vessels with identical name, These are the original spelling of the name before removing punctuation, the vessel status that indicates if the ship is active or idle and the owner group of the vessel. Table 3.3 provides an example for the vessel names "ALLEGRO" and "HONGKONGBRIDGE". In the case of "HONGKONGBRIDGE", the original spelling is enough to differentiate, because it shows that the removal of a blank space made the names equal. For "ALLEGRO", this is not possible, but one of the vessels has "idle" as status. In both cases, the owner group can also provide information through the Bureau of International Containers (BIC) codes of the companies. BIC codes are included in a container's unique number and indicate who owns it. At least the larger vessel op-

Table 3.3: Duplicate vessel names and distinguishing factors.

Name	Size TEU	Dwt	GT	Flag	Built	Month	Owner Group	Status	Original Spelling
ALLEGRO	868	11200	9990	Antigua & Barbuda	2004	5	Eicke Schiffs. KG	Idle	Allegro
ALLEGRO	366	4830	2986	St. Vincent & Grenadines	1996	12	Baltnautic Shipping	In Service	Allegro
HONGKONGBRIDGE	4050	50953	39941	Marshall Islands	2001	12	Sinokor Merchant	In Service	Hongkong Bridge
HONGKONGBRIDGE	8212	99214	98747	Singapore	2009	9	K-Line	In Service	Hong Kong Bridge

erators have their own containers, so identifying which company's BIC code is on a vessel in a large quantity will also give an indication of who operates the vessel.

Route selection For the performance analysis, a specific route was selected with the following considerations. First of all, the geographical area was kept as small as possible to keep computation time down. Secondly, with the data being U.S. import records, possible lines were limited to those with an origin outside the U.S. and with a destination on U.S. territory. A third consideration was the significance of the route in terms of transported volumes. The decision was made to focus on East-West trades, as transported volumes are much larger in that direction than for the North-South trades (Notteboom et al., 2017). Furthermore, Asian countries' exports are generally higher than their imports. This results in a trade imbalance, with more cargo to be transported away from Asia and less in the opposite direction. Some containers are transported while empty to compensate for such trade imbalances. As these empty containers are not included in the U.S. import records and with the assumption that the number of empty transports is minimal on the positive side of the imbalance, it was decided to focus on a transpacific route. Finally it was considered that a route with neighbouring ports would provide extra flexibility to the model. As a result, the port pairs of Shanghai/Ningbo in China and Los Angeles/Long Beach on the U.S. West Coast (U.S. WC) were selected for the analysis.

Vessel Arrivals Once the route was selected, the next step was to determine which vessels carried containers that were transported between the chosen ports, because this indicates that the vessel made calls to those ports. In the data set, the registered arrival date corresponds to when the container was processed, which is not necessarily equal to the arrival date of the vessel. By counting the number of unique containers per day for every vessel, it was possible to identify days on which vessels had arrived, because on those days the total number of containers was much larger than on previous days. The total amount of cargo on the vessels at their port arrival was then determined by adding the containers on the day of arrival and the containers of all days following that arrival and preceding the next. With the route given for this study, the data set was reduced to vessels that carried any cargo with Shanghai or Ningbo as port of lading and Los Angeles or Long Beach as port of unlading.

Container Sizes Since vessel capacity is given in terms of TEU, the sole number of containers on board of a vessel is not sufficient to determine utilisation rates. This is because containers have different sizes. Unfortunately, the data set does not provide the size of the containers, but it does mention the unique container numbers. A sample of vessels on the route and the container numbers corresponding with their cargo was sent to the company ContainerWeight. This company possesses a database of container numbers and their corresponding sizes. They were able to determine an average conversion factor of 1,83 TEU / container for the sample of vessels on this specific route.

Overview Vessel Trips What results is an overview of all the trips vessels made on the chosen route. Per voyage, it is known what vessel was used, who it was operated by, when it arrived, which ports it visited and how much cargo was on board, as well as what the total capacity of the vessel was.

4

Analysis of a Transpacific Route

An analysis of a specific shipping route is performed to determine the current state of the market and to investigate which factors influence utilisation rates of vessels. This analysis leads to more detailed insights on the trends found in literature and identifies factors that should be included in a synergy model. The time period for which data is used is January 2014 - May 2018. Important to note is that the analysis therefore does not cover 2018 entirely, since data availability was limited to only the first 5 months of the year. The route that is analysed is between the ports of Ningbo and Shanghai in Asia and Los Angeles and Long Beach on the U.S. West Coast (see section 3.3 for more information). The starting point of this analysis is on route level, examining how much cargo is transported every year, what kind and how many vessels are used for this transport. This is followed by an analysis of vessel utilisation rates on alliance and company levels. Competition is also included in this analysis, with information on both route and company level.

4.1. Transported Cargo and Deployed Capacity

Literature has shown that the market's overcapacity is a challenge for liner shipping companies. Table 4.1 gives an overview of the number of TEU transported, deployed ship capacity and average utilisation of these vessels for each year in the considered time period (2018 is smaller because only Jan-May are considered). It also shows the average number of arrivals per month. The overcapacity in the market is clearly visible, as the total capacity on the route exceeds the total amount of cargo transported in every year. Furthermore, the amount of yearly transported cargo fluctuates during the time period, showing the unpredictability of the liner shipping market. The industry's trend of using increasingly large vessels is also visible on this specific route. Looking at the mean capacity deployed on the line, it appears that the average vessel size increases every year: from 7049 TEU in 2014 to 8263 TEU in 2018. Interestingly, the years 2015 and 2017 have relatively similar numbers for total transported TEU and vessel capacity. Even despite the lower number of vessels arriving per month in 2017 than in 2015, the utilisation rates of vessels are similar in both years. This implies that as carriers use larger vessels to transport a similar amount of containers, they adjust their service frequency to keep utilisation rates high. Furthermore, the changes in the total number of vessels operated on the route, also shown in Table 4.1, shows that vessels are removed from the route to realise these changes in service frequency.

Table 4.1: Yearly overview of cargo and deployed capacity on route. Compiled by author from vessel trip overview.

	Total cargo transported [TEU]	Total capacity deployed [TEU]	Mean capacity [TEU]	Mean utilisation	Arrivals per month	Number of vessels on line
2014	5281821	5796496	7049	91.33%	68	271
2015	5237158	5924569	7307	88.58%	68	286
2016	4637957	5481277	7793	84.83%	59	232
2017	5200359	5864591	7901	88.42%	62	236
2018*	2105075	2430639	8263	85.80%	59	140

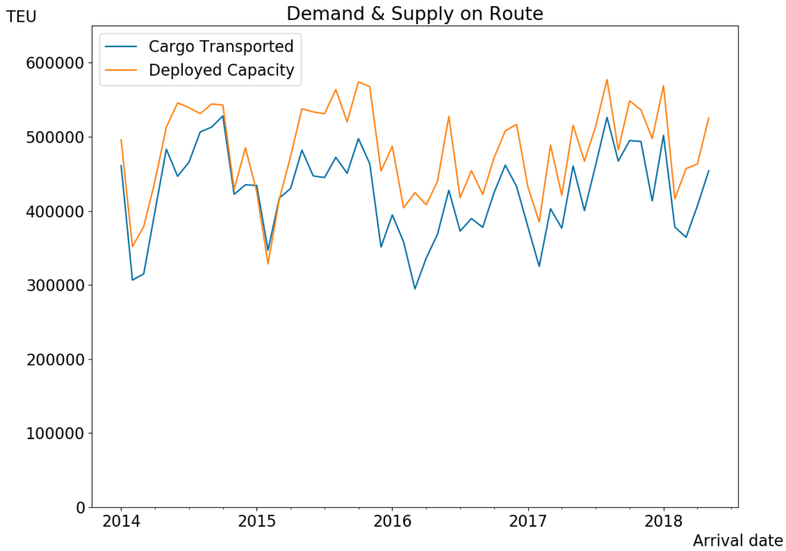

Figure 4.1: Deployed capacity and utilisation 2014-2018.

4.1.1. Flexibility of Capacity Deployment

Investigating this flexibility in capacity deployment further, both the number of transported containers and deployed vessel capacity on the route are presented in Figure 4.1. The figure can thus be said to present the impact of local demand and supply on the utilisation levels of the vessels. It shows that the earlier identified overcapacity indeed exists for the largest part of the analysed time period, even though there are periods in which the amount of transported TEU is near the deployed capacity. Two observations can be made from this figure. The first is that the amount of cargo transported shows considerable fluctuations, of which the largest differences can be explained by seasonality. To illustrate this, Figure 4.2 presents the average demand per month over the years. Most clear is the yearly dip in transport demand that occurs in February. This coincides with the celebration of the Chinese new year, a time at which Chinese operations are on hold. It can also be seen that container transport is high in the months August-November. This is most likely the result of preparations for Christmas with Americans importing more goods from China.

The second observation is that the deployed capacity follows a pattern similar to that of transport demand. A partial explanation can be found in the data available: the import records only contain information on vessels that actually made a voyage and therefore does not include scheduled trips that were cancelled. However, the similar pattern of transported TEU and vessel capacity also confirms that liner shipping companies are actually quite able to adjust their capacity to changes in demand. Such flexibility in vessel deployment was also observed by Fusillo (2004). Taking seasonality into account when looking at Figure 4.1, it can be seen that capacity is well adjusted to available cargo around Chinese new year, but less so in the rest of the year. A possible explanation is that operations closing down is easier to predict than what is needed in the run-up to Christmas (which depends on many more external factors). What is more, it seems that this flexibility in vessel deployment has increased in recent years. This is based on the difference between the years 2014-2015 in Figure 4.1, where capacity is relatively stable for the most part of the year, and the years after 2015 where this is not the case. Fluctuations increase from 2016 onward, indicating that demand has become more irregular. However, after a period with a relatively large amount of idle capacity on the vessels in 2015 and the beginning of 2016, operators seem to have become more adept in adjusting the deployed capacity to these fluctuations since late 2016. Another explanation for the increased fluctuations can be found in the size of the vessels. The changes made by operators with larger vessels also lead to larger fluctuations than was the case with the smaller vessels in the previous years.

4.1.2. Increasing Vessel Sizes on the Route

Following the observation from Table 4.1 that the service frequency is adjusted to available demand, it is also interesting to examine the sizes of vessels on the route and what changes in vessels on the route can be

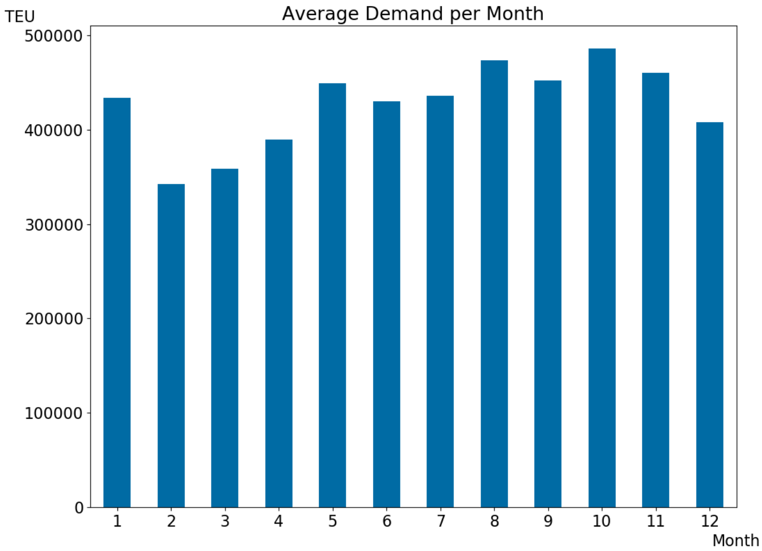

Figure 4.2: Seasonality in monthly demand on the route.

identified.

Table 4.2 presents more detailed information on the size of vessels. It shows that in 2014, both very small and extremely large vessels were deployed. The median ship size of that year is also low compared to the subsequent years, which implies a large number of smaller vessels. Over the years, the size of the smallest vessels has increased, as well as the average size, which is most likely the result of the carriers pursuing economies of scale. On the other hand, the size of the largest vessels decreased in 2015-2017 (the largest vessel increases again in 2018, but this concerns just one voyage, so no real conclusions on this can be drawn). These larger vessels allow liner shipping companies to transport more cargo with the same number of sailings. If these vessels have high enough utilisation rates, this results in lower unit costs. However, without improving demand, operators have to choose between sailing with lower utilisation or reducing the number of sailings to maintain their cost reductions. With the increasing vessel size, flexibility in deployment thus becomes even more important. On the other hand, the larger vessels themselves are likely to decrease this flexibility. This is because their size reduces the number of ports they can visit, which also limits the options carriers have to deploy the vessels elsewhere.

Table 4.2: Sizes of vessels on the route in TEU. Compiled by author from vessel trip overview.

	Smallest vessel	Largest vessel	Average size	Median size
2014	1398	21413	7060	6763
2015	1702	14036	7314	8157
2016	2128	14036	7797	8400
2017	2526	13892	7914	8063
2018	2526	17292	8267	8212

To see if reasons for changing vessels can be found in liner shipping companies' behaviour, a further look is taken at how the deployed capacity changes over the years. Table 4.3 compares the different years and total the number of vessels, the new vessels and the ones that are no longer on the line. The 'removed' vessels represent the number of vessels that were on the route in the year before, but are no longer active in the given year. The 'added' vessels are active on the route for the first time. The year 2018 is not included in this table, because that year's figures are distorted by the fact that data only covers part of the year. The table shows how especially in 2016 many vessels were removed from the route, resulting in a smaller number of vessels in total. Based on previous information, this likely considers mostly smaller vessels. This assumption is proven right by the sizes of the removed and added vessels. In fact, in all years the average size of vessels added is larger

Table 4.3: Changes in vessel deployment compared to previous year. Compiled by author.

Year	Total number of vessels	Removed from Route			Added to Route		
		Number of vessels	Size in TEU	Year built	Number of vessels	Size in TEU	Year built
2015	286	96	6465	2006	115	7428	2007
2016	232	146	6868	2007	92	8384	2009
2017	235	95	7990	2008	98	8237	2008

than the average size of the vessels removed from the route. This is in line with the growing average vessel size that was also visible in Table 4.1. Interestingly, the size of the vessels added on the line has been decreasing since 2016, which implies that the growth of vessel sizes might come to a halt on the route. Furthermore, the age of the vessels does not seem to influence whether or not a vessel is deployed on this line. The newly added vessels to the line per year are on average only 1 or 2 years younger than the vessels they replace.

It appears that the main reason for carriers changing the vessels they operate on the route is based mostly on available demand. However, removing vessels from the route can be costly and difficult, because the vessel's fixed costs still have to be paid. There is also no guarantee that the vessel can be deployed on the spot market or other routes and sailing the vessel to another location also bears costs. It turns out that operators still prefer the option of flexible capacity deployment over lower utilisation rates. Figure 4.1 thus shows that the flexibility of operators in deploying their vessels is rather high and that it has increased in recent years, most likely resulting from a change in strategy by the operators.

4.1.3. Freight Rates

Freight rates are also analysed, as they serve as a balancing mechanism for supply and demand. This implies that utilisation goes up as freight rates go down and vice versa, but only as long as capacity remains constant. With the increasingly flexible capacity deployment, it is interesting to see how this effects freight rates. There are two ways in which the price for transporting cargo on the container vessels can be determined. The first is through long-term contracts negotiated between carrier and shipper. The second is via the spot market. The China Containerized Freight Index (CCFI) reflects the spot price of transporting containers from all major ports in China and thereby summarises the container market situation. The freight index for vessels from China to North America and utilisation rates of the vessels on the route are given in Figure 4.3. If prices balance supply and demand, one would expect periods with similar utilisation levels to also have similar freight rates. However, as Figure 4.3 shows, this is not the case on this route. In fact, the utilisation levels stay around the same level, while the CCFI drops to a significantly lower level. The CCFI in 2017 is 40% lower than the 2014 level. More specifically, utilisation and freight rates follow the expected behaviour in the first few years, with rates going down in an attempt to fill the excess capacity resulting from declining utilisation levels. However, after a dip in utilisation in the beginning of 2016, utilisation levels start climbing again. In this period, freight rates also increase slightly, but not to the same extent as before. Then in 2017, the CCFI drops again and stays at this low level, but this is no longer connected to utilisation levels. This clearly shows how carriers have been lowering their margins to keep utilisation levels stable and to remain competitive. Evidence for the necessity of lower prices can be found in Table 4.1, where the total deployed capacity in 2017 exceeds the capacity on the route the year before.

4.2. Utilisation

With low margins on their services, the utilisation rates of vessels are an important factor for operators in the liner shipping industry. For that reason, it is necessary to understand what affects vessel utilisation.

4.2.1. Distribution

Utilisation on this route has an average of 88.04%, with a standard deviation of 17.77% for the period of 2014-2018[1]. This is high, considering that literature reported an industry-wide overcapacity of about 20%. On the other hand, an above-average rate was expected due to the fact that the route from Asia to the U.S. is on

[1] Calculated utilisation levels are sometimes higher than 100%, which may be caused by differences TEU/container ratios. Furthermore, the model does not determine all vessel arrival dates accurately, which may result in cargoes being counted for the wrong vessel. Extreme outliers that result from this have been removed.

Figure 4.3: Vessel utilisation and freight rates (Clarkson Research Services Limited, 2019a).

the positive side of the trade imbalances (i.e. more cargo is transported from Asia to the U.S. than the other way around). As can be seen in Figure 4.4, the distribution of all vessels on the line during the years 2014-2018 follows a normal distribution. This entails that the vessels operated on this route perform more or less equally in terms of utilisation. However, there is still a sufficient difference between the top-performers and those vessels that are less efficiently utilised.

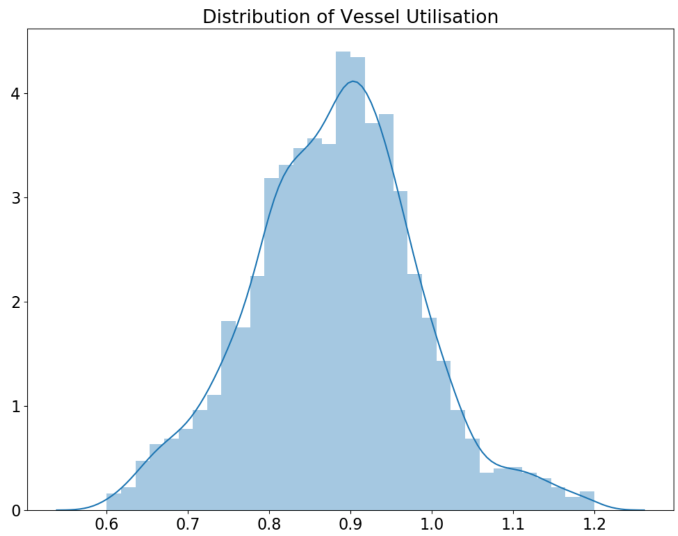

Figure 4.4: Distribution of vessel utilisation on route (Clarkson Research Services Limited, 2019a).

4.2.2. Factors Influencing Utilisation

From the analysis of transported TEU and deployed capacity, two factors that are likely to influence utilisation are already identified. The first is the increase in average vessel size. Table 4.1 has shown that the mean size of vessels increased on the route in the years 2014-2018. In that same period, mean vessel utilisation has dropped from 91.3% to 85.8%, despite a lower number of vessels arriving per month. It can be argued that the increasing vessel size is the cause for these lower figures for vessel utilisation, because larger vessels are in theory also more difficult to fill completely. This is, however, contradicted by Figure 4.5, which plots vessel size against vessel utilisation and shows no direct relation between the two factors.

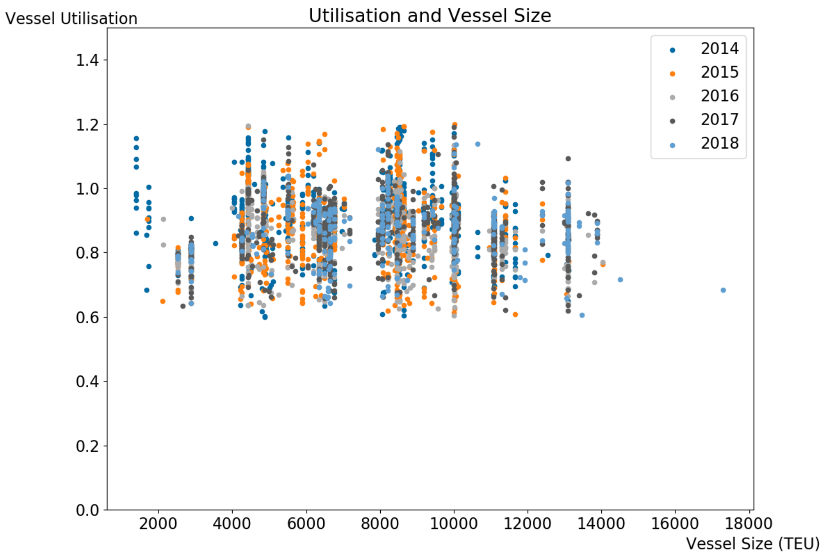

Figure 4.5: Utilisation of vessels plotted against vessel size. Compiled by author.

The sailing frequency also seems to influence vessel utilisation. It shows that despite the large gap between capacity and transported cargo in 2015, vessel utilisation was very high in 2014-2015. Furthermore, the number of vessels arriving in those years was high compared to following years. As carriers aim to prevent having to reject customers because their ship is completely full, they generally have some unused capacity on their vessels. In other words, they do not strive for 100% vessel utilisation, because turning down customers may be expensive on the long term. However, as a company is able to offer a larger number of vessel arrivals, this gives the them more leeway. This is because they have more other options to transport the cargo around the same period, so there is less risk of having to reject it. This means they can increase utilisation per vessel, while keeping enough margin in their schedule to welcome new customers. This is supported by Table 4.4, which shows that the companies that are not part of any alliance have lower utilisation rates than the alliance members. The table also shows the periods in which the alliances were active, as there was a large shift in 2017. Even though the alliances existed before 2014 and after May 2018, the utilisation rates are only based for the period in between those dates, as is the case for this entire analysis.

Because the departments such as sales and marketing are not shared within alliances, there must be another factor that leads to higher utilisation. This leads back to the conclusion drawn at the end of Section 4.1.1 about how a higher number of vessel sailings allows higher utilisation rates. The larger number of vessels available in the alliances also gives the opportunity for operators to match cargoes and vessel capacity more efficiently.

When interpreting Table 4.4, it is important to note that there are some inaccuracies due to data availability. Currently, the model is only able to recognise the companies to which the vessels belong at the time of writing. This means that any mergers or vessel sales that have happened in recent years are not represented accurately in the data. To illustrate, Table 4.5 provides an overview of major mergers in the liner shipping industry in the years 2014-18 and the effect the merger had on the alliances. It shows for example how COSCO merged with CSCL and Hapag-Lloyd with UASC. As a result, CSCL and UASC, which were both member of the O3 alliance, do not exist as separate companies in the current data set. This means that the utilisation rate of the O3 alliance in Table 4.4 of 98.08% is only based on the vessels of CMA CGM, the third member of the O3 alliance. In the case of the acquisition of APL, this inaccuracy does not occur, because APL is still operating as a separate company and its vessels can thus be recognised by the model. The other two mergers also do not distort the utilisation levels of the alliances, because Hamburg Süd was not part of an alliance before its

Table 4.4: Average utilisation rates per alliance. Compiled by author from vessel trip overview.

Alliance	Utilisation	Period When Alliance Existed
CKHYE Alliance	88.14%	2012-2017
G6 Alliance	89.10%	2012-2017
O3 Alliance	98.08%	2014-2017
2M Alliance	86.48%	2015 - Present
Ocean Alliance	91.30%	2017 - Present
THE Alliance	89.00%	2017 - Present
Not part of alliance	82.36%	-

Table 4.5: Overview of M&A in liner shipping in 2014-2018. Compiled by author from various sources.

Resulting Name	Companies	Year	Effect on Alliances
COSCO	COSCO, CSCL	2015	CSCL exits O3 Alliance
Hapag-Lloyd	Hapag-Lloyd, UASC	2016	UASC exits O3 Alliance
CMA CGM, APL	CMA CGM, APL	2016	APL moves from G6 to Ocean Alliance
Maersk, Hamburg Süd	Maersk, Hamburg Süd	2017	Hamburg Süd part of 2M
ONE	’K’ Line, NYK, MOL	2018	-

acquisition and all companies in ONE have been in the same alliance during in the considered years.

On company level, an overview of the average vessel utilisation per operator is given in Figure 4.6. It shows large differences between the companies and it can thus be concluded that utilisation is operator-dependent, even within alliances. This implies that for example a sales and marketing department has a major influence on utilisation rates.

4.3. Level of Service

Another way to get more insights in the behaviour of operators on the route is by looking at the kind of services they offer. The literature review gave evidence that liner shipping companies have significantly lowered their service level over the past years. To get an indication of the level of service provided on this route, the number of sailings and the number of ports visited by the vessels on their voyages are examined.

4.3.1. Sailing Frequency

As already indicated in Table 4.1, the number of sailings per month has decreased. Where in 2014-15 there were on average 68 sailings per month, this was only 59 and 62 in 2016 and 2017 respectively. With a lower sailing frequency, shippers have fewer options to ship their cargo, which is seen as a lower level of service.

4.3.2. Ports of Call

The other indicator for the level of service is investigated by looking at which ports are visited by the vessels on the route. This is derived from the origin and destination ports of the cargoes on board the vessels. Table 4.6 shows the percentage of vessels visiting which ports.

The first three rows in the table show the division of vessels that take on board cargo only in the port of Shanghai, vessels that carry cargo from Ningbo only, and vessels that visit both ports for cargo. Over the years, there is little change in the percentages of vessels visiting. The majority of the vessels on the route have a stop in both Chinese ports. Furthermore, if vessels have only one origin port, Shanghai is more frequently visited than Ningbo, even though Ningbo’s share is growing slightly. The division of vessels in the U.S. ports of Los Angeles and Long Beach is much less constant. In the years 2014 and 2015, about 75% of all vessels visit both ports to deliver cargo and the rest of the vessels are more or less evenly spread among the two. From 2016 onward, however, this changes drastically to only 10-18.5% of the vessels still visiting both Los Angeles and Long Beach. The majority of the vessels now makes only one stop in the area to unload cargo. Furthermore, where previously Los Angeles welcomed a larger share of vessels, it is now the port of Long Beach that receives the bigger share.

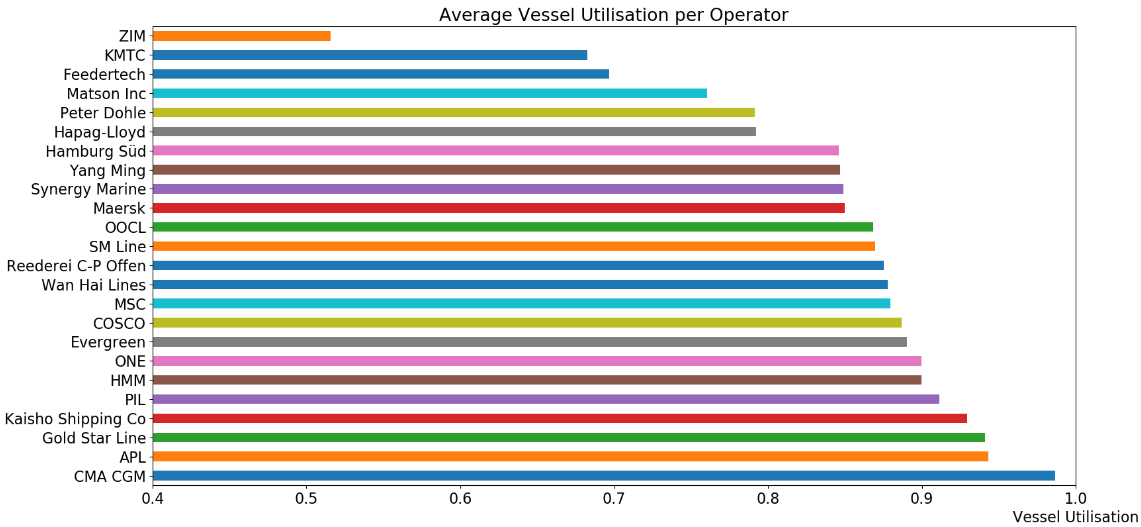

Figure 4.6: Average utilisation per operator. Compiled by author.

Table 4.6: Distribution of port calls among vessel services. Compiled by author from vessel trip overview.

	2014	2015	2016	2017	2018
Vessels with stop in Shanghai	30.3%	30.7%	30.0%	28.9%	25.5%
Vessels with stop in Ningbo	6.6%	2.7%	3.0%	4.2%	9.5%
Vessels with stops in Shanghai & Ningbo	63.1%	66.5%	67.0%	66.9%	65.0%
Vessels with stop in Los Angeles	13.6%	17.5%	44.1%	34.3%	29.6%
Vessels with stop in Long Beach	10.4%	10.7%	45.9%	47.2%	53.7%
Vessels with stops in Los Angeles & Long Beach	76.0%	71.7%	10.0%	18.5%	16.7%
Vessels with multiple stops in Asia	9.1%	12.8%	84.1%	81.5%	84.4%
Vessels with multiple stops in U.S.	0.6%	0.2%	0%	0.5%	0%
Vessels with multiple stops in Asia & U.S.	89.6%	86.2%	15.5%	16.6%	15.6%

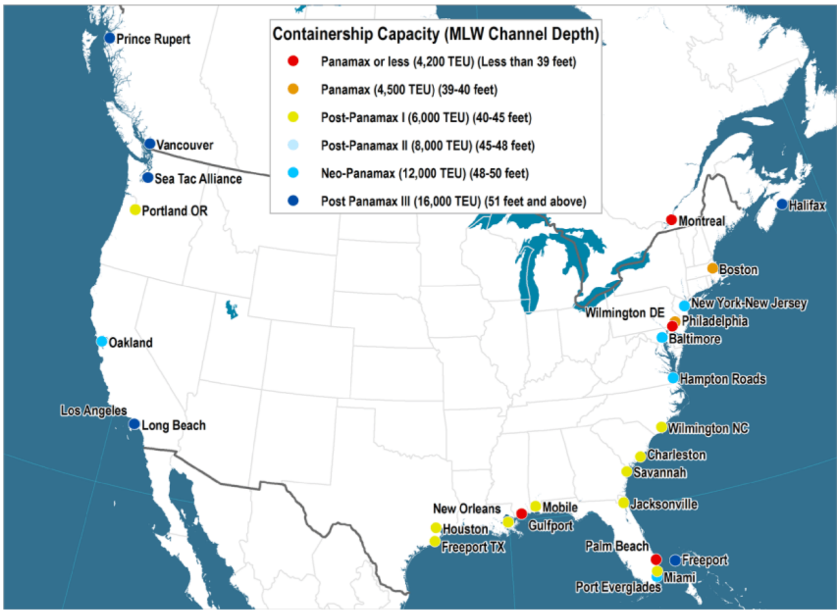

Figure 4.7: Channel depth at major North American container ports (Rodrigue et al., 2017).

The final three rows of Table 4.6 provide information on whether the vessels also visit ports other than the four that define the route (Shanghai, Ningbo, Los Angeles and Long Beach). Again, a change occurred in 2015. In the first two years, some vessels make multiple stops in other ports than Ningbo and Shanghai before crossing the ocean. On the other hand, there are extremely few vessels that visit more U.S. ports, but do not have multiple stops in Asia. In the years 2014-2015, the majority of the vessels had multiple port calls on both continents. This changed significantly in 2016, with the preference shifting to routes with multiple ports in China and only one port visit in the U.S. This coincides with the decision of liner operators to visit either Long Beach or Los Angeles, instead of both of them.

An explanation for this could be that operators reduce costs by not having to pay port charges for the many ports they visit (Merk et al., 2015). Improvements in inland infrastructure may also have lead to fewer port calls in the U.S. Even so, the main reason for a change in ports on call is most likely the increasing vessel size. For one, the water depth must be sufficient to accommodate these large vessels. Figure 4.7 shows the average height of mean low water (MLW) over a period of 19 years and the vessel sizes that can thus visit the ports. On the West Coast, it can be seen that Portland and Oakland have size constraints that keep the larger vessels on the route (see Table 4.2) from entering. Even though larger ships are able to enter these ports when they are not fully loaded, this increases unit costs and may even dissolve the advantages of the larger vessel size (see section 2.2.4). For that reason, it may be the case that smaller vessels are used to visit these ports specifically. This can be examined further by extending the geography used in this analysis. Limits on the height of vessels (air draft), imposed by bridges in the waterways or crane heights, and cargo-handling speeds also contribute to the change in port choices.

Even though the ports on the U.S. East Coast are geographically not near the analysed route, their size does influence container throughput in the ports of Los Angeles and Long Beach. It can also be seen in Figure 4.7 that the ports on the East Coast of the U.S. are generally smaller than their West Coast counterparts and an important reason for this are size limits of the Panama Canal. All cargo transported by sea from Asia to the East Coast has to pass the channel. As a result, much cargo is shipped to the West Coast and further transported to its destination by train instead. However, the Panama Canal has been expanded and thereby now allows larger vessels to sail through. As a result, the East Coast ports have become more serious competitors to the ports on the West Coast (Ullmann, 2019). With further investments for growth planned, the East Coast ports are likely to take part of the West Coast ports' current market. It would be interesting to analyse the role of the liner shipping companies in this change.

4.4. Competition

For more information on the development of the operators active on the line, their growth in the amount of cargo transported and in market share is analysed. Additionally, with the companies' market shares, the competition among them is investigated for this route. An overview of the top 8 firms in terms of market share on the route is given in Table 4.7. One of the first things to notice is that COSCO has been market leader during the entire period and that it has had a significant lead compared with the other firms. It is interesting that COSCO's once strong market position has been challenged by the other companies on the route and its lead has decreased. The table also shows how in the lower part of the top 8, firms change positions frequently, indicating considerable competition among them.

Table 4.7: Top 8 operators per year on the route in market share. Compiled by author from vessel trip overview.

2014		2015		2016		2017		2018	
Operator	Share	Operator	Share	Operator	Share	Operator	Share	Operator	Share
COSCO	24.49%	COSCO	28.42%	COSCO	28.75%	COSCO	21.50%	COSCO	19.80%
MSC	13.03%	Maersk	10.85%	Maersk	13.66%	Maersk	16.93%	Maersk	18.18%
CMA CGM	11.46%	ONE	9.57%	MSC	10.32%	ONE	11.39%	ONE	10.99%
ONE	9.10%	MSC	9.26%	ONE	9.21%	MSC	8.19%	Evergreen	8.99%
HMM	8.17%	HMM	7.79%	Evergreen	7.41%	APL	6.95%	APL	8.03%
APL	6.93%	Evergreen	7.21%	APL	7.15%	Evergreen	6.41%	MSC	6.29%
Maersk	6.17%	CMA CGM	6.12%	HMM	4.90%	OOCL	5.95%	OOCL	5.81%
Yang Ming	4.63%	APL	5.50%	Yang Ming	4.62%	Yang Ming	5.31%	HMM	5.28%

4.4.1. Company Growth

Growth of the companies on the line is evaluated by two factors: growth in the amount of TEU transported by each carrier and growth in their market share. Table 4.8 shows the amount of TEU they transported in 2014 and 2017 and the percentage of growth this constitutes for the entire period. It presents the companies on the route with at least 10 sailings per year. Also, the year 2018 is not included in this table because data is not available for the full year. On this route, Maersk has by far experienced the highest growth in terms of TEU, over 166% in three years. Interestingly, there are also many large liner operators that have experienced negative growth. For example CMA CGM and Hapag-Lloyd have transported a significantly lower amount of TEU in 2017 than they did in 2014. COSCO, which is the largest operator on the route (see Table 4.7), has also experienced a decline in transported TEU over the entire period. Looking at the year to year growth rates of the companies, it appears that there is not a certain year in which all operators have started to experience negative growth. The negative growth rates are spread over all the years. In fact, all companies except Maersk and OOCL have at least one year with negative growth. This indicates the heavy competition among the carriers. However, to see how the companies perform relatively to one another, Table 4.9 shows the growth of companies on the route in terms of market share.

Also in terms of market share there are companies with large positive growth and companies that have lost a great amount of market share. This makes sense, as one company can only gain market share at the cost of another. The sequence of companies in terms of growth in market share is equal to that of growth in transported TEU. Again Maersk and OOCL are the largest growers and the only companies without any negative values. The way in which they grew is different however. Maersk increased its market share significantly in 2015 and then continued to grow but at a declining rate. OOCL on the other hand, has increased its market share growth year by year with large steps. On the bottom end of the table, Hapag-Lloyd and CMA CGM are shown to have been losing market share during all years in 2014-17 as a result of their declining amount of transported TEU. The year on year growth of COSCO is also interesting. Where in 2015 it was able to increase its already large market share of 24.5% to 28.4% (an increase of 16%), the year after its growth in market share stalled and was just barely positive. Then the year after that, in 2017, its market share dropped by 25% to a value even below its 2014 market share. Even though COSCO is still the biggest operator on the route, its competitors will catch up if this pattern continues in the following years.

4.4.2. Concentration and Competition

Based on the market shares of the LSCs on the route, several indicators for competition can be determined: the Herfindahl-Hirschman Index and the concentration ratios CR4 and CR8. These provide information on

Table 4.8: Year on year transported TEU and growth per operator. Compiled by author from vessel trip overview.

Operator	2014	2015		2016		2017		2014-2017
	# TEU	# TEU	Change	# TEU	Change	# TEU	Change	Total Change
Maersk	325895	561628	72.33%	633487	12.79%	868905	37.16%	166.62%
OOCL	150446	152554	1.4%	178084	16.74%	309487	73.79%	105.71%
Evergreen	224381	377854	68.4%	331976	-12.14%	320712	-3.39%	42.93%
ONE	480574	498093	3.65%	427233	-14.23%	592074	38.58%	23.20%
Matson Inc	88010	86524	-1.69%	88668	2.48%	96980	9.37%	10.19%
APL	332886	288109	-13.45%	331413	15.03%	361569	9.1%	8.62%
Reederei C-P Offen	14299	22547	57.68%	28381	25.87%	12513	-55.91%	-12.49%
Yang Ming	227302	221752	-2.44%	163914	-26.08%	197678	20.6%	-13.03%
COSCO	1293286	1488256	15.08%	1333219	-10.42%	1118071	-16.14%	-13.55%
MSC	688145	484928	-29.53%	478457	-1.33%	425811	-11.0%	-38.12%
HMM	431429	408216	-5.38%	227251	-44.33%	263695	16.04%	-38.88%
Hapag-Lloyd	203356	153061	-24.73%	73006	-52.3%	76887	5.32%	-62.19%
CMA CGM	605153	320559	-47.03%	188586	-41.17%	132640	-29.67%	-78.08%

Table 4.9: Year on year market share and growth per operator. Compiled by author from vessel trip overview.

Operator	2014	2015		2016		2017		2014-2017
	Share	Share	Change	Share	Change	Share	Change	Total Change
Maersk	6.17%	10.72%	73.74%	13.66%	27.43%	16.71%	22.33%	170.83%
OOCL	2.85%	2.91%	2.11%	3.84%	31.96%	5.95%	54.95%	108.77%
Evergreen	4.25%	7.21%	69.65%	7.16%	-0.69%	6.17%	-13.83%	45.18%
ONE	9.1%	9.51%	4.51%	9.21%	-3.15%	11.39%	23.67%	25.16%
Matson Inc	1.67%	1.65%	-1.2%	1.91%	15.76%	1.86%	-2.62%	11.38%
APL	6.3%	5.5%	-12.7%	7.15%	30.0%	6.95%	-2.8%	10.32%
Reederei C-P Offen	0.27%	0.43%	59.26%	0.61%	41.86%	0.24%	-60.66%	-11.11%
Yang Ming	4.3%	4.23%	-1.63%	3.53%	-16.55%	3.8%	7.65%	-11.63%
COSCO	24.49%	28.42%	16.05%	28.75%	1.16%	21.5%	-25.22%	-12.21%
MSC	13.03%	9.26%	-28.93%	10.32%	11.45%	8.19%	-20.64%	-37.15%
HMM	8.17%	7.79%	-4.65%	4.9%	-37.1%	5.07%	3.47%	-37.94%
Hapag-Lloyd	3.85%	2.92%	-24.16%	1.57%	-46.23%	1.48%	-5.73%	-61.56%
CMA CGM	11.46%	6.12%	-46.6%	4.07%	-33.5%	2.55%	-37.35%	-77.75%

how firms interact and can be included in strategic decisions of liner operators and can later be used in the decision for the type of integration that is preferred and to assess the likelihood that regulators will allow the cooperation. The results for the HHI, CR4 and CR8 are shown in Table 4.10 and indicate that the route can be considered a loose oligopoly, but there is only a small difference with what would be called a 'tight' oligopoly and where collusion is likely to occur (see also Table 3.2 on page 16).

Table 4.10: Competition indices for the route. Compiled by author from vessel trip overview.

	2014	2015	2016	2017	2018
CR4	59%	58%	62%	58%	58%
CR8	84%	85%	86%	83%	83%
HHI	1203	1329	1395	1152	1141

What is interesting about the results in Table 4.10 is that there is little change over time, especially in the competition ratios. A possible explanation for this can be found in the Transpacific Stabilization Agreement (TSA). This is an agreement between shipping companies that allows information sharing regarding their activities on routes between ports in the Far East and ports in the United States. Its purpose is stated as follows:

> '*... to promote a commercially viable and economically sound transportation system in the Trade covered by this Agreement, to foster commerce, service and stability in the Trade and, as a matter of overall policy, to effect revenue recovery and restoration, reduce costs, improve profitability and increase efficiency of the Parties' transportation operations.*' (Federal Maritime Commission, 2016)

The TSA is therefore likely to have influenced the relatively stable competition ratios. However, antitrust concerns and consolidation in the liner shipping industry had already reduced the number of parties involved and have lead to dissolving of the agreement in February 2008 (Meyer, 2018; Szakonyi, 2017).

Where concentration ratios have remained stable over the years, the HHI shows a peak in the years 2015/2016. As the HHI assigns more weight to larger firms in the equation, this peak can be seen as evidence of the larger firms pushing smaller competitors out of the market (see also Table 4.7). The HHI reduces again in the years after, which can be explained by the reduced market share of COSCO, the largest operator on the route.

A critical note must again be placed on the way in which merged companies are included in the model. Both Table 4.7 and the growth tables (Table 4.8 and Table 4.9) are influenced by the inaccurate representation of companies that merged. This is most apparent in the mentioning of ONE as a separate company, even though 'K' Line, NYK and MOL only started operating this joint venture in 2018. Separating the original companies in the entire table would not only provide a more accurate representation of the market, but would also provide even more interesting information on company growth, as it would make a merger visible in the numbers. With regards to the concentration indices in Table 4.10, they would also become more accurate if mergers are included in the data. Because these indices are determined based on the market shares, not all consolidation activities on the route are fairly represented. If information of the companies before the mergers are included, the indices are likely to portray larger differences between the years.

5

Sub-Conclusion 1: Implications of Company Performance for Potential Synergies

This analysis of the route from Shanghai/Ningbo to Los Angeles/Long Beach has provided more insights into the liner shipping industry on a route and company level. It shows how the performance of operators is pressured on the route and how this drives them to only deploy the capacity they need and adjust their fleet on the route accordingly.

Over the entire period of 2014-2018, the route is in a state of overcapacity. Furthermore, analysis of vessel utilisation and the China Containerized Freight Index (CCFI) shows that freight rates have decoupled from utilisation rates and no longer serve as a balancing mechanism between (local) supply and demand. This puts pressure on operators' profit margins. As a result, minimisation of unit costs has become a main focus for liner shipping companies.

The route analysis shows how this focus on cost reduction manifests itself in two ways. On the one hand, the size of vessels deployed on the route has increased, as is also the industry wide trend. On the other hand, it drives the process of operators adjusting their deployed capacity to demand. By doing so, they are able to keep vessel utilisation levels high. It turns out that carriers are able to modify their sailings rather flexibly, with vessels changing routes on at least a yearly basis.

When it comes to vessel utilisation in general, the analysis shows that average utilisation rates are high on this transpacific route, even considering the fact that imports from Asia to the U.S. are on the positive side of the trade imbalance. However, even though all operators show relatively high utilisation rates, it differs per operator how well they perform. This can be the result of differences in the effectiveness of the operators' sales and marketing department, but also of the sailing frequency an operator can offer and its ability to adjust deployed capacity. The smaller the time period between sailings, the higher the extent to which vessels can be filled without the risk of having to reject customers. Moreover, a larger and more diverse fleet helps in adjusting the service frequency to keep utilisation levels high. Being part of an alliance is found to have a positive effect on utilisation rates, mainly because of the larger fleet and network as well.

Concentration indices demonstrate that the market on this route is approaching a 'tight oligopoly', in which collusion is likely to occur. In such markets, the focus is generally on profit maximisation, while the level of service offered to the customer is deemed less important. This is also apparent on the analysed route, specifically in the size of the vessels used. Even though the larger vessel size has no direct influence on utilisation levels, it has considerable implications on the level of service. For one, the larger vessels have been reason for carriers to reduce the number of sailings on the route, leaving customers with fewer options for their shipments. Furthermore, the larger vessel size limits which ports can be accessed. Especially in the U.S., this has caused liner shipping companies to change the ports on their routes, eliminating extra stops. It can thus be concluded that compatibility between vessels and ports is an important factor if multiple types of ports are included. More importantly, the model should consider the level of service when assessing synergy potential, as this is an area in which liner shipping companies can gain a competitive advantage.

III

Synergy Modelling

6
Method for Synergy Model

6.1. Improved Cooperation

Strategic cooperation is widely adopted in the liner shipping industry. It allows companies to expand their network and to reduce costs. In theory, it also allows carriers to increase the level of service they offer to their customers. With a larger network coverage, they can offer transport to more locations. Moreover,the larger fleet would allow a higher sailing frequency than the companies could provide on their own. However, the analysis of the route in Part II shows that this is not what is happening in practice. Instead, the operators exhibit behaviour befitting a too concentrated market, emphasising cost reduction at the expense of the level of service. As was reported in Chapter 4 the number of connecting ports has reduced over the past years. The number of sailings offered is also lower.

Current alliances are mostly based on vessel-sharing agreements. This means that each partner has a percentage of available cargo slots on the vessels operated in the agreement, often based on how much capacity each company contributes to the partnership. Though this allows operators to lower their costs per unit transported and to extend their network coverage, it does not provide a long-term sustainable advantage (Brooks, 2000). This is because competitors apply the same tactics and catch up. To reap further benefits of cooperation, this study builds on the more sophisticated model for alliances proposed by Sanders et al. (2015). They argue that liner shipping companies can create a long-term competitive advantage through further integration, not only because it leads to extra cost synergies, but also because the partners are more invested and face a higher exit barrier. With the further integration, the partners are also more dependent of one another. Because of that, the need for a thorough partner selection process is even more important.

Three different levels of integration in the more sophisticated alliances are presented in Figure 6.1. The first level, conventional alliance, is what is currently the most common form of alliances in the liner shipping industry, which is based on sharing the capacity on vessels, but otherwise remaining entirely separate. One level further is a value-added alliance. As described by Sanders et al. (2015), companies can generate extra cost savings from joint procurement, joint operations and pooling equipment besides their vessels. The deepest level of integration involves integrating the partners' back-offices, resulting in significant cost savings. Furthermore, IT is a big cost component for liner shipping companies, on which can be saved by joint development as well. Because this integrated kind of alliance is very similar to an actual merger, this study includes M&A in this level of integration as well.

Further integration also allows the partners to develop a long-term strategy. This allows them to differentiate themselves from their competitors, for instance by offering a higher level of service (Murnane et al., 2016). Differentiation in service offerings would enable carriers to better serve their customers and could also help container shipping to attract cargo from other transport modes or shipping sectors (Merk et al., 2018). What is more, higher service levels can also be achieved without leading to an increase in costs (Murnane et al., 2016).

A large problem in the liner shipping industry that restricts the partnerships from reaching their full potential is the number of companies involved (Midoro and Pitto, 2000). Coordinating operations becomes increasingly complex with a larger number of partners, especially with the cultural differences that often exist among the parties involved (Song and Panayides, 2010). For that reason, another improvement proposed in this study is that they consist of fewer partners.

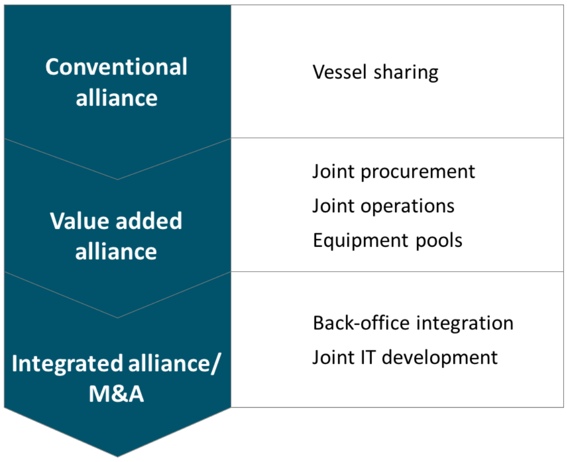

Figure 6.1: Levels of integration in the liner shipping industry. Adapted from Sanders et al. (2015).

Because selecting the right partner becomes even more important when pursuing this improved kind of cooperation, the aim of this part of the study is to present a model that identifies and assesses potential partnerships, taking this improved kind of cooperation into consideration.

6.2. Model Description

Figure 6.2 shows a schematic overview of the model that is developed for this purpose. Where previous studies on cooperation in liner shipping have either adopted a qualitative or a quantitative approach, this research integrates both in the partnership decision to assess a potential partnership both on a tactical and a strategic level. The different colours in the figure distinguish between the types of model components: input (orange), the modelling parts (blue) and output (grey).

6.2.1. Input for Synergy Model

Three types of input are required in the model. The first is operational data of the cargo transported on the route and the vessels used for it. This data is used for the quantitative analysis. The second type of input needed is to come from the client. This is used for both the quantitative and the qualitative parts of the model. It includes information on which companies and what area the client would like to consider, but also the intended level of cooperation and its motivations for pursuing a partnership. The third set of data includes company information on strategy, assets, finances and culture, all used for the qualitative analysis. All three types of input are discussed in more detail in the following paragraphs.

Operational Data (A1) The model developed from the Bill of Lading data for the route analysis in Part II also serves as the basis for the route component of the synergy model. It follows that the operational data in this model thus includes cargo and vessel information as well. The amount of information needed for the vessels is expanded in this case to allow determination of vessel costs. As total vessel costs differ per vessel size and age, a further description of how the vessel costs are determined is given in Section 6.4.

Client Input (A2) The client input serves two main purposes. On the one hand, the client for whom this model is executed defines the size and scope of the analysis by choosing a certain route or region. It is also possible for the client to limit the optimisation to only a specific set of potential partner companies, or to exclude certain firms. On the other hand, the client input indicates the objective for the partnership, which can be used to assign extra weight to different factors in the model. The client's motivation for entering a partnership could for example be cost reduction, but it is also possible for a company to search for opportunities to increase their market share despite this leading to higher costs. The intended level of cooperation is also important to receive from the client. A higher level of integration is more complex and may offer greater risks, while it also leads to increased synergy effects. Information on the extent to which the partners are intended to cooperate is thus necessary for evaluation of the results. The different levels of integration have been presented in Figure 6.1.

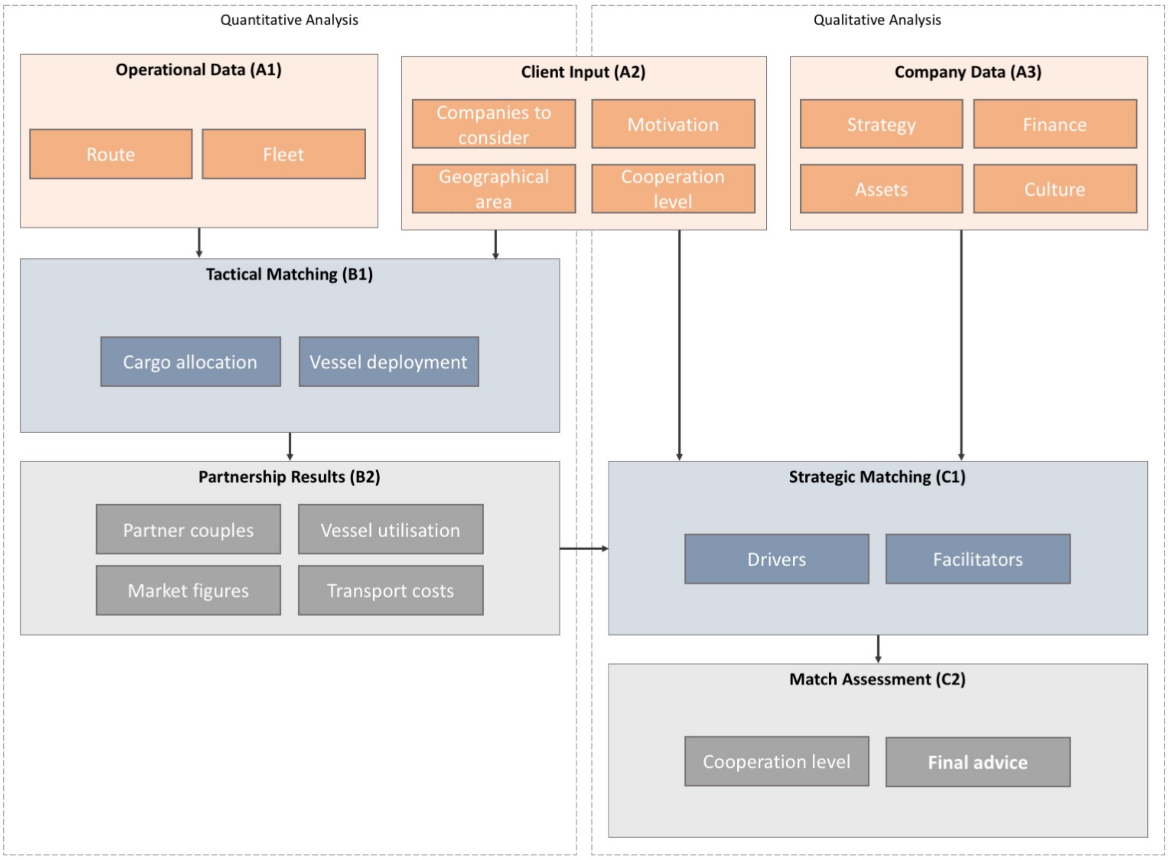

Figure 6.2: Schematic overview of synergy model.

In this study, a route was selected to represent the client's input. The selection of this route was done with the following considerations. First of all, the geographical area was kept as small as possible to keep computation time down. Secondly, with the data being U.S. import records, possible lines are limited to those with an origin outside the US and with a destination on US territory. A third consideration was the significance of the route in terms of transported volumes. The decision was made to focus on East-West trades, as transported volumes are much larger in that direction than for the North-South trades (Notteboom et al., 2017). Furthermore, with Asian exports exceeding their imports, trade imbalances exist that lead to the transport of empty containers. As these empty containers are not included in the US import records and assuming that the number of empty transports is minimal on the positive side of the imbalance, it was decided to focus on a transpacific route. Finally it was considered that a route with neighbouring ports would provide extra flexibility to the model. As a result, the port pairs of Shanghai/Ningbo in China and Los Angeles/Long Beach on the U.S. West Coast were selected for the analysis. The objective for the partnership in the case study was determined based on company and newspaper reporting.

Company Data The model also requires more detailed business information about the operators. This is split in four main categories: Strategy, Assets, Finance and Culture, shown with their sub-items in Figure 6.3. This data is derived from the annual reports published by the liner shipping companies included in the model.

It shows that strategy includes information on the company's trade footprint. This indicates, for example, whether a firm has a global or regional focus. Market share can also provide information on the presence of the firm in the considered area in specific.

How the company handles its assets may also differ. Some companies prefer to own most of their vessels, while others prefer to charter them. Furthermore, the average size and age of a company's fleet give some indication of the vessel's costs and whether the fleets of two companies would supplement each other.

Part of the financial data is the ownership structure of the company. This indicates if company is family or government owned and whether it is listed or private. Financial strength is based on the indicators defined by Ding and Liang (2005) and consists of the company's return on equity (RoE, Equation 6.1), profit margin (Equation 6.2) and return on assets (RoA, Equation 6.3). The RoE indicates the profitability of the owners investment, while the profit margin measures the the net income that is generated by every dollar of sales and the RoA measures the overall profitability of assets (Ding and Liang, 2005). The way in which the company pursues growth, for example internal or external, is also part of the company data input.

The final category in company data is culture, which is an important part of this model, because cultural differences are one of the main reasons presented in literature for the failing of strategic cooperation. Culture is addressed in two ways. The first is based on the distance between the home regions of the companies, as proximity increases the quality of information and offers familiarity and shared background, which would benefit the partnership Das (2011); Yeo (2013). However, distance is not all-conclusive. For that reason, Meyer (2014) devised a method to map a country's business culture among 8 dimensions: Communicating, Evaluating, Leading, Deciding, Trusting, Disagreeing, Scheduling and Persuading. By plotting this map for the home countries of both companies, it can be seen if and how they overlap.

$$RoE = \frac{Net\,income}{Average\,stockholders'\,equity} \tag{6.1}$$

$$Profit\,margin = \frac{Net\,income}{Net\,sales} \tag{6.2}$$

$$RoA = \frac{Net\,income + Interests\,after\,tax}{Average\,assets} \tag{6.3}$$

6.2.2. Components of Quantitative Analysis

The first step in the model is to perform the matching of potential partners based on the tactical problem of cargo allocation to vessels and the deployment of these vessels. This is part of the quantitative analysis.

Matching Model (B1) In this part of the model, potential partners are identified based on the synergies that can be expected when they would cooperate. This is done by matching sets of cargoes and vessels based on the lowest unit cost, aiming for high vessel utilisation and low costs. In this way, the allocation of resources,

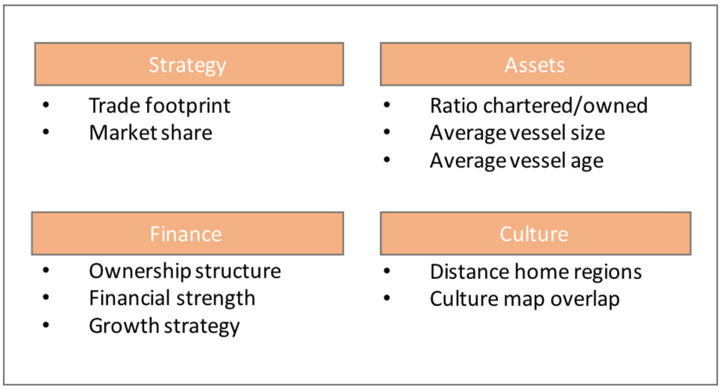

Figure 6.3: Information required about operators.

Table 6.1: Components of match assessment. Adapted from Douglas et al. (1996).

Drivers	Facilitators
Asset/cost efficiency	Culture
Profit stability/growth	Symmetry
Customer service	Prior Experience
Marketing Advantage	

which is what the tactical level of management is concerned with, is performed while minimising costs. By reallocating cargo to vessels on the route, it can be determined which vessels should be assigned to the route. Additionally, the number of partners is limited by the model. The mathematical foundation of this part of the model is given in Chapter 7.

As the intention is to build a long-term partnership, this part of the model includes all companies on the route. Because the liner shipping industry is identified as an oligopoly, there is a large degree of interdependency among liner shipping companies. Furthermore, it can be assumed that these companies are all striving for profit optimisation. It might seem too extensive to have the model form partnerships for all parties on the route when only a partner for the client has to be found. Instead of optimising for all companies, one could only look at the performance of the client and test each of the other companies as potential partners. Even though this would lead to an optimal partner for the client, this does not guarantee that the client is also the best partner for the selected company. To ensure that both partners would prefer a partnership with one another specifically, the optimisation and partner formation comprises all companies on the route.

Potential partnerships (B2) What results from the optimisation is an overview of which parties should cooperate together in the ideal situation for the analysed route(s). This consists of a list of partnership combinations and their vessels being used, with corresponding utilisation levels and costs. These results can be compared to the performance of the companies without cooperation. This is then also be used as input for the strategic matching in C1 and can be included in the final advice than can be given to the client. An overview of the new market figures such as market shares and concentration ratios is also generated.

6.2.3. Components of Qualitative Analysis

The results on the performance of the potential partners identified in the optimisation model are used for the qualitative analysis. The aim of this part of the model is to identify how well the companies are expected to work together on a strategic level.

Strategic comparison (C1) The strategic comparison is based on two factors: drivers and facilitators. The drivers are reasons for companies to enter into a partnership and those are evaluated for each company individually. The facilitators are factors that allow partnerships to grow and these are filled in from the view point of the future merged entity. The company information (A3) and performance results (B2) were used to assign scores to the different drivers and facilitators, of which a general overview is given in Table 6.1. These items will be explained in more detail in Chapter 8.

Table 6.2: Shares of operators in alliances based on their deployed capacity on the analysed route. Compiled by author.

Operator	2M Alliance	CKHYE Alliance	G6 Alliance	O3 Alliance	Ocean Alliance	THE Alliance
MSC	41%					
Maersk	59%					
COSCO		72%			47%	
Evergreen		17%			15%	
Yang Ming		11%				23%
APL			22%		18%	
HMM			24%			
Hapag-Lloyd			10%			9%
ONE			32%			68%
OOCL			12%		16%	
CMA CGM				100%	4%	

Match assessment (C2) The comparison of the potential partner companies on a strategic level results in a match assessment. Each of the criteria has received points in section C1. The sum of these scores gives an indication of the type of integration that would be advisable. The scores on the criteria can also identify the weaker factors of the match that may require extra attention. A more detailed description of how these points are converted to an advice for the level of integration is also provided in Chapter 8.

Advice to Client Once the results of both the tactical and the strategic matching have been derived, the final advice for the client can be formulated. This includes an overview of the combined performance in terms of costs, utilisation levels and market share. It also identifies how well the two partners match and what level of integration is feasible between them. Furthermore, areas that might cause difficulties in the cooperation are identified. These results are then related to the client's main objective and the division among the partners is explained in more detail. In all, the aim is to answer the question of whether it is possible to form a partnership with fewer parties, what level of cooperation would be achievable in that case and what considerations need to be taken into account. If concessions need to be done, it must be determined whether these are acceptable with the benefits of having fewer partners in mind and how this influences the integration.

6.3. Data

The cargo data from the U.S. Customs and Border Protection's Automated Manifest System (AMS) and the World Fleet Register Clarksons Research Services Limited are again used to produce a list of vessel arrivals with information on arrival date, load, capacity, ports visited and operator (see Section 3.3). Some extra data is required to calculate the vessel costs. For that reason, the data set derived from the World Fleet Register is extended to also include deadweight (DWT), vessel length (L_{oa}), crew size and fuel consumption. With this information, the overview of vessel arrivals from Part II is transformed further, which is shown in Figure 6.4. The cargo transported on vessels with operators that are part of an alliance are divided among all members. This division is based on the total capacity (CAP_{op}) of each member on the route with respect to the total capacity of the alliance (CAP_{al}) in total, as shown in Equation (6.4). The percentages for the alliance members that result for the route Shanghai/Ningbo - Los Angeles/Long Beach are given in Table 6.2.

$$Capacity\ share = \frac{CAP_{op}}{CAP_{al}} \tag{6.4}$$

A third data set is also used in the synergy model. The part of the synergy model that determines how well companies fit on a strategic level requires business information about the liner shipping companies. This data is retrieved from their annual reports and includes strategic, financial, geographical and asset data.

6.4. Calculating Vessel Costs

Another important element of the model is the costs of the vessels. All ships are divided into groups based on their size and age, depending on the type of cost being calculated. Literature named five main cost categories

Figure 6.4: Further steps taken in translation from data to model input.

for liner shipping companies. These are running costs, voyage costs, cargo handling costs, periodic maintenance costs and capital costs. Part of the running costs category is general maintenance. For simplicity, the periodic maintenance costs are also included in this part of the running costs and are not presented as a separate category.

In this study, the vessel costs are determined before the data is put into the optimisation model. This means that cargo-related costs cannot currently be included in the model, because utilisation rates are not yet known for the vessels. The different types of costs used in this model are shown in Figure 6.5.

Vessel Costs		
Capital Costs	**Running Costs**	**Voyage Costs**
Interest	Manning	Fuel costs
Depreciation	Stores and Consumables	Port charges
	Insurance	Canal dues
	Maintenance and Repair	
	Management and Administration	

Figure 6.5: Overview of Vessel Cost Components (Van Hassel et al.).

6.4.1. Capital Costs

The main components of capital costs are interest and depreciation. Both are based on the newbuilding price of the vessel. This price is estimated according to Mulligan (2008), with the formula given in Equation 6.5. This formula uses the vessel's deadweight (DWT) and the producer price index (PPI) of the year in which the vessel was built. The PPI is a factor published by the Federal Reserve Bank of St. Louis's Federal Reserve that allows for adjustments for inflation. Mulligan (2008) originally used the PPI for heavy industry, but this has been replaced by the *Producer Price Index by Commodity for Final Demand: Private Capital Equipment* (Federal Reserve Bank of St. Louis Economic Research Division, 2019), which is used in this research.

$$P = -402.727 + 2.60PPI + 1.8053DWT - 0.01009DWT^2 + 0.0000189DWT^3 \tag{6.5}$$

Interest For the interest costs it is assumed that 80% of the newbuilding price has been financed and that the interest rate is 6% (Van Hassel et al.).

Depreciation The average lifetime of a vessel is estimated to be 25 years in which the owner of the vessel has to deprecate the entire value of the vessel (Van Hassel et al.). This comes down to yearly depreciation costs of 4% of the newbuild price determined in Equation 6.5 per year.

6.4.2. Running Costs

The running costs are all costs connected to the day-to-day operations of the vessel and are split into manning, insurance, stores and consumables, maintenance and repair and management.

Manning The average number of crew members on the vessels is given per vessel type in Table 6.3. For the Post-Panamax vessels, no information on the needed number of crew members is available, so it is estimated that this number is similar to the Neo-Panamax vessels. Remarkable in the graph is that the larger vessel types have a lower number of crew members than the smaller vessels. A possible explanation is that the larger vessel groups contain many newer ships and that advancements in technology have reduced the size of crews needed. However, analysis shows no clear relation between age and crew size, for which reason the age of the vessels is not used to differentiate further in these categories. Besides technological advancements, older ships might also require more crew to cover the increase in maintenance work (Stopford, 2009). It is assumed these additional crew members are not included in the vessel data and therefore the crew size is increased by 4 for every 10 years of age. The crew costs are then calculated according to Aalbers (2000), with the formula in Equation 6.6. In this formula r is an upper roll factor of 1.5 to compensate for things as holidays and the value of \$50,000 per crew member per year is corrected for inflation.

$$C_{crew} = Crew * r * 50000 * 1.03^{year-2000} \tag{6.6}$$

Table 6.3: Average crew size per vessel type. Compiled by author from Clarkson Research Services Limited (2019c).

	Crew Size
Post-Panamax 15,000+ TEU	*20.6*
Neo-Panamax 12-14,999 TEU	20.6
Neo-Panamax 8-11,999 TEU	20.7
Intermediate 3-7,999 TEU	21.1
Feeder 2-2,999 TEU	22.4
Feeder 1-1,999 TEU	20.0
Feeder 100-1,000	16.2

Stores and Consumables For stores and consumables, Watson (1998) provides an estimation of \$7 per person per day, which results in \$13.02 daily per person in present values. As multiple years can be run in the model, the Equation 6.7 is used to determine the costs for stores and consumables;

$$C_{stores} = \$7 * 1.03^{year-1998} * Crew * 365 \tag{6.7}$$

with 1.03 a fixed inflation rate and $year$ the year of the period that is run in the model.

Insurance Insurance is needed to protect against physical loss or damage of the vessel and its machinery and for third-party liability. Van Hassel et al. determined an equation based on the Gross Tonnage (GT) of the vessel. This formula has been corrected for inflation and is shown in Equation 6.8, with 1.03 a fixed inflation rate and $year$ the year of the period that is run in the model.

$$C_{ins} = (6.0393 * GT + 212983) * 1.03^{year-1998} \tag{6.8}$$

Maintenance and Repair Vessels must undergo regular surveys with a dry docking every two years and a special survey every four years Stopford (2009). These become more costly as the ship ages, as more maintenance and repair work is required. An overview of these costs as a percentage of the newbuild price is given in Table 6.4. As operators can already put aside money for the periodic maintenance in advance, these costs are split over the years between the vessel's previous survey and the upcoming survey. Furthermore, costs also exist for general maintenance and repairs in between these dockings, for which a value of 4% of capital costs is assumed.

Management Management and administration fees are also part of this category. These are estimated at 0.5% of the newbuild price (Aalbers, 2000).

6.4.3. Voyage Costs

Costs also have to be paid for every journey a vessel makes. These costs are called voyage costs, with costs for fuel, canals and ports as main components.

Table 6.4: Docking and special survey costs as percentage of newbuild price (Aalbers, 2000).

Vessel Age (Years)	Dry Docking	Special Survey
3	1.1%	-
5	-	1.4%
8	1.2%	-
10	-	1.6%
13	1.3%	-
15	-	1.8%

Fuel costs The largest component of the transport costs are the costs for fuel consumption. Ship size and speed are the most important factors in this calculation because they influence the vessel's resistance. Table 6.5 provides an overview of the average service speed and the associated fuel consumption at this speed for the different vessel types[1]. The fuel costs can then be determined by filling in Equation 6.9, with F the vessel's fuel consumption (tpd), T the transit time in days and p_b the bunker price in \$/tonne.

$$C_{fuel} = F * T * p_b \tag{6.9}$$

Table 6.5: Fuel consumption per vessel type. Compiled by author from Clarkson Research Services Limited (2019c).

	Service Speed (knots)	Main Consumption at Service Speed (tpd)
Post-Panamax 15,000+ TEU	22.9	230.2
Neo-Panamax 12-14,999 TEU	23.9	257.5
Neo-Panamax 8-11,999 TEU	24.1	230.9
Intermediate 3-7,999 TEU	23.9	158.8
Feeder 2-2,999 TEU	21.4	80.4
Feeder 1-1,999 TEU	19.2	47.4
Feeder 100-1,000	16.7	28.1

Canal dues and port charges In case the model is to analyse a route that requires canal dues to be paid, for example the Suez or Panama canal, these can be approximated with the vessel's net tonnage. There are no such canal dues necessary on the route between China and the US West Coast. Port charges are calculated based on the costs of dockage in the destination ports. An overview of these charges in the Port of Long Beach is presented in Figure 6.6 as an example. It shows that the length of the vessels and the time in port determine the height of the fees charged. In this model it is assumed that the time in port is equal for all vessels, so only vessel length is used as a variable in this calculation. By plotting these charges and a trend line, a formula for determining the port costs is derived (see Figure 6.7).

6.4.4. Costs per Trip

The costs calculated in the previous sections have different time spans, as shown in Table 6.6. To allow for comparison on a trip basis, all costs are converted to a daily rate. This can then be multiplied by the number of days that is given as trip duration for the route that is analysed. The yearly costs (C_{yearly}) are divided by the 360 days that a ship is assumed to be running on average per year (Watson, 1998). These are then supplemented by the costs that are already calculated per day (C_{daily}) for fuel and stores and consumables. For a route with no charges for a specific canal, the calculation of cost per trip (C_{trip}) is presented in Equation 6.10, with T_{sea} and T_{port} the days at sea and days in port during the trip respectively.

$$C_{trip} = \left(\frac{C_{yearly}}{360} + C_{daily}\right) T_{sea} + C_{port} * T_{port} \tag{6.10}$$

[1] Sea conditions might increase the fuel consumption even further. This can be included in a later version of the model.

Overall Length of Vessel in Meters			Overall Length of Vessel in Meters		
Over	But Not Over	Charge Per 24-Hour Day	Over	But Not Over	Charge Per 24-Hour Day
0	30	$ 77	210	225	$ 3371
30	45	115	225	240	3899
45	60	159	240	255	4463
60	75	221	255	270	5066
75	90	329	270	285	5706
90	105	519	285	300	6379
105	120	682	300	315	7096
120	135	1004	315	330	7848
135	150	1304	330	345	8641
150	165	1644	345	360	9467
165	180	2016	360	375	10337
180	195	2428	375	390	11242
195	210	2882	390		(1)

(1) Dockage charges for vessels over 390 meters in overall length shall be $11,242.00 per day plus $29.00 per day for each meter of overall length or fraction thereof in excess of 390 meters.

Figure 6.6: Dockage charges Port of Long Beach (2019).

Table 6.6: Frequency at which the different cost types are determined. Based on equations 6.5 - 6.10.

Cost Type	Frequency
Interest	Yearly
Depreciation	Yearly
Manning	Yearly
Stores & Consumables	Daily
Insurance	Yearly
Maintenance & Repair	Yearly
Management	Yearly
Fuel	Daily
Port & Canal	Per trip

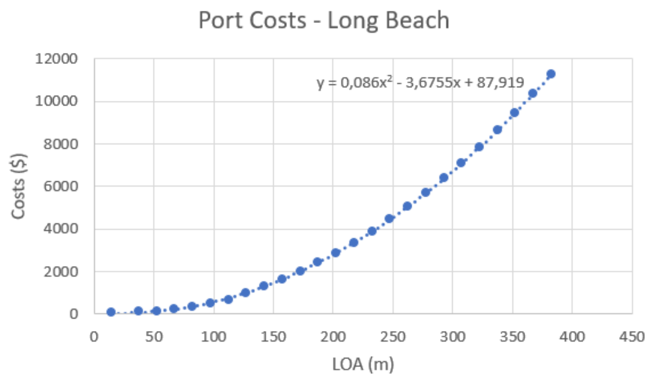

Figure 6.7: Daily port dockage charges. Compiled by author from Port of Long Beach (2019).

6.5. Validation

After completing these stages, the developed model is applied to a case study for validation. By doing so, it is determined whether the model can be used for the intended purposes.

Three main requirements have been considered in the selection of the case. First, there had to be enough data both before and after the integration, so best was to have an event that took place in the middle of the time range for which data is available. Secondly, it had to be possible to distinguish between the vessels operated by the companies both before and after the integration. This meant that M&A is better suited than an alliance for this case. Furthermore, the goal of the integration needed to include operational synergies to be in line with the objective of this research. Based on these requirements the acquisition of Neptune Orient Lines (NOL), the parent company of APL, by the French carrier CMA CGM was chosen. The acquisition was announced in December 2015 and completed in November 2016, so there is enough data available to determine performance both before and after (CMA CGM, 2015). Furthermore, APL still operates as a separate entity, which means that both the companies' vessels can be easily distinguished. The case also satisfied the final requirement, because improved market position, optimisation of vessels and occupancy rates on routes, economies of scale and more flexible vessel deployment were listed by the companies' leadership as the main motives for this integration (**?**).

7 Tactical Matching Model

7.1. Objective

The aim of the entire model is to analyse synergies through strategic cooperation and to identify potential partners. Part of this model (B1) is an optimisation of operations in terms of allocating cargo to be transported optimally to vessels in operators' fleet. It is considered important to have a simple model with limited computing time that demonstrates the possibilities of assessing synergies on a tactical level with an optimisation model than that it is extremely accurate. To achieve this simplicity, several assumptions are made. The assumptions and mathematical foundation of tactical matching part of the model is presented in this section.

7.2. Assumptions

The main idea behind this part of the synergy model is that all companies have batches of cargo that need to be transported between a defined set of ports and that this demand is known. For simplicity reasons, it is assumed that this demand does not depend on transit time and freight rate. This is an assumption that is typically made in models for the liner shipping industry (Wang and Meng, 2017). The carriers also have vessels that can be deployed to serve the route between those ports. To keep computing time low, all container sizes are converted to TEU. This means that even though a FEU (the equivalent of two TEU) can realistically not be divided over two separate vessels, this is possible in the model. This is also mentioned as a frequently made assumption by Wang and Meng (2017). The vessels that can be assigned to transport the sets of cargo have several characteristics that play a role in the allocation process. The maximum capacity of the vessel is important because it imposes a physical limit on how much containers it can transport on a voyage. Each vessel is also assigned to a time period in which it is available. The model assumes that within this time period, the vessel can transport the cargo immediately and can also be serviced by the port of destination when it arrives. Reason for this assumption is again to reduce the model's complexity.

To determine vessel costs, all ships are classified in types based on capacity and age. Wang and Meng (2017) mention that it is frequently assumed that the fleet is entirely homogeneous. This model does differentiate in terms of capacity, but does assume that within these vessel types sailing speed is constant and the cost structure is homogeneous. For simplicity of the optimisation model, the costs of the vessels are determined before the optimisation. This means that in the model, fuel consumption is not influenced by the loading condition of the vessel. The model also assumes that bunker prices, port charges (and canal dues) are known and constant over the considered time period.

One of the main findings from the route analysis is that operators have flexibility in how they deploy their vessels, even on the short term. For that reason, it is assumed that if the number of vessels used to operate a route can be reduced, these vessels can be deployed, elsewhere, leading to higher profits. In the future, the model can be extended to optimise multiple routes simultaneously and to also consider costs for vessel lay-up or for transferring the ship to another route.

Because vessels almost never sail with only full containers, a factor is added that reserves a percentage of the vessels' capacity for empty containers. The current model assumes this factor equal for all vessels on the route, but if a backhaul is also included in the optimisation, it is likely that both directions need a separate factor to include trade imbalances.

7.3. Model Parameters

The model involves three main sets. The first is a set (C) of cargoes to be transported on the route. For every cargo in this set, data is included on its size in TEU (D_c) and the time period in which it is available (T_c). All companies on the route that can transport these cargoes are comprised in the set 0 of companies. By combining sets O and C, the matrix F_{co} can be constructed, giving a binary indication of which company in set 0 owns the cargo in set C. In this case, 'owns' means that the cargo is to be transported by that company, even though the real owner of the cargo is likely to be a third party (i.e. the customer of the liner shipping company). There is also a set of ships (V) with information on each vessel's capacity (Q_v), its sailing cost (SC_v) and also the time period in which the vessel is available for deployment (W_v). Another matrix is constructed with set 0 for an overview of which company operates which vessel (E_{vo}). There are also several other constant. α for example, is the maximum number of companies that are allowed to be in a partnership and is therefore an important aspect of this model. Furthermore, it is unlikely that the model is able to reach an optimal solution if all containers have to be transported by the assigned companies. For that reason, it is possible for the companies to reject containers. However, this rejection comes at a penalty, which it represented by β. Additionally, γ reserves a part of each vessel's capacity for the transport of empty containers. This is necessary because trade imbalances exist between regions. The values for α, β and γ can be adjusted to market trends or client preferences. Finally, M is a sufficiently large number that is necessary in some of the equations in the model.

The decision variables are the parameters that the model can change while searching for the optimal solution. There are three binary decision variables, meaning they can only have values of 0 or 1. Of these, x_{vc} is the variable used to place cargoes on vessels. Furthermore, y_v can be used to change whether a vessel is deployed or not. The final binary decision variable is z_{oj}, which indicated if two companies are in a partnership with each other. The model also includes a variable that represents the number of containers that are loaded on each vessel (L_{vc}) and one for the number of containers that are rejected and for which the penalty must be paid (U_c). These can both only be integers with a positive value. The sets, variables and parameters used in this model are summarised below. With these, the model can be modelled as shown in Section 7.4.

Sets

C	Set of Cargoes
O	Set of Companies
V	Set of Ships

Constants

Q_v	Capacity of vessel $v \in V$ in TEU
D_c	Size of cargo $c \in C$ to be transported in TEU
S_v	Sailing cost of vessel $v \in V$
E_{vo}	Vessel operator $o \in O$ for vessel $v \in V$
F_{co}	Owner $o \in O$ of cargo $c \in C$
T_c	Time period in which cargo $c \in C$ is available
W_v	Time period in which vessel $v \in V$ is available
α	Maximum number of cooperating partners
β	Penalty for failing to transport one TEU
γ	Percentage of capacity reserved for empty containers
M	100000

Variables

$x_{vc} \in \{0,1\}$	1 if vessel $v \in V$ transports cargo $c \in C$, 0 otherwise
$y_v \in \{0,1\}$	1 if vessel $v \in V$ is active, 0 otherwise
$z_{oj} \in \{0,1\}$	1 if company $o \in O$ cooperates with company $j \in O$, 0 otherwise
$L_{vc} \in \mathbb{Z}^+$	Total number of cargoes $c \in C$ loaded on vessel $v \in V$
$U_c \in \mathbb{Z}^+$	Number of declined cargoes $c \in C$

7.4. Model Formulation

The objective of the model is to minimise the total costs (7.1). This containers two parts. The first is the sum of the sailing costs of the vessels that are deployed on the left of the equation. On the right is the sum of the penalties incurred for the rejected cargoes. The solution for this objective is subject to certain constraints. The first of these, Constraint (7.2), ensures that the amount of containers loaded on the vessels does not exceed the vessel's total cargo-carrying capacity. This constraint also takes into account the capacity reserved for the transport of empty containers. Subsequently, constraint (7.3) sums the total of the loaded (accepted) containers and the not-accepted containers and ensures that this number equals total demand. Constraint (7.4) then determines on which vessel the different containers are loaded. If a vessel is assigned cargo to transport, this is registered by constraint (7.5) and a positive value for y_v is given. If the vessel is active, constraint (7.6) ensures that the company that operates the vessel also transports its own cargo on that vessel. Thereafter, it is determined which companies cooperate. Firstly, if a vessel carries the cargo of another company, this means that they are cooperating and the cooperation variable z_{oj} is set to 1 by constraint (7.7). As the vessel is also carrying its own company's cargo at all times, $z_{oj} = 1$ is also assigned to the vessel's operator (i.e. the vessel operator cooperates with itself). Constraint (7.9) ensures that cooperation is symmetric, if company o cooperates with company j then the opposite is also true. With these cooperation constraints, it is possible to impose a limit on the number of companies in a partnership. This is done in constraint (7.10). Constraint (7.11) then ensures that the vessel and the containers loaded on that vessel are available in the same time period. Finally, the bounds for the variables are given by constraints (7.12) and (7.13), with x_{vc}, y_v and z_{oj} binary variables and L_{vc} and U_c positive integers.

$$\texttt{Minimise} \sum_{v\in V} S_v y_v + \sum_{c\in C} \beta U_c \tag{7.1}$$

`Subject to:`

$$\sum_{c\in C} L_{vc} \le (1-\gamma)Q_v \qquad \forall v \in V \tag{7.2}$$

$$\sum_{v\in V} L_{vc} + U_c = D_c \qquad \forall c \in C \tag{7.3}$$

$$M x_{vc} \ge L_{vc} \qquad \forall v \in V, c \in C \tag{7.4}$$

$$M y_v \ge \sum_{c\in C} x_{vc} \qquad \forall v \in V \tag{7.5}$$

$$\sum_{c\in C}\sum_{o\in O} x_{vc} E_{vo} F_{co} \ge y_v \qquad \forall v \in V \tag{7.6}$$

$$\sum_{v\in V}\sum_{c\in C} x_{vc} E_{vo} F_{cj} \le M z_{oj} \qquad \forall \{o,j\} \in O \tag{7.7}$$

$$z_{oj} = 1 \qquad \forall \{o,j\} \in O \mid o = j \tag{7.8}$$

$$z_{oj} = z_{jo} \qquad \forall \{o,j\} \in O \mid o \neq j \tag{7.9}$$

$$\sum_{j\in O} z_{oj} \le \alpha \qquad \forall o \in O \tag{7.10}$$

$$x_{vc}(T_c - W_v) = 0 \qquad \forall v \in V, c \in C \tag{7.11}$$

$$x_{vc}, y_v, z_{oj} \in \{0,1\} \qquad \forall v \in V, c \in C, \{o,j\} \in O \tag{7.12}$$

$$U_c, L_{vc} \in \mathbb{Z}^+ \qquad \forall v \in V, c \in C \tag{7.13}$$

8

Strategic Matching Model

8.1. Objective

A partnership based solely on operational integration possibilities and tactical compatibility is unlikely to be successful. When two companies are to cooperate, it is also important that there is a solid strategic foundation for the partnership so that the companies can work well together. For that reason, the synergy model also includes an assessment of the potential partners on a strategic level. The factors on which the companies are evaluated are derived from literature and the results from the route analysis. Information that results from the tactical matching part of the model (e.g. combined market share and costs) also serve as input for the strategic part of the synergy assessment. What results is an indication of the feasible level of cooperation between two identified partners and the associated potential benefits of the partnership.

8.2. Strategic Matching Components

This section of the model consists of two main parts: drivers and facilitators. These are used to evaluate the potential partnership by assigning points for the different items. The criteria used in the strategic comparison and the questions with which to evaluate them have mostly been developed by Douglas et al. (1996). The items used to answer the questions are supplemented with findings of Ding and Liang (2005), Das (2011) and Sanders et al. (2015).

8.2.1. Drivers

Drivers are the reasons for companies to desire a partnership (Douglas et al., 1996). These are to be filled in for every partner individually. The drivers in the original model by Douglas et al. (1996) are intended as two separate questionnaires that can be filled in by both parties that wish to enter a partnership. This model on the other hand, is meant to assess the possible partnership in an earlier stage without input from the partnering company. For that reason, the scores for the drivers are mainly based on the results from the tactical optimisation. In this way, the model assesses whether the potential partnership offers sufficient motivation for both parties to explore their opportunities further. The client's input is also used when filling in the client's drivers.

As the drivers are worked out for both firms individually, two separate lists of drivers result. It must be noted that the existence of sufficient drivers for a partnership for both companies is more important than that the drivers are the same for all partners (Douglas et al., 1996).

The drivers of the companies are determined by answering four questions. These are presented in Table 8.1. Each question is assigned a score within a 1-5 range. These scores indicate the level of improvement for the company that is expected to arise from the partnership, as shown in Table 8.2. In case the score assigned to a question is 3 or higher and the improvement is regarded as sustainable on the long term, a bonus point can also be given.

Asset/Cost Efficiency The first question to be answered considers the efficiency of assets. To evaluate this factor, the following items are examined: ship-route fit, cost reductions and utilisation rates. The fit between vessels and route concerns how well the fleet of the company can be assigned to the route in the partnership.

Table 8.1: Questions to assess drivers. Adapted from Douglas et al. (1996).

Question	Score					Bonus
1. How is this relationship expected to affect costs and asset utilisation?	1	2	3	4	5	+1
2. How is this relationship expected to affect the customer service level?	1	2	3	4	5	+1
3. How is this relationship expected to affect marketing activities?	1	2	3	4	5	+1
4. How is this relationship expected to affect profit growth and variability in profit?	1	2	3	4	5	+1

Table 8.2: Scores to assess drivers. Adapted from Douglas et al. (1996).

1	2	3	4	5
No improvement		Some improvement		Significant/certain improvement

This takes into account how many vessels each company would bring into the partnership and how many of its vessels the operator has to assign to another route or lay-up. This information is derived from the tactical matching module. Expected cost savings are also obtained through the tactical matching. These are supplemented by the extra savings that result from the client's intended level of integration given as input. It can also be determined if the partnership lowers the average age of the company's fleet, as this is likely to lead to lower running and transport costs. Whether or not the partnership is expected to increase vessel utilisation is also taken into account when answering the question for this driver.

Customer Service Increased customer service can also be a main driver for an operator to enter a partnership. The factors to evaluate whether this will improve are the frequency of service, the geographical scope, the tracking of cargo and service channels and locations. If the partnership would allow the operator to offer a higher frequency of service on certain routes, this can be seen as an advantage. It is also possible that the partner operates in an area in which the company itself is not yet active. Furthermore, the ability to track cargo and provide accurate information to the customers is also taken into account in the assessment of the service level.

Marketing Advantage A third potential driver for the operators is improvements in their marketing activities. Coordinating marketing tasks together may result in cost reductions, but also higher revenues. Furthermore, a partner may offer better access to regional or local markets.

Profit Stability/Growth The final driver question evaluates the potential for profit improvement for the company. This involves growth of profits, for example as a result of an increase in long-term customer contracts. Increased profit stability from reduced variability in sales throughout the seasons can also benefit the company.

8.2.2. Facilitators

Facilitators are defined as the elements of a corporate environment that allow a partnership to grow and strengthen. For that reason, the facilitators are evaluated from the perspective of the joined entity instead of two separate companies. The questions to determine the facilitators of the partnership are presented in Table 8.3.

Table 8.3: Questions to assess facilitators. Adapted from Douglas et al. (1996).

Question	Score					Bonus
1. How are the organisation's cultures expected to match with each other?	1	2	3	4	5	+1
2. How symmetric are the organisations?	1	2	3	4	5	+1
3. Do the organisations have prior experience that benefits this relationship?	1	2	3	4	5	+1

Table 8.4: Scores to assess facilitators. Adapted from Douglas et al. (1996).

1	2	3	4	5
Not at all		Average		Perfectly

Culture One important facilitator of a successful partnership is the culture of the two companies. This is assessed by the proximity of the home regions of the potential partners and their business culture. Das (2011) described how companies that are geographically close have greater understanding of the home context, decision-making style, and management of operations of the other firm, ability to tap both formal and informal sources of information to assess the other firm, and higher chance of success in managing the other firm following the acquisition. However, the business style of the companies is also important beside proximity. Business culture is determined based on the dimensions described by Meyer (2014) for a culture map: Communicating, Evaluating, Leading, Deciding, Trusting, Disagreeing, Scheduling and Persuading.

Symmetry There are also several factors that benefit a partnership if they are symmetric. These factors are relative size in terms of sales, financial strength, asset strategy and ownership structure. Financial strength consists of Return on equity, Profit margin and Return on assets(Ding and Liang, 2005). The partners' asset strategy can be determined with both their ratios of owned versus chartered vessels. Ownership structure is based on whether the company is family or publicly owned and whether it is listed or private.

Prior Experience The final potential facilitator is prior experience, because the companies will have already learned important lessons they can apply to their new partnership. This can be experience with the type of integration, or with previous cooperation between the partners.

8.3. Determining the Match Potential

Once the drivers and facilitators have received their scores, these points are all added up and the total gives an indication of the type of integration that would be advisable. Figure 8.1 provides an overview of the original definition of the types of integration given by Douglas et al. (1996) and how these can be related to the levels of integration in the liner shipping industry as discussed earlier.

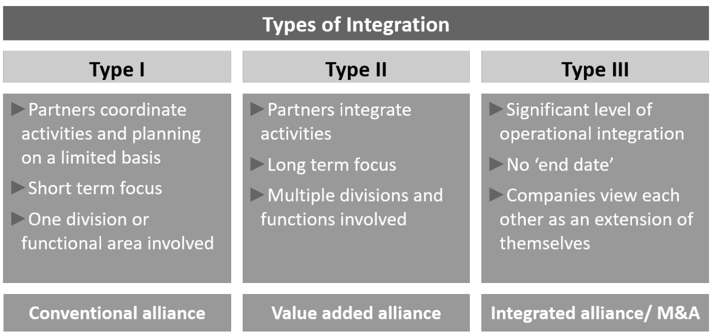

Figure 8.1: Link between types of integration and the levels of cooperation for LSCs. Compiled by author from Douglas et al. (1996) and Sanders et al. (2015).

The advisable level of integration can be determined with the matrix given in Figure 8.2. By reading of the total values for both the drivers and the facilitators, a maximum advisable level of integration is found. The stronger the drivers and facilitators, the further integration is possible.

This matrix can be found in the overview of the entire model (Figure **??**) in section D2, the match assessment. It is the output generated from the client's input, the companies' business details and the quantitative results of the match on a tactical level and the result from a qualitative assessment of these factors combined. The final advice to the client can be derived directly from these results.

Facilitator Score \ Driver Score	8-11	12-15	16-24
6-10	-	Type I	Type II
10-14	Type I	Type II	Type III
14-18	Type II	Type III	Type III

Figure 8.2: Integration Score Matrix. Adapted from Douglas et al. (1996).

9

Case Study: Partner Matching in CMA CGM's Acquisition of NOL

The CMA CGM Group is the world's third largest container liner shipping company with a broad global network. In December 2015, it announced the acquisition of Neptune Orient Lines (NOL), the parent company of APL and Southeast Asia's largest container shipping company at the time (CMA CGM, 2015). The merger was completed in November 2016. At the time of the acquisition, CMA CGM and APL were in opposing alliances. CMA CGM was a member of the O3 Alliance, with UASC and CSCL and APL was part of the G6 Alliance, together with Hapag Lloyd, HMM, OOCL, NYK and MOL (**?**). The aim in this case is to identify a suitable partner based on operations in 2015, assuming that is the moment when CMA CGM was exploring partnership opportunities, and to assess the fit between CMA CGM and the potential partner.

9.1. Client Input

The client in this case is CMA CGM, which in 2015 is looking for a liner shipping company that it can partner with and possibly even acquire. By doing so, it aims to improve its market position, to optimise vessel utilisation with increased flexibility in vessel deployment and to realise economies of scale in purchasing, logistics and chartering (The Loadstar, 2015). Another motivation for CMA CGM is to increase its ability to withstand market volatility. In terms of geography, this case study focuses on the route between the ports of Ningbo and Shanghai in China and Los Angeles and Long Beach on the U.S. West Coast.

The case study considers two points in time. Emphasis is on the year 2015, which is before the merger between APL and CMA CGM took place in reality. The year 2017 is used to examine performance after the merger. An additional advantage of these years in specific is that they are relatively similar in terms of total demand, deployed capacity and utilisation rates on this route and thus allow for a better comparison (see Table 4.1 on page 19). For both years, the analysis includes performance of the companies without cooperation, followed by the performance of the companies in cooperation with their selected partner.

9.2. Quantitative Case Analysis: Tactical Matching

To see what the model would advise as a potential partnership for CMA CGM, the tactical matching model is first applied to the case.

Table 9.1: Input parameters used in the case study.

	Trip Duration	Time in Port	Inflation Rate	Fuel Price	Max. Number of Partners (α)	Rejection Penalty (β)	Reserved Capacity (γ)
2015 2017	33 Days	1 Day	3%	320$/Day 350$/Day	2	60000$/TEU	5%

9.2.1. Input for Tactical Matching

The matching of potential partners on a tactical level involves the reallocation of cargo to vessels on the route. This is based on the operational data of the containers on the route and the fleet characteristics. For the latter, the sailing costs of the vessels have to be calculated, which requires additional input. The trip duration in this case is set to 33 days and a time in port of 1 day is assumed for all vessels that make a trip. Furthermore, an inflation rate of 3 % is used. These values are equal for both the 2015 and the 2017 scenarios. The fuel price on the other hand, differs for both years. In 2015, a fuel price of 320$/tonne is used, while the 2017 fuel price is set to 350$/tonne. These prices are based on the average fuel price per year in the port of Shanghai (Clarkson Research Services Limited, 2019b).

Beside the input required for the vessel costs, the optimisation model itself also has three constants that can be adjusted per case. The maximum number of companies in a partnership (α) is set to a value of 2 in this case. Reason for this is that it allows comparison of an alliance with a merger, without getting into too complex partnership structures. Additionally, as two partners is the minimum amount possible in a partnership, the results give a good indication of the extent to which the model is able to reduce the number of partners. If costs can already be reduced with only one partner, this shows that all levels of integration can be analysed.

The penalty for rejecting a container (β) is set to $60.000. During initial tryout runs, it was found that the penalty needed to have a high value for the model to function properly. With a lower value, it becomes too 'easy' for the companies to reject cargoes and cancel sailings. The value of $60.000 is based on approximately 20% of the average vessel sailing cost as a starting point.

The final parameter for which a value is needed is the amount of vessel capacity that is to be reserved for the transport of empty containers (γ). Because the route in this case study is located on the positive side of the trade imbalance between Asia and the U.S., it is assumed that few empty containers are transported in this direction. This is also in line with the high utilisation rates found in Chapter 4. The reserved capacity is therefore set to 5% of total vessel capacity. An overview of the used input parameters are given in Table 9.1. If only one value is shown in the column, that value is equal in both years.

9.2.2. Identifying a Potential Partner

Starting in the year 2015, which is before the merger took place, the operational data for the companies on the route is loaded in the tactical matching model. Cargo and vessels are assigned to periods with a monthly frequency. This means that for every month, there is a total amount of cargo to be transported and a set of available vessels, both aggregated per company. A vessel is regarded to be available in the month in which the data shows that it made a voyage. For the year 2015, the model is able to find an optimal solution. It redistributes cargo among the vessels and forms partnerships without exceeding the maximum number of partners, which is two in this case. For CMA CGM in particular, it finds that APL is the most suitable partner in this scenario. This means that the model's solution matches the partner that was selected in reality. To examine the effects of this potential cooperation, two scenarios are compared in Table 9.2. First, this table shows the performance of both companies without cooperation. This performance is generated before any changes are made in terms of cargo allocation or vessel deployment. For that reason, this scenario can be used as a reference case. All the model does is determine the performance parameters and calculate the costs of the vessels used. The second scenario presented in Table 9.2 is the one where the model has changed which vessels transport which cargo and identified CMA CGM and APL as partners. The columns given for both scenarios deserve some extra explanation. Columns 1 and 2 present the performance without cooperation for APL and CMA CGM respectively. Column 3 is the sum (and for utilisation and unit costs the average) of the performance of the companies combined. This column is used only for comparison with other scenarios. Then in the case where APL and CMA CGM do cooperate, columns 4 and 5 represent the individual performance of the companies in this partnership. These columns allow evaluation of the potential partnership from the perspective of both companies. The performance of the partnership itself is given in column 6, which is again the sum or average (depending on which row is considered) of the two previous columns. Important to note is that the optimisation of vessel deployment is not included in the scenario without cooperation. Being able to optimise operations and vessel deployment jointly is part of the more integrated partnerships, but a company can also optimise vessel deployment on its own. It is thus possible that the company can already improve its current individual operations without the need for a partner. However, if this would have lead to a better result than would be achieved with a partner, this would have been indicated in the result of the optimisation. In other words, the scenario 'with cooperation' allows companies to cooperate, but does not force them to do so if operating without a partner leads to better results. Nevertheless, the absence of vessel deployment optimisation in the stand-alone scenario should be considered when looking at the potential improvements that result from the model.

Table 9.2: Performance of companies in 2015 with and without cooperation.

	Without Cooperation			With Cooperation		
	(1) APL	(2) CMA CGM	(3) Combined	(4) APL	(5) CMA CGM	(6) Combined
Market Share	5.54%	6.31%	11.85%	6.11%	6.67%	12.78%
TEU Transported	335529	327310	662839	285418	311823	597241
Vessel Utilisation	90.1%	97.3%	93.7%	93.1%	95.0%	93.9%
Number of Trips	59	37	96	59	35	94
Total Cost ’000	$966,230	$1,733,350	$2,699,580	$966,230	$1,611,152	$2,577,383
Unit Cost $/TEU	3467	5218	4142	3209	5037	4030

Table 9.2 shows that by cooperating, CMA CGM and APL would both be able to increase their individual market shares. What is more, the combined market share almost double their own[1]. The partnership would also allow CMA CGM to reduce the number of sailings they perform. With two fewer vessel trips, CMA CGM reduces its total costs and its unit costs. This even despite a lower average utilisation rate. APL on the other hand, would still have the same amount of vessel trips and thus also has the same total costs, but cooperation with CMA CGM allows it to increase vessel utilisation and lower unit costs. Combined, APL and CMA CGM would improve vessel utilisation and reduce the number of sailings, resulting not only in lower total costs but in lower unit costs as well.

One interesting difference is that between the unit costs of CMA CGM and APL. In the reference case, the average unit costs for CMA CGM are 5218$/TEU, where those of APL are much lower at 3467$/TEU. Even though the optimisation lowers the unit costs, the difference remains. Two reasons for this difference can be identified. First of all, APL has an average vessel size of 5483 TEU on this route, while that of CMA CGM is 9011 TEU. Larger vessels are in general more expensive to operate due to a higher newbuild price, larger crew and higher fuel consumption. The second influencing factor is the age of the vessels. For the vessels deployed on the route by CMA CGM, the median year in which they were built is 2010. For APL, on the other hand, the median build year is 1995. This leads to differences in the newbuild price and in periodic maintenance costs. Beside the large difference between them, the unit costs for both companies also seem rather high compared to the average revenue per FEU (the equivalent of two TEU) of $3026 that APL lists on transpacific routes in 2015 (APL, 2015). Even though APL's operations resulted in a loss in this year, this does not explain the entire difference. It can thus be stated that the model presumably overestimates vessel cost in general. Not only that, it also seems that this overestimation increases for larger and/or newer vessels.

9.2.3. Future Performance of Partners

It is also interesting to evaluate the performance of the identified partners in a later year than for which their match was found. Looking at the base case performance of the two partners can give an indication of the success of the merger that took place. More information about the potential match can be found with the tactical model. By extending or changing the time period, the advised partner for the companies could change. However, as market conditions frequently change and this model is developed with the aim for long-term partnerships, it is also important to assess the performance in such periods. By forcing a partnership between APL and CMA CGM in the model (setting their z_{oj} value to 1), it can be determined if the partners would still achieve a cost reduction or increase their market share with each other, even though a better partner for that period might exist. The performance of the companies in 2017 is presented in Table 9.3, again for the scenario without cooperation and what they would achieve if they would cooperate. Adding the constraint that forces CMA CGM and APL to work together significantly increases the run-time of the model. For that reason, the solution presented for 2017 is feasible but not optimal. However with an optimality gap of only 7.75%, it still provides a good indication of the expected performance. It would seem that establishing a set of partners beforehand makes it easier for the model to find a solution. Yet, because the model is designed to optimise for all companies on the route, the opposite is true. With one set of partners predefined, the number of possibilities for the entire problem is reduced, making it harder for the model to reach an optimal solution.

[1] As all companies can decline cargoes and these cargoes are not included in the market share calculation, it is possible to increase market share despite transporting fewer TEU.

Table 9.3: Performance of companies in 2017 with and without cooperation.

	Without Cooperation			With Cooperation		
	(1) APL	(2) CMA CGM	(3) Combined	(4) APL	(5) CMA CGM	(6) Combined
Market Share	8.04%	2.75%	10.79%	6.70%	2.17%	8.87%
TEU Transported	387144	107595	552436	331527	107595	496818
Vessel Utilisation	94.1%	97.2%	95.7%	86.9%	87,8%	87,1%
Number of Trips	66	16	82	64	10	74
Total Cost '000	$1,993,439	$788,443	$2,781,882	$1,805,197	$305,219	$2,110,416
Unit Cost $/TEU	4251	5564	4526	4898	3978	4774

To start with, the performance of the companies when they do not cooperate (columns 1-3 in Tables 9.2 and 9.3) is compared. The first thing to notice is the decrease in combined market share. Even though APL was able to increase its market share on the route from 5.54% to 8.04%, CMA CGM's market share decreased by a larger amount. It could have been a strategic decision to transfer the majority of CMA CGM's cargo to APL vessels, which would explain these figures, but if that is the case the extent to which they did so was too large. The lower market share in 2017 is also reflected in the number of TEU transported in that year. Market conditions were slightly worse than in 2015 with a lower amount of cargoes transported in total on the route (see Table 4.1), but this was only by 0.7%. Therefore, even though it might account for a small part of the lower amount of TEU transported by CMA CGM and APL, it does not explain the decrease completely. It is thus likely that the causes for revenue dilution mentioned in Chapter 2 also occurred in this case. Still, from the perspective of CMA CGM, the merger has led to an increase in market share from 6.31% in 2015, to a combined market share of 10.79% in 2017.

What is also interesting is the average utilisation rates of the companies. After its acquisition by CMA CGM, APL was able to improve utilisation rates from 90.1% in 2015 to 94.1% in 2017. At the same time, CMA CGM's own average utilisation rate decreased slightly (0.1%). As a result, combined average vessel utilisation improved from 2015 to 2017, but it decreased by 1.5% compared to CMA CGM's utilisation when operating on its own.

The number of vessel trips offered by both companies also changed. APL increased its number of sailings, while CMA CGM more than halved this number. Combined, the companies reduced the number of vessel trips from 2015 to 2017 with 14 trips. Nevertheless, this did not lead to a cost reduction. This could partially be explained by the higher fuel price in 2017. Yet in case the fuel price in 2017 is set to the same value as 2015 (320$/$Tonne$), a cost reduction is still not achieved by the merged entity (total costs for 2017 with the fuel price from 2015 amount $\$2,766,727,556$). Unit costs would be 4816$/$TEU$ for APL, 5569$/$TEU$ for CMA and 4491$/$TEU$ combined. Based on both the scenarios with and without cooperation, the type of vessels deployed on the route turns out to be relatively expensive to own and operate. This can also be seen in the unit costs, which for both APL and CMA CGM were higher in 2017 than they were in 2015. It is also likely that the partners were still experiencing some coordination issues, because the partnership is still very young in 2017. However, one important factor that could explain why costs are higher in 2017 is not included in the current model: sailing speed. Literature has reported that carriers have widely adopted the practice of slow steaming in recent years. By lowering the speed at which vessels sail, fuel consumption decreases, which results in lower transport costs. If CMA CGM and APL have also lowered their vessel speed, total costs and unit costs would be lower than those presented in Table 9.3, but cannot be derived from the current data set.

Turning to the results of the optimisation, average unit costs are lower for the combined company, as well as the total costs. Yet market share and transported TEU are still low. This can be explained by the fact that the model cannot simulate higher demand, only demand lower than the actual data. The model is largely influenced by the actual operations of companies. This makes modelling the expected future performance of a potential partnership imprecise.

9.2.4. Potential Revenue

Even though revenues are not included in the current version of the model, they can be approximated. This is done for CMA CGM as a stand-alone company, CMA CGM in an alliance with APL and for CMA CGM and APL as a merged company.

$$Operating\ Margin = \frac{Revenue}{Operating\ Expenses} = \frac{\$15674.1}{\$14420.6} = 1.09 \tag{9.1}$$

An operating margin of 1.09 is derived from the annual report of CMA CGM (2015), as shown in Equation 9.1. This operating margin is then used to determine revenue for the base case with the total costs for that scenario. This leads to a total revenue of 1,884m$, which comes down to a revenue per TEU of $5756. Assuming revenue per TEU stays the same, the total revenue for the optimised scenario with an alliance or merger can also be calculated. In the case of a merger, the companies' increased market share, higher sailing frequency, combined marketing efforts and larger shipping network that result from the partnership are also likely to generate additional revenues. For that reason, an extra scenario is added in which the revenue of the optimised merger scenario is increased with 2%. An overview of costs, revenue and the resulting profit for CMA CGM with and without a partner is presented in Table 9.4. It shows that in an alliance, CMA CGM would be able to reduce its costs with 7%, resulting in an increase of profit of 22%. Moreover, even though a merger would lead to a significant increase in cost, the combined cost is almost twice CMA CGM's stand-alone cost, it would allow CMA CGM to increase its profit on this route by 471-517%. The costs shown in this table can be even further reduced depending on the type of integration (Sanders et al., 2015). Most interesting is that the profit per deployed capacity in TEU is improved in all cases presented in Table 9.4.

Table 9.4: Overview of potential profits from partnership.

	Stand-Alone	**Alliance**		**Merger**			
	CMA CGM (No Cooperation)	CMA CGM (Cooperation)		CMA CGM & APL (Cooperation)		CMA CGM & APL (Cooperation) +2%	
Capacity Deployed [TEU]	333399	314323		634621		634621	
Total Cost $'000	1,733,350	1,611,152	(-7%)	2,577,383	(+49%)	2,577,383	(+49%)
Total Revenue $'000	1,884,020	1,794,876		3,437,763		3,506,518	
Total Profit $'000	150,670	183,724	(+22%)	860,380	(+471%)	929,135	(+517%)
Profit per Deployed TEU	452$	585$	(+29%)	1,356$	(+200%)	1,464$	(+224%)

9.2.5. Competition and Regulation

The market shares of the companies on the route that result from the optimisation are presented in Table 9.5. It shows how CMA CGM and APL (with previous market shares of 6.31% and 5.54% respectively), would have a combined market share of 12.78%. This places them third on this route.

Because both companies were in competing alliances, the European Commission only approved the acquisition under the condition that APL would leave the G6 Alliance, because it identified routes (Northern Europe - North America and Northern Europe - Middle East) on which competition from liner shipping companies with no connection with the merged entity or its alliance partners would have been insufficient (**?**). There is no hard limit on companies' market share imposed by regulation, but if a company's or alliances market share exceeds 30%, the operators are responsible to prevent anti-competitive behaviour (Premti, 2016). On this route, however, the market share of CMA CGM and APL together is well below this 30%.

The concentration of the top 4 firms (CR4) found in the base scenario in 2015 is 0.59. This implies that the market on the route is a loose oligopoly, but it is also just below the threshold of 0.6 for a tight oligopoly. The tactical optimisation that identifies a partnership between APL and CMA CGM results in a market with

Table 9.5: Market shares resulting from optimisation.

Company	Market Share
COSCO	30.22%
Maersk	12.90%
CMA CGM & APL	**12.78%**
ONE	9.76%
MSC	8.36%
Evergeen	6.68%
Matson	5.05%
Yang Ming	4.74%
OOCL	3.79%
Hapag-Lloyd	2.87%

a higher CR4 value of 0.79. The effect on the CR8 is much smaller and increases only slightly, because APL and CMA CGM were both already part of the top 8 firms. The HHI of the market that results from the model is also increased, but it is still in the range that indicates '*moderate concentration*'. Only if the HHI is further increased to exceed 1800 would the market be marked as '*highly concentrated*'.

The values for these concentration indices presented in Table 9.6 are slightly different from the indices for the same year given in the route analysis (see Table **??** on page **??**) This may seem odd because the same data is used for both tables. The cause of this difference is found in how the companies' market shares are determined. In the route analysis, market share is calculated with the total amount of cargo that is on the vessels of each company. The market shares used for the results in Table 9.6 on the other hand, are determined after the cargo of the vessels is split among alliance members (see Section 6.3 for more detail on how this division is done).

Table 9.6: Concentration Indices 2015.

	Base Case		Simulated	
CR4	0.59	*Loose oligopoly*	0.66	*Tight oligopoly*
CR8	0.86		0.90	
HHI	1358	*Moderate concentration*	1526	*Moderate concentration*

9.3. Qualitative Case Analysis: Strategic Matching

With APL selected as a potential partner for CMA CGM, an analysis on strategic level is performed to determine how well the two companies would fit together and what level of integration would be advised among the two.

9.3.1. Input for Strategic Matching

The results presented in Table 9.2 of the optimisation in 2015 are used as input to determine the match of APL and CMA CGM on a strategic level. This is supplemented by the client's objectives and information derived from the companies' annual results (see Section 6.2.1).

9.3.2. Partnership Drivers

The first step in the strategic matching process is to determine the drivers for each of the companies separately. The scores for the different driver components for CMA CGM are shown in Table 9.7. Even though the acquisition in itself is costly, combining the fleets is expected to result in greater flexibility in the deployment of vessels, which allows cost reductions and higher asset utilisation. The first two are supported by the results from the tactical matching in Table 9.2, which shows a higher market share, reduction of total costs and lower unit costs for both CMA CGM alone and for the merged company. However, asset utilisation goes down. Customer service level is expected to improve, mainly from the higher number of sailings it can offer with APL, but also from the smaller number of partners allowing for more transparency to the customer. Furthermore, CMA CGM's marketing is likely to benefit from APL's knowledge of and access to the regional market. Combined, these factors and the increased market share are expected to lead to profit growth for CMA CGM. The total driver score for CMA CGM is 17 points.

The scores for the drivers from the viewpoint of APL are given in Table 9.8. In terms of total costs, APL is likely to remain on relatively the same level. Furthermore, even though vessel utilisation increases and

Table 9.7: Driver scores for CMA CGM.

Question	Score					Bonus
1. How is this relationship expected to affect costs and asset utilisation?	1	2	3	[4]	5	+1
2. How is this relationship expected to affect the customer service level?	1	2	3	[4]	5	+1
3. How is this relationship expected to affect marketing activities?	1	2	3	[4]	5	+1
4. How is this relationship expected to affect profit growth and variability in profit?	1	2	3	4	[5]	+1
Total Driver Score	17					

Table 9.8: Driver scores for APL.

Question	Score					Bonus
1. How is this relationship expected to affect costs and asset utilisation?	1	2	3	[4]	5	+1
2. How is this relationship expected to affect the customer service level?	1	2	[3]	4	5	+1
3. How is this relationship expected to affect marketing activities?	1	2	[3]	4	5	+1
4. How is this relationship expected to affect profit growth and variability in profit?	1	2	3	[4]	5	+1
Total Driver Score	14					

Table 9.9: Company information of CMA CGM and APL. Compiled by author from APL (2015); CGM (2016); Sanders et al. (2015).

	CMA CGM	APL
Home country	France	Singapore
Return on Equity	10%	-7%
Profit Margin	3%	-3%
Return on Assets	4%	-3%
Ownership	Family (private)	Government (listed)
Vessel Size	5483 TEU	9011 TEU
Year Vessel Built	1995	2010

unit costs for APL's vessels decreases, the unit costs are expected to rise for APL when combining operations with CMA CGM from 3467$\$/TEU$ to 4030$\$/TEU$. The customer service level is increased by a higher service frequency and through access to CMA CGM's global network. This means that it can offer more services and destinations to it customers. Combining marketing efforts is also likely to benefit APL's marketing activities, though the effect may be smaller when the companies keep operating as separate brands. As the partnership would allow APL to double its market share, profit growth is also considered a driver for APL. The driver scores for APL sum up to a total of 14 points.

9.3.3. Partnership Facilitators

The information used for the facilitators of the partnership is contained in Table 9.9. In this tabel, vessel size is the average size of the vessels deployed by the companies on the route. 'Year Vessel Built' refers to the median of the years in which the vessels on the route were built. To determine the match of the companies' culture, the first factor to evaluate is the distance between the companies home regions. As France (CMA CGM) and Singapore (APL) are over 10.000 km apart, this makes understanding each others situation and communication more difficult (Google Maps, 2019; Yeo, 2013). However, distance is not all-conclusive. To investigate the business cultures in the countries further, a culture map is drawn up (see Figure 9.1). The closer the countries' positions on the scale, the more alike the cultures are. This shows that cultures in France and Singapore actually match quite well in terms of business culture. Only their ways for evaluating and disagreeing are very different, with the French being very confrontational and direct in negative feedback. With CMA CGM already being a global operator and active in Asia, it can be expected that they also have some experience in overcoming cultural differences. When it comes to symmetry, it can be stated that even though company size is different, their market share on this route is very equal. However, there is a difference in the financial indicators, which are positive for CMA CGM and negative for APL, and in ownership structure. The size and age of the vessels they use are also different. Both companies have experience in alliances, albeit in competing ones. CMA CGM also has experience in the acquisition of (regional) companies, including DELMAS (2005), CMC, Comanov and US Lines (all three in 2007) and ODPR in 2014 (CMA CGM, 2019a,b). The only previous experience of APL is from when it was acquired by Neptune Orient Lines (NOL) in 1997 (APL, 2018). A bonus point is given for the culture of the companies, as this is believed to be an advantage that is sustainable in the long term. This results in a total facilitator score for a partnership between CMA CGM and APL of 10.

9.3.4. Advice to Client on Partnership

With the different drivers scores (14 for APL, 17 for CMA CGM) and the combined facilitator score (10), the advised level of integration can be derived from the score matrix as shown in Figure 9.2.

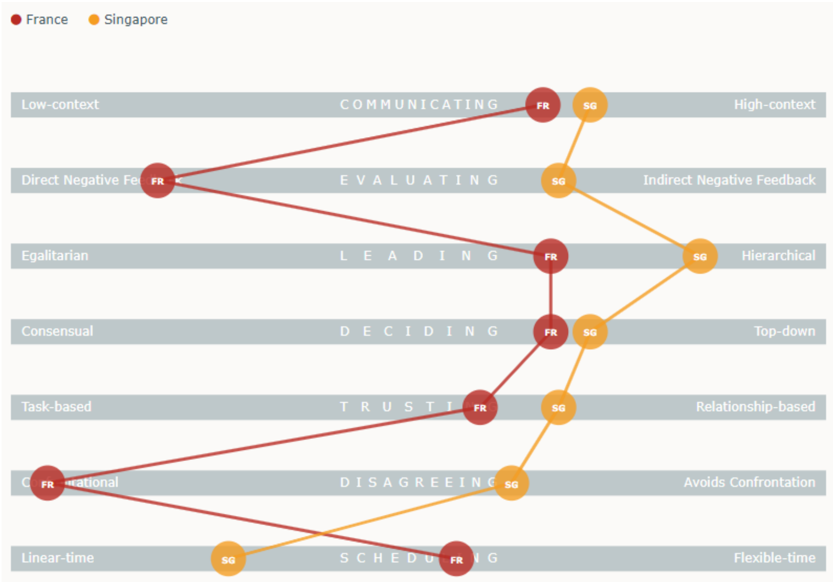

Figure 9.1: Comparison of business culture CMA CGM & APL (Meyer, 2019).

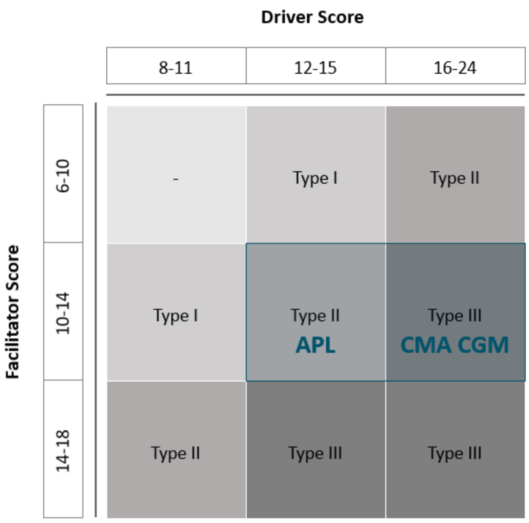

Figure 9.2: Feasible level of integration for APL and CMA CGM.

Table 9.10: Facilitator scores for CMA CGM & APL.

Question	Score					Bonus
1. How are the organisations' cultures expected to match with each other?	1	2	3	[4]	5	[+1]
2. How symmetric are the organisations?	1	[2]	3	4	5	+1
3. Do the organisations have prior experience that benefits this relationship?	1	2	[3]	4	5	+1
Total Facilitator Score	10					

Interesting is that even though there is sufficient basis for a partnership at both firms, the level of cooperation differs. For APL, the highest level feasible is Type II, which is a value added alliance where partners integrate activities of multiple divisions and functions and with a long term focus (see also Figure 6.1). For CMA CGM, the scores lead to a feasible level of integration of Type III. This is the highest level possible in this method and results in an integrated alliance or even M&A.

Based on this analysis, the advice to CMA CGM is to pursue a value-added alliance with APL. A summary of the results for this advice is given in Table 9.11. However, because CMA CGM decided to acquire APL, the results for this level of integration are also included in the table. It illustrates how CMA CGM may have focused too much on increasing market share and profits, without considering whether it would strategically be possible to achieve these results. Reason for this might be that because CMA CGM is a much larger company than APL, it did not include APL's motivation for the integration in its decision. However, it must also be noted that this analysis only considers one route, where the actual integration covers a much larger area. Especially in areas where APL has less regional presence, it is likely that APL's driver score is higher, which could indicate a deeper level of integration as well. Even though the advised level of a value added alliance leads to lower growth, this analysis indicates that it would be much more feasible. Furthermore, it is likely that choosing a too high level of integration not only prevents the realisation of potential profits, but also generates additional costs due to integration difficulties.

Table 9.11: Comparison of advised and executed level of partnership for the analysed route.

	Advised level	Reality
Integration Type	Value-Added Alliance (Type II)	Acquisition (Type III)
Market Share	+6%	+96%
Total Cost	-7%	+49%
Unit Cost	-3%	-23%
Vessel Utilisation	90%	94%
Profit/Deployed Capacity	+29%	+200%

9.4. Sensitivity Analysis

To test how sensitive the model is to changes in parameters, several other scenarios are also executed in the tactical matching model. The first parameter that is changed, is the fuel consumption of the vessels. This is because the model does not adjust fuel consumption to loading condition and because it is not certain if sea conditions are included in the data from the World Fleet Register. In the model itself, fuel consumption is not included. However, changing vessels' fuel consumption does impact the cost calculations, which means that it changes the data that is loaded into the model. The other parameter that is changed to test sensitivity is the penalty for declining cargo. Because this penalty is included in the model's objective function, it is likely to influence the results significantly. Finally, sensitivity to changes in the percentage of capacity that is reserved for empty containers is tested. The results of the sensitivity analysis are presented in Table 9.12.

The first part of the sensitivity analysis concerns the performance of the model itself. One can observe that the changes in fuel consumption and rejection penalty significantly increase the run time of the model. For the first scenario of +10% fuel consumption, a time limit of 25000s is installed. However, because the optimality gap does not improve with longer run time, the time limit for the sensitivity analysis is reduced to 5000s. This is still over twice the time the original optimisation needed to reach an optimal solution and the model

Table 9.12: Sensitivity of the model to changes in parameters.

	Model Performance		Model Results			
Changed Parameter	Run Time	Optimality Gap	Partner	Total Cost ('000)	Transported TEU	Utilisation
+10% fuel consumption	25000s	40.38%	Gold Star Line	$1741911	288979	0.92
+10% fuel consumption	5000s	40.38%	Gold Star Line	$1741911	284345	0.92
-10% fuel consumption	5000s	42,08%	Evergreen	$1464370	315080	0.93
+10% penalty ($6600000)	5000s	73.34%	Evergreen	$1486048	327310	0.92
-10% penalty ($5400000)	5000s	67.71%	APL	$1611152	316866	0.94
10% for empty containers	1606s	Optimal Solution	Evergreen	$1544542	305943	0.88
20% for empty containers	5000s	32.72%	Gold Star Line	$1733350	248372	0.80
Constraint (7.6) removed	2276s.	Optimal Solution	APL	$1611152	311823	0.95

is not able to solve to optimality[2] In fact, the runs with ±10% fuel consumption leave an optimality gap of 40-42%. The ±10% penalty scenarios perform even worse with 68-73% optimality gap. Both these parameters are part of the decision whether it is more cost efficient to sail with an extra vessel or to reject some cargoes. The deterioration of model performance when changing one of these interconnected values apparently makes this decision much harder. The decision of deploying a vessel thus requires a certain balance between sailing cost of the vessels and the penalty for deleting cargo. This is supported by the fact that the change of 10% in penalty impairs the model's performance more than 10% change in fuel consumption. Reason for this is that fuel costs are only part of total vessel cost, so an equal change in penalty and fuel consumption leads to a larger imbalance from the change in penalty. Furthermore, the penalty currently represents not only the costs of missed (future) revenues, but also serves to force the companies to cooperate[3].

How reserving a larger share of capacity for empty containers affects model performance is found to depend on the size of the change. With 10% of vessel capacity for empty containers, the model solves to optimality in a time of 1606s. However, at 20% empty capacity, the model only reaches an optimality gap of 33% in the given time of 5000s. Because increasing the reserved capacity first improves the model performance and then decreases it, it seems that this capacity parameter is also part of the balance that is needed in the model. The poorer performance of the 20% reserved also has a reduced number of solutions, so it might be necessary to increase the available vessel fleet to allocate all cargo efficiently.

Changing parameters in the model not only affects model performance, but also leads to different results. Even though APL was identified as a suitable partner in the tactical optimisation in this case study, Table 9.12 shows that in other scenarios Evergreen and Gold Star line are potential partners for CMA CGM as well. However, it appears that the other partners identified in the scenarios are part of a consistent set. For that reason, one way to deal with the model's sensitivity would be to include a Monte Carlo simulation in the solver, thereby replacing the specific values for the sensitive parameters by a range of values. The strategic level match assessment can also be performed for several potential partners to identify the final partner that is advised.

The other values presented in Table 9.12 are difficult to compare in absolute terms, because they also depend on the selected partner. However, variance among these parameters is low.

In terms of cost, no remarkable results are shown. Higher fuel consumption leads to higher total cost, while lower fuel consumption reduces it. The higher penalty ensures that all cargoes are transported. The lower penalty scenario presents a number of transported cargo higher than in the original optimisation (which was 311823), but this is most likely the result of the large optimality gap, which shows that it is far from the optimal solution.

The final scenario tested does not involve the change of a variable, but a change in the model. This is because one of the constraints currently ensures that if a vessels sails, it must also transport at least some of its own cargo. Technically, it would also be possible in a partnership that the vessel of one company is loaded with only cargo from its partner, which is prevented by this constraint. It is found that removing this constraint results in the same optimal solution as the original optimisation and the change in running time is so small that this constraint can indeed be removed if desired by the client.

[2]This does not mean that there is no optimal solution. The optimality gap indicates there are other solutions to be evaluated. It could be that these lead to a better solution, but it is also possible that the current solution stays the best one and is thus the optimal solution.

[3]Because of this subjectivity in the penalty value, it is not included in the total costs for the companies. Total cost is the total sum of all costs of sailing the vessels, calculated as described in Chapter 6.

10

Sub-Conclusion 2: On Partnerships Resulting from the Synergy Model

Based on the findings from the performance analysis of liner shipping companies, a synergy model has been developed. As a foundation to this model, it is proposed that carriers change the way they cooperate. The recommended partnership type entails further integration among fewer partners. When a company pursues this kind of collaboration though, it is even more important that a suitable partner is selected and the integration is well prepared. Even though more information is probably needed to make a final decision on a partnership, the model developed in this study provides a good starting point for the partner selection process.

The model is able to identify potential partners by optimising vessel deployment on a route. It achieves this by allocating sets of cargo that need to be transported to vessels that can be deployed on the route, while minimising costs. Furthermore, the number of partners that can cooperate is limited in the model, as is part of the proposed kind of cooperation.

The results of this quantitative analysis can be used as input for a further assessment of the potential partners on a strategic level. This part of the model is of a more qualitative nature and evaluates whether both companies have enough incentive to cooperate (integration drivers) and whether the companies' combined environment is suitable for cooperation (integration facilitators).

What results is an advice on which companies should cooperate together and to what extent an integration would be feasible, so that they can reduce costs, improve their service level and develop a shared long-term strategy.

The model has been applied to the case of CMA CGM's acquisition of APL in 2016. The aim was to identify a suitable partner based on operations in 2015 and to assess the fit between CMA CGM and the potential partner. The case study is confined to the route between the ports of Ningbo and Shanghai in China and Los Angeles and Long Beach on the U.S. West Coast. As the model composes potential partnerships on the route by matching cargo and vessels in 2015, it indeed identifies APL and CMA CGM as partners in the optimal solution. Potential cost savings derived from the model and approximated revenues show that cooperation in both an alliance and M&A would be beneficial for CMA CGM.

On a strategic level, the analysis indicates that from the perspective of CMA CGM, the furthest level of integration would be possible. Because this also leads to the largest profit growth, it means that CMA CGM would prefer to pursue an integrated alliance or M&A. For APL, however, a different kind of partnership is found to be preferred. Mainly because APL already has good market knowledge and access in the analysed region, the benefits it would receive from partnering with CMA CGM are smaller than the other way around. This results in a lower score for the APL's drivers for the partnership and a value added alliance as the deepest level of integration that would be preferred.

Relating the advised partnership that results from this analysis to what was executed in reality leads to several conclusions about the model. First of all, comparing the performance of the companies before the integration (2015) and afterwards (2017) shows signs of revenue dilution, but no definitive conclusion can be given on how successful the acquisition was. This is because some coordination issues are not unlikely in the first few years and these do not necessarily mean that the integration was unsuccessful. Furthermore, with the absence of speed in the model, it cannot be determined with certainty that costs have indeed increased in reality. Reason for this is that if the sailing speed was reduced, this would also have resulted in lower fuel costs.

It follows that including speed is recommended to include in future versions of the model, not only for more clarity in this case, but to allow for the modelling of different sailing speeds in general. Another conclusion is that the actual level of integration is higher than the model would advise for CMA CGM and APL. This could explain why the integration did not reach its full potential, if costs were indeed higher in 2017 than they were in 2015. More likely, it suggests that the advice found by the model for the largest of the two companies is leading, at least in the case of M&A. In either case, it presents the perspective of both companies involved. This is valuable for both partners as they can better prepare the integration and shows what items need extra attention. Having both perspectives can also be used in determining negotiation strategies.

This case study also shows that analysis of one route does not cover a potential partnership fully. Especially when considering a partnership with a global company, the region considered plays an important role on a strategic level. More (types of) routes that would be included in the partnership should therefore be analysed to reach a comprehensive advice.

Besides this execution of the partner selection and synergy potential, the model also serves as a useful tool to analyse competition. This provides valuable information for both liner shipping companies that are exploring partnership opportunities and regulatory bodies that aim to prevent anti-competitive behaviour. This is especially important for a route such as the one analysed in this study, where concentration ratios indicate the market approaching a 'tight oligopoly' in which collusion is likely to occur. Performing such analysis for multiple (or all) routes will identify where competition measures might be necessary.

IV

Discussion & Conclusion

11
Discussion

The objective of this study was to develop a model that analyses operational synergies resulting from strategic cooperation and identifies partnership opportunities in terms of cost reduction and improved service levels. Literature describes how a high capital intensity, volatile freight rates and overcapacity lead to strategic cooperation in alliances and M&A. However, because these partnerships frequently change, do not reach their full potential and have lowered the level of service in the industry, this study proposes a new model to identify potential partners and determine the feasible level of integration. Where previous studies on cooperation in liner shipping have either adopted a qualitative or a quantitative approach, this research integrates both in the partnership decision. In this way, it is possible to assess a potential partnership both on a tactical and a strategic level.

Optimisation of Vessel Deployment

The identification of potential partnerships relies on the optimisation of vessel deployment for available demand. This optimisation is based on cost minimisation. By using this complex part of liner operators' operations, a good foundation for the partnership analysis is found. However, because speed is not included in this model and only the current fleet of companies is considered, total costs can only be reduced by reducing the number of sailings. This does not contribute to the model's aim of increasing the level of service. On the other hand, the more integrated kind of cooperation on which this model is based does allow for improvements in the level of service. The long-term strategy that the partners can develop allows them to focus more on their customers. Next to that, the companies' cooperation can increase the number of sailings they offer relative to what they would achieve on their own. Also, the combined fleet of the companies presumable offers not only more more ships, but also more variations in ship types, which they can deploy more effectively. The larger variety in vessel types can be used to keep the sailing frequency at the desired level and still reduce (or maintain low) costs. It would also be better to ensure a minimum sailing frequency per operator, to ascertain that the level of service does not drop below a specified level. Currently, the sailing frequency is indirectly included in the monthly period for which cargo demand and vessel availability are given and in the high rejection penalty. Adding a minimum sailing frequency would thus not only represent the liner shipping industry better, it would also lower the value needed for the penalty, making it more transparent.

The large number of partners that cooperate is frequently named by literature as a major cause for the failing of alliances. For that reason, the limit on the number of partners in the optimisation of the tactical vessel deployment problem is an important part of the synergy model. In this research, the maximum number of partners is set to two, which makes the results suitable for alliances as well as M&A. This number can be increased to allow the formation of larger alliances, in which case M&A is only considered an option for those partnerships that still have just two members.

Another question that may arise about the results of the optimisation is what causes the improvements in the performance of the companies. This study compares the performance of companies with and without cooperation. However, the optimisation of vessel deployment only occurs in the scenario with cooperation. This means that the study possibly shows a more negative individual performance than the companies could achieve on their own if they would optimise vessel deployment. Because the model only assigns companies to cooperate if this leads to lower costs, it does not force partnerships where they are not beneficial. However, including the stand-alone scenario with optimisation would provide more information on what causes the improvements.

The decision of which vessels to deploy is for a large part based on the costs of the vessel and the assumption that unused vessels can be deployed elsewhere. This assumption is based on the results of the route analysis. At the moment, because the model only considers one route, it is unclear what exactly happens with the vessels that are not used. This is the case for the route analysis, but also in the optimisation model. Only when more routes are included, it becomes possible to study and optimise vessel deployment without vessels 'disappearing'.

The findings of the case study also suggest that the model overestimates costs. More accurate determination of vessels costs, which could for example be provided by the client, would improve the model. However, because the costs for all vessels are calculated in the same way and the results are used for comparison, it is still useful as an initial indication of the potential cost savings. A large part of the cost overestimation is likely the result of how the newbuild price of vessels is determined. This conclusion is based on the difference in unit costs between CMA CGM and APL that result from the optimisation. The unit costs for APL are much lower than those of CMA CGM. Looking at the composition of their fleets, it turns out that the vessels of CMA CGM are both newer and larger than those deployed by APL. The formula used for the newbuild price includes both the PPI, which depends on the year in which the vessel was built, and the deadweight of the vessel, which is related to its size. Furthermore, this price influences many of the other cost component calculations. The costs for interest, depreciation, management and general and periodic maintenance all depend on the newbuild price, which amplifies any overestimation even further. Another explanation for the difference can be found in the generalisation of fuel consumption. In this study, fuel consumption is determined based on the average per size range, which may disadvantage newer vessels that are much more fuel efficient.

Another improvement regarding the vessels costs is derived from the sensitivity analysis, which suggests that a balance between vessel cost and cargo rejection penalty is required for the model to run properly. This implies that the value of the penalty should be adjusted to changes in vessel costs. It would also be advised to split the penalty in two parts: one for revenue loss and another that makes companies prefer cooperation over rejecting all cargoes.

Level of Integration

The main aim of the strategic-level analysis is to assess whether there is enough incentive and a suitable environment for cooperation at both companies and which level of partnership is feasible. For the company looking for potential partners, the reasons for pursuing cooperation are, at least to some extent, known in advance. This means that the drivers for that company can be filled in relatively easily. The results from the tactical matching in terms of costs, revenues and asset utilisation improve the driver assessment even further. For the identified partner however, much less information is known, which shows the value of integrating the quantitative and the qualitative analysis. Without the quantitative data of the potential synergies from the tactical matching, assessing another company's drivers would involve a high degree of guessing and uncertainty.

The synergy model distinguishes between three levels of integration: (1) a conventional alliance, based on vessel sharing, (2) a value added alliance with joint operations and (3) an integrated alliance/M&A with joint back-office and IT. The potential cost savings and estimated profits can be derived from the tactical matching part of the model for each of these types of integration. These results can be improved with more accurate determination of vessel costs and by including revenues in the model. With an advised level of integration from the strategic matching and the synergy results for that level from the tactical optimisation, the model provides a clear overview of the potential synergies.

Data Availability

In this study, the data used is publicly available, which allows analysis of all companies in the market. When working for a client, company specific data can make the analysis more accurate. There are, however, also some other ways that would increase accuracy of the model. Port calls of vessels, for example, would no longer require an estimate of the arrival dates of the vessels and lead to more precise numbers of loaded containers. Furthermore, as the departure date of the vessels is then also known, further analysis of performance on the route can also be done on elements such as sailing speed and delays. Departure dates are expected to be more regular than arrival dates, which would allow recognition of specific liner services and make it possible to ascertain that the vessels studied are also part of these liner services.

Another issue concerning data availability relates to how the number of containers is determined. This is currently done by determining an average conversion factor from a set of vessels on the route. Because the ratio of TEU and FEU differs per ship, this leads to utilisation levels over 100% for some vessels. With access to actual container sizes, the conversion from container to TEU will become more accurate. This would result in more realistic utilisation rates and also improve the ability to spot errors if they occur. Finally, the lack of data on the shares of operators in alliances may result in deviations between the generated cargo batches per operator for the optimisation. Especially in the case study, these alliance shares are likely to have resulted in larger amounts of cargo for CMA CGM than was actually the case. This is also the result of the way in which historical data on mergers is included in the model. As mentioned earlier, if a company is no longer operating under its own name, this means that the vessels of that company are counted as part of the new company, even before this merger actually took place. In the case of CMA CGM in 2015, the other members of the O3 Alliance at the time were UASC and CSCL. However, since then, CSCL became part of COSCO and UASC merged with Hapag-Lloyd, leaving the model to interpret CMA CGM as the only member of the O3 alliance. Nevertheless, this problem only occurs when a case is analysed that took place in the past. When applying the model to a present case, the vessel data will be adequate. This would also improve the values of the concentration indices.

Recommendations for Future Research

Three recommendations for future research are formulated based on the findings in this study. First of all, it is advised that further research should focus on extending the coverage of the model. Currently, the analysis is performed for just one route and with no port calls other than origin and destination. The more routes and ports are included in the model, the more comprehensive the result on the synergy potential will be. This will also allow testing of the assumption that unused vessels on one route can be deployed on another. It would also be interesting to investigate if the performance and strategy of companies differ per route and how this affects a potential partnership. Another possibility for extending the model's coverage would be in terms of the size of the available vessel fleet. This can be done by increasing the amount of available vessels for one route by also including other ships from the fleet. Another possibility is inherent to the recommendation of covering more routes, because that more routes directly lead to a larger fleet. An interesting question is if increasing the available fleet results in a lower number of rejected cargoes per route.

A second recommendation for future studies is to model time more realistically. The current version of the model links vessel availability to the period in which they arrived according to the U.S. import records. An improvement would be to model sailing time and vessel availability dynamically. This would mean that a vessel is available in a certain period and that the next time it can be used is after a round-trip has been performed. Not only does this better represent real operations, it also allows for inclusion of different sailing speeds. Speed is very interesting to include because that will allow examination of the effects of slow steaming. With newer vessels designed for lower sailing speeds, the opposite is also interesting to analyse, to see what happens when demand increases but these vessels are not designed to go faster.

The third direction for future research is to focus on applying the model for competition policy. This could include monitoring and visualisation of competition on multiple routes. It would also require analysis of which variables to be included in the model to test different scenarios. A further possibility would be to analyse route characteristics and their degree of competition for a large set of routes and investigate if any relations can be found. This could even lead to a prediction model that is able to determine other companies that might form a partnership in reaction to the announcement of a deal by their competitors.

12 Conclusion

Strategic cooperation in alliances and mergers and acquisitions (M&A) has become the norm in the liner shipping industry. Unfortunately, these alliances are not sustainable and M&A do not realise their full potential. This study argues that liner shipping companies should move towards more intensive and long-term partnerships that allow them to realise synergies that reach beyond lower unit costs and network expansion. As the proposed type of cooperation generally requires higher investment and creates a larger degree of interdependence, identification of the right partner is essential. For that reason, a model has been developed that identifies and assesses potential partnerships among liner shipping companies on both a tactical and a strategic level.

Prior to the development of this model, a route-level analysis was done into the performance of liner shipping companies. It was found that carriers are able to adjust the vessels they deploy with considerable flexibility. This allows them to keep vessel utilisation levels high. On the route, vessel utilisation was high in general. However, where imbalances between local demand and supply were previously balanced by freight rates, this was not the case in the last few years. Freight rates remained low, even at times of high utilisation rates. Moreover, the analysis confirmed that there was indeed an overcapacity throughout the considered period (2014-May 2018). This shows how even more pressure is put on operators' already low profit margins. It also explains the extreme focus of liner shipping companies on cost reduction.

Because cost reduction is so important for liner shipping companies, this is also included in the first part of the developed model. It optimises vessel deployment at minimum cost, while keeping the number of companies in a partnership below a set limit. An overview of which companies should cooperate can be derived from the results, including their synergy potential in terms of cost reduction, vessel utilisation and market share. However, a fit on tactical level alone does not necessarily mean that the companies will be able to work well together. For that reason, all this information is used for further analysis of the match on a strategic level. To assess how each of the companies are positioned towards the potential partnership, the model evaluates the drivers, or motivations, for both of them individually. After this, is it is determined how well the environment created by both companies combined accommodates growth and strengthening of the partnership. Scores are given for the drivers and facilitators, indicating which level of integration is feasible from both companies' perspectives.

The developed model has been applied to a case study. The case focuses on CMA CGM, which acquired APL in 2016, and is confined to the same transpacific route as the performance analysis. The partner identified by the model based on operational data from 2015, which is before the actual merger, is indeed APL. The companies that decided to cooperate are thus also selected by the model as potential partners. However, the strategic level analysis pointed to a difference in both companies' drivers for the partnership. This was mainly caused by the fact that CMA CGM would benefit more from the regional ties of APL on this route from China to the U.S. than APL would from CMA CGM. Because of this difference in drivers, a different level of integration results for both companies. For CMA CGM, the model advises an integrated alliance or M&A, where APL would be better off with only a value-added alliance, which involves a lower degree of integration. Though it is possible that APL would have a higher driver score when considering more routes, the fact that in reality CMA CGM decided to acquire APL suggests that the model's output for the largest company is leading, at least in the case of M&A. By any means, the model is very useful for the initial stages of starting a partnership, because it quickly shows the different points of view for all parties involved. Even though more information is needed to make the final decision on whether to pursue the partnership, the model developed in this study offers a solid foundation for further talks and negotiations. With some adaptions, the model can also be applied to analyse how partnerships influence competition on certain routes.

The model would improve further from the use of more accurate data on the vessel's sailings and costs and from better calibration of the variables in the mathematical model for the optimisation. Furthermore, using variable transit times in the model to determine when vessels are available would make the model more realistic and would also allow changes in vessel speed to be included in the analysis. Extending the coverage of the model in terms of ports and vessel fleet would also be advised, as this leads to more encompassing results. Nevertheless, the model developed in this study can already provide route-specific insights in both the synergy potential of a proposed partnership and its effect on competition for liner shipping companies and regulatory bodies.

It is recommended to extend the coverage of the model to include more routes, ports and vessels for a more comprehensive analysis. Furthermore, using variable transit times in the model to determine when vessels are available would make the model more realistic and would also allow changes in vessel speed to be included in the analysis. It is also advised to explore opportunities for regulatory bodies to apply this model for monitoring and assessment of the effects partnerships have on competition per route.

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