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Research Article

Structural Analysis of Shipping Fleet Capacity

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With the unprecedented growth of the shipping transportation demand, substantial vessels have been built and delivered to the market. This has led to oversupply after the financial crisis in 2008 because of the abrupt decrease in transportation demand. Notwithstanding the importance of shipping market studies in the investment decision-making, there are relatively few empirical studies modelling the impacts on the structural changes of the fleet supply variables. By considering new orders, current fleet size, and demolitions in ship capacity supply, this study develops a systematic model in both bulker and container markets. The three-stage least squares method is employed to estimate the model to avoid endogenous issues. The primary finding suggests the significant impact of market, cost, and operational factors on fleet capacity supply. It also reveals the relatively rational activities in ordering new vessels and cautious in demolition decisions in the container market because of the large capital investment required. These are relevant to investment and demolition decisions in both the bulker and container markets.

1. Introduction

The shipping industry has a long history, with the first cargoes being moved by sea more than 5,000 years ago [1]. It has been becoming indispensable to global trade; it is estimated that more than 80% of the international cargo is transported by ship [2]. According to Clarksons research [3], world trade has grown from 8,491 million tons in 2007 to 11,091 million tons in 2016, a growth rate of 30.62%. Along with the significant increase in world trade, shipping capacity has grown rapidly. According to Clarksons research [3], the global shipping fleet increased by 71.29% in million deadweight tons from 2007 to 2016, despite the 2008 financial crisis. In fact, it has become clear in recent years that, despite the growth in world trade, the shipping capacity supply has surpassed the demand for trade transportation.

Similar to other markets, dynamic changes in supply and demand in the shipping market can pose a variety of problems. For example, when transport capacity exceeds trade needs, the freight rate will decline; stakeholders must respond quickly to reduce losses, and they may reduce the number of fleet in operation by laying up vessels, reducing new orders or scrapping old ships [1, 4]. This asymmetrical movement of supply and demand has attracted many scholars to investigate the dynamics of the shipping market, hoping to identify a relevant model to capture changes in the market.

It is obvious that among the four submarkets in the shipping industry—freight, new-building, second-hand, and demolition—only operations in the new-building and demolition markets can affect the actual fleet numbers in shipping transportation. In a rising market, shipping companies can place new orders to increase capacity, while in a depressed situation, old and obsolete vessels can be sent to scrap dealers for demolition [1]. However, a search of the literature discloses that most previous studies have focused on the characteristics of freight rate or analysed the relationship between various freight variables [5–8]. Although some scholars pointed to factors that affect changes in shipping market capacity [1, 9–11], few of them have investigated these factors using empirical models. Therefore, this study innovatively employs the Simultaneous Equations Model (SEM) to analyse the structural changes in shipping capacity, a model that can help to eliminate endogeneity problems introduced by interdependent dependent variables. This systematic econometric SEM can help in deriving the marginal effect of each factor on endogenous variables. We believe the results of this study

could help company managers, investors, and shipowners make strategic decisions to enhance profits.

The study is organized as follows: Section 2 reviews previous research about shipping supply, demand, and demolition markets. Section 3 analyses the dynamics of the shipping market and the factors influencing changes in the market. Section 4 describes the data, introduces the method used in this study, and reports the empirical results. Finally, Section 5 concludes.

2. Literature Review

Many researchers have studied the shipping freight market to gain a clear understanding of the movement of freight. Broadly speaking, two approaches have been developed. First, many researchers have focused on modelling the demand and supply for transportation using the structural model [12–15]. Second, in recent years, inspired by developments in financial economics, the focus has been on modelling the freight rate or freight derivatives directly in a stochastic-statistical model [5, 16–26].

In addition to studying the relationships between various rates, many scholars have studied the factors affecting shipping supply, demand, and investment. Svendsen [9] introduced the determinants of maritime demand and supply. He argued that the volume of cargoes, the distance of transport, political factors affect trade and shipping, total tonnage in operation, the age of ships, and ship operating efficiency determine the supply of capacity. Stopford [1] concluded that there are five key factors influencing the demand for sea transport: the world economy, the level of seaborne commodity trade, average haul, random shocks, and transport costs. He also explained that there are three key aspects influencing the supply of merchant ships: size of the fleet, shipbuilding, and demolition. Therefore, these three variables will be the focus of this study. Volk [10] studied the factors which led to changes in the supply and demand curves related to shipping. He concluded that it is difficult to forecast freight rates in the long term because of the unpredictability of factors influencing these rates. Luo, Fan [15] developed an econometric model to analyse the fluctuation of the container freight rate and fleet capacity. They estimated the Simultaneous Equations Model using three-stage least squares, demonstrating a high degree of accuracy for in-sample and out-sample prediction. Lun and Marlow [27] analysed that shipping capacity is associated with profitability and revenue in the liner shipping industry. It is also claimed that non-mega operators are the most efficient firms in operation. Fan and Luo [11] analysed capacity expansion and ship choice decisions in the liner shipping industry. They developed a theoretical model describing the probability of capacity expansion and tested the model empirically using ship investment data. Their results suggest the market-driven and competitive strategies are relevant to capacity expansion. Notwithstanding of the significant contribution of above studies, a key variable, demolition fleet, which influencing the market supply, has been missing in analysing the shipping market supply.

As pointed out by Stopford [1], ship demolition is a key factor influencing fleet capacity. However, relatively few studies have discussed demolition. Among these, some have focused on the social, environmental, and safety issues, such as Matzluck [28], which noted that the Hong Kong Ship Recycling Convention on ship demolition has not been adopted and implemented by most countries and that this convention does not prohibit the beaching method in ship demolition. In an empirical analysis, Buxton [29] explored the basic characteristics of the shipbreaking market and analysed the trends in the market from the 1960s to the 1990s. He argued that the scrap value of a ship depends on the realisable value of the ship's materials and the cost of demolition. Mikelis [30] argued that shipbreaking prices are affected not only by the supply of steel but also by the needs of the steel market and the fleet supply. Knapp and Kumar [31] analysed the probability of ship demolition using a binary logic regression model. Kagkarakis and Merikas [32] constructed a VAR model to study the causal relationship between international scrap prices and demolition prices and showed that the model can also be used to predict scrapping prices. Yin and Fan [33] discussed that ship demolition is an important strategy in balancing fleet capacity. By employing Cox proportional hazards regression, they analysed the different demolition activities for shipowners from different countries at different market cycles. Different from these studies focusing on the single variable of demolition fleet, this study tries to investigate the impacts on fleet supply of new orders, current fleet size, and ship demolitions. Meanwhile, it tries to investigate the structural connections among them.

Although some of these previous studies have discussed the freight, capacity, and demolition markets, the literature lacks a systematic and quantified analysis of the supply of shipping. To understand how the characteristics determining fleet capacity have evolved, we develop a systematic theoretical model to explain the interdependence among demand and supply variables. We describe the structures behind the three key variables, i.e., new orders, current fleet size, and ship demolitions, by constructing an SEM model. This model is capable of eliminating problems brought about by the existence of interdependent endogenous variables. It can also derive the marginal effect of each of the market-related factors described in Section 3.2 below on the key endogenous variables by systematic estimation methods. This may provide valuable information for various decision- and policy-makers.

3. Structural Movement of the Shipping Fleet Market

It is no doubt that the bulk shipping market is almost a complete competitive market, where thousands of shipping companies are providing transportation service and the freight rate is determined by the interaction of market demand and supply. However, there are some different opinions on the contestability of the container market [34, 35]. Through analysis of three requirements, i.e., same access to technology for entrants and incumbents, low sunk costs (ships can be

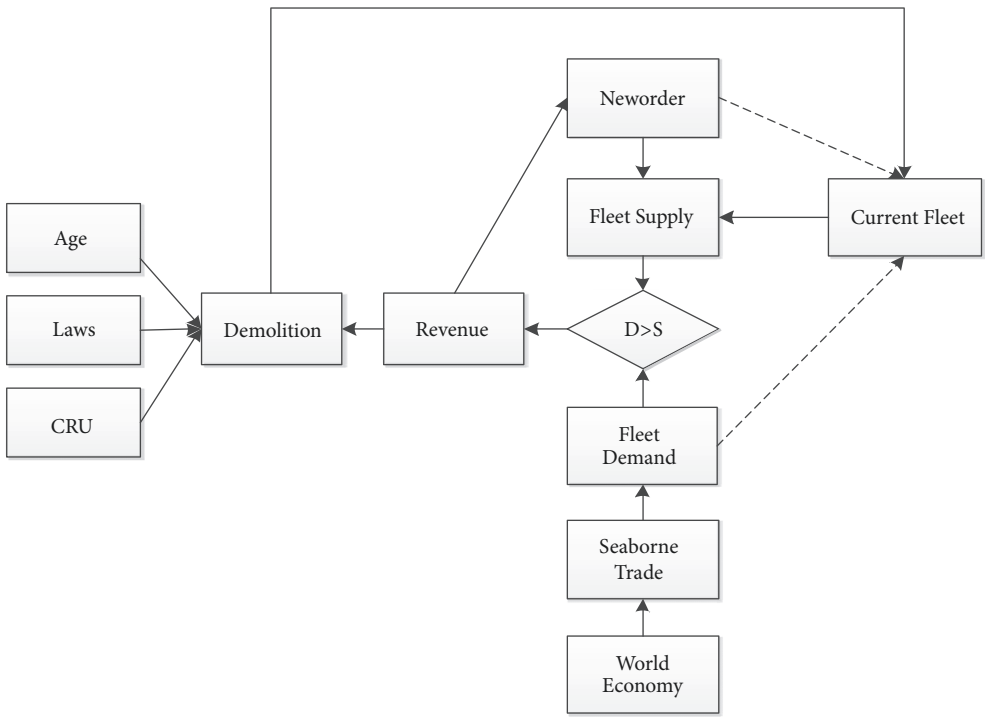

Figure 1: *Dynamic analysis of shipping market*. Note: CRU represents the steel price index.

easily diverted from one route to another), and competitions from tramp and bulk carrier, Davies [36] concluded that the container industry is a contestable market. Haralambides [37] also claimed that, irrespective of market structure and capital concentration, the real issue is how accessible (contestable) the market is to new competition. If entry (and eventually exit) to the market by new competitors is easy, the market is said to be contestable. He further analysed that liner shipping is a contestable market. Through explanatory and empirical studies, Notteboom [38], Munim and Schramm [26] and Hirata [39] all concluded that the container market is contestable. As Munim and Schramm [26] claimed "...in times of sudden demand increase, there are many ways to solve the problem, including increasing the cruise speed or increasing loading factor, whereas at the same time, there is a high supply side flexibility present, too...Thus, for the container shipping industry, we can assert that both demand and supply are flexible enough to confirm the assumption of market equilibrium model by Beenstock and Vergottis [14]".

3.1. The Interaction of Supply and Demand. Shipping is a complex industry. On the supply side, there are four different submarkets: freight, second-hand, new-building, and demolition. Each sector has its own unique methods of operation. The main assets (ships) in the shipping industry provide an entire range of services with respect to a variety of goods. The demand for transport is derived from the demand for the goods being transported. International cargo trade is a key factor that affects the demand for shipping transportation services. Stopford [1] observed that the level of world economic output (e.g., GNP or GDP) is by far the most important factor affecting the volume of seaborne trade.

As with any market, the intersection of demand and supply determines the price in the shipping freight market, which in turn affects demand and supply. This dynamic relationship is illustrated in Figure 1. When the demand for seaborne trade exceeds the supply of fleet, the freight rate increases. The higher rate suggests higher profits, so new orders are placed to increase transport capacity. Over time, when the capacity supply exceeds the need for transport, the freight rate decreases. New orders will be decreased and older and inefficient ships are laid up or sent for breaking [10]. It is obvious that activities in the new-building and demolition markets determine changes in the shipping capacity. Because second-hand transactions and lay-ups do not affect the number of ships in the market, they are not depicted in the figure.

3.2. Factors Influencing the Shipping Market. Many factors affect the demand for shipping, including the state of the world economy and international maritime trade, average achieved profit, political events, and transportation costs [40]. The supply of shipping capacity is also affected by various factors, including the size of the world fleet and its productivity, shipbuilding, demolition, and freights (revenue) [41]. Functionally, the fleet capacity supply depends on the size of the existing fleet, plus the delivery of new ships minus the number of ships scrapped.

Shipbreaking has been seen as an essential element for balancing shipping supply and demand because the scrapping of uneconomical vessels can reduce the ship supply [29, 33].

Similar to the shipping supply and demand, ship demolition is also affected by many factors: whether a vessel is technologically or economically outdated, the age of the vessel, shipbreaking industry regulations, scrap prices, and others.

Summarizing the literature, factors influencing the supply of shipping can be classified into market factors, cost, and operational factors. These factors are described in the following subsections and are also illustrated in detail in Table 1.

3.2.1. Market Factors Affecting Shipping Capacity. Shipping companies provide global shipping services to meet the demand for sea transport; i.e., the demand for shipping transportation is derived from the world trade [1]. Shipping companies have to make ship investment decisions according to the transportation demand. When the world economy is booming, the transportation demand is increasing. If the capacity supply cannot satisfy with the demand, the freight rate will increase. This will motivate the shipping companies to place new orders for new ship investment. Because of the construction lags, when the new-buildings are delivered to the market, the market situation may have changed, which determines the new freight level [1, 15, 25]. The uncertain transportation demand plus this shipbuilding lag make the freight market volatile.

On the other hand, when the prosperous economy turns into depression, although new orders will be decreased, the large orders placed in previous increasing situations are kept delivering to the market. If the shipping capacity increases faster than demand, a limited recovery in economic growth may not be effective in bringing the shipping freight rate up. Such as the current situation after the 2008 financial crisis. Some old and obsolete vessels have been sent for demolition. Stopford [1] analysed from the perspective of psychology that the recessionary phase of the shipping cycle will not end until some successive ships are sent for scrapping to decrease the oversupply. In general, ship demolition is a primary element in balancing the supply of and demand for ships [29].

To sum up, the key factors influencing the demand for the shipping market are the world economy and the level of seaborne commodity trade, while the supply of merchant ship capacity is determined by the size of the fleet, shipbuilding (new orders), and demolition. In addition, the relative strength of demand and supply determines the market freight rate level and its profitability.

3.2.2. Cost and Operating Factors Affecting Shipping Capacity. In addition to ordering or demolishing vessels, shipping companies can also control the actual fleet capacity by various supply side flexibility tactics [26], such as laying off vessels, slow steaming, and rescheduling routes. However, these tactics are effective in the short run for individual participants. In the long run, the investment and disinvestment are more strategically important. Since this study is focused on the aggregate market level with yearly data, these tactics are not considered in the empirical model.

The shipping market is different with other markets as in which the main assets (ships) are invested to carry cargoes around the world. When making the investment decision, all buyers pay the same price for the same new ship [10]. That is to say, the new-building price is not only a kind of capital cost; it represents the amount of future investment in the shipping market as well. High freight rates mean high profits, which will attract shipping companies to invest in new-buildings. With increases in demand for new orders, prices in the shipbuilding market increase, leading to an increase in capital costs for shipping companies [42].

As discussed above, there are construction lags in the shipbuilding market. This suggests that there are vessels under construction (it is called 'order book') when shipping companies making investment decisions. This order book actually implies the potential capacity supply in subsequent years. Therefore, it is considered as an influencing factor when shipping companies make investment decisions [43].

In the shipping industry, bunker consumption is a major voyage cost in operating a vessel [1]. Ships face less pressure to operate at slow steam to save fuel when oil prices are low, and higher speeds lead to more capacity. Therefore the bunker price is considered as an influencing factor for fleet deployment.

In addition to above factors, there are some unique variables influencing the demolition market: First, the age of a ship: in general, the average lifespan of a ship is about 30 years. Ships may be scraped because of economic, technical, and regulatory limitations, which could be represented by the age of a ship. As discussed by Evans [44], a ship's cost of repairs, maintenance, surveys, and associated time out of service will increase with the increase of age; since we are focusing on the fleet variables on an aggregated level, a variable, *HighAage*, is designed to be included in the empirical model, which is the ratio of older (20+ years old) vessels to the total fleet (see detail in Table 1). Second, the price of steel: as ship demolition can provide an important source of cash flow when freight rates are low [1], it could be impacted by the global demand of steel resources. Through empirical analysis, Mikelis [45] found a positive correlation between ship demolition and global steel production. So, the steel price is also included in the statistical model in this study. Finally, regulations on ship demolition activities: along with the development of the ship demolition industry, issues of unacceptable worker conditions, pollution, and environmental degradation have aroused much concerns [33]. International conventions and guidelines have attempted to address these problems, such as the Basel Convention, the International Maritime Organization (IMO) guidelines on ship recycling, the International Labor Organization (ILO) guidelines, and Hong Kong International Convention for Safe and Environmentally Sound Recycling of Ships (HKIC). Hence, the impact of demolition laws and regulations on the demolition behaviour is also considered in the statistical model.

4. Data and Methodology

4.1. Data Sources and Description. The data used in this study are collected from two sources: the Shipping Intelligence Network (SIN) by Clarkson Research and the Qianzhan Database (https://qianzhan.com). The SIN database proves various

Table 1: Description of the variables used.

Markets	Variables	Description	Factor	Mean	Maximum	Minimum	Std. Dev.
Bulker	*Neworder*	New order ship (million dwt)	Market	45.378	159.338	8.935	40.627
	Trade	World seaborne iron ore, coking coal, steam coal, phosphate rock, bauxite/alumina, minor bulk trade (Million tonnes)	Market	3102.547	4543.477	1850.778	938.013
	Fleet	Fleet capacity in (million dwt)	Market	422.703	776.653	243.719	184.663
	NBPI	New-building price index	Cost and Operational	133.402	232.09	91.889	36.382
	Freight	Baltic Exchange Dry Index	Market	2265.762	7071.000	673.000	1797.090
	Earings	Clarksons Average Bulker Earnings ($/Day)	Market	14904.048	44267.000	6200.000	10888.390
	Orderbook	Oderbook of Bulkcarrier (million dwt)	Cost and Operational	124.197	326.080	23.973	105.078
	Bunkerprices	380cst bunker prices, Rotterdam	Cost and Operational	289.051	639.635	67.621	191.154
	Demolition	Total Bulkcarrier Demolition (million dwt)	Market	11.516	33.413	0.357	10.351
	HighAge	20 years and over (%)	Cost and Operational	26.599	41.180	8.040	10.193
	CRU	Steel price index	Cost and Operational	136.969	234.883	74.917	44.764
Container	*Neworder*	New order ship (,000 TEU)	Market	1137.342	3314.011	60.479	872.586
	Trade	World Seaborne Container Trade (,000 TEU)	Market	111689.4	181128.2	46779.62	44759.81
	Fleet	Fleet capacity in (,000 TEU)	Market	9714.625	19743.70	2920.019	5447.255
	NBPI	New-building price index	Cost and Operational	89.369	123.565	69.017	16.667
	Freight	Containership Timecharter Rate Index	Market	76.238	152.000	35.000	31.607
	Earings	Clarksons Average Containership Earnings ($/Day)	Market	12000.143	25018.000	5070.000	5531.321
	Orderbook	Oderbook of container (,000 TEU)	Cost and Operational	3069.479	6626.198	626.928	1856.390
	Bunkerprices	380cst bunker prices, Rotterdam	Cost and Operational	289.051	639.635	67.621	191.154
	Demolition	Total container Demolition (,000 TEU)	Market	146.495	654.411	2.3460	181.601
	HighAge	20 years and over (%)	Cost and Operational	13.551	24.200	4.1400	6.866
	CRU	Steel price index	Cost and Operational	136.969	234.883	74.917	44.764

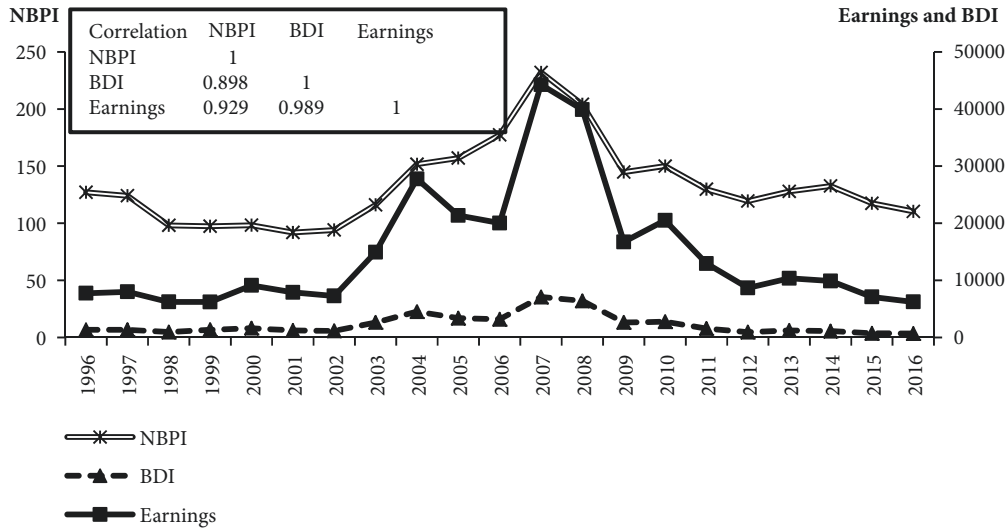

Figure 2: Correlations between new-building price, BDI, and earnings in the bulker market.

time series data for the shipping industry. As an aggregated model analysis, this study only considers the bulker and the container submarkets using yearly time series. The fleet size, demolition, order book, new order, and seaborne trade are from the SIN database. Considering the availability of the data, the sample is finally determined from 1996 to 2016. The Qianzhan database is a public data source which provides weekly, monthly, and yearly data for international, regional, national, and industrial aspects. In this study, the steel price index is obtained from the Qianzhan database. A detailed description of the variables can be found in Table 1.

According to the table, the ratio of new orders to the total fleet is 10.735% (45.378/422.703) for the bulker market and 11.708% (1137.342/9714.625) for the container market. Similarly, the order book ratio for the bulker market is 29.382% (ratio of order book to fleet) which is slightly lower than the container market of 31.596%. The ratio of demolitions to the fleet is 2.724% for the bulker market and 1.508% for the container market. This suggests the relatively active demolition behaviour in the bulker market. It can also be confirmed by the higher ratio of the older ships (*HighAge*) for the bulker ships (26.599%) than for the container ships (13.551%), as usually older ships are more inclined to be scraped than younger ones.

4.2. Simultaneous Equations Model. As discussed above, the three key variables influencing shipping fleet capacity are new orders, current fleet size, and demolitions. Considering the factors discussed in Section 3, we analyse the impact of new orders, current fleet and demolitions from two points of view: market and cost and operations (see detail in Table 1). Since the magnitudes of the values are different, the model is estimated separately for the bulker and container markets.

$$Neworder = c_{11} + c_{12} \times Trade + c_{13} \times Fleet + c_{14} \times NBPI + c_{15} \times Orderbook + \varepsilon_1 \quad (1)$$

$$Fleet = c_{21} + c_{22} \times Neworder\,(\text{-2 or} - 3) + c_{23} \times NBPI + c_{24} \times bunker\ price + c_{25} \times Trade + \varepsilon_2 \quad (2)$$

$$Demolition = c_{31} + c_{32} \times HighAge + c_{33} \times Laws + c_{34} \times Fleet + c_{35} \times Neworder + c_{36} \times CRU + \varepsilon_3 \quad (3)$$

It is noteworthy that the correlations between the new-building price, freight, and average earnings are high (Figures 2 and 3). Therefore, only *NBPI* is included in the equations since it also represents the investment cost of a new ship. There is a lag for the *Neworder* variable in (2), which is determined by calculating the mean difference between the time placing a new-building order and the time it is delivered to the market. In this study, the mean shipbuilding lag is 2 and 3 for the bulker and container ship separately. In (3), the dummy variable, *Laws*, refers to industry-related scrapping guidelines. In recent years, international organizations such as the IMO, the ILO, and Greenpeace, as well as countries around the world, have given unprecedented attention to the shipbreaking industry and have developed guidelines to promote safety, health, and environmental protection in scrapping operations. For example, the ILO promulgated 'Safety and Health in Shipbreaking: Guidelines for Asian Countries and Turkey' in 2003 [46], and 'Guidelines on Ship Recycling' in the 23rd Assembly in November-December 2003 by Resolution A.962 [46, 47]. Therefore, the value of *Laws* is 1 in 2004 and after, while in previous years it is 0.

In this SEM system, *Neworder*, *Fleet,* and *Demolition* are endogenous variables which will be determined by all the other exogenous variables. In the system, the endogenous variable *Neworder* is an independent in the *Fleet* and *Demolition* equations, and the *Fleet* variable is an independent in the *Demolition* equation, so the system is interdependent.

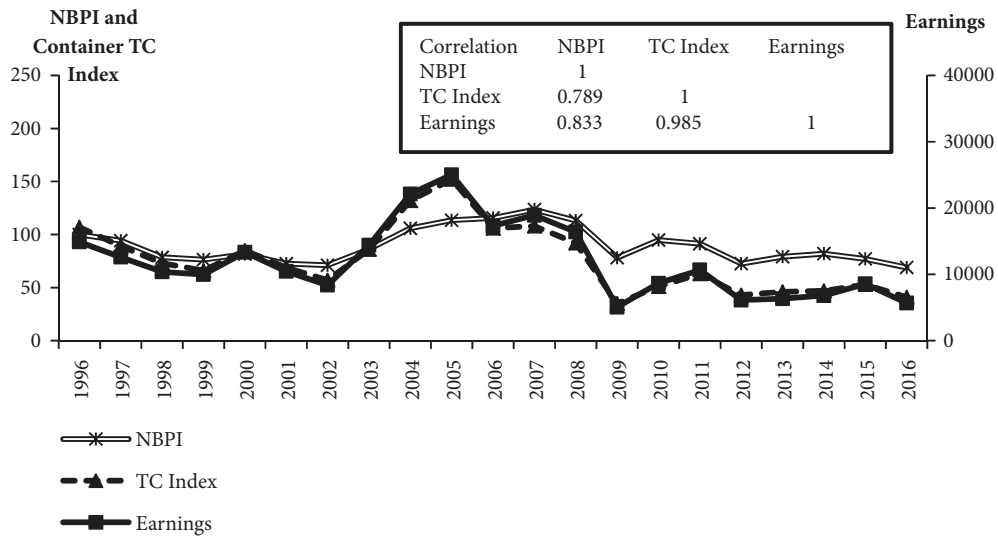

Figure 3: Correlations between new-building price, time charter index, and earnings in the container market.

This suggests that the residuals are correlated: cov(ε_1, ε_2)≠0, cov(ε_1, ε_3)≠0, cov(ε_2, ε_3)≠0. Put (1) to (2), and (1) and (2) to (3). It is obvious that cov(*Fleet*, ε_1)≠0, cov(*Demolition*, ε_1)≠0, and cov(*Demolition*, ε_2)≠0. Since the endogenous variables are correlated with the disturbances, the least squares estimators of the parameters with endogenous variables on the right-hand side are inconsistent.

A general method of obtaining consistent estimates is the method of instrumental variables (IV). All the exogenous and predetermined variables in the system are perfect instrumental variable for the estimation, because they are correlated with the endogenous variables as they appear in the equations, and they are independent to the error term as they are exogenous variables. The IV estimator will be consistent and have asymptotic covariance matrix. Based on the principle of instrumental variables, there are generally two approaches for estimation of SEM. One is limited information estimators which will estimate the structural parameters of each equation separately using all the information of the exogenous and predetermined variables in the whole system. Ordinary least squares estimator, instrumental variable estimator, two-stage least squares (2SLS) estimator, and limited information maximum likelihood (LIML) estimator all belong to this. But this type of estimator ignores information concerning that one endogenous variable may appear in other equations. It also ignores information that the error terms among the equations are correlated. Another type of estimation is full information estimator or system methods of estimation. It jointly estimates the equations in the model and get a more efficient estimation. System methods include three-stage least squares (3SLS) estimator and full information maximum likelihood (FIML) estimator. Detailed analyses can be obtained from Greene [48]. In this study, the 3SLS is adopted in the estimation where the exogenous variables and the predetermined endogenous variables in the system are used as instruments.

4.3. Empirical Results. Tables 2-3 are the estimated results from simultaneous equations for the bulker and container markets separately. The results show that most of the variables are significant, and the high adjusted R-squares suggest the goodness of the model fit.

4.3.1. Bulker Shipping Market. Table 2 is the estimated results for the bulker market. Equation (1) takes into account the effects of *seaborne trade*, *current fleet, new-building price,* and *order book*. However, the results show that only the *new-building price index* is significant with a positive coefficient. Generally speaking, new investment is usually negatively correlated with investment cost. Here the positive coefficient of the new-building price index suggests that new orders of ships increase with the increase of the new-building price. This can be explained by the high correlation (0.898) of the new-building price with the freight rate (BDI). Hence, the high new-building price implies high freight rate, which suggests a booming market. In this situation, shipping companies are eager to invest in new ships.

To further understand the results in (1), we illustrate the development of the *new order*, *order book*, *seaborne trade,* and *fleet* in the bulker market in Figure 4. The new order fluctuates regardless of the increasing trend in seaborne trade and fleet. It is interesting to see that ships on order are not a determinant factor for shipping companies making investment decisions. Although the order book stayed very high after 2008, there is no obvious decreasing trend in new orders and there were actually big jumps in 2010 and 2013. This indicates the irrationality of shipping company decisions to invest in the bulker market.

Equation (2) analyses the factors influencing fleet capacity in the bulker market. Since it usually takes two years to deliver a new-building to the bulker shipping market [3], we add the two-year lagged variable of *Neworder* to the regression. However, the coefficient is not significant.

Table 2: Estimated results of the SEM for bulker ship.

Simultaneous equations/Dependent	Variables	Coefficient	Std. Error	Prob.	Adjusted R-square	Durbin-Watson stat
Equation (1) *Neworder*	*Constant*	-75.511	42.749	0.085	0.612	1.972
	Trade	-0.020	0.079	0.807		
	Fleet	0.117	0.360	0.746		
	NBPI	**0.995**	**0.441**	**0.030**		
	Orderbook	0.014	0.079	0.861		
Equation (2) *Fleet*	***Constant***	**-159.629**	**48.180**	**0.002**	0.994	1.834
	Neworder(-2)[a]	0.022	0.079	0.783		
	NBPI	**-0.970**	**0.134**	**0.000**		
	Bunkerprice	**-0.090**	**0.036**	**0.018**		
	Trade	**0.232**	**0.011**	**0.000**		
	AR(1)	**0.632**	**0.176**	**0.001**		
Equation (3) *Demolition*	***Constant***	**-34.914**	**7.816**	**0.000**	0.828	2.089
	HighAge	**0.413**	**0.170**	**0.020**		
	Laws	**-11.522**	**3.009**	**0.001**		
	Fleet	**0.077**	**0.010**	**0.000**		
	Neworder	**-0.131**	**0.024**	**0.000**		
	CRU	**0.118**	**0.032**	**0.001**		
	AR(1)	**-0.471**	**0.234**	**0.051**		

Note: [a]Neworder (-2) is the two-year lagged variable of Neworder. The Durbin-Watson statistics suggest one-order serial correlation of the residuals in the equations, so *AR*(1) is added to deal this issue.

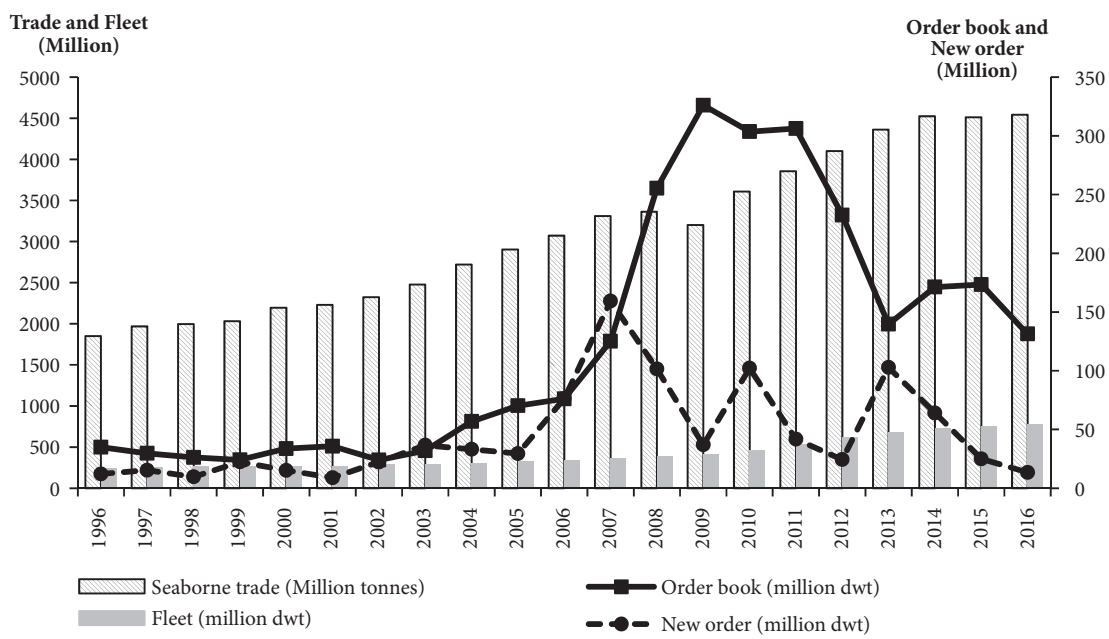

Figure 4: *New order*, *order book*, *seaborne trade,* and *fleet* development in the bulker market.

The coefficient for the new-building price, *NBPI*, is negatively significant. High new-building price not only suggests a boom in the shipping market but also represents the shipping company's investment cost. In a booming market, shipping companies rush to order new vessels, which pushes up prices. To keep pace with the demand for shipping transportation, some companies choose to invest in second-hand vessels as these can be put into the market immediately.

Bunker price represents the cost of operating the ship. Therefore, it is reasonable that the coefficient for bunker price is negatively significant.

Table 3: Estimated results of the SEM for container ship.

Simultaneous equations/Dependent	Variables	Coefficient	Std. Error	Prob.	Adjusted R-square	Durbin-Watson stat
Equation (1) Neworder	***Constant***	**-2862.771**	**436.579**	**0.000**	0.780	1.914
	Trade	**0.077**	**0.018**	**0.000**		
	Fleet	**-0.487**	**0.152**	**0.003**		
	NBPI	14.510	10.717	0.185		
	Orderbook	**-0.371**	**0.051**	**0.000**		
	AR(1)	**-0.766**	**0.162**	**0.000**		
Equation (2) Fleet	*Constant*	624.384	721.757	0.393	0.995	1.990
	Neworder(-3)[a]	0.067	0.078	0.395		
	NBPI	**-61.243**	**5.328**	**0.000**		
	BunkerPrice	-0.977	0.729	0.189		
	Trade	**0.129**	**0.004**	**0.000**		
	AR(1)	**0.487**	**0.218**	**0.032**		
Equation (3) Demolition	*Constant*	35.462	285.670	0.902	0.740	2.127
	HighAge	-0.223	10.615	0.983		
	Laws	15.786	89.884	0.862		
	Fleet	**0.034**	**0.012**	**0.006**		
	Neworder	**-0.072**	**0.030**	**0.021**		
	CRU	-1.086	0.741	0.152		

Note: [a]Neworder (-3) is the three-year lagged variable of Neworder.

The coefficient for the *trade* variable is positively significant. Obviously, with an increase in market demand, ship capacity supply will increase.

Equation (3) investigates the impacts on the scrapping market. The coefficient for *HighAge* is positively significant. Since the inspection of older ships by PSC authorities is more stringent, they are more likely to be demolished.

The coefficient for *Laws* is negatively significant, which is to say that the environmental laws do have an impact on shipbreaking activities.

Current fleet and new orders represent the capacity supply of the shipping market. When the supply exceeds demand, shipping companies will choose to scrap some obsolete or inefficient vessels to ease the pressure on the market. Conversely, when the demand exceeds supply, companies will choose to increase new orders to meet the demand and ship scrapping will be suspended. So the coefficient for *Fleet* is positively significant, but that for *Neworder* is negatively significant.

CRU represents the demand in the steel industry. The higher the steel price index, the larger the demand for steel. The positive coefficient for *CRU* suggests profit-motivated behaviour in the scrapping market. This result echoes to the main findings from Mikelis [30].

4.3.2. Container Shipping Market. The estimated results for the container market (Table 3) are different from those for the bulker market. In (1), the coefficient for *Trade* is positively significant and the coefficient for *Fleet* is negatively significant. This is reasonable because the higher the amount of maritime trade, the higher the demand for capacity. To meet the market demand, shipping companies will increase the number of new orders. On the contrary, when the capacity of the current fleet increases, shipping companies aiming to maximise profits will not choose to add new orders. Because an increase in new orders will lead to oversupply in the subsequent few years, the freight rate and profitability will decline.

The coefficient for *Orderbook* is negatively significant. This suggests that a high volume of order book will decrease shipping companies' investment in new ships as otherwise an overcapacity may result. This indicates the rational decision-making of the shipping companies in the container market.

The estimated results of (1) for the bulker and container markets are totally different. For the bulker market, only the new-building price is significant, while all the other variables (except new-building price) are significant for the container market. This indicates that capacity development in the container market is more rational than in the bulker market, as the investment decisions in the container market consider demand, supply, and operational conditions.

Similar to the results in Table 2, the estimates in (2) suggest that the capacity supply of the container market is mainly affected by trade and new-building price. It should be noted that it usually takes three years to build a container vessel [3], so the three-year lagged variable of *Neworder* is included in (2).

In (3), only the coefficients for *Fleet* and *Neworder* are significant. Similar to the results for the bulker market, the coefficient for *Fleet* is positive but is negative for *Neworder*. However, the coefficients for *HighAge* and *Laws* are insignificant. This is possibly due to the higher capital cost of a

container ship, and it is more difficult to scrap a container ship just because of old age. In contrast, bulker ships are relatively small and cheap, and the demolition decision can easily be impacted by market and operational factors.

5. Summary and Conclusion

As one of the most important modes of transporting goods, shipping has made a significant contribution to globalisation. Through an analysis of the shipping market, we propose an econometric model focusing on the three key variables of its fleet supply: new orders, current fleet size, and demolitions. Our review of the literature indicates that the main factors influencing these variables are related to markets, costs, and operations. Considering the interdependence between these three endogenous variables, the 3SLS method is used in the regression analysis, leading to a better degree of fitting. Considering concerns about environmental protection in recent years, we add the regulations issued by international agencies to the factors influencing the demolition equation to examine the impact of these regulations on the shipbreaking industry.

The estimated results suggest the significant impact of market, cost, and operational factors on new orders, fleet development, and ship demolition. The results also indicate that new ship investment in the container market is conducted more rationally than in the bulker market, as market, cost, and operational factors all impact the investment decision in the container market. This is to be expected because there is a relatively larger requirement of capital investment for container ships. The result also suggests that shipping companies are more hesitant to engage in demolitions in the container market than in the bulker market.

In short, the model developed in this study is useful for providing information relevant to public policy and for decision-makers in private enterprises. Maritime organizations and environmental organizations may be able to use this information to regulate the shipbreaking industry so as to reduce environmental pollution. In addition, investors can use this information in ship financing decisions to minimise investment risks. Finally, the owner and the ship operator can use these results to design and implement business strategies to maximise their profits.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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