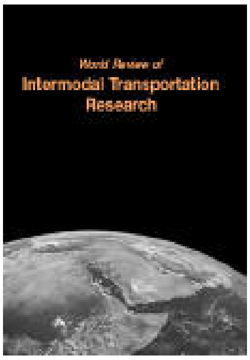

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The determinants of the sea freight fee in container shipping – an analysis by route

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Abstract: This paper analyses the effect of supply and demand through an econometric model of price definition in the short term in the five main trades from Asia to the world. The increase in the capacity of ships aiming at gains in scale has generated a global idleness of services. To reduce the effects of service idleness, shipping companies have consolidated into three major alliances, leading the market to an oligopoly status. Understanding how the price definition is done in this self-regulated market provides valuable insights that empower maritime industry professionals to make decisions and contribute to efficient and effective policies and practices in the sector. The results show that specific route-region markets behave in different ways and the incidence of ex-post rates in region-routes with great volume does not allow the offer and demand operate in balance, because of the sector's oligopoly's structure.

Keywords: sea freight; container; oligopoly; supply; demand.

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1 Introduction

With the supply chain becoming more global and more operations being outsourced and transferred abroad, the impact of international transport is increasingly greater on the final value of the product. According to UNCTAD (UNO, 2017) maritime transport is the backbone of international trade and the global economy. Over 80% of the volume of international trade in goods is carried by sea, and the percentage is even higher for most developing countries.

The official start of the use of the container for maritime transport occurred in 1976, when it was possible to transport cargo in ships with a capacity of 1,500 TEUs (20-foot equivalent unit). Due to advances in technology and the interest of shipping companies in making gains in scale, today, a container ship can transport up to 21,000 TEUs of general cargo. This increase in the size of the ships aimed at gains in scale, increasing the capacity of the ships and, consequently, the total global supply gradually, as new ships are built every year, while their useful life is, on average, 20 years. However, according to data from Drewry (2016), we have 9% of the global capacity (1.7 million TEUs) idle in the world.

In order to join forces and to create a cooperative agreement forming a strategic alliance covering various trade routes between its members on a global level (Carnarius, 2017) ocean carrier started to make cooperation agreements between each other. By the year of 2017, 81% of container ship capacity was hold by 3 alliances. Shipping alliance is designed to achieve cost effectiveness, consolidation, cooperatives and collaborative global supply chain with efficiency and profit maximisation as the expected outcome (Ezinna et al., 2022).

As freight rates are a significant component of maritime transport costs, the ability to accurately forecast future changes and fluctuations is critical for decision making for all international maritime trade and transport stakeholders, including shippers and carriers (Saeed et al., 2023). Jeon et al. (2021) explain that effective freight rate prediction can help cargo owners and shipping lines make timely decisions related to their asset management policies and invest in new shipbuilding that can save a significant amount.

Studies have been done (Luo et al., 2009; Lun et al., 2013) analysing the difference between supply and demand and its impacts on the price of international freight in containers, using global aggregate data, as an average, and disregarding bilateral data. In these studies, there is no differentiation of analysis between China, which holds 30% of the container handling market, and Brazil, with only 1%. In addition, annualised data are used. Historical series show that the variation of container freight may have a monthly fluctuation of 100% of its value. In 2016, it was possible to bring a 20-foot container from the port of Shanghai, China, to the port of Santos, Brazil, paying international freight of USD 452.00 in April and USD 1,479.00 in May (Drewry, 2019). Considering that the time between the order request, production and the actual shipment of the cargo can take more than 30 days. Due to changes in freight, the amount provided for the purchase of the product is not the same price that will impact your final cost when it arrives at the destination. This result may impact on the decision to import or buy in the national market, changing the entire configuration of international trade. To address these issues, unlike Luo et al. (2009), this article proposes the analysis of detailed routes, using monthly data.

There is limited research attention on container freight rates (see Luo et al., 2009; Nielsen et al., 2014; Munim and Schramm, 2017; Jeon et al., 2021; Saeed et al., 2023).

Therefore, this study aims to investigate whether the interactions between supply and demand are enough to explain the fluctuations in freight in the maritime container market in the short term. This will be identified by analysing trade on Asia's top five export and import routes. In an innovative way in the literature, the main sea trade routes in Asia will be detailed and analysed by the same model, showing that the routes behave differently from the same point of view. To this end, an econometric model will be used that determines the rate of sea freight in containers, considering the interactions between the supply resulting from the decisions of the shipping companies' arrangements and the demand for transport.

The research gap in studies focusing on the freight prediction of detailed maritime routes using monthly data is evident, requiring further exploration in this specific context. Besides the studies already cited Luo et al. (2009), Nielsen et al. (2014), Munim and Schramm (2017), Jeon et al. (2021), Saeed et al. (2023), which provides estimations of freight models but does not specifically address the detailed maritime routes and the utilisation of monthly data. There is a lack of studies investigating the accuracy and effectiveness of prediction models specifically designed for these detailed routes and utilising monthly data. Moreover, limited attention has been given to the identification and analysis of factors that significantly influence freight prediction accuracy on a monthly basis, such as seasonal patterns, market fluctuations, and specific characteristics of the detailed maritime routes.

2 The container maritime transport industry

2.1 The evolution of ships in maritime transport

Davies (1983) defined the container shipping industry as the part of the shipping market that specialises in providing cargo transportation services on certain trade routes. Stopford (2006) updated this definition, adding that it was a fixed itinerary, included in a regular service with the obligation to accept and load cargo from all locations, regardless of whether the ship is full or not, different from the services provided by the ships that did not have a fixed scale.

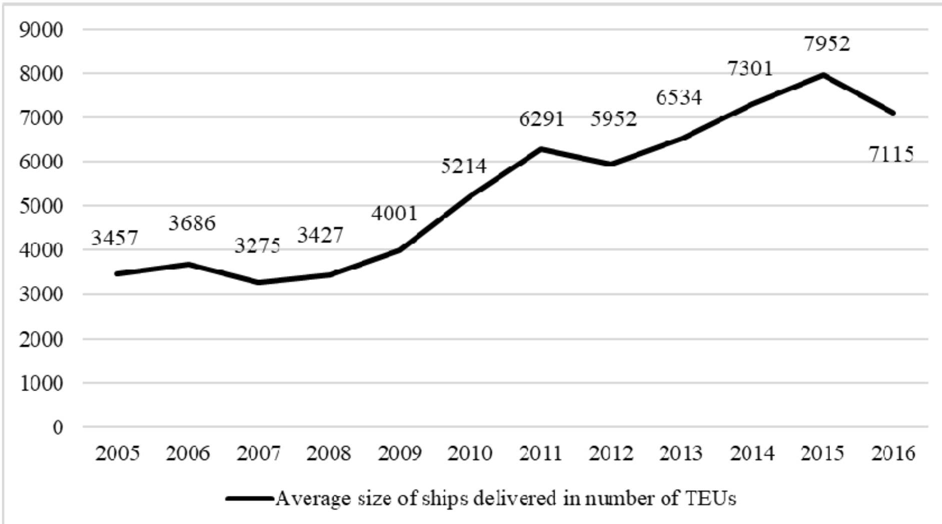
The maritime industry is supposed to be driven by economies of scale. When used properly, larger ships are more cost efficient than smaller ships. On average, overlooking idleness, the cost of space occupied by 1 container (TEU) is reduced by 50% from a 2,500 TEU vessel to a 10,000 TEU vessel (Drewry, 2019).

Between 2005 and 2016, the capacity of TEUs per vessel has doubled, with the average in 2016 of 8 thousand TEUs per vessel, according to Figure 1.

Kearney (2012) explained that using more large and modern ships is a cost reduction lever for the following reasons: costs, speed reduction, smaller crew, and low capital costs.

However, the increase in the size of ships aiming at economies of scale generated idle capacity in the world. According to data from Drewry, in 2016, there was 9% of the global capacity (1.7 million TEUs) idle, while this proportion was 5% in 2012. This means that one in ten ships are waiting for cargo. An important factor is that, with the expansion of the locks in the Panama Canal in 2016, the shipping companies give preference to the use of larger ships, leaving the old ships (from 4,000 to 5,000 TEUs).

Figure 1 Average size of ships delivered from 2005–2016 in number of TEUs



Source: Data extracted from UNCTAD (UNO, 2017)

To reduce this idle capacity, shipping companies carried out mergers and acquisitions, reducing the number of market participants.

2.2 Maritime companies and the oligopoly structure

Most studies of container literature (Hoffmann, 1998; Notteboom, 2004) use information from the AXS-Alphaliner to describe participants in the container shipping industry and each one's share in the market. According to Alphaliner (2019), currently 81% of the global capacity is concentrated in 3 major alliances (Table 1), with technical cooperation between the main shipping companies.

According to Lu et al. (2006), this type of formation emerged in 1995 and can be characterised by technical agreements. In these alliances, shipping companies share the occupation of the ship, but each member remains responsible for marketing activities, fleet operation, issuing documentation and pricing. In this way, shipping companies can share decisions such as, for example, carrying out a blank sailing (market practice in which there is no ship call in the week determined by them).

Table 1 Alliances

Alliance	*Shipping companies*	*% of capacity offer in the global market in TEUs*
The Transport High Efficiency Alliance	K-Line, Hapag Lloyd, NYK, MOL, Yang Ming	17%
The Ocean Alliance	CMA CGM, Evergreen Cosco Shipping, Orient Overseas Container Line	28%
The 2 M	Maersk, MSC	36%

Source: Data extracted from Alphaliner (2019)

According to UNCTAD (UNO, 2016), the recent mergers and mega-alliances between shipping companies can better support the handling of supply and use of the fleet, which, in turn, can help to improve the financial situation of the container transport sector. The increasing concentration of the market has led to oligopolistic structures.

When analysing this context by route, the degree of concentration is even greater, as shown in Table 6. The 'The 2 M' alliance has 40% of the space capacity available in TEUs on the trade route between Asia and Europe and 44% on the route between Europe and North America. On the route between Asia and North America, the 'The Ocean Alliance' holds 41% of capacity.

Table 2 Alliances and market share by route

Alliance	*Shipping companies*	*Asia – North America*	*Asia – Europa*	*Europe – North America*
The Transport High Efficiency Alliance	K-Line, Hapag Lloyd, NYK, MOL, Yang Ming	28%	23%	18%
The Ocean Alliance	CMA CGM, Evergreen Cosco Shipping, Orient Overseas Container Line	41%	36%	31%
The 2 M	Maersk, MSC	20%	40%	44%

Source: Data extracted from Alphaliner (2019)

All of this is in accordance with Regulation (EC) number 906/2009 of the European Commission, extended by Commission Regulation (EU) number 697/2014 until 2020 (EU, 2009).

However, this consolidation can threaten competition, and exporters can be adversely affected if the consolidation leads to reduced competition, restricted supply and higher rates and prices. Shipping lines that do not form alliances will also have a harder time competing. Certain ports, likewise, may be left out or lose market share, as shipping companies have greater bargaining power and may limit stopovers at a given port. By reducing the number of stopovers, container transport connectivity at the country level can be impaired, which means that exporters may end up having to redefine their supply chains.

Ezinna et al. (2022) performed explanatory research to examinate the impact of carrier alliances on freight rates using market power as the framework for the study. It was defined as the ability of a company or group of companies in determining or influencing the price of their product or service that gives them the leeway to make the kind of profit which otherwise would not have been possible in a perfect market situation.

2.3 Definition of price in the oligopolistic market

When studying a market, we seek to identify the price and quantity in equilibrium (Pindyck and Rubinfeld, 1988). In a market of pure competition, the equilibrium price is found, when the quantities offered and demanded are equal.

The oligopoly is a market model that follows the concept of imperfect competition, which is a type of market failure. This means that demand and supply do not operate in equilibrium, causing a certain dominance and influence of companies in directing prices.

Competition does not occur through price reductions. This strategy does not work, because when one company goes down, the others follow the same procedure. Thus, competition must occur based on the quantity of goods produced and sold. The balance happens when companies correctly estimate the quantity that their competitor will produce and, thus, perfectly determine their level of production to maximise profits. It can be concluded, then, that one company will produce the amount of production that will maximise its profits according to a decreasing projection of how much it believes the other company will produce.

The consolidation of shipping companies has reduced considerably the number of service providers, bringing the market to an oligopoly status. Within this new context, fluctuations in supply and demand are not enough to explain the variation in price.

2.4 International shipping

According to data from UNCTAD (UNO, 2000, 2017), the global movement of cargo transported in containers grew more than 4 times from the year 2000 (165 million TEUs) to 2016 (701 million TEUs).

Table 3 shows the variation of freight in the months of January of each year in the period from 2015 to 2018 for the ten routes analysed in this study. There is no pattern of increase or decrease and each route varies differently.

Until then, studies have shown that when capacity was high, freight was low. If the overall capacity increases, it will result in a reduction in freight. When this happens, demand increases, again reducing capacity. The price change resulting from fluctuations in supply and demand is a fundamental economic problem and has been well studied in the literature (Luo et al., 2009)

With the change in the market configuration, there is a possibility that the price will no longer behave that way. The fleets 'capacities are pre-defined in the shipowners' agreements with the ports that already provide, months in advance, the forecast of the scale that will dock at the port. There is also a small variation in supply in the short term when shipowners decide to divert a ship to some route due to specific demand. The journey of a ship is not conditioned to a specific port, it is a round trip (back and forth) from the point of departure to the final destination, carrying out the transport of cargo related to trade in specific countries, passing through several ports on a trip.

For a long time in the history of the shipping industry, companies collectively combined freight and capacity values in a type of organisation called a conference (Chen et al., 2017). Freight rates were negotiated quarterly and if, for some reason, there was a need to increase the tariff, the shipping companies, together, applied the general rate increase (GRI), name given, at the time, to the freight increase that was publicly announced to the market. In recent years (from 2008), these conferences were banned, and this freight agreement mechanism ceased to exist. Therefore, shipping companies negotiate their freight independently from each other. The GRI announcement was also made separately through publication on the internet or, often, by e-mail. Despite being announced two to three weeks in advance, the GRI rate may not materialise or partially materialise, so the final freight value is only known after the actual cargo is shipped; the fee being added to the freight previously agreed.

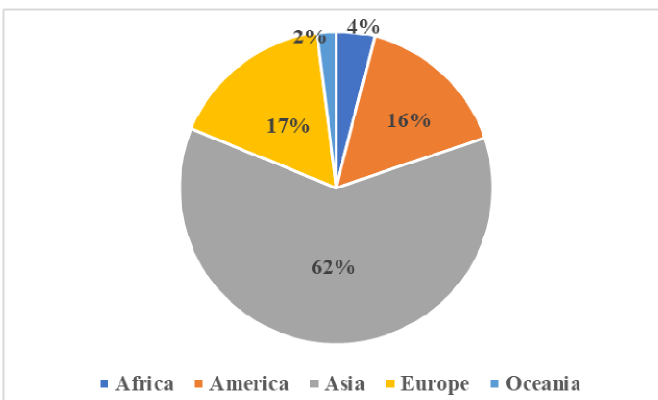
Table 3 Freight rate per TEU on the main routes

Route	*January 2015*	*January 2016*	*Variation 1*	*January 2017*	*Variation 2*	*January 2018*	*Variation 3*
Northern Europe – Asia	USD 514.00	USD 401.00	–21.98%	USD 665.00	65.84%	USD 909.50	36.77%
Asia – Northern Europe	USD 1,227.36	USD 668.61	–45.52%	USD 1,069.34	59.93%	USD 944.34	–11.69%
Mediterranean – Asia	USD 483.00	USD 332.00	–31.26%	USD 313.00	–5.72%	USD 382.00	22.04%
Asia – Mediterranean	USD 1,367.17	USD 512.33	–62.53%	USD 1,256.58	145.27%	USD 883.63	–29.68%
South America – Asia	USD 653.67	USD 616.00	–5.76%	USD 743.00	20.62%	USD 769.67	3.59%
Asia – South America	USD 1,034.29	USD 253.29	–75.51%	USD 1,918.71	657.52%	USD 2,265.86	18.09%
North America – Asia	USD 946.18	USD 688.18	–27.27%	USD 653.36	–5.06%	USD 638.27	–2.31%
Asia – North America	USD 2,976.96	USD 2,039.83	–31.48%	USD 2,672.55	31.02%	USD 2,497.79	–6.54%
Oceania – Asia	USD 882.54	USD 522.25	–40.82%	USD 478.63	–8.35%	USD 534.50	11.67%
Asia – Oceania	USD 891.10	USD 505.60	–43.26%	USD 556.17	10.00%	USD 892.00	60.38%

The European Commission believed that GRI announcements do not provide exporters with enough price information and allow shipping companies to signal their price intentions to other shipping companies. These rates became regular in exports from Asia and led to a formal trust process by the European Commission (EC) in 2013 to 2016, as it was believed to be a mechanism for controlling market behaviour. The commission adopted a preliminary opinion in accordance with article 9, paragraph 1, of Regulation (EC) 1/2003 (EU, 2003), which expressed the concern that the shipping companies' practice of publicly announcing the intention to, in the future, raising prices could allow them to exchange information on pricing intentions and thus restrict competition in the market for container shipping services on Europe's export and import routes. At the time, about 15 shipowners undertook to stop making GRI announcements; however, until today, the market uses this rate, often announced every two weeks.

In 2009, a study by the Department of Logistics and Maritime Studies at the University of Hong Kong conducted a survey of the main factors that determine freight fluctuations in the global container market with 28-year data, which resulted in the first article published with a econometric model for the container freight market: Luo et al. (2009) done an econometric analysis for the fluctuation of the container freight rate through the interactions between supply and demand analysing global data.

Figure 2 Movement of TEUs by continent (see online version for colours)



Source: Data extracted from Drewry (2019)

The study considered the fluctuation of freight from the perspective of demand and supply, using global data from ports on an annual basis, disregarding the differences in international trade between countries and the fluctuation of freight in the short term, since the attractiveness of each route for a shipowner varies. Container transport is very unbalanced since Asia (especially China) alone accounts for 62% of the market (Figure 2).

In a recent investigation, Munim and Schramm (2017) commented on the pioneering study by Luo et al. (2009) and stated that the parameters estimated by the model, despite having a high statistical significance, could be since the data set is based on annual data, which is obviously less volatile than weekly and monthly data. Despite this, they did not comment on the fact that the study analyses global trade as being unique, which may also have helped in the high significance of the model when using the average of all routes of the supply, demand, and freight variables. We propose to detail this analysis in terms of route and temporal frequency.

Recent study analysed the dynamics of GRI in the definition of freight. Munim and Schramm (2017) believe that the GRI is a price increase strategy that contributed to the volatility of freight, as an attempt to increase its value. They discussed the dynamics of freight rates and their forecast for the commercial strip from the Far East to Northern Europe, using the Integrated Auto-regressive Moving Average (ARIMA) observing a notable influence of the increase in the general rate increase (GRI) in the volatility of the container freight rate.

The imbalance in the market, considering that Asia is responsible for 62% of global trade, the fact that there is no study in the literature that performs an analysis comparing more than one route using the same methodology and the frequent applications of the GRI in freight motivated this study on the variation of freight from the perspective of supply and demand, considering the capacity and specific demand of each route.

3 Empirical analysis

The methodology used in this study was adapted from the article by Luo et al. (2009), being carried out a first econometric analysis for the fluctuation of the freight rate in container through the interactions between supply and demand, analysing global data compiled. Their estimated parameters of the model have high statistical significance, and the general explanatory power of the model is above 90%. As explained by Munim and Schramm (2017), one of the reasons for the high significance may be the use of annual data. Therefore, in this investigation, monthly data will be used. The model will be adapted, analysing the five main trade routes in Asia. The demand variable from the other countries of the route will be added (a ship never berths only in one port; several ports are considered in its voyage) and it will be considered that it is the increase in demand and the cost reduction that causes shipowners to implement more capacity in the market and not the profit generated by the freight charged per container (TEU). This modification makes the model better adapt to the reality of the market, where capacity is added according to the increase in demand (Lun et al., 2013) and is driven by economies of scale (Kearney, 2012). The demand is derived from international trade and is exogenous, considering the movement of containers in the selected countries. The market for new ships and ship destruction will not be considered, as capacity information will be provided by data currently available on the market. As it is an ex-post fee, the GRI fee was not added to the model.

The total capacity defined by the shipowners is a result of the gains in scale resulting from the cost reduction. The greater the demand relative to supply, the more the shipowners tends to increase the capacity to obtain economies of scale.

$$N_t = \eta\left(Y_t - c_1 X_t\right) \quad (1)$$

where N_t is the total size of new orders of ships at year t, η is the adjustment coefficient of the increase in capacity, Y_t is the total number of containers handled (demand) by the importing or exporting country, X_t is the fleet capacity in TEU and c_1 is the adjustment coefficient of fleet capacity reallocating ships among routes. Supply is defined by demand of each country. When $c_1 < 1$, the carrier reduced capacity on the route, when $c_1 > 1$, the carrier increased capacity on the route including ships from other routes.

As a ship does not travel only between two ports (origin and arrival), capacity cannot be considered only for the demand of a specific country, but of all the countries participating in that route. Therefore, demand from other countries on the specific route will be added:

$$N = \eta\left(Y_t - Y_{ot} - c_1 X_t\right) \tag{2}$$

Y_{ot} is the total number of containers demanded in the other countries of the route.

The variation in capacity can be defined by $X_t = X_t - X_{t-1}$, which is also represented by $N_{t-\theta}$, with θ being the average time it takes for shipping companies to change capacity on a given route (construction of a new ship). The construction time of a new ship is one of the most important characteristics in the analysis of the maritime market (Binkley and Bessler, 1983) and is present in many studies in the area (Luo et al., 2009). Luo et al. (2009) considered two years as the average construction time of the ship. For this research, the same definition will be used. To define the two years, the authors constructed six statistical equations, between the delivery of the finished ship and the new orders and selected the most significant one to use in the model.

$$X_t = \eta\left(Y_{t-\theta} + Y_{ot-\theta} - c_1 X_{t-\theta}\right) \tag{3}$$

Below, it is described how the freight rate is altered by the demand for container transport and capacity. The change in the market price occurs due to variations in supply and demand.

$$\Delta P_t = \delta\left(Y_t - \varphi X_t\right) \tag{4}$$

where ΔY_t is the change in the total number of containers transported, X_t is the fleet capacity, $\varphi > 0$ is the constant that represents the monthly average utilisation of the TEU slot and $\delta > 0$ is the price adjustment factor for changes in demand and supply.

This equation informs that the price will rise when there is excessive demand and fall when there is excessive supply.

The TEU slot is the designated space within the vessel for the transportation of 1 TEU, which means the space within the vessel of 6 metres x 2.4 metres x 2.4 metres. This space is fixed when the ship is built. Any load larger than this is called an out of gauge (OOG) and will occupy more than 1 TEU slot. When this happens, the market calls it lost slots, because when having an OOG load, the containers cannot be stacked, reducing the available capacity.

To test the model, monthly data for the following variables will be used: freight market, installed capacity and total number of containers handled.

Equation (3) is estimated accordingly to equation (5). We follow Luo et al. (2009) and we estimate equation (4) accordingly to equation (6).

$$\Delta X_t = \alpha_1 Y_{t-\theta} + \alpha_2 Y_{ot-\theta} - \alpha_3 X_{t-\theta} + \varepsilon_{1t} \tag{5}$$

$$\Delta P_t = \alpha_4 \Delta Y_t + \alpha_5 \Delta Y_{ot} - \alpha_6 \Delta X_t + \varepsilon_{2t} \tag{6}$$

where $\alpha_1 = \eta$, $\alpha_3 = C_1\eta$, $\alpha_4 = \delta$ e $\alpha_6 = -\delta\varphi$.

Equations (5) and (6) are differential equations that describe the two biggest forces in the containerised maritime transport market: the offer of services and the definition of price. The last term ε is the error term. The first equation can be estimated by itself. Since ΔX_t appears on the left side of equation (5) and on the right side of equation (6), the error terms are not independent; and, therefore, the method of simultaneous equations is applied.

3.1 Data

The demand for container transport service will be extracted from the movement of containers in global trade. The database used was from Seabury Consulting (2020), which provides data on the movement of containers in TEU by country, informing the number of units imported and exported to other countries monthly. The database contains the total handling of containers, including empty and transhipment containers (when goods are transferred from one ship to another ship before reaching destination). Container handling will be used, not global trade transported by sea, as many cargoes that are transported by sea cannot be stuffed in containers due to their dimensions. A differential to be highlighted is that this database considers the clearance of cargo at the port as the measurement point, that is, the moment when the cargo is available for shipment. The purpose of using this base was to identify the cargo that is in the port cleared and does not board, since even if the cargo does not board, it must be part of the month's demand (in the case of exports). A cargo may be cleared at the port and not be shipped due to the shipowners' decision, for example, to cancel the ship's departure in the specific week.

The freight rates and the ship's capacity have been extracted from the Drewry database, which provides the freight rate and capacity in number of TEUs for routes monthly. The bunker information is already embedded within the freight, with no possibility of extraction for all the months considered. For this study, therefore, the bunker will be considered included in the freight, that is, adding it separately would duplicate the information.

The period from 2015 to 2018 will be considered due to the lack of availability of capacity information per route prior to that period. Some routes have data availability as of 2011; however, to have the same period on the five routes, we must consider the period informed. In the studies carried out until then, the global capacity dispensed in the market by the ships was considered, considering the number of TEUs that each ship could carry added to the new ship market (it should be noted that a ship takes, on average, two years to be built). So, currently, we have real capacity through Drewry's database monthly so that we can capture the fluctuation of freight in the short term. According to the source, the database considers the actual offer and not the nominal one. In the nominal offer, the sum of the ships expected for a specific route is informed. In the real offer (used in this work), possible blank sailings (when the ship's call is cancelled) are disregarded, leaving only the effective offer available on the route, in the specific month.

According to our econometric specification, demand, supply, and price from the countries of the main routes in Asia with the rest of the world (export and import) were considered. The countries formed by each region are reported in Table 4.

The analysis totalled 267,468 observations on trade between the countries described above, with Asia as a starting point for export and arrival in import.

Table 4 Countries by region

Region	*Countries*
Asia	China, Brunei, Burma, Cambodia, Mariana Islands, Indonesia, Japan, South Korea, Malaysia, Myanmar, Philippines, Russia, Singapore, Taiwan, Thailand, East Timor, and Vietnam
North America East Coast	USA, Canada, and Mexico
South America East Coast	Brazil, Argentina, and Uruguay
Oceania	Australia, Fiji, Mariana Islands, Marshall Islands, Solomon Islands, New Zealand, Palau, Papua New Guinea, French Polynesia, Samoa, Tonga, and Vanuatu
Mediterranean	Albania, Bulgaria, Croatia, Cyprus, Egypt, Spain, France, Georgia, Gibraltar, Greece, Israel, Italy, Lebanon, Malta, Morocco, Romania, Russia, Syria, Slovenia, Turkey, Ukraine
Northern Europe	Germany, Belgium, Denmark, Spain, Estonia, Finland, France, Ireland, Iceland, Latvia, Lithuania, Dutch, Norway, Poland, Portugal, UK, Russia, Sweden

Source: Data extracted from Drewry (2019)

4 Results

The model was built using equations (5) and (6) on the 10 routes described below. We included the corresponding columns and Tables of reported results.

- 1 – Asia → South America [columns (1) and (2) of Table 6]
- 2 – South America → Asia [columns (3) and (4) of Table 6]
- 3 – Asia → North America [columns (5) and (6) of Table 6]
- 4 – North America → Asia [columns (7) and (8) of Table 6]
- 5 – Asia → Mediterranean [columns (1) and (2) of Table 7]
- 6 – Mediterranean → Asia [columns (3) and (4) of Table 7]
- 7 – Asia → Northern Europe [columns (5) and (6) of Table 7]
- 8 – Northern Europe → Asia [columns (7) and (8) of Table 7]
- 9 – Asia → Oceania [columns (1) and (2) of Table 4]
- 10 – Oceania → Asia [columns (3) and (4) of Table 7].

The summary of the theoretical parameters is reported in Table 9, and the econometric results are shown in Tables 6 to 9 with a summary in Table 9. As some estimated coefficients corresponds to a combination of theoretical parameters ($\alpha_1 = \eta$, $\alpha_3 = C_1\eta$, $\alpha_4 = \delta$ and $\alpha_6 = -\delta\varphi$), theoretical parameters can be obtained from estimated coefficients.

On the route number 1 – Asia – South America (export) route, the estimate of η indicates that 454 TEUs will be added to the capacity due to a 1.000 TEU increase in demand relative to supply. The positive result of c_1 shows that there was an increase in capacity with the inclusion of ships from other routes. In the freight equation, the estimate of δ shows that if the difference of demand relative to the of supply increases by 1,000 TEUs, there will be an increase of USD 21.90 in the variation of the freight for the month, considering the total demand for the route. Finally, the estimated value of φ is 1.151, indicating a reuse of slots in this route.

Table 5 Summary of theoretical parameters

Theoretical parameter	*Estimated coefficient*	*Description*
η	α_1	Propensity to increase supply by increasing demand relative to supply
c_1	$-\alpha_3 / \alpha_1$	Propensity to increase or reduce supply reallocating ships among routes
δ	α_4	Price adjustment factor for differences in demand relative to supply
φ	$-\alpha_6/\alpha_4$	Monthly TEU slot productivity

Source: Prepared by the authors (2020)

On the 'way-back' route number 2 – South America – Asia (import), the estimate of α_1 indicates that 295 TEUSs will be removed from capacity due to a 1,000 TEU increase in demand. This result can be explained by the fact that a ship's trip is a round trip (back and forth). Asia has more export demand than import (about 50% above); therefore, capacity is defined on the route with the highest volume (export), explaining the result on the import route, in which demand reduction apparently increases supply. The negative result of c1 shows that there was a reduction in capacity with the removal of ships from this route. The estimation of δ shows that a difference of 1,000 TEUs in the demand relative to supply will decrease freight by USD 11,40. The annual rate of use of the container per slot is 0.111 TEU, that is, in one year, no slot is completely used. Brazil accounts for 80% of the trade on the South American East Coast route, both for import and export. The difference in results between the two routes is the result of different trade with Asia for import and export, a context in which Brazil buys much more than it sells (cargo transported in containers).

To obtain validation of the model, the actual values of demand and supply from 2015 to 2018 were entered the equations and calculated for comparison with real freight in countries that trade on the route (China and Brazil). In addition to the freight result of the equations for this model, a comparison was made with the original model, to verify which model is closest to reality.

For the sake of clarity, results from Tables 6, 7 and 8 are resumed in Table 9, which is used as the basis for the following analysis.

Figure 3 shows the results of the freight calculation considering exports from China to Brazil. The blue line represents the results of the equation of the article written in 2009 by Luo et al., where annual data were analysed with no distinction per route – the general explanatory power of 2009 model is over 90%. The pink line represents the result of the model equation described in this article. Actual freight is represented by black columns. Although the results of this study are closer to the real freight value than the original model, the values are still far from the real values. Therefore, supply and demand are not enough to explain the variation in freight, considering the export trade data from China to Brazil. When observing the result of imports from Brazil (Figure 4), the freight resulting from the equations of this study is very close to reality. This fact can be explained because there are no GRI rates on the Brazilian import route.

Table 6 Econometric results for South and North America

Variables	*Coeff.*	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
		Asia – East Coast South America	*Asia – East Coast South America*	*East Coast South America-Asia*	*East Coast South America-Asia*	*Asia – East Coast North America*	*Asia – East Coast North America*	*East Coast North America – Asia*	*East Coast North America – Asia*
		ΔX_t	ΔP_t	ΔX_t	ΔP_t	ΔX_t	ΔP_t	ΔX_t	ΔP_t
		(ΔSupply)	*(ΔSea Freight)*	*(ΔSupply)*	*(ΔSea Freight)*	*(ΔSupply)*	*(ΔSea Freight)*	*(ΔSupply)*	*(ΔSea Freight)*
$Y_{t-\theta}$ (demand)	α_1	0.454***		–0.295***		0.708***		1.446***	
		(0.0219)		(0.0663)		(0.0460)		(0.0641)	
$Y_{ot-\theta}$ (demand other countries)	α_2	0.452***		–0.294***		0.701***		1.455***	
		(0.0108)		(0.0224)		(0.0332)		(0.0260)	
$X_{t-\theta}$ (supply)	α_3	–1.211***		–1.102***		–0.707***		–0.269***	
		(0.00767)		(0.0116)		(0.0220)		(0.0115)	
ΔY_t (ΔDemand)	α_4		0.0219**		–0.0114***		0.0104		0.00269
			(0.00867)		(0.00414)		(0.00663)		(0.00192)
ΔY_{ot} (Δdemand other countries)	α_5		0.0326***		–0.00521***		0.00910***		0.00139***
			(0.00104)		(0.000566)		(0.000896)		(0.000369)
ΔX_t (ΔSupply)	α_6		–0.0252***		0.00127***		–0.00952***		0.00213***
			(0.000818)		(0.000300)		(0.000745)		(0.000310)
Constant		93,072***	273.3***	107,611***	87.58***	117,362***	99.19***	–90,083***	–169.5***
		(1,098)	(18.31)	(1,419)	(4.078)	(9,193)	(32.87)	(6,121)	(16.06)
Observations		1,734	1,734	1,734	1,734	1,734	1,734	1,734	1,734
R-squared		0.936	0.492	0.847	0.050	0.374	0.096	0.675	0.050

Notes: Standard errors in parentheses
***p < 0.01, **p < 0.05, *p < 0.1

Table 7 Econometric results for Mediterranean and North of Europe

Variables	*Coeff.*	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
		Asia – Mediterranean	*Asia – Mediterranean*	*Mediterranean – Asia*	*Mediterranean – Asia*	*Asia – North of Europe*	*Asia – North of Europe*	*North of Europe – Asia*	*North of Europe – Asia*
		ΔX_t	ΔP_t	ΔX_t	ΔP_t	ΔX_t	ΔP_t	ΔX_t	ΔP_t
		(ΔSupply)	*(ΔSea Freight)*	*(ΔSupply)*	*(ΔSea Freight)*	*(ΔSupply)*	*(ΔSea Freight)*	*(ΔSupply)*	*(ΔSea Freight)*
$Y_{t-\theta}$ (Demand)	α_1	–0.245***		0.237***		0.226***		0.669***	
		(0.0896)		(0.0748)		(0.0354)		(0.0561)	
$Y_{ot-\theta}$ (Demand other countries)	α_2	–0.263***		0.236***		0.209***		0.688***	
		(0.0218)		(0.00729)		(0.00403)		(0.0106)	
$X_{t-\theta}$ (Supply)	α_3	–0.254***		–0.472***		–0.759***		–0.987***	
		(0.0237)		(0.00944)		(0.0122)		(0.0133)	
ΔY_t (ΔDemand)	α_4		–0.00557		–6.33e-05		4.29e-05		0.00407**
			(0.00864)		(0.000495)		(0.00113)		(0.00207)
ΔY_{ot} (Δdemand other countries)	α_5		–0.00195***		–1.26e-05		–0.000273***		0.00544***
			(0.000320)		(1.41e-05)		(2.97e-05)		(0.000179)
ΔX_t (ΔSupply)	α_6		0.00202***		3.07e-05		0.00330***		0.00558***
			(0.000527)		(3.97e-05)		(0,00008)		(0.000176)
Constant		249,749***	–117.2***	132,182***	1.527**	549,591***	8.281**	406,345***	–66.75***
		(8,893)	(10.62)	(3,106)	(0.649)	(10,551)	(3.776)	(8,218)	(5.313)
Observations		12,138	12,138	11,782	11,782	10,404	10,404	10,372	10,372
R-squared		0.065	–0.026	0.193	–0.001	0.336	–0.403	0.405	–0.315

Notes: Standard errors in parentheses
***p < 0.01, **p < 0.05, *p < 0.1

Table 8 Econometric results for Oceania

Variables	*Coeff.*	*(1)*	*(2)*	*(3)*	*(4)*
		Asia – Oceania	*Asia – Oceania*	*Oceania – Asia*	*Oceania – Asia*
		ΔX_t	ΔP_t	ΔX_t	ΔP_t
		(ΔSupply)	*(ΔSea Freight)*	*(ΔSupply)*	*(ΔSea Freight)*
$Y_{t-\theta}$ (Demand)	α_1	0.381***		0.0156	
		(0.0218)		(0.0417)	
$Y_{ot-\theta}$ (Demand other countries)	α_2	0.439***		0.138***	
		(0.0119)		(0.0128)	
$X_{t-\theta}$ (Supply)	α_3	–0.883***		–0.565***	
		(0.0128)		(0.0123)	
ΔY_t (ΔDemand)	α_4		–0.000616		–0.00422
			(0.00128)		(0.00328)
ΔY_{ot} (ΔDemand other countries)	α_5		3.20e-05		–0.00787***
			(0.000185)		(0.000169)
ΔX_t (ΔSupply)	α_6		–0.00911***		–0.00467***
			(0.000271)		(0.000376)
Constant		189,922***	150.9***	139,332***	–9.964**
		(2,514)	(4.888)	(2,426)	(4.935)
Observations		6,935	6,935	6,935	6,935
R-squared		0.289	–0.612	0.171	–0.151

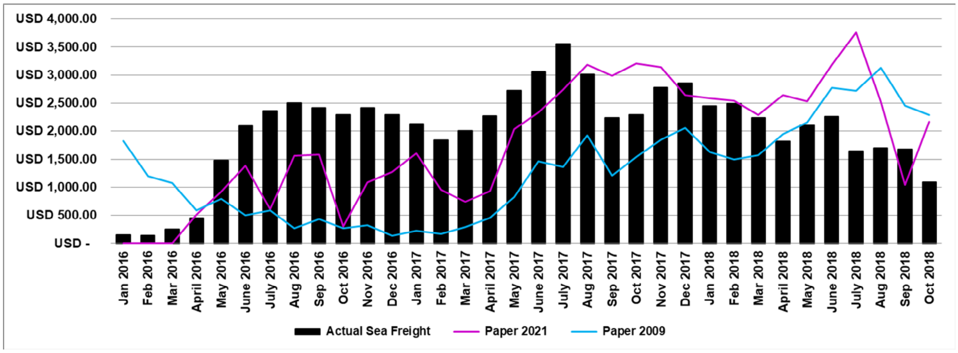
Notes: Standard errors in parentheses
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Table 9 Theoretical parameters (see online version for colours)

Route number	Route	Table	*Theoretical parameters*				*Estimated coefficients*			
			η (α_1)	c_1 (α_3/α_1)	δ (α_4)	φ (α_6/α_4)	α_1	α_3	α_4	α_6
1	Asia – East Coast South America	1.2	0.454	2.667	0.0219	1.151	0.454	–1211	0.0219	–0.0252
2	East Coast South America – Asia	1.2	–0.295	–3.736	–0.0114	0.144	–0.295	–1102	–0.01114	0.00127
3	Asia – East Coast North America	1.2	0.708	0.999			0.708	–0.707	0.0104	–0.00952
4	East Coast North America – Asia	1.2	1.446	0.186			1.446	–0.269	0.00269	0.00213
5	Asia – Mediterranean	1.3	–0.245	–1.037			–0.245	–0.254	–0.00557	0.00202
6	Mediterranean – Asia	1.3	0.237	1992			0.237	–0.472	–6.33E-05	3.07E05
7	Asia – North Europe	1.3	0.226	3358			0.226	–0.759	4.29E-05	0.0033
8	North Europe – Asia	1.3	0.669	1475	0.0041	–1.371	0.669	–0.987	0.00407	0.00558
9	Asia – Oceania	1.4	0.381	2318			0.381	–0.883	–0.00062	–0.00911
10	Oceania – Asia	1.4		36218			0.0156	–0.565	–0.00422	–0.00467

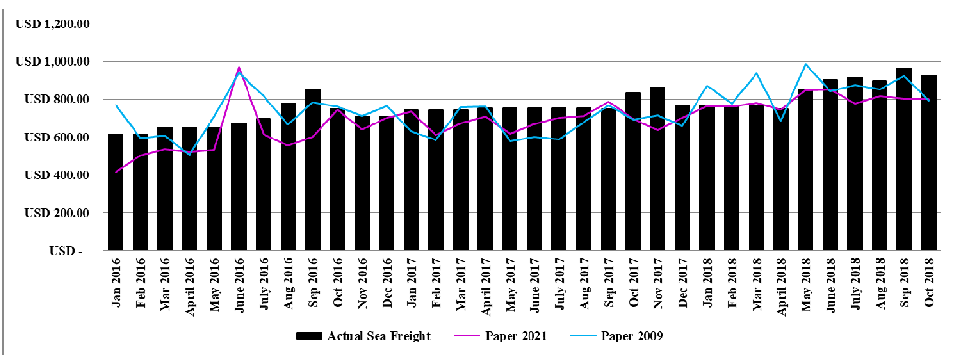
Notes: Estimated coefficients are collected from Tables 6, 7 and 8. Non-significant coefficients (p-valor ≥ 0.1) are in red; in those cases, we do not calculate the related theoretical parameter.

Figure 3 Comparison of both models x actual freight: exports from China to Brazil (see online version for colours)



Source: Prepared by the author (2020)

Figure 4 Comparison of both models x actual freight: exports from Brazil to China (see online version for colours)



Source: Prepared by the author (2020)

On the Asia – North America route (number 3) results, the estimate of η indicates that 708 TEUs will be added to the capacity due to a 1.000 TEU increase in demand. The positive result of c_l shows that there was an increase in capacity with the inclusion of ships from other routes. On the way-back route 4 – North America – Asia, the estimate of η indicates that 1.466 TEUs will be added to the capacity due to a 1.000 TEU increase in demand. Although smaller than in the previous route, the positive value of c_l there was an increase in capacity with the inclusion of ships from other routes. Freight parameters are not computed in routes 3 and 4, as underlying estimates are not statistically significant. One may notice that these routes are more balanced than route 1 and 2, indicating high volumes of trade also from North America to Asia.

For the sake of conciseness, we report that routes 7 (Asia – North of Europe) and 8 (North of Europe – Asia), and routes 9 (Asia – Oceania) and 10 (Oceania – Asia) present similar qualitative results comparing to routes 3 and 4. The only difference is that freight equation gives significant coefficients in route 8 (North of Europe – Asia), the estimate of δ shows that if the difference of demand relative to the of supply increases by 1,000 TEUs, there will be an increase of USD 4.10 in the variation of the freight for the month, considering the total demand for the route. Finally, the estimated value of φ is –1.151, indicating an idle capacity.

We propose a model that utilises more realistic hypotheses and incorporates detailed routes data, including intermediary ports and monthly information, to predict sea freight. While we do not claim to provide a definitive solution, our model offers a valuable tool for industry professionals to compare and assess different freight estimations available in the market. This alternative estimation enhances robustness and can be utilised by the container shipping industry to optimise shipping strategies, identify cost-effective routes with intermediary ports, and make informed decisions.

5 Conclusions

The deployment of large ships and their real impacts is being much discussed in the maritime economy and international trade market, as well as the oligopolies network that emerged as a result of the alliances formed by the shipowners and the volatility of international freight resulting from this scenario. In this paper, the effect of supply and demand on the rate of sea freight in containers on the five main routes from Asia to the world was investigated, with the aim of proving that supply and demand are not sufficient to explain freight fluctuations in the world containerised maritime market in the short term.

The literature, until then, did not present a study of the dynamics of international freight in maritime transport for more than one route from the same point of view, only for the global market as a whole, thus generating generalised results that do not apply when it comes to the reality of each specific region. That's the case at Luo et al. (2009) and to correct that, in the present work, we sought to detail the main routes from Asia to the world, thus proving that each market acts differently; and the interactions between supply and demand are not enough to explain the values of international freight. The incidence of ex-post rates in the regions and routes with the highest volume does not allow supply and demand to operate in balance, resulting in an oligopolies structure in the sector. Understanding how the price definition is done in this self-regulated market will help governments and international bodies to take action against ocean carriers for alleged service failures and unfair pricing. The trend is for the concentration of shipping companies to continue; therefore, future studies may arrive at some economic model that makes it possible to predict the future behaviour of freight. The dominance of the Alliances in the current container shipping market has killed competition, making the market self-regulated. Governments and international bodies concerned should intervene on that.

It is important to acknowledge limitations and potential sources of error of this study. One limitation is the availability and completeness of the data used in the model. The accuracy of the estimates heavily relies on the quality and quantity of the data collected. In some cases, there may be limited historically of geographically, which can introduce uncertainty into the predictions. Additionally, the dynamic nature of the shipping industry and unforeseen events, such as natural disasters or geopolitical changes, can significantly impact freight rates but may not be adequately captured in the model due to the lack of real-time data. It is crucial to understand that our model provides an alternative estimation, but it should be interpreted with caution and used alongside other available estimations to make well-informed decisions within the container shipping industry.

Efforts to gather more comprehensive and up-to-date data will be valuable in improving the accuracy and reliability of future predictions.

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References

Alphaliner (2019) *Página Inicial*, Disponível em [online] https://alphaliner.axsmarine.com /PublicTop100/ (accessed 15 December 2018).

Binkley, J.K. and Bessler, D.A. (1983) 'Autoregressive modelling of bulk shipping', *Review of Economics and Statistics*, Vol. 65, No. 3, pp.516–520.

Carnarius, J. (2017) *Shipping Alliances: What Do They Do and What Does it Mean?*, Forto [online] https://forto.com/en/ blog/shipping-alliances-mean/ (accessed 15 July 2019).

Chen, G., Rytter, N.G.M., Jian, L. and Nielsen, P. (2017) 'Pre-announcements of price increase intentions in liner shipping spot markets', *Transportation Research Part A: Policy and Practice*, Vol. 95, No. C, pp.109–125.

Davies, J.E. (1983) 'An analysis of cost and supply conditions in the liner shipping industry', *Journal of Industrial Economics*, Vol. 31, No. 4, pp.417–435.

Drewry (2016) *Idle Containership Fleet Surges amid Overcapacity* [online] https://www.offshore-energy.biz/drewry-idle-containership-fleet-surges-amid-overcapacity/ (accessed 8 Januany 2020).

Drewry (2019) *Supply Chain Advisors..* [online] https://www.drewry.co.uk/supply-chain-advisors/supply-chain-expertise/world-container-index-assessed-by-drewry (accessed: 20 August 2018).

European Union (EU) (2009) *Regulations (CE) N.O 906/2009 of Commission*, 28 September, UE, Bruxelas [online] https://eur-lex.europa.eu/legal-content/PT/TXT/PDF/?uri=CELEX :32009R0906&from=DE (accessed 13 January 2020).

Ezinna, P.C., Nwanmuoh, E., Ozumba, U.I. and Ogbuka, J. (2022) 'Ocean carrier alliances and the impact on container freight rate', *Journal of International Maritime Safety, Environmental Affairs, and Shipping*, Vol. 6, Nos. 2–3, pp.117–127.

Hoffmann, J. (1998) 'Concentration in liner shipping: causes and impacts for ports and shipping services in developing regions', *World Trade Service Review*, Vol. 1, pp.68–74.

Jeon, J-W., Duru, O., Munin, Z.H. and Saeed, N. (2021) 'System dynamics in the predictive analytics of container freight rates', *Transportation Science*, Vol. 55, No. 4, pp.946–967.

Kearney (2012) *The Financial Crisis Contributed to a Supply-Demand Imbalance: As Freight Rates and Profit Margins Fall, Carriers are Looking for Answers* [online] https://www.fr.kearney.com/article/?/a/balancing-the-imbalances-in-container-shipping (accessed 10 January 2019).

Lu, H.A., Cheng, J. and Lee, T.S. (2006) 'An evaluation of strategic alliances in liner shipping – an empirical study of CKYH', *Journal of Marine Science and Technology*, Vol. 14, No. 4, pp.202–212.

Lun, Y.H., VLai, K.H., Wong, C.W.Y. and Cheng, T.C.E. (2013) 'Demand chain management in the container shipping service industry', *International Journal of Production Economics*, Vol. 141, No. 2, pp.485–492.

Luo, M., Fan, L. and Liu, L. (2009) 'An econometric analysis for container shipping market', *Maritime Policy & Management*, Vol. 36, No. 6, pp.507–523.

Munim, Z.H. and Schramm, H.J. (2017) 'Forecasting container shipping freight rates for the Far East–northern Europe trade lane', *Maritime Economics & Logistics*, Vol. 19, No. 1, pp.106–125.

Nielsen, P. et al. (2014) 'An investigation of forecast horizon and observation fit's influence on an econometric rate forecast model in the liner shipping industry', *Maritime Policy & Management*, Vol. 41, No. 7, pp.667–682.

Notteboom, T.E. (2004) 'Container shipping and ports: an overview', *Review of Network Economics*, Vol. 3, No. 2, pp.1–21.

Pindyck, R.S. and Rubinfeld, D.L. (1988) *Econometric Models and Economic Forecasts*, McGraw-Hill, Singapore.

Saeed, N., Nguyen, S., Culliname, K., Gekara, V. and Chhetri, P. (2023) 'Forecasting container freight rates using the Prophet forecasting method', *Transport Policy*, Vol. 133, No. C, pp.86–107.

Seabury Consulting (2020) *Seabury's Capacity Database* [online] https://seaburycargo.com/login. (accessed 17 January 2020).

Stopford, M. (2006) *Maritime Economics*, 6th ed., Routledge – Taylor & Francis Group, London, ISBN: 0-203-44266-0.

United Nations Organization (UNO) (2000) *Review of Maritime Transport*, United Nations Conference on Trade and Development (UNCTAD) [online] https://unctad.org/en/Docs/rmt2000_en.pdf (accessed 13 January 2020).

United Nations Organization (UNO) (2016) *Review of Maritime Transport*, United Nations Conference on Trade and Development (UNCTAD) [online] https://unctad.org/en/PublicationsLibrary/rmt2016_en.pdf (accessed 11 January 2020).

United Nations Organization (UNO) (2017) *Review of Maritime Transport*, United Nations Conference on Trade and Development (UNCTAD) [online] https://unctad.org/en/PublicationsLibrary/rmt2017_en.pdf (access 6 January 2020).