

# Major Factors Affecting Shanghai Shipping Freight Rates during the Covid-19 Pandemic: Inspecting and Ranking by Grey Relational Analysis

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**Abstract** This study aims to GRA (Grey relational analysis) method to analyze the factors that affect Shanghai shipping rates( $\Delta$ SCFI) and which factors will play a key role under the impact of COVID-19 epidemic outbreak. GRA method can analyze the weight relationship between factors and their attributes to explore the factors that affect the shipping rates. We find that the change rate of the main route's on-time rates of receiving and dispatching scheduled services ( $\Delta$ OTRADSCI) affects the change rate of Shanghai shipping freight rates the strongest, followed by the change rate of the main route's on-time arrival and departure service rates ( $\Delta$ OTRRSRCI) and the change rate of China export container freight rates ( $\Delta$ CCF). Subsequently, the change rate of China international seafarer salary ( $\Delta$ CISSI), the change rate of China senior seafarer salary ( $\Delta$ CSSSI) and the change rate of China ordinary seafarer salary ( $\Delta$ COSSI) gave the strong influence to the Shanghai shipping freight rates. While, the change rate of Shanghai port container handling volumes (or throughput) ( $\Delta$ SPCV) gave the least effect to the Shanghai shipping freight rates during the COVID-19 pandemic in 2019-2020. It is hoped that these findings can help policy makers in making decisions on port management/operations and future port development.

**Keywords:** COVID-19 epidemic, Shipping freight rates, Grey relational analysis (GRA)

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## 1. Introduction

The COVID-19 (Coronavirus Disease-2019) pandemic has triggered enormous and heterogeneous global public health and economic crises. Fang, Collins and Yao [1] point out that the COVID-19 is a health and geopolitical crisis, simultaneously spilling over into the real economy and financial markets with the focus shifting from Asia first to Europe, then to North America, and finally to the rest of the world.

Research by Nguyen and Dinh [2] showed self-isolation, compulsorily staying at home, forbidding to go out, and so on, can be reduced the COVID-19 infections and deaths. As a result, governments have responded quickly and are increasingly imposing strict public health measures. For example, lockdown and embargo measures have disrupted the global trade order. Thus, the lockdown of ports and shipping caused the container to stay and not return to the production base. This also causes shipping cost to increase or extra freight. Then the crew is difficult to replace due to the epidemic prevention and isolation; some ships are detained or waited for a long time to enter the port due to epidemic

prevention, and even the ships were out of stock to enter the port for longer due to epidemic prevention requirements, and even ships are lacking. Finally, there is a lack of air transportation has caused demand to move from air to ocean freight, driving freight rates soaring.

On the other hand, the global maritime industry is entering a new era in which carbon reduction and air pollution reduction are the main issues. Container ships need to improve fuel efficiency and air pollution reduction. As a result, they are running slower and more container ships must be invested in to meet customer demand, also driving up freight rates. The chaos of shipping and the slow weekly change of containers has led to skyrocketing shipping prices and chaos in global trade. The Baltic Dry Index (BDI), which is widely used to measure the rise and fall of the shipping industry, rose 353 % from 393 points in 2020 to 1,779 points in early March this year.

In addition to causing human cases and deaths, the COVID-19 pandemic has affected shipping stock markets and Baltic indices. Michail and Melas [3] argued that such incidents directly affect the dry bulk and dirty tanker industries. Furthermore, the shipping container market has been slow to develop due to limited capacity supply, huge import demand and the disruption of the epidemic. Port

congestion, container shortage will become a normal phenomenon. Therefore, the uncertainty of shipping freight prices has increased the operational risks of the relevant operators. Regardless of freight rates, if managers can detect and master the influencing factors and future trends of shipping freight rates, it will provide important reference information for business decision-making and effectively reduce business risks of their operations.

In this research, we aim to find the possible factors affecting the Shanghai shipping freight rates of regular container shipping and their relative effects during the period of Covid-19 pandemic. In addition, the above documents indicate that the shipping freight rates are characterized by volatility and uncertainty. Huang and Liao [4] pointed out that grey relational analysis (GRA) can find key factors for decision-making and provide solutions for systems with uncertain models or incomplete information. Additionally, it provides efficient solutions to uncertainty, multiple input, and discrete data problems. Specifically, we apply the GRA method to identify key factors affecting shipping freight rates during the period of Covid-19 pandemic based on the Shanghai export containerized freight index (SCFI), so-called the Shanghai shipping freight rates in this study. Hopefully, the empirical results can provide useful information to explain the main determinants affecting the Shanghai shipping freight rates during the period of Covid-19 pandemic.

This research is organized as follows. Section 1 introduces the research background and the purpose of this research. Section 2 reviews the main related literature. Section 3 briefly describes the GRA methodology. Section 4 discusses the empirical results. Section 5 presents the conclusions of this study.

## 2. Literature Review

Research by Robinson [5] showed that ports are a critical element at the intersection of multiple independent supply chains and have great potential to add value to supply chains. However, this position at the intersection of supply chains creates coordination challenges such as landside congestion. The consequences of landside congestion range from delays, lost time or sales, service uncertainty for transporters and logistics service providers [6,7], and increased supply chain costs [8], uncertainty, and ultimately decreased competitiveness. However, in a global context, supply chains compete [9]. Therefore, increased costs and uncertainty in some supply chain areas can have broader competitiveness implications.

There are many documents on the influence of shipping freight rates fluctuations, such as traditional models, the autoregressive integrated moving average (ARIMA) models, and approximated diffusion flame (ADF) were applied to study freight rate volatility [10]. However, since Kavussanos [11,12] firstly introduced ARCH (autoregressive conditional heteroskedasticity) models into worldwide shipping market, the research on shipping freight rates and vessel price volatility has gained its popularity. Research on freight rates and ship price volatility has become popular. In addition, a series of studies by Kavussanos [13,14] pointed out that the price of dry bulk cargo and the price of second-hand ships vary

over time; freight rates for larger vessel sizes showed to have better effect of fluctuations; freight rates and vessel prices were first-order stationary; and a derived class of generalized autoregressive conditional heteroskedasticity (GARCH) model had been widely used in dry bulk shipping market research [13,14].

Kavussanos and Alizadeh-M [14,15] indicated that global dry bulk shipping is an important part of the global economy and trade. Since most of the studies in the above literature show that they are to find out the factors that affect the freight rate, the literature has established macroeconomic determinants of shipping freight (charter) rates because they are all abstract indicators (such as prosperity indicators, oil prices, currencies, etc.). In addition, vessel load, age and voyage route are important determinants of dry bulk shipping rates. In contrast, the determinants of the lay-out period of a chartered vessel include the age of the vessel, the level of freight rates and the volatility of freight rates. But some of these factors cannot be displayed instantly and respond immediately to shipping freight rates. Today's COVID-19 pandemic remarkably affected the ocean shipping markets in 2020. According to the estimates from the Clarkson Shipping Intelligence Network in year 2020, global seaborne trade will contract by 4.4% in 2020, similar to the decline following the international financial crisis (2009:4.1%). Michail and Melas [3] argued that the COVID-19 event directly impacts the dry bulk and dirty tanker industries. They further examined changes in freight rates for dry bulk and clean and dirty tankers in response to the COVID-19 pandemic. The results show that such incidents have a direct impact on dry bulk and dirty liquid cargoes. Emphasize that there are second-round effects, mainly due to lower oil prices, and in some cases, third-round effects due to market trading behavior affected by the COVID-19 event.

As mentioned above, COVID-19 cause port congestion to affect the logistics operation of the entire supply chain. Most of the solutions proposed by academics to the effects of port congestion seem to follow the pattern of solutions proposed for port pricing or ocean shipping freight rating problems. Transport operators are most affected by congestion due to lost queuing time, increased costs, fuel consumption, emissions [16], and reduced asset productivity. It is characterized by fluctuating ocean shipping freight rates and uncertainty. Therefore, there are still some difficulties in determining the optimal influence variables, and it is difficult to deduce the optimal influence parameters of many variables by mathematical model. In addition, if ocean freight prices fluctuate greatly, the shipping manufacturer cannot make appropriate strategic decisions on shipping freight rates, especially the COVID-19 event occurred.

Recently, Mańkowska, Pluciński, Kotowska, and Filina-Dawidowicz [17] applied an inductive reasoning approach to identify sources and types of disruptions observed in various marine supply chains (MSCs) due to the COVID-19 pandemic and their impact on various port terminal operations, that is, handling bulk (general, specialty) and general port terminal cargo (general, specialty). The findings suggest that due to the COVID-19 pandemic, some ocean freight supply chains have ceased to exist, some shipments have decreased, and in other

cases transshipment has actually increased during the pandemic and has further led to changes in ocean shipping freight rates in response to the COVID-19 pandemic demand for dry bulk as well as clean and dirty tankers. Lin, Chang and Hung [18] used a hybrid MCDM (multi-criteria decision making) to identify a critical factor from four dimensions (financial performance, bond financing, ESGs (environmental, social and governance) and COVID-19) and twenty criteria affecting the sustainability of global shipping companies. Regarding the impact on shipping freight rates, it has been strongly affected by the increase in coronavirus cases during the Covid-19 outbreak, with a decline in the volume of goods transported, and is more pronounced and immediate in the case of the Baltic dry index. The findings of this study also suggest that shipping companies must first strictly enforce social distancing policies to achieve crew safety and timely deliveries and receipts, preventing disruptions to the sustainability of shipping operations during the COVID-19 pandemic. Zhou, Dai, Jing, Hu and Wang [19] further attempted to explore the impact of COVID-19 on the operation of Shanghai container port, clarify the potential economic losses of the port and propose countermeasures for recovery. The results and sensitivity analysis show that the slower the recovery progresses, the more losses the ports will bear. Losses from port arrears, handling charges, security charges for facilities and berthing charges are the main losses. In addition, port handling efficiency and fleet structure are also crucial to reducing economic losses. Those losses may also have impact on the Shanghai shipping freight rates, despite the handling time of container ships and servicing larger ships will help ports reduce economic losses.

The purpose of this study is to propose an effective method to determine the critical influence variables affecting Shanghai shipping freight rates under the influence of COVID-19 pandemic. In addition, the GRA method can estimate and select the best controllable variables. It can also discover the rank of influence of these variables. On the other hand, Above-mentioned researches of Huang, Lasserre and Chiu [20], Fang, Collins and Yao [1] and Zhou, Dai, Jing, Hu and Wang [19] showed that in 1988, the Chinese government opened China's shipping market to the outside world. As a result, China's shipping market has boomed since the 1990s. This rapid expansion has led to massive port traffic expansion, containerization development, port terminal construction and large dry and liquid bulk imports, fueling export-led economic growth. Thus, it can be seen that the proportion of China's coastal shipping in ocean shipping capacity increased from 25% in the late 1990s to about 47% in 2010, and China's shipping fleet capacity still ranks the top four. In addition, China shipping is the world's largest exporter and rates will mainly be quoted by the Shanghai Shipping Exchange (SEE). Using Shanghai shipping freight rate index can effectively reflect the current global trade supply and demand situation.

To sum up, in order to determine the optimal influencing variables or factors of this problem, this research adopts the GRA method to study the shipping freight rates of the entire shipping market, and selects market-first indicators (through freight index markets such as Shanghai Shipping Exchange) to change, so as to allow

the operators of container shipping industry to make appropriate strategic decisions by changing the mechanism over time.

### 3. GRA Method

The main process of GRA methodology firstly converts the performance of all alternatives into a comparability sequence. This step is called grey relational generation [21]. The purpose of Deng [21,22] dealing with grey relational analysis is to allow investigators to analyze the degree of association of discrete data series when the system information is unclear and incomplete. Thus, according to these sequences, a reference sequence (ideal target sequence) is defined. Then, the grey relational coefficient between all comparability sequences and the reference sequence is calculated. Finally, based on these grey relational coefficients, the grey relational rank between the reference sequence and each comparable sequence is calculated [23]. If the comparable sequence translated from the alternative has the highest level of grey relation between the reference sequence and itself, the alternative will be the best choice. The details of the GRA method are summarized as follows:

#### 3.1. Grey Relational Generating

Deng [24] suggested that the GRA methodology includes three stages:

Stage 1. List the factors that will affect the system. It is not necessary to list the relevant influencing factors, but they must have an effect on the system.

Stage 2. GRA method is called gray relational generating, which converts the performance of all alternatives into a compatibility sequence similar to that in the normalized process [25].

Stage 3. In a multi-attribute decision making (MADM) problem with  $m$  alternatives and  $n$  attributes,  $y_{ij}$  denotes the performance value of attribute  $j$  of alternative  $i$ . In this stage  $y_{ij}$  is converted into comparability sequence  $x_{ij}$ . The normalization can be done in the following three different ways (Kirubakaran and Ilangkumaran, 2016):

$$x_{ij} = \frac{y_{ij} - \min\{y_{ij}, i = 1, 2, \dots, m\}}{\max\{y_{ij}, i = 1, 2, \dots, m\} - \min\{y_{ij}, i = 1, 2, \dots, m\}} \quad (1)$$

for  $i = 1, 2, \dots, m$   $j = 1, 2, \dots, n$

$$x_{ij} = \frac{\min\{y_{ij}, i = 1, 2, \dots, m\} - y_{ij}}{\max\{y_{ij}, i = 1, 2, \dots, m\} - \min\{y_{ij}, i = 1, 2, \dots, m\}} \quad (2)$$

for  $i = 1, 2, \dots, m$   $j = 1, 2, \dots, n$

$$x_{ij} = 1 - \frac{|y_{ij} - y_j^*|}{\max\{\max\{y_{ij}, i = 1, 2, \dots, m\} - y_j^*, y_j^* - \min\{y_{ij}, i = 1, 2, \dots, m\}\}} \quad (3)$$

for  $i = 1, 2, \dots, m$   $j = 1, 2, \dots, n$

Eq. (1) is used for the larger-the-better attributes, Eq. (2)

is used for the smaller-the-better attributes, and Eq. (3) is used for the-closer-to-the-desired-value- $y_j^*$ -the-better.

### 3.2. Definition of the Reference Sequence

An ideal reference sequence  $x_0$  is defined as  $x_0 = (x_{01}, x_{02}, \dots, x_{0j}, \dots, x_{0n}) = (1, 1, \dots, 1, \dots, 1)$ . Because all performance values obtained from Eq. (1), (2) or Eq. (3) is scaled into (0, 1), the nearer  $x_{ij}$  to 1 means the better performance of alternative  $i$  in attribute  $j$ . In other words, the goal is to find the alternative whose comparability sequence is the closest to the reference sequence.

### 3.3. Calculation of the Grey Relational Coefficients

A grey relational coefficient is calculated to represent the relationship between the ideal and actual normalized results, which can be expressed as follows [21,22,24]:

$$\gamma(x_{0j}, x_{ij}) = \frac{\Delta_{\min} + \zeta \Delta_{\max}}{\Delta_{ij} + \zeta \Delta_{\max}} \quad (4)$$

for  $i = 1, 2, \dots, m; j = 1, 2, \dots, n$

In Eq. (4),  $\gamma(x_{0j}, x_{ij})$  is the grey relational coefficient between  $x_{ij}$  and  $x_{0j}$ , and

$$\Delta_{ij} = |x_{0j} - x_{ij}|,$$

$$\Delta_{\min} = \min\{\Delta_{ij}, i = 1, 2, \dots, m; j = 1, 2, \dots, n\},$$

$$\Delta_{\max} = \max\{\Delta_{ij}, i = 1, 2, \dots, m; j = 1, 2, \dots, n\},$$

$\zeta$  is the distinguishing coefficient;  $\zeta \in [0, 1]$

### 3.4. Calculation of the Grey Relational Grade

The grey relational grade (GRG) can be calculated using Eq. (5).

$$\Gamma = (x_0, x_i) = \sum_{j=1}^n w_j \gamma(x_{0j}, x_{ij}),$$

$$\sum_{j=1}^n w_j = 1, i = 1, 2, \dots, m \quad (5)$$

Where  $w_j$  represents the normalized weighting value of attribute  $j$ . In addition,  $\sum_{j=1}^n w_j = 1$ . the grey relational grade (GRG) indicates how similar the comparable sequence is to the reference sequence. As noted above, on each attribute (factor), the reference sequence represented the best performance achievable by any of the comparable sequences. Therefore, if an alternative comparable sequence has the highest grey relationship with the reference sequence, it means that this particular comparable sequence is more important to the reference sequence than other comparable sequences and will be the best alternative (factor) to choose. In summary, GRA is applied to search for grey relational grade (GRG), which can be used to describe relationships between data attributes and identify significant factors that significantly affect one or some of the defined target variables.

In Eq. (5), the  $\Gamma$  represents the grey relational degree, which shows the degree of similarity between the comparable sequence and the reference sequence. Therefore, the "rule of thumb" for interpreting grey relational grade (GRG) scales is as follows: 0 to 0.20 is negligible, 0.21 to 0.35 is weak, 0.36 to 0.67 is moderate, 0.68 to 0.90 is strong, and 0.91 to 1.00 is considered very strong (Taylor [34]; Ruiz-Primo, Shavelson and Mitchell [33]), the grade of grey relational coefficient shows in Table 1. The GRG values are used to rank the alternatives according to the similarity to reference series. The higher GRG value indicates the higher similarity.

Table 1. The rank of GRG from GRA

| Rank | GRG scales or values | Variable correlation degree |
|------|----------------------|-----------------------------|
| 1    | 0.81-1.00            | Very strong                 |
| 2    | 0.61-0.80            | Strong                      |
| 3    | 0.41-0.60            | Moderate                    |
| 4    | 0.21-0.40            | Weak                        |
| 5    | 0.00-0.20            | Negligible                  |

Source: Authors' Compilation

## 4. Empirical Results and Analysis

This section includes three parts: part 1 describes the definition and represented indicator of Shanghai shipping price. Part 2 presents model setups and variables in model system. Part 3 will adopt the GRA method to identify the key factors affecting Shanghai shipping freight rates, by studying the relationship and arrangement between the factors.

### 4.1. Shanghai Export Containerized Freight Index Selected as an Indicator of Shanghai Shipping Freight Rates

The price for Shanghai Shipping Exchange such as Shanghai Export Containerized Freight Index (SCFI) are chosen to represent Shanghai shipping freight rates in this study. Briefly, this study chooses Shanghai Export Containerized Freight Index (SCFI) as an indicator for two reasons:

- (1) According to the 2020 Asian shipping load volume exported to the U.S., Shanghai container shipping port is ranked 1st. Hence, Shanghai containerized freight index (SCFI) is chosen to represent the Shanghai shipping freight rates in this study.
- (2) The data are published monthly and can instantly reflect changes in container shipping freight rates imported and/or exported from Shanghai ports.

### 4.2. Model Setups and Variables

#### 4.2.1. Model Setups

Before establishing the empirical model, we list as many preliminary assessment factors to affect Shanghai shipping freight rates (SCFI or  $y_{it}$ ) as possible. To achieve the purpose of this study, the basic model setting to detect the influencing factors of the change rate of Shanghai shipping freight rates ( $\Delta SCFI$  or  $\Delta y_{it}$ ) can be described as

the following Eq. (6), where we select the representative indicators or indexes of the influencing factors such as  $\Delta x_{1it}, \Delta x_{2it}, \Delta x_{3it}, \Delta x_{4it}, \Delta x_{5it}, \Delta x_{6it}, \Delta x_{7it}$ . Then, the GRA method is used to identify the key factors affecting the Shanghai shipping freight rates. It is important to note that this study uses rates of change from 2019 to 2020 to reflect the impact of changes in these variables ( $\Delta SPCV, \Delta CCFI, \Delta OTRADSCI, \Delta OTRRDSCI, \Delta CISSI, \Delta CSSSI, \Delta COSSI$ ) during the onset of COVID-19 pandemic event. The rate of change for these variables is the natural logarithm of the data in 2020 divided by the data in 2019:

$$\Delta y_{it} = \ln(y_{it} / y_{i,t-1}) \times 100 = (\ln y_{it} - \ln y_{i,t-1}) \times 100 \text{ and } \Delta x_{it} = \ln(x_{it} / x_{i,t-1}) \times 100 = (\ln x_{it} - \ln x_{i,t-1}) \times 100.$$

$$\Delta y_{it} = f(\Delta x_{1it}, \Delta x_{2it}, \Delta x_{3it}, \Delta x_{4it}, \Delta x_{5it}, \Delta x_{6it}, \Delta x_{7it}) \text{ or}$$

$$\Delta SCFI = f(\Delta SPCV, \Delta SPCV, \Delta CCFI, \Delta OTRADSCI, \Delta OTRRDSCI, \Delta CISSI, \Delta CSSSI, \Delta COSSI) \quad (6)$$

We selected the Shanghai container freight index (SCFI) to represent as Shanghai shipping freight rates due to SCFI can reflect the selling price of China's shipping services, which is a major factor affecting the international trade between China and other countries on these routes. The fluctuation of SCFI can explain the change of Shanghai's shipping capacity supply and demand, and reflect the business performance of Shanghai shipping enterprises and their competitiveness in the international shipping market [26]. Under these considerations, the fluctuation or change rate of SCFI, expressed as  $\Delta SCFI$ , can explain the changes in Shanghai shipping capacity supply and demand, which might be caused by the rates of change of Shanghai port container handling volumes (throughput,  $\Delta SPCV$ ), China export container freight rates ( $\Delta CCFI$ ), main route's on-time rates of arrival and departure services ( $\Delta OTRADSCI$ ), the main route's on-time rates of receiving and dispatching scheduled services ( $\Delta OTRRDSCI$ ), Chinese international, senior and ordinary Seafarer Salaries ( $\Delta CISSI, \Delta CSSSI, \Delta COSSI$ ) during the onset of COVID-19 pandemic. Finally, we listed Shanghai shipping freight rates and a total of seven affecting factors (variables) in the empirical model we initially evaluated, which are explained below:

#### 4.2.2. Variables in Model

All variables in model can be described as follows:

##### Explained variable

The change rate of Shanghai containerized freight index (%) ( $\Delta SCFI$  or  $\Delta y_{it}$ )

This index refers specifically to the freight index of 13 routes exported from Shanghai to the world. Since Shanghai is the world's largest port with a large volume of cargo, the changes in the freight rate index are also very representative. Cargo cost, freight, volume and number of containers all affect shipping prices.  $\Delta SCFI$  shows fluctuations in ocean freight rates and container freight rates on port routes for China's exports to the world. In addition, the study by Jeon [27] also pointed also pointed

out that SCFI affects shipping rates. On the other hand, Shi [28] indicated out that SCFI has an important index role in the Asian liner shipping industry, which can demonstrate climate scenarios and establish commodity derivatives in the liner shipping market. Therefore, this study believes that the SCFI variable will be represented as an important indicator of Shanghai shipping freight rates. Furthermore, this study uses the change rate from 2019 to 2020 to reflect the change of this variable ( $\Delta SCFI$ ) during the COVID-19 epidemic. In general, the analysis is based on monthly data that indicate COVID-19-affected Shanghai shipping activities in China in a period of January 2019 to December 2020.

##### Explanatory variables

- (1) The change rate of Shanghai port container handling volumes (throughput) (%) ( $\Delta SPCV$  or  $\Delta x_{1it}$ )

Research of Yin, Khoo, and Chen [29] shows that container shipping has undergone a major transformation over the past decade. As a result, the surge in shipping demand and the introduction of mega ships have created many challenges for ports and terminals. Containers mainly deal with international trade, which means that port container throughput is an important indicator of port container handling volumes. Therefore, Shanghai port container volumes (SPCV) will directly or indirectly affect shipping prices, the so-called Shanghai shipping freight rates. In addition, this study uses the rate of change from 2019 to 2020 to reflect variable changes ( $\Delta SPCV$ ) during the COVID-19 epidemic.

- (2) The change rate of China export container freight index (%) ( $\Delta CCFI$  or  $\Delta x_{2it}$ )

The calculation of the freight charged for the transportation of goods (containers) by large shipping containers has become an important international shipping indicator. In addition, the study of Chen and Abdullah [30] also pointed out that CCFI affects shipping rates. On the other hand, Shi [28] indicated that CCFI is an important indicator for the Asian liner shipping industry, which can demonstrate climate scenarios and establish commodity derivatives in the liner shipping market. In addition, Shi [28] showed that the CCFI index can obtain better information than the SCFI index. Therefore, this research believes that China export container freight index (CCFI) will have an impact on shipping costs in Shanghai, the so-called Shanghai shipping freight rates (SCFI). Furthermore, this study uses the rate of change from 2019 to 2020 to reflect the variable changes ( $\Delta CCFI$ ) during the COVID-19 epidemic.

- (3) The change rate of the main route's on-time rates of arrival and departure services comprehensive index (%) ( $\Delta OTRADSCI$  or  $\Delta x_{3it}$ )

The port to port pairing format is adopted. When the ship leaves the port, the shipping company announces the estimated time of berthing (ETB, often used to indicate the date and time that the ship is expected to call at the port/terminal,) and the actual time of berthing (ATB, all units discharging at any port need to be referred to by the import customs and arranged by the shipping company's cargo team) and the deviation does not exceed 24 hours as the scheduled departure service. Therefore, the on-time

rates of arrival and departure services refer to the proportion of the number of flights on-time arrival and departure services at the pick-up port (PP) to the total number of flights. In addition, the study of Huang, Lasserre and Chiu [20] also pointed out that the PP on-time rate variable affects shipping freight rates. Therefore, this research believes that this PP on-time rate (OTRADSCI) will have an impact on Shanghai shipping freight rates (SCFI). Furthermore, this study uses the rate of change from 2019 to 2020 to reflect the variable changes ( $\Delta$ OTRADSCI) during the COVID-19 epidemic.

- (4) The change rate of the main route's on-time rates of receiving and dispatching scheduled services comprehensive index ( $\Delta$ OTRRDSCI or  $\Delta x_{4it}$ )

Using the single-port dimension, based on the data of 10 sample routes and 50 essential ports, the liner company will berth the ship 15 days before the actual berth. In our research, we will use "Estimated Time of Berth (ETB)" instead of "Estimated Time of Arrival (ETA)" for all vessel arrivals. Huang, Lasserre and Chiu [20] found the published ETB is compared with the ATB, and the deviation does not exceed 24 hours as the delivery service schedule. The receipt and delivery schedule rate refers to the proportion of scheduled programs for collection and delivery services to the total number of shifts, (referred to as the service point (SP) schedule rate). Using the single-port dimension, based on the data of 10 sample routes and 50 essential ports, the liner company will berth the ship 15 days before the actual berth. In our research, we will use "Estimated Time of Berth (ETB)" instead of "Estimated Time of Arrival (ETA)" for all vessel arrivals. Huang, Lasserre and Chiu [20] found the published ETB is compared with the ATB, and the deviation does not exceed 24 hours as the delivery service schedule. The main route's on-time rates of receiving and dispatching scheduled services refer to the proportion of the number of shifts for collection and delivery services to the total number of shifts, which is called the service point (SP) scheduling rate. Study of Huang, Lasserre and Chiu [20] have also pointed out that this variable can affect shipping freight rates. Therefore, the research believes that this on-time rates of receiving and dispatching scheduled services (OTRRDSCI) will impact shipping freight rate (SCFI). This study uses the rate of change from 2019 to 2020 to reflect the variable changes during the COVID-19 epidemic. Furthermore, this study uses the rate of change from 2019 to 2020 to reflect the variable changes ( $\Delta$ OTRRDSCI) during the COVID-19 epidemic.

- (5) The change rate of Chinese international seafarer salary index (%) ( $\Delta$ CISSI or  $\Delta x_{5it}$ )

One of the key issues in today's seafaring market is the lack of skills among seafarers. Despite steady growth in the global supply of seafarers, demand is still higher than supply. In addition, when the demand for shipping increases, the demand for cargo ships (such as merchant ships that carry goods, goods and materials from one port to another) increases, and the relevant technical personnel will increase accordingly. For shipping companies, the decision-making process for foreign crew recruitment is largely determined by crew costs, as these are the highest of all "fixed costs" borne by seafarers [31,32]. Therefore, this study believes that China international seafarer salary

(CISSI) will have an impact on Shanghai shipping freight rates (SCFI). Furthermore, this study uses the rate of change from 2019 to 2020 to reflect the variable changes ( $\Delta$ CISSI) during the COVID-19 epidemic.

- (6) The change rate of Chinese senior seafarer salary index (%) ( $\Delta$ CSSSI or  $\Delta x_{6it}$ )

The employed seafarers consist of senior and ordinary seafarers. The main determinants of maritime labor demand include total crew cost, technical and cultural competence, and the quality of seafarers influenced by marine education and training [31,32]. Therefore, this research believes that senior seafarer salary (CSSSI) will have an impact on Shanghai shipping freight rates (SCFI). Furthermore, this study uses the rate of change from 2019 to 2020 to reflect the variable changes ( $\Delta$ CSSSI) during the COVID-19 epidemic.

- (7) The change rate of Chinese ordinary seafarer salary index (%) ( $\Delta$ COSSI or  $\Delta x_{7it}$ )

Based on above discussion, since the employed seafarers include senior and ordinary seafarers, the relative price of personnel increases and thus ordinary seafarer salary also affects freight rates [27,31,32]. Therefore, this research believes that senior seafarer salary (COSSI) will have an impact on Shanghai shipping freight rates (SCFI). Furthermore, this study uses the rate of change from 2019 to 2020 to reflect the variable changes ( $\Delta$ COSSI) during the COVID-19 epidemic.

The above factors which have stronger influence on the change rate of the Shanghai shipping freight rates ( $\Delta$ SCFI) will be discussed later.

### 4.3. Data Collection and Descriptions of Shanghai Container Throughput and Shipping Freight Rates

#### 4.3.1. Data Collection of Relevant Variables

This study aims to analyze what factors affect the Shanghai shipping freight rates and which factors will play a key role under the impact of the COVID-19 epidemic. Based on the literature review and model setups in this study, the change rate of Shanghai shipping freight rates ( $\Delta$ SCFI) is affected by the change rate of Shanghai Port Container Volumes ( $\Delta$ SPCV), China Export Container Freight ( $\Delta$ CCFI), main route's on-time rates of arrival and departure services ( $\Delta$ OTRADSCI), main route's on-time receiving and dispatching service rates ( $\Delta$ OTRRSRI), Chinese International, Senior and Ordinary Seafarer Salaries ( $\Delta$ CISSI,  $\Delta$ CSSSI and  $\Delta$ COSSI) during the onset of COVID-19 pandemic. The data of these relevant variables for empirical evaluations are collected from Shanghai Shipping Exchange (SSE) based on monthly data from 2019 to 2020.

#### 4.3.2. The Changes and Trend of Shanghai Container Throughput (Handling Volumes)

Container throughput (handling volumes) refers to the sum of the amount of import and export containers in a certain port within a certain period of time. It reflects the quantity of goods loaded and unloaded by the port for ships within a certain period of time under certain

conditions of technical equipment and labor organization. As indicated in Figure 1, compared with the monthly data of 2019, container throughput at Shanghai Port decreased by more than 15 million TEUs in 2020, indicating that the impact of the COVID-19 pandemic has indeed had an impact on container throughput at Shanghai Port. We can also recognize and expect that the volume of imports and exports can change Shanghai port container handling volumes ( $\Delta\text{SPCV}$ ) and affect the on-time service rate of receiving and dispatching services ( $\Delta\text{OTRDSRCI}$ ,  $\Delta\text{OTRRSRCI}$ ), seafarer salary ( $\Delta\text{CISSI}$ ,  $\Delta\text{CSSSI}$ ,  $\Delta\text{COSSI}$ ) and further Shanghai shipping freight rates ( $\Delta\text{SCFI}$ ).

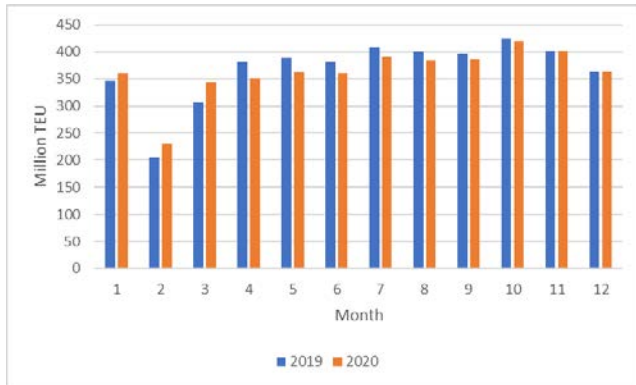


Figure 1. The Shanghai port container throughput of 2019-2020

#### 4.3.3. The Change and Trend of Shanghai Shipping Freight Rates

This study uses the data of 12 months in 2020 and compares it with the data of the same month in 2019 to analyze the changes and trends of the Shanghai shipping freight rates 2019-2020. As shown in Figure 2 and Figure 3, we also find that during the COVID-19 pandemic, Shanghai shipping freight rates changed and showed multiple increases. Its top shipping rates have nearly quadrupled since the pre-Covid-19 pandemic period. The more important reason can be described by the rate of change of China by the change rate of Chinese international seafarer salary ( $\Delta\text{CISSI}$ ), Chinese senior seafarer salary ( $\Delta\text{CSSSI}$ ) and Chinese ordinary seafarer salary ( $\Delta\text{COSSI}$ ).

#### 4.4. Estimated Results by Using GRA Method

Table 2 The relationship values estimated by GRA

| Variable                    | $\Delta x_1$        | $\Delta x_2$        | $\Delta x_3$            | $\Delta x_4$            | $\Delta x_5$         | $\Delta x_6$         | $\Delta x_7$         |
|-----------------------------|---------------------|---------------------|-------------------------|-------------------------|----------------------|----------------------|----------------------|
|                             | $\Delta\text{SPCV}$ | $\Delta\text{CCFI}$ | $\Delta\text{OTRDSRCI}$ | $\Delta\text{OTRRDSCI}$ | $\Delta\text{CISSI}$ | $\Delta\text{CSSSI}$ | $\Delta\text{COSSI}$ |
| GRG values                  | 0.628               | 0.805               | 0.871                   | 0.891                   | 0.801                | 0.794                | 0.761                |
| Variable correlation degree | Moderate            | Very strong         | Very strong             | Very strong             | Strong               | Strong               | Strong               |

Source: This Study

Overall, based on the grade values, the ranking of the factors that affecting the change rate of Shanghai shipping freight rates ( $\Delta\text{SCFI}$ ) during the COVID-19 pandemic in 2019-2020 by GRA is as following Inequality (7):

$$(\Delta\text{OTRDSRCI}, \Delta x_{4it}) > (\Delta\text{OTRDSRCI}, \Delta x_{3it}) \\ (\Delta\text{CCFI}, \Delta x_{2it}) > (\Delta\text{CISSI}, \Delta x_{5it}) > (\Delta\text{CSSSI}, \Delta x_6) > (\Delta\text{COSSI}, \Delta x_{7it}) > (\Delta\text{SPCV}, \Delta x_{1it})$$

GRA aims to measure the correlation or similarity degree between the compared series. The gray relational grade (GRG) values are used to rank the factors affecting the change rate of Shanghai shipping freight rates according to the similarity to reference series. The higher GRG value indicates the higher correlation degree or similarity and also finds the critical factors affecting Shanghai shipping freight rates. Based on the GRA method, the empirical results to identify the main factors that affecting the change rate of Shanghai shipping freight rates ( $\Delta\text{SCFI}$ ) during the COVID-19 pandemic in 2019-2020 are shown in Table 2.

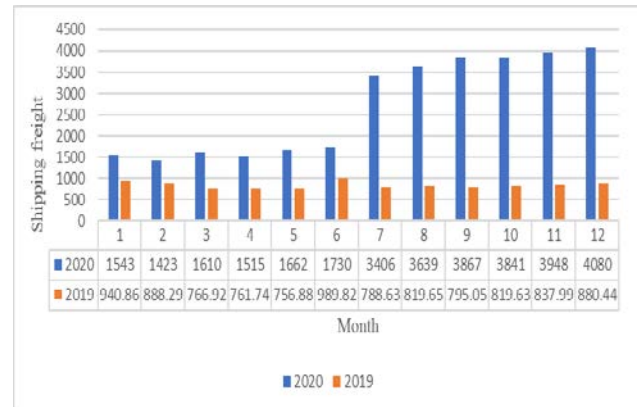


Figure 2. The Shanghai export container freight index with monthly data of 2019-2020



Figure 3. The change rates of the Shanghai export container freight index by the event of COVID-19

$$(\Delta\text{COSSI}, \Delta x_{7it}) > (\Delta\text{SPCV}, \Delta x_{1it})$$

Thus, according to the GRG values that reflect the relevance of each affecting factors and the change rate of Shanghai shipping freight rates ( $\Delta\text{SCFI}$ ), we can say that the change rate of the main route's on-time rates of receiving and dispatching scheduled services ( $\Delta\text{OTRDSRCI}$ ,  $\Delta x_{4it}$ ) affects the change rate of Shanghai

shipping freight rates the most strong, followed by the change rate of the main route's on-time arrival and departure service rates (  $\Delta\text{OTRADSCI}$ ,  $\Delta x_{3it}$  ) and the change rate of China export container freight rates (  $\Delta\text{CCFI}$ ,  $\Delta x_{2it}$  ). Subsequently, the change rate of China international seafarer salary (  $\Delta\text{CISSI}$ ,  $\Delta x_{5it}$  ), the change rate of China senior seafarer salary (  $\Delta\text{CSSSI}$  or  $\Delta x_{6it}$  ) and the change rate of China ordinary seafarer salary (  $\Delta\text{COSSI}$ ,  $\Delta x_{7it}$  ) gave the strong influence to the Shanghai shipping freight rates. While, the change rate of Shanghai port container handling volumes (or throughput) (  $\Delta\text{SPCV}$ ,  $\Delta x_{1it}$  ) gave the least effect to the Shanghai shipping freight rates during the COVID-19 pandemic in 2019-2020.

Focusing on the 7 variables (or factors) with their attributes that affect the change rate of Shanghai shipping freight rates (  $\Delta\text{SCFI}$  ) and their gray relational grade (GRG) estimates in Table 2. Now, we evaluate and discuss the estimated results for each variable (or factor) as follows:

- (1) The change rate of Shanghai port container handling volumes (throughput) (  $\Delta\text{SPCV}$  or  $\Delta x_{1it}$  )

As indicated in Table 2, the evaluation result reveals that the effect (0.628, estimated value of GRG) of the change rate of Shanghai port container handling volumes (  $\Delta\text{SPCV}$  ) on the change rate of the Shanghai shipping freight rates (  $\Delta\text{SCFI}$  ) is moderate, ranking the seventh. During Covid-19 outbreak, with ports closed and ocean shipping restricted, many goods or cargos still cannot be shipped out of the port, coupled with limited flights and shipping schedules, the change rate of container handling volumes (throughput) (  $\Delta\text{SPCV}$  or  $\Delta x_{1it}$  ) at Shanghai port may not have much of Shanghai shipping freight rates (  $\Delta\text{SCFI}$  ). The research results of Zhou, Dai, Jing, Hu, and Wang (2022) support our research findings.

- (2) The change rate of China export container freight rates (  $\Delta\text{CCFI}$  or  $\Delta x_{2it}$  )

The evaluation result shows that the effect (0.835, estimated value of GRG) of the change rate of China export container freight rates (  $\Delta\text{CCFI}$  or  $\Delta x_{2it}$  ) on the change rate of the Shanghai shipping freight rates (  $\Delta\text{SCFI}$  ) is very strong, ranking the third. Shanghai port is one of the major and important ports in China. Regarding the China export container freight rates (CCFI), it reflects all the roles of China in exporting / importing containerized cargo on the container freight market. Thus, we can realize that the change rate of China export container freight rates (  $\Delta\text{CCFI}$  or  $\Delta x_{2it}$  ) during the COVID-19 epidemic will lead to or drive a greater change rate of the Shanghai shipping freight rates (  $\Delta\text{SCFI}$  ). The results are consistent with the research findings of Chen and Abdullah [30] and Huang, Lasserre and Chiu [20].

- (3) The change rate of the main route's on-time rates of arrival and departure services comprehensive index (  $\Delta\text{OTRADSCI}$  or  $\Delta x_{3it}$  )

As mentioned earlier, main route's on-time rates of arrival and departure services refers to the proportion of the number of flights of on-time arrival and departure services at the pick-up port (PP) to the total number of flights. The evaluation result shows that the effect (0.871,

estimated value of GRG) of the change rate of the main route's on-time rates of arrival and departure services (  $\Delta\text{OTRADSCI}$  or  $\Delta x_{3it}$  ) on the change rate of the Shanghai shipping freight rates (  $\Delta\text{SCFI}$  ) is very strong, ranking the second. Regarding the impact of the change rate of the main route's on-time arrival and departure service rates on the change rate of the Shanghai shipping freight rates, during the COVID-19 epidemic, the increase of coronavirus cases, port congestion or even closure lead to a decline in the main route's on-time rates of arrival and departure services (  $\Delta\text{OTRADSCI}$  or  $\Delta x_{3it}$  ), affecting delivery and pickup times further strengthening its impact on Shanghai shipping freight rates (  $\Delta\text{SCFI}$  ) in the period 2019-2020. The results of this study are consistent with those of Jeon [27], Mańkowska, Pluciński, Kotowska, and Filina-Dawidowicz [17] and Lin, Chang and Hung [18].

- (4) The change rate of the main route's on-time rates of receiving and dispatching scheduled services (  $\Delta\text{OTRRDSCI}$  or  $\Delta x_{4it}$  )

As mentioned above, the main route's on-time rates of receiving and dispatching scheduled services refer to the ratio of the number of shifts for collection and delivery scheduled services to the total number of shifts, which is called the service point (SP) scheduling rate. The evaluation result shows that the effect (0.891, estimated value of GRG) of the change rate of the main route's on-time rates of receiving and dispatching scheduled services (  $\Delta\text{OTRRDSCI}$  or  $\Delta x_{4it}$  ) on the change rate of the Shanghai shipping freight rates (  $\Delta\text{SCFI}$  ) is most strong, ranking the first. With respect to the impact of the rate change of the main route's on-time rates of receiving and dispatching scheduled services on the change rate of the Shanghai shipping freight rates, COVID-19 has had a larger economic impact on maritime transport, ports and shipping, with negative growth in cargo volumes and reduced ship traffic during the COVID-19 epidemic. Blockade and liquidity restrictions have caused a greater degree of uncertainty, and the duration of berth is uncertain or increased, so that the loss of port arrears, handling service charges, facility security charges and berth fees will increase due to port congestion, that is, port congestion will increase the port service charges of shippers. Congestion in ocean freight can lead to reduced operational efficiency and long delays in the unloading of containerized cargo, as well as difficult or unworkable scheduling services, and further missing the main route's on-time rates of receiving and dispatching scheduled services (  $\Delta\text{OTRRDSCI}$  or  $\Delta x_{4it}$  ) at service points. Further enhancing its impact on Shanghai freight rates (  $\Delta\text{SCFI}$  ) is more direct and obvious in the period 2019-2020. The results of this study are consistent with the research findings of Huang, Lasserre and Chiu [20], Mańkowska, Pluciński, Kotowska, and Filina-Dawidowicz [17] and Lin, Chang and Hung [18].

- (5) The change rate of Chinese international seafarer salary index (  $\Delta\text{CISSI}$  or  $\Delta x_{5it}$  ), Chinese senior seafarer salary index (%) (  $\Delta\text{CSSSI}$  or  $\Delta x_{6it}$  ) and Chinese ordinary seafarer salary index (  $\Delta\text{COSSI}$  or  $\Delta x_{7it}$  )

Here, we discuss together the impact effects of these three seafarer salary index (  $\Delta\text{CISSI}$  or  $\Delta x_{5it}$ ;  $\Delta\text{CSSSI}$  or  $\Delta x_{6it}$  and (  $\Delta\text{COSSI}$  or  $\Delta x_{7it}$  ). The evaluation results show that

the effect (0.801, 0.794 and 0.761, estimated value of GRG) of the change rate of Chinese international seafarer salary ( $\Delta \text{CISSI}$  or  $\Delta x_{5it}$ ), Chinese senior seafarer salary ( $\Delta \text{CSSSI}$  or  $\Delta x_{6it}$ ) and Chinese ordinary seafarer salary ( $\Delta \text{COSSI}$  or  $\Delta x_{7it}$ ) on the change rate of the Shanghai shipping freight rates ( $\Delta \text{SCFI}$ ) all show strong, ranking the fourth, fifth and sixth. With respect to the impact of the change rate of Chinese international, senior and junior seafarer salaries ( $\Delta \text{CISSI}$  or  $\Delta x_{5it}$ ;  $\Delta \text{CSSSI}$  or  $\Delta x_{6it}$  and  $\Delta \text{COSSI}$  or  $\Delta x_{7it}$ ) on the change rate of the Shanghai shipping freight rates ( $\Delta \text{SCFI}$ ), the COVID-19 has triggered an economic crisis with widespread impacts on sea transportation, ports, shipping and supply chains during the COVID-19 epidemic. The outbreak has also caused severe supply disruptions, port closures and labor shortages. The pandemic has had a negative impact on the global economy, with labor markets facing increased volatility and uncertainty due to trade contraction, international lockdowns, safe distancing and restrictions on offshore labor movement. Chinese ports have by far the largest number of ship calls and port container throughput in the world as it is the largest trading nation. Therefore, Chinese seafarers (senior and/or ordinary) in Chinese ports have more opportunities for crew changes than other nationalities in home ports. Many multinational companies and ship-owners who used to employ foreign seafarers have turned to Chinese seafarers during the COVID-19 pandemic as many countries, including China, do not allow foreign crews (international seafarers) to change shifts within their borders. Consequently, during the COVID-19 pandemic, there has been a significant shift in supply and demand for international and Chinese seafarers (senior and/or junior) and resulted in a greater impact of changes in their wages or salaries ( $\Delta \text{CISSI}$  or  $\Delta x_{5it}$ ;  $\Delta \text{CSSSI}$  or  $\Delta x_{6it}$  and  $\Delta \text{COSSI}$  or  $\Delta x_{7it}$ ) on each other, and further enhancing the impacts on the Shanghai freight rates ( $\Delta \text{SCFI}$ ). The research results of Lin, Chang and Hung [18] and Zhou, Dai, Jing, Hu and Wang [19] support our research findings.

## 5. Concluding Remarks

This study aims to analyze what factors affect the Shanghai shipping freight rates, and which factors will play a key role under the impact of the COVID-19 epidemic. Specifically, we apply the GRA method to analyze the weight relationships between factors (variables) with their attributes, and explore the factors that affect the Shanghai shipping freight rates. In this section, we highlight and describe the main findings and implications of this study.

This study explores the factors affecting the Shanghai shipping freight rates and considers them from the perspective of four important indicators (cargo throughput, shipping prices in China, on-time rates of receipt and delivery, and seafarer salary). The result of the experiment is that among the four important influencing indicators, the punctuality rate is the most important, followed by China's shipping price and seafarer salary, and finally the cargo throughput. Their implications are describe as follows.

First of all, in terms of time punctuality rate, the main route's on-time rates of receiving and dispatching scheduled services ( $\Delta \text{OTRRDSCI}$ ) is most crucial to impact on the Shanghai shipping freight rates ( $\Delta \text{SCFI}$ ). Hundreds of container ships lined up to enter overloaded ports (by charging port waiting costs), mainly in the US and China, where port services are closed due to the impact of COVID-19, resulting in lower on-time rates leading to higher freight rates. The main route's on-time rates of arrival and departure services ( $\Delta \text{OTRADSCI}$ ) is the second most important impact factor followed by the main route's on-time rates of receiving and dispatching shifts (scheduled services). The surge in shipping rates is largely related to the COVID-19 pandemic. Not purely for economic reasons, but because the pandemic continues to occur, causing delays and closures of port services and spurring higher payment rates. In addition, constant demand and lack of shipping capacity from Asia to the US also contribute to the high freight rates, especially since shipping times are also erratic. In fairness, effective control of the epidemic and efficiency of port services are the main ways to improve on-time rates of receipt and delivery rate and stabilize ocean freight rates.

Secondly, regarding the changes in China (export) container freight rates ( $\Delta \text{CCFI}$ ), the  $\Delta \text{CCFI}$  is classified as having a substantial impact (effect is very strong) on the Shanghai shipping freight rates ( $\Delta \text{SCFI}$ ). Because  $\Delta \text{CCFI}$  reflects all the roles of China in exporting / importing containerized cargo on the container freight market. It can be seen that the change rate of China export container freight rates during the COVID-19 epidemic will drive a greater change rate of the Shanghai shipping freight rates ( $\Delta \text{SCFI}$ ). It may also be suggested that the  $\Delta \text{CCFI}$  index be used as a reference for interpretation or prediction of ocean freight rate changes at China's major export/import ports.

Thirdly, with respect to the impact of the change rate of Chinese international, senior and junior seafarer salaries ( $\Delta \text{CISSI}$ ,  $\Delta \text{CSSSI}$  and  $\Delta \text{COSSI}$ ) on the change rate of the Shanghai shipping freight rates ( $\Delta \text{SCFI}$ ), all show strong effects, despite ranking fourth, fifth and sixth during the COVID-19 pandemic. The COVID-19 has triggered an economic crisis with widespread impacts on sea transportation, ports, shipping and supply chains during the COVID-19 epidemic. The outbreak has also caused severe supply disruptions, port closures and labor shortages. The COVID-19 pandemic has had a negative impact on the global economy, with labor markets facing increased volatility and uncertainty due to trade contraction, international lockdowns, safe distancing and restrictions on offshore labor movement. China is the largest trading country in the world, and its number of ship calls and port ship throughput is far ahead. Chinese seafarers (senior and/or ordinary) in Chinese ports have more opportunities for crew changes than other nationalities at home ports. Many multinational companies and ship-owners who used to employ foreign seafarers have turned to Chinese seafarers during the COVID-19 pandemic, as many countries, including China, do not allow foreign crews (international seafarers) to change shifts within their borders. Consequently, during the COVID-19 pandemic, there has been a significant shift in supply and demand of international and Chinese seafarers (senior and/or junior), leading to changes in their wages or

salaries ( $\Delta$ CISSI,  $\Delta$ CSSSI and  $\Delta$ COSSI) to have greater influence on each other, and further enhancing the impacts on the Shanghai freight rates ( $\Delta$ SCFI).

Fourthly, regarding the impact of the change rate of Shanghai port container handling volumes (throughput) ( $\Delta$ SPCV) on the change rate of the Shanghai shipping freight rates ( $\Delta$ SCFI), the impact is moderate, ranking the seventh. The results of our assessment indicate that during the Covid-19 outbreak, many cargoes or shipments remain unable to ship out of ports due to port closures and ocean shipping restrictions, coupled with limited flights and shipping schedules, the change rate of container handling volumes (throughput) ( $\Delta$ SPCV) at Shanghai port may not have much impact and only have a moderate effect on the change rate of Shanghai shipping freight rates ( $\Delta$ SCFI).

Last but not least, for this research, it is necessary to recognize the findings and implications presented in the study, which are based on the relevant research methods, actual data, and empirical model setups in this study. When applying the empirical results of the text, the spatial-temporal environment changes and policy impacts of the Shanghai and/or Chinese ocean shipping market during the relative study period should be taken into account, so as to flexibly apply them in the actual situation.

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