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COVID-19's impact on dry bulk shipping market: time series analysis method

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WORLD MARITIME UNIVERSITY

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COVID-19's impact on dry bulk shipping market: Time series analysis method

By

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Declaration

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

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(Date): 2022/6/4……

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ABSTRACT

Title of Dissertation: **COVID-19's impact on dry bulk market: Time series analysis method**

Degree: **Master of Science**

The Covid-19 broke out in January 2020 and caused a heavy blow to both the world economy and the international dry bulk shipping market, which is closely related to the world trade. This paper makes an attempt to study the impact of the Covid-19 on the international dry bulk shipping market from the perspective of qualitative and quantitative analysis.

Firstly, this paper analyzes the change trend of BDI and its fluctuations since the outbreak of the pandemic. The conclusion is that, on the demand side, at the outbreak stage, the Covid-19 had a negative effect on the dry bulk shipping market. After China resumed production, the demand for dry bulk cargo shipping gradually recovered, subsequently pushing up freight rates. On the supply side, the port congestion is the most important factor. The shortage of transport capacity has caused great changes in the trading volume of second-hand ships and triggered significant increase of the prices of newbuildings.

Secondly, this paper makes the empirical analysis based on the time series data of weekly Baltic indices from January 2020 to March 2022 and the cumulative weekly increase number of infectors. Baltic indices are used as the explained variable, and the number of infectors is used as the explanatory variable. An AR-X model is established to analyze the impact of Covid-19 on dry bulk freight rates in the whole epidemic process. Then, BCI, BPI and BSI were introduced to the ARX model in the same way to analyze the impact of Covid-19 on these three markets in the sub sample interval from the resumption of production in China to the outbreak of Omicron virus. It is concluded that changes of Baltic indices caused by Covid-19 is dynamic, which has a "not significant" model result over the whole period. While, the impacts for Capesize, Panamax and Supramax during the sub period are statistically significant. The coefficient of explanatory variable is positive, which means after China's recovery, the epidemic has a significant positive impact on the three dry bulk ship markets.

KEYWORDS : Dry bulk, BDI, COVID-19, AR-X model

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1. Introduction

1.1. Research background

The WHO announced in March 11, 2020 that Corona Virus Disease 2019 (Covid-19) was a global pandemic. Until now, the shipping industry is still on a high alert for the epidemic. Recently, the outbreak of multinational Covid-19's fifth concern mutation “Omicron” has aggravated the global shipping crisis. In response to the outbreak of new coronavirus, in the past two years, many countries, ports and organizations have adopted corresponding restrictive measures. The tightening inspection and quarantine of global ports has also reduced the efficiency of global maritime transport.

Although the severity of the epidemic expressed by the number of confirmed cases varies in different countries and regions, each country and region has been negatively affected, and the negative impact continues to spread. Under the influence of market environment, economic policy and other factors, the dry bulk shipping market may have slight fluctuations in the state of the system, which provides a variety of possibilities for the evolution of the shipping industry. Covid-19 is not only the spread of epidemic among countries, but also the impact of the fluctuation of economic and trade activities caused by the linkage of countries and regions in the global value chain. This impact directly affects international dry bulk shipping. The outbreak of the virus coincided with the Chinese Lunar New Year, which is the traditional off-season of the shipping market. The long-term shutdown weakened the shipping market and seriously affected the freight. In addition, in terms of supply and demand, dry bulk shipping heavily relies on strong Chinese imports, because China imports about 40% of the global dry bulk cargo. China needs to import a large amount of iron ore and coal for

steel production. At the same time, the import demand for agricultural products is also very high, which is the main driving force of the dry bulk market. As China's economic growth has a decisive impact on the global dry bulk freight market, the long term shutdown of China's economy led to a sharp slowdown in industrial production after the outbreak of new coronavirus's disease. It inevitably deepened the seasonal decline of dry bulk. However, with the recovery of China's productivity, the dry bulk cargo capacity showed a sharp increase again. Since the outbreak of the epidemic, the Baltic dry bulk cargo comprehensive freight index (BDI) has fallen continuously, falling to 393 points on May 14, 2020, a new low in recent years, and reaching 5650 on October 7, 2021, a new high in a decade.

1.2. Research purpose and process

International dry bulk logistics plays a very important role in the development of the world economy. The prosperity of the shipping market is often closely related to the fluctuations of the world economy. The Baltic dry bulk index reflects the spot freight changes of several major routes in the world. The Baltic dry bulk freight index (BDI) is known as the barometer of bulk commodities and the barometer of the global economy. BDI also includes BCI, BPI and BSI, which are the most direct reflection of the prosperity of the dry bulk market and the development of the global economy. This paper will discuss the long-term and short-term impact of novel coronavirus disease on the international dry bulk shipping market and deal with the turbulent international trade under the novel coronavirus epidemic, to provide direction and suggestions for the development of the dry bulk shipping market.

From the qualitative point of view, the direct and indirect impacts of the COVID-19 are analyzed from the two aspects of supply and demand. From the quantitative point of view, the qualitative analysis conclusion is verified by establishing the

autoregressive time series models, and the extent of the epidemic impact on different dry bulk index is calculated. Then, the impacts have been analyzed on Capesize, Panamax, Supramax markets respectively to find out the particularity of this disaster and the opportunities we will face in the future. Finally, suggestions are put forward for port enterprises and shipping enterprises.

1. To study on the fluctuations of Baltic dry bulk indices during the epidemic period from 2020 to 2022.
2. To analyze the demand side fluctuations and research global seaborne trade demand for iron ore, coal and grain.
3. To analyze the changes of dry bulk shipping capacity on the supply side from the perspectives of port congestion and volumes of new or second-hand ships.
4. To make the quantitative analysis of the relationship between freight rate and epidemic situation by AR-X model.

1.3. Research structure

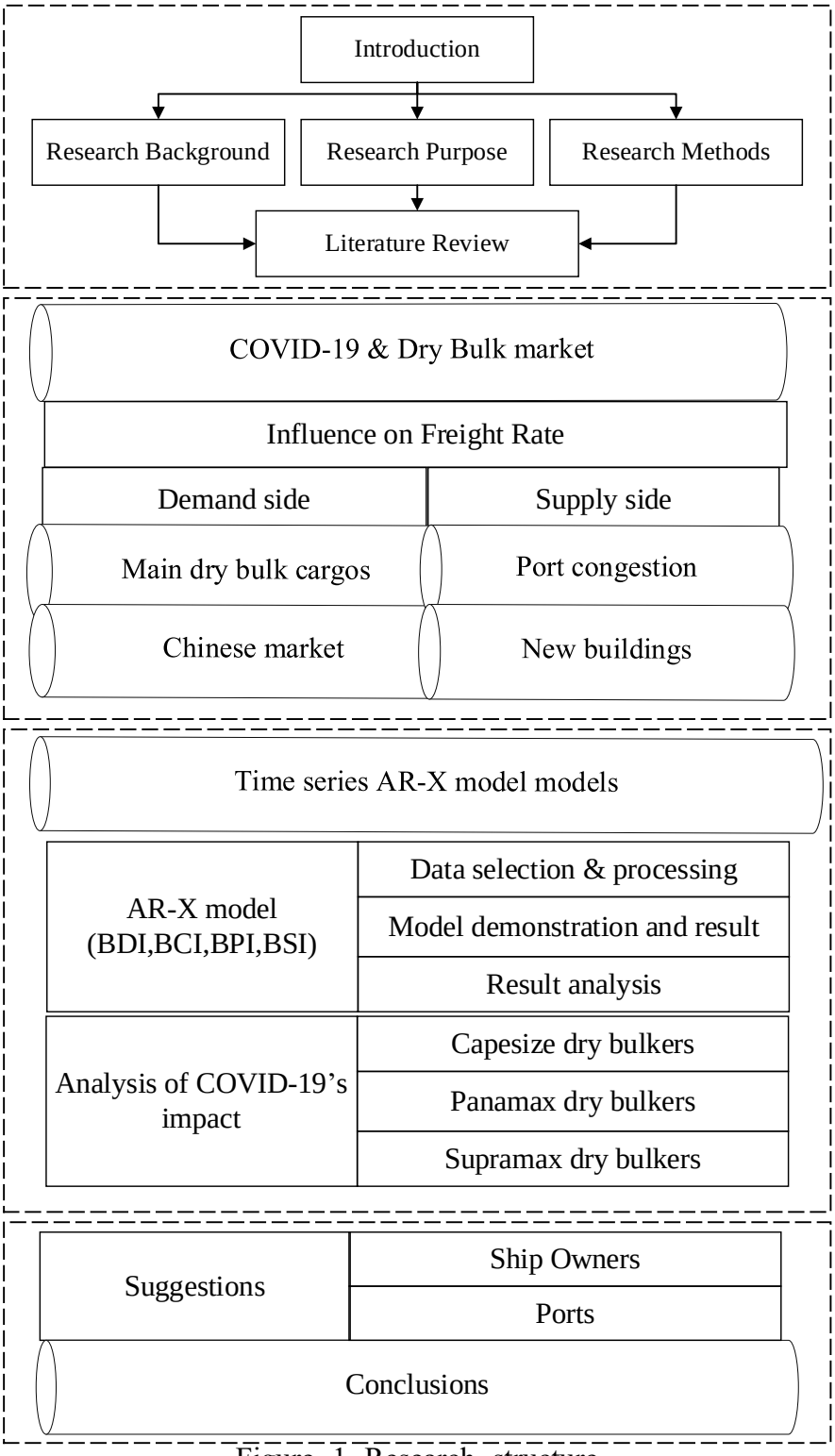


Figure 1 Research structure

1.4. Auto regression model

1.4.1. Modeling

Autoregressive model, referred to as AR model for short, is a process of using itself as regression variable, and using the linear combination of random variables at some time in the early stage to describe the linear regression model of random variables at a certain time in the future. It is a common form in time series. This is a statistical method to deal with time series. It uses the performance of the previous periods of the same variable to predict the performance of the variable in the current period, and assumes that they are linear, to study the stationary random process.

The ARX model introduces exogenous variables based on the traditional time series model. In this paper, the epidemic is a factor that affects the system but is not affected by the system, to further investigate the relationship between the sequence of exogenous variables and the sequence of explained variables.

The general AR(p) model is as follows:

$$y_{k+1} = \sum_{i=1}^{n_a} a_i y_{k-i} + \varepsilon_t \qquad (1-1)$$

The ARX model after exogenous variables are added:

$$y_{k+1} = \sum_{i=1}^{n_a} a_i y_{k-i} + \sum_{i=1}^{n_b} b_i u_{k-i+1} + \varepsilon_t \qquad (1-2)$$

where a_i are the parameters of the model, and ε_t is white noise. An autoregressive model can thus be viewed as the output of an all-pole infinite impulse response filter whose input is white noise.

1.4.2. Stationary test and lag order

AR model is based on the fact that the time series is stationary. Therefore, if there is a unit root in the time series, it is a non-stationary series, which may lead to the deviation of the estimated value of autoregressive coefficient. In order to avoid the pseudo regression problem of two mutually independent unit root variables, it is necessary to carry out the unit root test to verify its stationarity. The unit root test used in this paper is ADF test (Augmented Dickey Fuller Unit Root Test).

Secondly, the autoregressive model and its order can be determined according to the tailing or truncation characteristics of the autocorrelation coefficient and partial autocorrelation coefficient of each order of the dependent variable sequence. After the autoregressive model of the sequence is completed, the heteroscedasticity test is performed on the residual term. If there is heteroscedasticity, the GARCH model is further constructed to fit the sequence. The partial autocorrelation of an AR (p) process equals zero at lag which is not bigger than order of p and provides a good model for the correlation between y_k and y_{k-1}. So the appropriate maximum lag is the one beyond which the partial autocorrelations are all zero. The order of GARCH model can be determined according to the tailing and truncating characteristics of the autocorrelation coefficient and partial autocorrelation coefficient of each order lag term by making the autocorrelation diagram of the residual sequence.

2. Literature review

2.1. Covid-19's impact on shipping market

The outbreak of Covid-19 has brought a major blow to the world dry bulk shipping market, especially the dry bulk shipping market of China, and has caused a long-term oscillation. This thesis has taken the latest international research findings, including many Chinese scholars' contributions. These literatures can be divided into early outbreak stage, and post epidemic stage. In addition, oil price is also an important component of the dry bulk shipping cost. Covid-19 also has a significant impact on the crude oil market. In order to study the extent of its impact, the thesis has also referred to many studies on the relationship between oil price and BDI. With the above foundation, we can introduce the time series analyzing method to explore the impact of Covid-19 on the dry bulk market.

According to the existing research, Dimitris G. & Theodoros S. (2022) used a market-model event study approach to investigate how fast and comprehensively shipping markets react upon certain latest evidence to quantify the pandemic's economic impact. The conclusion that global dry bulk transportation was largely affected by lockdown policies in the second month during Covid-19 was verified by Zhao H.M. (2022) with exponential smoothing model method. Prathvi T.N & Pradyot R.J. (2021)'s dissertation *the impacts of COVID-19 on seaport transportation and the maritime supply chain field and its related issues in India,* introduced the COVID-19's impact on maritime supply chain. Masha M. (2021) introduced how worldwide economic activities were devised by the lockdown measures imposed by the affected countries. Nektarios A. M. & Kostis D.M. (2020) using both GARCH (1,1) and VAR

specifications, suggested that Covid-19 pandemic outbreak is directly affecting the dry bulk and the dirty tanker segments. They also suggested that second round effects, mostly via the decline in oil prices and, third round effects via the impact from the stock market. Covid-19 Baldwin (2020) predicted that the COVID-19 epidemic is both a supply shock and a demand shock, which would lead to a decrease in import and export. Zhang, Y.F. (2020) of Shanghai Maritime University believed that the COVID-19 epidemic has a great impact on the world economy, trade and industry, and is transmitted to the shipping industry through the global supply chain. The daily increase of the epidemic cases has a strong Granger causality with the dry bulk index (BDI). Wan, C.P. (2020) believed that the superposition of the double factors of the COVID-19 and the slow season of the Spring Festival has brought a great negative impact on the international shipping industry, not only in the short-term adverse impact during the epidemic period, but also in the long-term industrial chain ripple effect. Xu Peihong (2020) believed that the impact of the COVID-19 epidemic on bulk cargo transportation market is mainly concentrated in the first quarter. Ge, Y.N. (2020) of Shanghai Maritime University thought COVID-19 has indirectly affected the shipping industry by influencing the supply-demand relationship of the market. Lee et al. (2018) believe that the shipping market sentiment has a significant impact on the cyclical revival of the shipping industry. For the research on the benign development of shipping market, Grainger (2014) believed that the implementation of strict inspection and quarantine measures in the port prolonged the time of ships in the port and reduced the operation efficiency of the port.

2.2. Time series regression model

Time series forecasting method which applied in this thesis is a technique for the prediction of events like BDI through a sequence of time. It predicts future dry bulk

market by analyzing the trends of the present and past market, on the assumption that future BDI trends will hold similar to historical trends.

My supervisor Chen, S. (2011) modeled the price behavior and forecasted prices in the freight market, the newbuilding ship market and the second-hand ship market, through an extensive investigation of the dry bulk shipping market over the period from 1950 to 2010, in her dissertation *Modelling and Forecasting in the Dry Bulk Shipping Market.* Zhang, X. & Wang, Q. (2020) used time series method + combined prediction technology to predict the container throughput of Tianjin port from 2030. Tan, W. (2009) of Dalian maritime university used the vector Autoregressive model studying the relationship between the time charter level of dry bulk shipping market and other related markets. Yang, H.L.(2014) *Research on forecasting fluctuation law of Baltic Sea Freight Index Based on GARCH model* showed the analysis model of fluctuation spillover effect of Baltic dry bulk freight index is constructed. The research shows that the three main dry bulk carriers have fluctuation spillover effect on the corresponding BCI, BPI and BSI.

3. Impact on dry bulk shipping market

3.1. The overview of the dry bulk shipping market

3.1.1. Dry bulk cargoes

Dry bulk cargo refers to material in either liquid or granular, particulate form, as a mass of relatively small solids, that can be easily handled and transported in bulk. Typical dry bulk cargoes, such as iron ore, sandstone, coal, grain (millet, wheat) salt, and sugar, etc. are transported in bulk. Fertilizer and cement are also transported in bulk, which also belongs to dry bulk.

The world's iron ore resources are concentrated in Australia, Brazil, Russia, Ukraine, Kazakhstan, India, the United States, Canada, South Africa, and other countries. As the world's largest demander of iron ore, China needs to import from Australia, Brazil and other countries rich in iron ore.

Coal can be divided into coking coal and thermal coal. Coking coal is an important raw material for the above steel manufacturing industry, and power coal is an important raw material for energy power generation. Iron ore and coal are the important foundation of national industrial development.

The representative routes of coal and iron ore are Australia to China route, Americas to Europe route, Brazil to China route, Atlantic to Pacific route, Pacific to Atlantic route. The Capesize 5TC Average Index is basically the weighted average of 5 different routes above.

Grain, including soybean, wheat and corn, is a necessity for human and animal survival, other small dry bulk cargoes include bauxite, apatite, etc. Considering that

small dry bulk cargo can be transported by general cargo ship or container ship, the dry bulk cargo transportation studied in this paper is only for large dry bulk cargo such as iron ore, coal, and grain. China is the largest grain import country as well.

The representative routes of grains are Canakkale trip via Med or Bl Sea to China-South Korea, US Gulf trip to China-south Japan, North China one Australian or Pacific round voyage, North China trip to Wes US Gulf trip to Skaw-Passero, South China trip via Indonesia to south China.

The trade volume of dry bulk cargo is gradually increasing with the macroeconomic growth, and the demand fluctuation is positively related to the global economic cycle. The proportion of iron ore and coal has been increasing compared with that of grain, which reflects the global industrialization process. That is, industrial development provides the main increment of economic growth, while stimulating the demand for iron ore and coal. Dry bulk freight and economic growth are related variables in the process of industrialization.

3.1.2. Dry bulk transportation

Bulk carrier is the abbreviation of bulk carrier, which is specially used to transport unpacked goods, such as coal, ore, wood, livestock, grain, etc. The ships that transport grain, coal, mineral sand, salt, cement and other bulk dry bulk goods in bulk can be called dry bulk carriers, or bulk carriers for short. According to the ship type, dry bulk cargo transportation can be divided into Supramax, handymax, handysize, Panamax and Capesize dry bulk carriers.

Table 1 Main dry bulk ships

Vessel type	Standard deadweight tonnage	Main cargoes
Capesize	100,000+	Iron ore, coking coal, Thermal coal
Panamax	70,000-100,000	Iron ore, Thermal coal, Grain
Supramax	40,000-60,000	Fertilizer, Cement, Grain
Handysize	10,000-40,000	Fertilizer, Cement, Grain

Source: Clarksons Shipping Intelligence

Dry bulk cargo is mainly transported by unscheduled routes, which is characterized by the fact that the type of berthing, port of call, shipping date, rate, route and other aspects are not fixed. Capesize is divided into newcastlemax, conventional Capesize and babycape Panamax ships are divided into post Panamax, kamsarmax and Panamax. Handysize is divided into Ultramax, Supramax, Handymax and handysize.

3.1.3. Market characteristics

Competitiveness：The international dry bulk shipping market is close to a perfect competitive market. Firstly, the international dry bulk shipping market has a high degree of marketization and less government intervention; Secondly, the ship owner only needs a small amount of money to purchase cargo ships to enter the market and provide transportation capacity. In addition, the degree of marketization is high, so the ship owner can freely enter or exit the market; Moreover, as the cargo side has no special requirements for the speed and cabin facilities of dry bulk cargo transportation, the dry bulk cargo transportation provided by the ship side has certain homogeneity;

Finally, due to the development of Internet information technology and the improvement of shipping exchanges, both the supplier and the demander of dry bulk cargo transportation can obtain more complete information. To sum up, the international dry bulk shipping market can be approximately regarded as a complete economic market. The supplier and the demander are the recipients of freight rates, and their behavior is based on freight rates.

Derivability: The international dry bulk shipping market can be regarded as a derivative market of the international trade market. Its demand comes from the international trade market, so the market law has linkage with the international trade market, and at the same time has a certain lag.

Periodicity: The international dry bulk shipping market has a cyclical characteristic, that is, the process of "prosperity recession depression recovery". During the boom period, the world economy is developing well and the international trade volume is rising. Driven by the demand for dry bulk cargo capacity, the freight rate is rising. At the same time, the market prosperity was transmitted to the second-hand ship market and shipbuilding market, and the supply of transport capacity increased significantly. When the capacity supply exceeds the capacity demand, the dry bulk freight rate will decrease. The market turned into recession, and the ship breaking market boomed to reduce the supply of transport capacity, which began again and again. At the same time, according to the time series data of international dry bulk freight rates for many years, the duration of depression is longer than that of prosperity.

3.2. Influence of Covid-19 on freight rates

3.2.1. Covid-19 pandemic

To study the influence on dry bulk freight rate, it is also necessary to understand the

novel coronavirus itself. Since December, 2019, some hospitals in Wuhan, Hubei Province have successively found a number of cases of unexplained pneumonia with a history of exposure to the South China seafood market, which has been confirmed as an acute respiratory infectious disease caused by the 2019 novel coronavirus infection. On February 11th, 2020, the director general of the World Health Organization (WHO), Tedros Adhanom Ghebreyesus, announced in Geneva, Switzerland that the pneumonia infected by novel coronavirus would be named "Covid-19". Since then, the Covid-19 has rapidly spread to every country in the world, Novel coronavirus not only threatens the safety and health of people all over the world, but also has a huge negative impact on the global economy and politics, disrupting the normal production and living order of all countries.

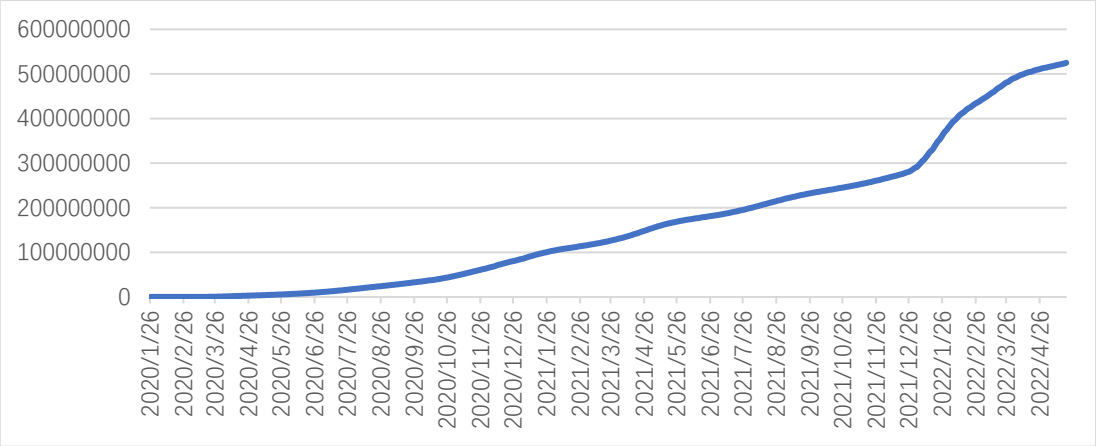


Figure 2 Covid-19 cumulative new cases

Source: Johns Hopkins University

Since China imports about 40% of the global dry bulk cargo. This makes China play an important role in the global supply chain. Despite political factors and subjective views, China's response to the epidemic is indeed very timely. Precise prevention and control by zoning and grading is adopted. Under the guidance of the State Council's joint prevention and control mechanism in response to the Covid-19, the country is divided into high, medium, and low-risk areas based on the epidemic

risk assessment at the county level. Governments at all levels are responsible for classified and hierarchical management and take different prevention and control measures. Pay close attention to the epidemic situation in various regions, conduct risk assessment, and timely adjust the risk level and prevention and control measures.

It is not only the epidemic prevention policies of various countries, but also the factors of vaccine that cause the instability of the number of confirmed cases of the current epidemic. The vaccine can effectively inhibit the spread of the virus and reduce the severe rate. Now, the new coronavirus is also mutating in the direction of low mortality and high transmissibility. At present, the novel coronavirus has mutated 11 times, including alpha, beta, gamma, Delta, etc., and the latest South African Omicron and Xe virus. With the gradual reduction of the harm of the virus, the global epidemic situation will be very different after 2022. As mentioned above, the freight rate of dry bulk cargo is not only affected by the epidemic, but also by other factors. Therefore, the impact of the epidemic on the freight rate of dry bulk cargo tends to be a dynamic change.

3.2.2. Influence on Baltic indices

BDI is an intuitive reflection of freight rate in the international dry bulk shipping market. BDI measures the shipping costs of dry bulks such as coal, iron ore and grains. Composed of Baltic Exchange Capesize Index (BCI), Baltic Exchange Panamax Index (BPI) and Baltic Exchange Supramax Index (BSI), BDI is a global leading economic indicator and BCI is for industrial materials like iron ore, cocking coal and phosphate. BPI is for bulks like grains. BSI is for phosphate fertilizer, potassium carbonate, sawdust, and cement. Especially, iron ore is the largest among all bulks, whose price movement correlates with BDI. So BDI is selected to reflect the fluctuation of the international dry bulk shipping market.

The Baltic Exchange Capesize Index (BCI) is a daily average calculated from the reports of an independent international board of panellists. These panellists are required to make a daily assessment on a basket of timecharter and voyage routes in the dry bulk shipping market representative of Capesize vessels. Capesize ships are the largest dry cargo ships. They are too large to transit the Suez Canal or Panama Canal ,and so have to pass either the Cape Agulhas or Cape Horn to traverse between oceans.Ships in this class are bulk carriers, usually transporting coal, ore and other commodity raw materials. The average size of a Capesize bulker is around 180,000 DWT . It can carry any type of cargo, such as iron ore and coal in main.

The Baltic Exchange Panamax Index (BPI) is a daily average calculated from the reports of an independent international board of Panellists. These Panellists are required to make a daily assessment on a basket of timecharter and voyage routes in the dry bulk shipping market representative of Panamax vessels. "Panamax" is the name of the largest class of ships able to transit the Panama Canal. These vessels are up to 900 feet long with a breadth of up to 106 feet .

The Baltic Exchange Supramax Index (BSI) is a measure of the strength of spot freight earnings for smaller dry bulk vessels, currently based on a a standard 58,000 dwt bulk carrier. Supramax vessels are medium-sized vessels with a carrying capacity between 50,000 and 60,000 DWT, with a typical draught of 12.2m and 199m length. Since 2012, the first proposals for a major change in routes and ship sizes for the BSI started to be formulated. After a time of discussion, market observations and revised proposals, a decision was made.

In the past few years, the shipping market has remained depressed on the whole. In the face of the adverse conditions of the increasing downward pressure on the global economy, the increasing complexity of International Geopolitics and the serious excess of shipping capacity in the shipping market, the novel coronavirus epidemic appeared as a huge "black swan". It seriously affect the investment psychology and expectations

of the international shipping market in the short term, increase the market pessimism, and then affect the dry bulk shipping market.

From the perspective of impact logic, no matter what kind of epidemic situation, the impact on the market generally follows the path of "epidemic spread - government measures - market impact - industry impact". The large-scale spread of the epidemic has forced the worldwide governments to take intervention measures. People will also reduce travel and consumption for health reasons, and enterprises will delay production. This will seriously affect the international economy, especially the tertiary and secondary industries, reduce the demand for consumption and transportation, and reduce the demand for energy, raw materials and finished products such as oil, coal, iron ore, steel, semi-finished products and manufactured products, which will drag down the growth of maritime trade, especially the demand side performance of Capesize market, Panamax market, Supramax market and Handysize market in the short term, Finally, it will affect the supply-demand relationship of the whole dry bulk shipping market.

In addition, the epidemic will also increase the operational risk of shipping enterprises. In the face of the epidemic situation, most countries and regions will put forward strict health declaration and quarantine requirements, check the body of crew members and strengthen ship quarantine. These strict preventive measures make the docking operation of ships in relevant ports complicated and the non productive berthing time of ships prolonged. As the World Health Organization listed the novel coronavirus epidemic as a public health emergency of international concern on January 31 2020, it is expected that more countries and regions will take strict preventive measures before the epidemic is eliminated in the future. At the same time, shipping enterprises will also face potential risk costs such as forced detour due to crew infection and the resulting voyage costs.

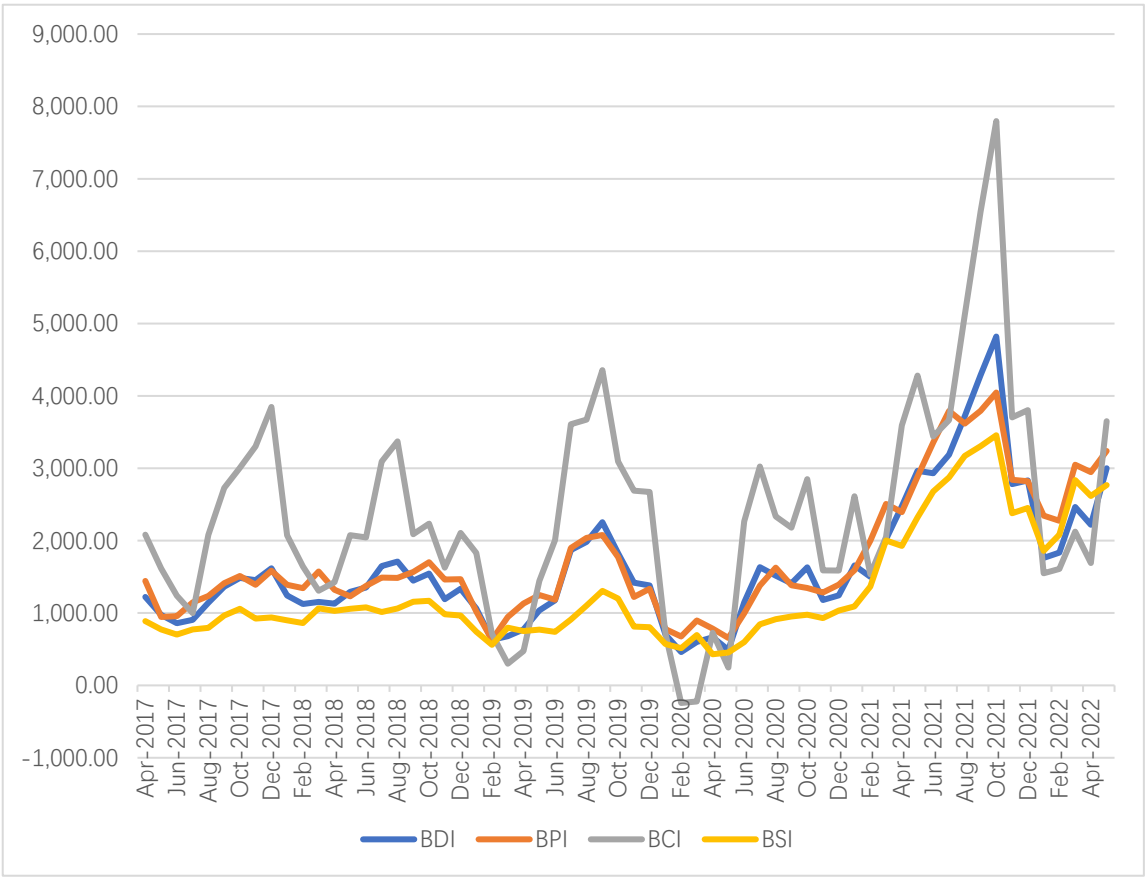


Figure 3 Baltic indices

Source: Clarksons Shipping Intelligence

However, the dry bulk shipping market could also be affected by such factors as China US relations, China Australia relations and FFA speculation, the market fluctuation may also be greatly. It cannot be directly concluded that the dry bulk shipping market must be completely related to the Covid-19. The above figure is the broken line chart of Baltic index from Clarkson fitted by Excel, including the change trend of BDI, BCI, BPI and BSI in the five years from 2017 to now. BDI is a quantitative index of the rise and fall of dry bulk shipping market. The Baltic Dry Index (BDI) is issued daily by the London-based Baltic Exchange. The BDI is a composite of the Capesize, Panamax and Supramax Timecharter Averages. It is reported around the world as a proxy for dry bulk shipping stocks as well as a general

shipping market bellwether. As can be seen from the figure below, this is a line chart of Baltic Dry Index daily data from 2019 to 2021. Since the outbreak of the epidemic, the BDI has fallen continuously, falling to 393 points on May 14, 2020, In fact, for more than a decade after the financial crisis, the BDI index has been fluctuating at a relatively low level, with few opportunities to rise above 2000 points. However, since June 2020, the BDI index has been abnormal and continued to rise reaching 5650 points, an exaggerated level on October 7, 2021. And it began to decline sharply in 2022.

It can be seen from the above figure that the BCI index fluctuated most violently. In February 2020, when the epidemic was the most rampant, it even fell below 0 point and entered a negative range. After China resumed work and production in May, it began to grow rapidly all the way until the end of 2021, reaching the highest point in the past decade, close to 7000 points. Then descend again. This shows that the world's iron ore trade has been significantly affected during this period. As the most serious disaster in decades and even in the history of mankind, Covid-19 is likely to be the culprit of this dramatic change.

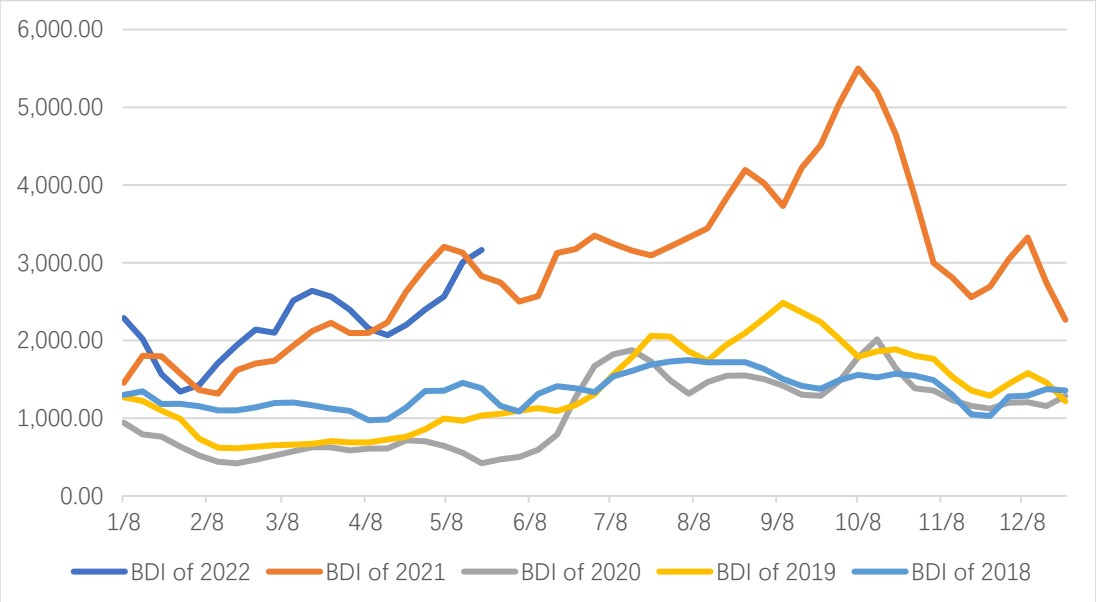


Figure 4 Comparison chart of BDI trend from 2018 to 2022

The three indices are corresponding to the Capesize ships with the largest tonnage, which are used to transport ore; Panamax ships, with a tonnage of 60000-0000 tons, are used to transport grain, etc; Handysize ship, with the smallest tonnage, is used to transport cement, wood, fertilizer, etc. As a barometer of the international shipping industry and international trade, the BDI index has been declining, and even its important component BCI index has entered the negative range for the first time in the history after the outbreak. The root cause of BDI downturn lies in a series of negative developments, including the outbreak of novel coronavirus pneumonia. In 2020, the trend of international dry bulk shipping market went a fall and rise, the overall performance was significantly worse than that of the previous year. The trend comparison of Baltic dry index (BDI) in recent three years is shown in the figure. The average BDI of the whole year was 1066 points, down 21.3% from the average of 1355 points of the previous year. In terms of ship types, the rent levels of all types of ships fell year-on-year. Among them, the average time charter rate of the Capesize Bulker 5TC (Time Charter of five representative routes) was US $13070 / day, a year-on-year decrease of 27.6%. The average time charter rate of Panamax Bulkers 5TC was US $9923 / day, a year-on-year decrease of 20.3%. The average time charter rate of Handymax Bulker 10 TC was US $8189 / day, a year-on-year decrease of 17.8%. The average time charter rate of Handysize Bulker 7TC was US $8003 /, a year-on-year decrease of 140%.

For dry bulk shipping, the epidemic period can be divided in two, with lower volumes and earnings in the first half followed by a recovery in the second, as China split from the rest of the world, boosting tonne and tonne mile demand, and sending freight rates to profitable levels. June was the turning point as volumes reached their highest point of the year, and earnings jumped, especially for Capesize ships. Next, this paper will focus on the demand side and the supply side to analyze the shipping market during early outbreak stage and post epidemic stage.

At the early stage of the outbreak of Covid-19, the International Chamber of Shipping (ICS) issued guidelines on novel coronavirus to global shipowners on January 27, 2020. The guidelines actively respond to the measures of the World Health Organization (WHO), aiming to ensure the normal operation of global ports and shipping industry, and suggest its members to take necessary measures to control the spread of novel coronavirus. On January 31, 2020, WHO listed the novel coronavirus epidemic as a public health emergency of international concern (PHEIC) and issued interim recommendations, but did not recommend any measures to interfere with travel and trade. China needs to import large quantities of iron ore and coal for steel production. At the same time, the import demand of agricultural products is also very high, which is the main driving force of the dry bulk market. Until the outbreak of the epidemic, overseas countries / regions did not take varying degrees of control measures on China's trade in goods. At present, mining enterprises in Brazil, Chile and other places have applied for delayed delivery. Indonesian coal producers also asked to postpone the transportation of electric coal to China, which further slowed down the import of domestic dry bulk goods and forced the postponement of China's industrial production cycle.

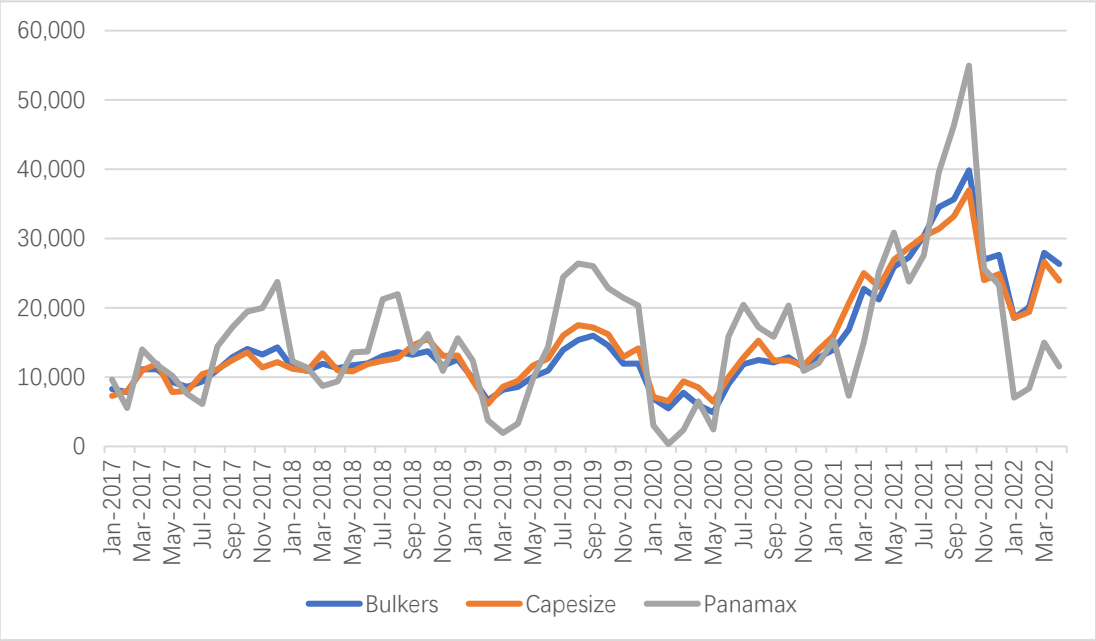


Figure 5 Dry bulk earnings 2017-2022

Source: Clarksons Shipping Intelligence

Across the board, dry bulk earnings averaged below breakeven levels in 2020, though no sectors experienced average earnings below 2016 levels. Capesizes and Supramaxes were the hardest hit, averaging daily spot market losses of USD 2,271 and USD 1,170 throughout 2020, while Panamax and Handyssize ships were just a few hundred dollars below breakeven levels estimated by BIMCO.Timing had a crucial role in determing owners' profitablity, as rates in the second half of the year were much better than those in the first, as the recovery in China helped lift the dry bulk market. The slight growth in tonne mile demand did little to offset the 3.8% fleet growth in 2020, or 33.3 million DWT, thereby adding 2020 to the growing list of years which experienced a deterioration in the fundamental market balance.

3.2.3. Influence on crude oil prices

As we all know, oil price is also one of the important factors that determine the freight rate of dry bulk cargo. The major blow of the new coronavirus to the global economy and the weak effect on the consumption side of crude oil are obvious. This impact will also be transmitted to the impact of international trade on dry bulk shipping. This set of data is the Brent crude oil index from the official website of the U.S. energy information administration. Brent crude oil is light and low sulfur crude oil produced in Brent and Ninian Oilfield in the North Sea. It is widely traded in futures, OTC swaps, forward and spot markets. At present, more than 65% of the real crude oil in the world is priced by Brent system. The loading port of Brent crude oil is Sullom Voe in Shetland Islands North Sea. The main users are refineries located in northwest Europe and the east coast of the United States. As the futures trading of London Intercontinental Exchange, it is the benchmark of market oil price. It is obvious that the oil price plummeted at the beginning of the outbreak.

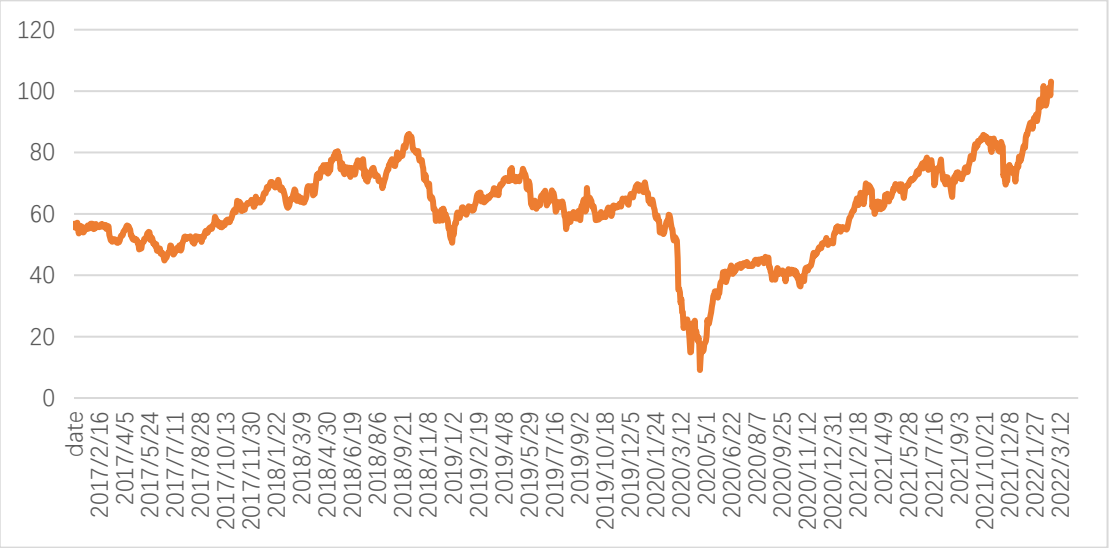


Figure 6 EBSP from 2017 to 2022

Source: U.S. energy information administration

Note: EBSP refers to European Brent crude oil price index

Since 2020, the trade environment in the oil transportation market has deteriorated significantly due to the impact of the Covid-19. As the world's second largest crude oil consumer and the largest crude oil importer, the outbreak of the epidemic has greatly weakened the demand for crude oil imports. Although the epidemic situation in China has improved significantly in recent days, with the rapid spread of the epidemic in many countries in the region, the concern of the global energy market about the weakening growth of crude oil demand continues to deepen. In mid-February, IEA, OPEC and EIA lowered the growth rate of global crude oil demand in 2020 at the same time. Among them, IEA lowered the growth expectation of global crude oil demand in 2020 by 230000 barrels / day, a new low since 2011. Although supply side factors such as the expected slowdown in shale oil production in the United States, OPEC + production reduction and geopolitical tensions in the Middle East have supported the international crude oil price, the international crude oil price has continued to decline under the drag of the demand side. By the end of February, the price of Brent crude oil had fallen to US $49.4/barrel, a new low since 2018.

In the near future, considering that the spread of Covid-19 overseas is still on the rise, the global demand for crude oil will still suffer a major impact, and the international oil price will continue to be under pressure. The insufficient demand for crude oil imports mainly from China will continue to affect the oil transportation market, leading to the deterioration of the relationship between supply and demand of transportation capacity, and the market freight continued to fall.

The following figure shows the changes of BDI and international crude oil prices in the sample interval. Before the outbreak of Covid-19, the average BDI reached 1380 points in December 2019. After the outbreak of Covid-19, the BDI quickly dropped to about 500 points and fluctuated below 1000 points for a long time. This proves that the outbreak of the epidemic has had an impact on the international dry bulk shipping market. In mid-June 2020, BDI returned to more than 1000 points and reached 1054

points on June 15. This shows that with the passage of time, the world economy is gradually adapting to the impact of the epidemic, and its impact on the international dry bulk shipping market is gradually decreasing. From June 15 to December 11, BDI fluctuated at 1000 ~ 2000, which reflects that the dry bulk shipping market can breathe in the post epidemic period. However, the overall situation of world trade has not been ended due to the impact of the epidemic. For example, the shipment volume of commodity producers represented by vale cannot be guaranteed, and the delay rate and blockade rate of the demolition and shipbuilding market are all obstacles to the full recovery of the dry bulk shipping market; Before and after the outbreak of Covid-19, the international crude oil price rapidly increased from the average price in December 2019 to 67 US $2 / barrel fell to about US $10 / barrel. Its fluctuation trend on the time axis is very close to that of BDI, reflecting the linkage between the two markets. In the supply market, with the implementation of OPEC's production reduction policy, crude oil prices have bottomed out and rebounded. The international crude oil price is also facing the long-term impact of the global Covid-19 on the demand side. The market is expected to focus on the spread of the epidemic and the progress of vaccine research and development. The epidemic has not been effectively controlled, and the crude oil demand will not be completely recovered.

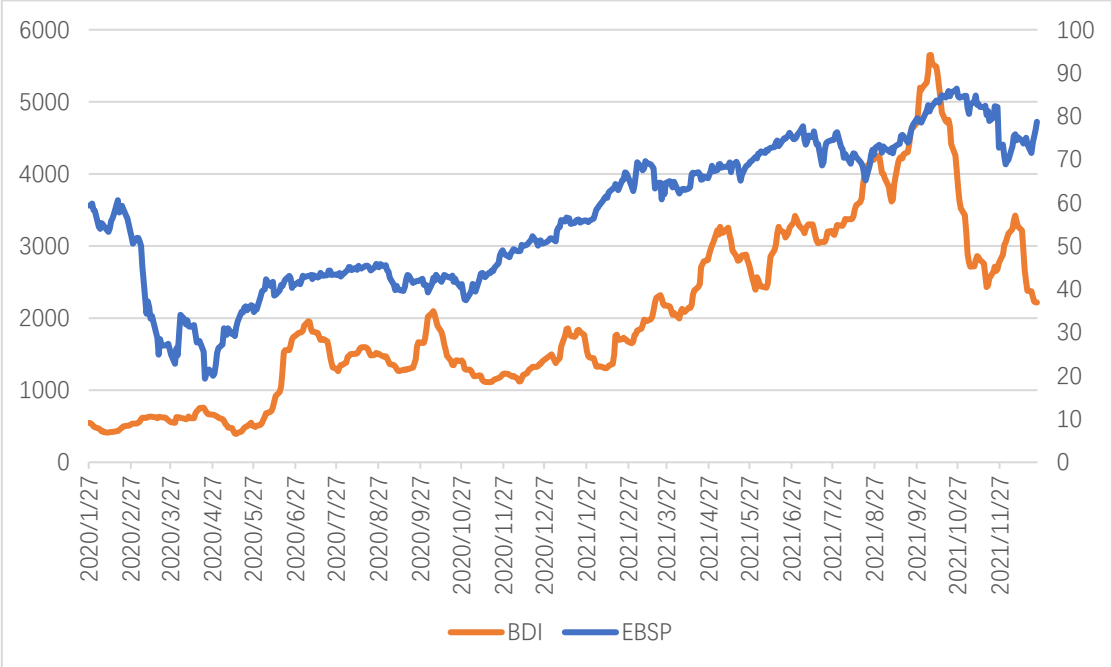


Figure 7 BDI and international crude oil price trend chart

Source: Clarksons Shipping Intelligence

3.3. Influence of Covid-19 on dry bulk seaborne demand

3.3.1. The seaborne iron ore trade

Since the beginning of 2020, affected by the rainstorm in Brazil, hurricane in Australia and the traditional off-season of Chinese Spring Festival, the international dry bulk cargo market has been weak. In addition, the outbreak of pneumonia has further deepened the negative situation of the market, and the International (especially China) dry bulk cargo demand has been seriously affected. The extension of the Spring Festival holiday and restrictions on population mobility have impacted domestic industrial production. The resumption of production of steel mills and other manufacturing enterprises has been delayed, and the construction of real estate and infrastructure projects have also been stopped one after another, resulting in a sharp

decline in China's steel output and import demand for raw materials such as iron ore / coal. Specifically, in terms of iron ore, due to the impact of the epidemic, domestic logistics and transportation have been delayed, the resumption time of steel mills has been delayed, and enterprises in some regions have taken the initiative to reduce production. The operating rate of blast furnace has fallen from 66.7% at the beginning of the year to 62.9% at the end of February. The low operation of domestic steel production has weakened the demand for import and transportation of iron ore. In terms of coal, affected by the long Spring Festival holiday and the delayed commencement of the epidemic, the national power consumption fell by a cliff. The average daily coal consumption of the six major power plants in China fell rapidly from 772000 tons at the beginning of the year to 431000 tons at the end of February, and the average available days of inventory rose to 41.3 days, showing a significant deterioration trend. Although coal mines have resumed production since February 2, it is still tense, and the logistics link has not been restored. The domestic coal market is in a pattern of weak supply and demand. Based on the above factors, the overall performance of domestic dry bulk cargo import demand is weak, which further inhibits the market demand of international dry bulk cargo ships.

In 2021, almost all countries entered the post epidemic stage, and the international dry bulk shipping market rose sharply. The Baltic dry bulk index (BDI) reached the highest 5650 point in 12 years, and then fell. Commodity prices have been rising all the way, and the enthusiasm for replenishing stocks in the downstream has been rising. Coupled with the serious pressure on ports all over the world, there are periodic tensions in the available transport capacity of the market from time to time.

The global demand for seaborne trade of iron ore will continue to grow steadily. With the rapid recovery of China's economy, the expansionary policy will be gradually reversed, and China's steel demand is expected to be flat as a whole. With the gradual recovery of foreign market economy from the impact of the epidemic, steel production

and demand will gradually improve, thus driving the growth of iron ore demand. The global iron ore trade volume in recent years is shown in Figure 8.

Figure 8 Changes in global iron ore trade volume

Source: Clarksons Shipping Intelligence

According to the latest BIMCO data of the Baltic Shipping Association, overall, the total transportation volume of the global dry bulk shipping industry in 2020 decreased by 1.3% from 5.56 billion tons in 2019 to 5.49 billion tons, but still higher than 5.46 billion tons in 2018. Its leading position in China's bulk shipping market has been further consolidated. In terms of transportation distance (ton miles), China's imports have accounted for nearly 50% of the market share. In terms of breakdown, the sea transportation data of various global bulk dry goods in 2019 are different. Among the three major commodities of iron ore, coal and grain, coal is the only one that has declined; 102.2 million tons (7.4%) lower than that in 2019. On the other hand, the trade volume of iron ore and agricultural products increased by 36.9 million tons (+ 2.3%) and 33.3 million tons (+ 4.9%) respectively in 2020. In terms of percentage,

the goods with the largest increase in trade are construction materials, which increased by 8.1% in 2020. However, due to the much lower absolute volume of trade, this means that the total volume has increased by only 29.6 million tons. The largest commodity in the construction materials category is cement, which increased by 13.4% between 2019 and 2020. China accounted for half of the increase of 21.5 million tons, and its seaborne cement imports increased by 52.2% (about 12.7 million tons).

As mentioned above, in 2020, the BDI fell by stages. On the one hand, it was affected by seasonal factors such as the Spring Festival in China, hurricane Claudia in Australia and the climate in Brazil. There were fewer goods and more ships in the market. According to the situation before and after the Spring Festival over the years, the BDI index showed a downward trend periodically. On the other hand, the sudden factor that made the BDI bottom in 2020 was the virus epidemic. The impact of the epidemic on the shipping market is mainly reflected in China's import and export demand for dry bulk cargo. In 2019, China's import volume of bulk cargo by sea accounted for 22% of the global import volume of bulk cargo by sea, especially the import volume of ore by sea accounted for 72% of the global import volume of ore by sea.

In order to prevent large-scale epidemic infection, the workers' Spring Festival holiday was extended. Subsequently, in order to avoid workers' centralized operation and increase the possibility of epidemic transmission, some enterprises slowed down the scale of workers' resumption of work or extended the downtime. The speed of China's industrial production was limited, further affecting China's import demand for raw materials and the export of finished products. In addition, in order to prevent and control the global spread of the epidemic, the number of ships arriving at or passing through China's major ports has decreased significantly, which has limited the arrival of imported goods to a certain extent. The issues related to ports will be detailed in the next chapter. At present, the impact of the epidemic on China's bulk commodity dry

bulk shipping cannot be underestimated.

From the perspective of specific domestic downstream demand, the resumption of work and production of steel mills and manufacturing enterprises will be delayed, and the construction of real estate and infrastructure projects will also be stopped. The date of resumption of work will depend on the development of the epidemic. The demand for steel in the upstream will decline, and the procurement of iron ore in the downstream is expected to be difficult to start in a short time, resulting in a significant slowdown in the import of raw materials such as iron ore and coking coal and the export of finished products. In terms of coal, due to the delay in the resumption of work in relevant industries, the demand for electricity has decreased, and the seasonal demand for coal due to the warming weather has a great impact on the short-term demand for coal.

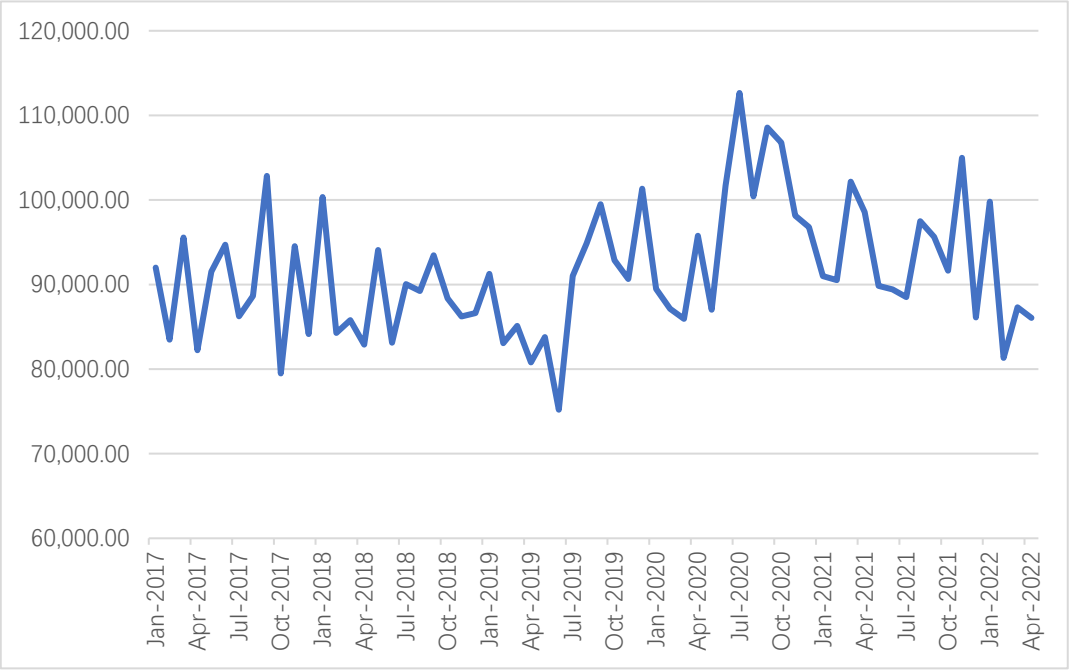


Figure 9 China total iron ore imports (1000 tonnes)

Source: Clarksons Shipping Intelligence

On the one hand, China's steel market is also an important target of dry bulk shipping demand. China is the world's largest iron ore importer and the world's largest steel producer. The above figure shows the statistical data of China's iron ore imports provided by Clarkson from 2018 to 2021. It is obvious that China's iron ore imports show cyclical changes and an overall increasing trend. At the beginning of the outbreak, China was in the off-season of the lunar new year, and the negative effect of the outbreak was not obvious, at least in terms of the number of iron ore imports. However, it is obvious that after the resumption of work and production in May, China's demand for iron ore has increased significantly, with an increase over the same period in 2019.

Figure 10 China steel production (1000 tonnes)

Source: Clarksons Shipping Intelligence

Take another look at China's steel production capacity. The above figure shows the statistical data of China's steel production from 2018 to 2021 provided by Clarkson. It can also be seen that China's steel production capacity has always changed periodically and increased year by year. During the epidemic period in 2020, the decline and rise in the first and second quarters were significantly greater than those in 2017, 2018 and 2019, but the impact was not obvious. Instead, the production

restriction policy in 2021 caused a huge decline.

In 2020, China's crude steel output reached 1.053 billion tons, a year-on-year increase of 5.2%, breaking the 1billion ton mark for the first time. According to the data released by the National Bureau of statistics, China's crude steel output will reach 1.053 billion tons in 2020, with a year-on-year increase of 5.2%; The output of pig iron was 888 million tons, a year-on-year increase of 4.3%; Steel output was 1.325 billion tons, a year-on-year increase of 7.7%. By quarter, the crude steel output in the first quarter increased by 1.2% year-on-year, 1.7% in the second quarter, 10.3% in the third quarter and 8.8% in the fourth quarter. On a monthly basis, affected by the epidemic, the crude steel output in March decreased year-on-year, and the output in other months increased year-on-year.

In 2020, the national economy will gradually recover under the action of macro policies. Especially after the second quarter, with the national policy of returning to work and production and stabilizing the economy, the start of major project investment, the rapid recovery of downstream industries such as machinery, automobile and household appliances, the economic indicators closely related to steel consumption continued to improve, and the steel consumption reached a new high. In this year, with the gradual improvement of the epidemic situation, the global economy has recovered, and the revival of industry and construction industry has promoted the rising demand for steel; At the same time, the measures taken by many countries to stimulate their own economies have further increased the demand for steel. Since May 2021, in order to achieve the "double carbon" goal and promote the development of China's steel industry towards high-end, China has imposed certain restrictions on the crude steel production capacity. All steel enterprises in the 36 regions limited their production by 30%, and the decline of steel production capacity also reduced China's demand for iron ore, and the demand for iron ore by sea decreased.

3.3.2. The seaborne coal trade

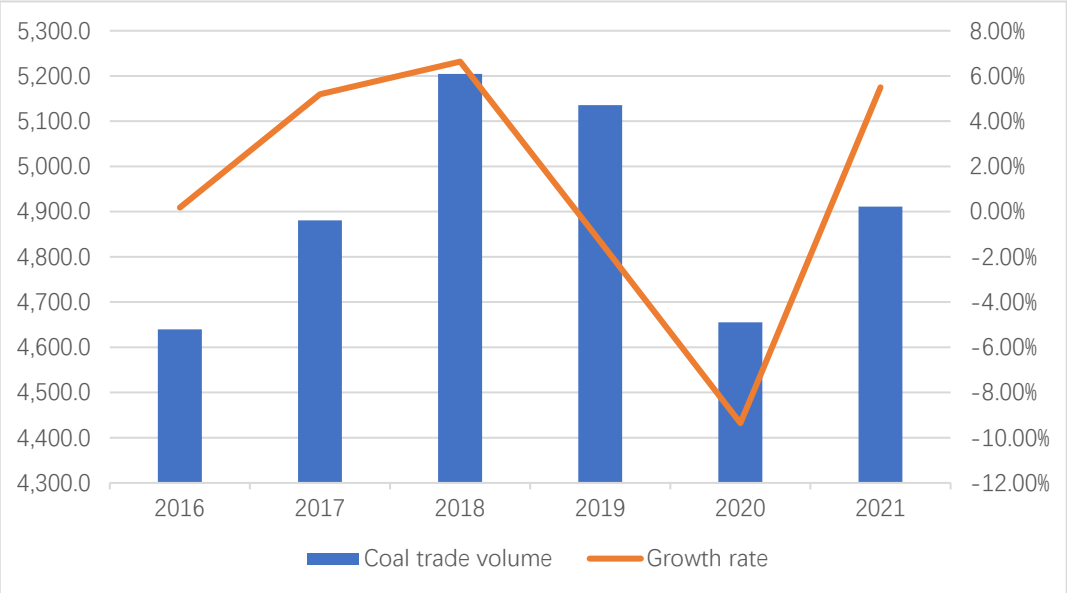


Figure 11 Changes in global coal trade volume

Source: Clarksons Shipping Intelligence

The above figure shows the change of global coal shipping trade volume. It can be seen that in 2020, the global coal shipping demand is significantly lower than that in 2019, falling from 5135.7 billion tonne-miles in 2019 to 4655.2 billion tonne-miles, the first decline in five years. In 2021, the demand for coal rebounded, with an increase of 5.5%

The worst affected by the epidemic is China's coal market. The downstream demand industries in China's coal industry are roughly: power industry (53%), iron and steel industry (16%), building materials industry such as cement (13%), chemical industry such as urea (7%), and bulk coal (12%). Due to the outbreak of the epidemic, the government has fully controlled the vehicles entering and leaving the province. It is difficult for transport vehicles from outside the province to enter the province for transportation, and the local transport fleet in the epidemic area cannot be put into operation. Therefore, the automobile transport vehicles are limited, and the number of

medium and short distance vehicles returning to work is small, resulting in insufficient transport capacity, even more long-distance vehicles, and the freight rate rises accordingly.

3.3.3. The seaborne grain trade

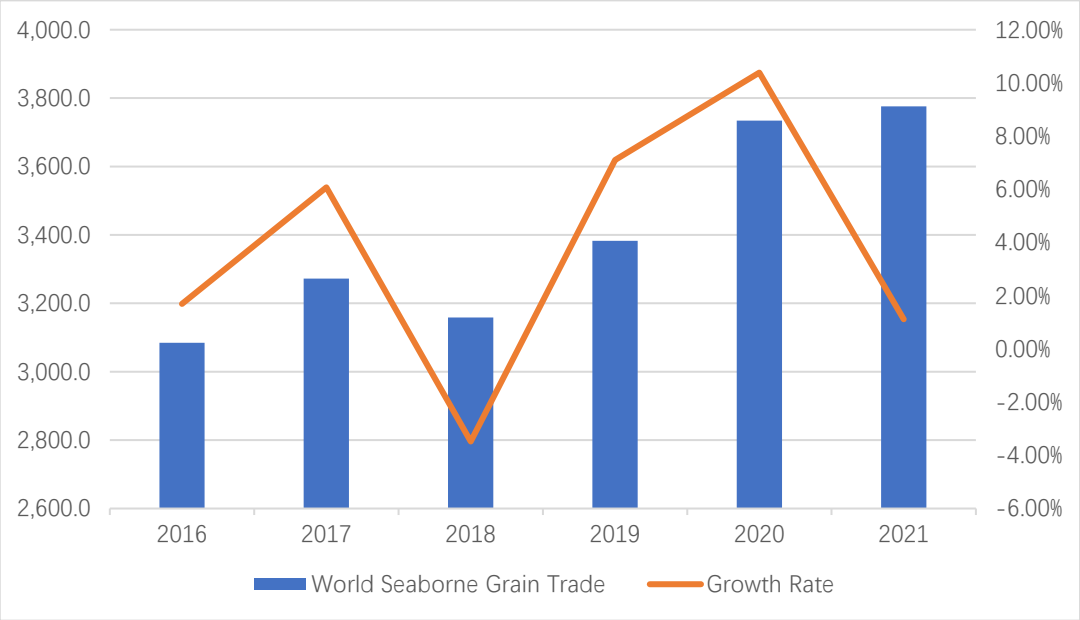


Figure 12 Changes in global grain trade volume

Source: Clarksons Shipping Intelligence

For grain, from 2016 to 2021, the global demand for grain by sea is more intense, showing a rapid upward trend as a whole, with an increase of about 9% during the epidemic period. Unlike other dry bulk cargoes, the transportation demand for grain has not declined from the annual data

During the pandemic period, dozens of countries have put in place temporary restrictions on food trade. Argentina temporarily suspended maize exports, Ukraine put a cap on its maize exports, and Korea applied a tax to discourage grains exports. Many other governments are increasing production support for grains in the form of direct farmer payments or input subsidies. Amidst Covid-related measures, unexpected

surges in grains purchases by China had consequences for global distribution and increased the global price of grains for food import-dependent countries. China's latest Five-Year Plan and related policies make clear that China is looking well past the current environment to shape the global food system in ways that support its own long-term food security. China is not facing unusual supply disruptions or a looming food shortage. Grain output in 2020 reached a record high of 669.5 million tons, exceeding the new official target of 650 million tons. At the same time, due to rising incomes and diversifying diets, China has become the world's largest importer of food, surpassing the European Union and the US with imports totaling US$ 133.1 billion in 2019. Beijing defines food security as relative balance in domestic demand and supply of grains. China's recently announced food security policies are therefore designed to protect China's farmland dedicated to these crops, to accelerate the development and commercialization in China of gene-edited seeds, and to ensure China's farmers maintain production while making bigger gains in yields of wheat, rice, maize, and soybeans. To achieve a grains balance, the government has long maintained controls over domestic grains production, stock levels, and imports. It makes annual adjustments to the prices at which it will guarantee purchases to incentivize its farmers. The country continues to build massive stockpiles equivalent to almost half of the globally available reserves of wheat, rice, maize, and soybeans.

3.4. Influence of Covid-19 on dry bulk shipping supply

3.4.1. Port congestion

As an important node connecting world production and consumption, port hubs play an important role in the global integrated transportation system. Since the beginning of this year, major ports around the world have experienced "death congestion" similar

to traffic jams. The scope of congestion has spread around the world and continues to deteriorate. At the same time, it has also brought a series of chain reactions, such as soaring freight rates and declining supply chain efficiency, which has brought great uncertainty to the maritime supply chain and the world economy and trade. This reason is caused by the continuous and repeated impact of the global epidemic, including but not limited to: low operating efficiency of ports and related supporting facilities, shortage of truck drivers, insufficient railway capacity, limited storage space, slow speed of customers' picking up and returning containers, etc., which makes terminal congestion a global problem. With the continuous outbreak of a new round of epidemics in ports in 2021, a series of port operations have been blown, leading to a sharp decline in the overall efficiency of the supply chain. Except during the epidemic period, requiring all personnel on board to be tested will slow down the unloading progress. The high freight rate in the centralized transportation market makes many traders choose to rent bulk carriers, and there are even many cases of loading containers with bulk carriers, so the congestion of dry bulk terminals is more serious.

The following figure reflects the change trend of dry bulk carrier congestion in ports around the world from 2017 to now. It can be seen that the major ports in the world, whether Panamax ships or Capesize ships, are at a high level from 2020 to 2021, with a 28% level. Port congestion is serious. Although the highest point is less than the pressure on the port caused by the Sino US trade war in April 2019, this pressure on the port has lasted for a long time and worked for a long time, which has had a huge impact on the freight rate of dry bulk cargo. Although the port congestion problem is the result of multiple factors, including the Covid-19, oil producing countries' negotiations, Suez Canal blockage (only affected Supramax vessels), China Australia coal trade, Russia Ukraine conflict, the biggest factor that causes the congestion problem to continue is the Covid-19.

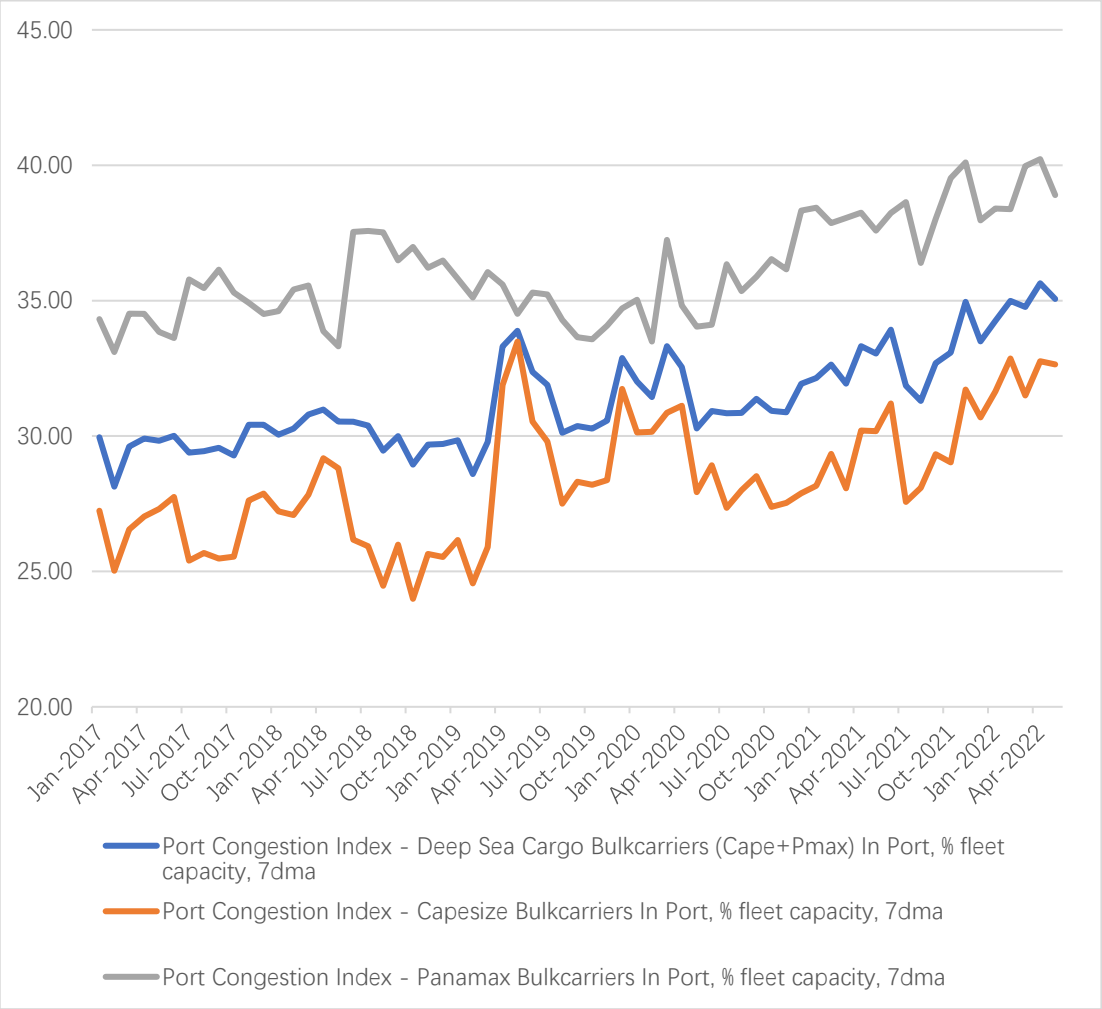


Figure 13 Port congestion index

Source: Clarksons Shipping Intelligence

As the largest importer of dry bulk cargo, China's port congestion is also noteworthy. China has adopted the "zero tolerance" policy for Covid-19 and adopted stricter disinfection measures, which undoubtedly lengthens the ship's berthing cycle. Especially in 2021, due to the recovery of consumer spending, strong demand, bad weather and the slowdown of operation caused by covid-19, China's port congestion is close to a record level. According to the data of Braemar ACM, Capesize iron ore ships that finish unloading in China in 2021 will spend an average of nearly 4 days waiting for landing after arrival. In 2019, the average is about 1.5 days. The port

congestion along the Yangtze River is particularly serious. If it were not for the congestion in China, the freight rate of Capesize would be much lower than the current freight rate.

The figure below shows the combination of the average congestion index of China's major ports, BCI and BPI. As Clarkson did not provide percentage data, the following data are reflected by deadweight tons. It can be seen that Capesize has shown a trend of decreasing first and then increasing in vibration, reaching the lowest point in may 2020 and the highest point in July 2021. This trend is consistent with the change trend of BCI, and the lowest and highest points are close to the first month of China's resumption of work and production, and the first month of China's energy conservation & steel production restriction. Capesize is the main ship type carrying coal and iron ore. It can be explained that BCI is highly correlated with China's port congestion index.

However, Panamax has been slowly rising since 2020. Except for the traditional off-season such as the Chinese Lunar New Year, there is no obvious downward trend and it has been in a state of congestion. Only the first quarter of 2021 experienced a short decline, which is contrary to the market of Capesize and lags behind the fluctuation of BPI, but the overall change trend is consistent. It also shows that the congestion of Chinese ports has a great impact on BPI. Not only mineral resources, China is the world's largest grain importer in 2021 as well, with a total import of about 164.53 million tons of grain, especially soybeans, soybean products and oilseeds. Soybeans and oilseeds are the two products with the highest degree of dependence on foreign countries in China.

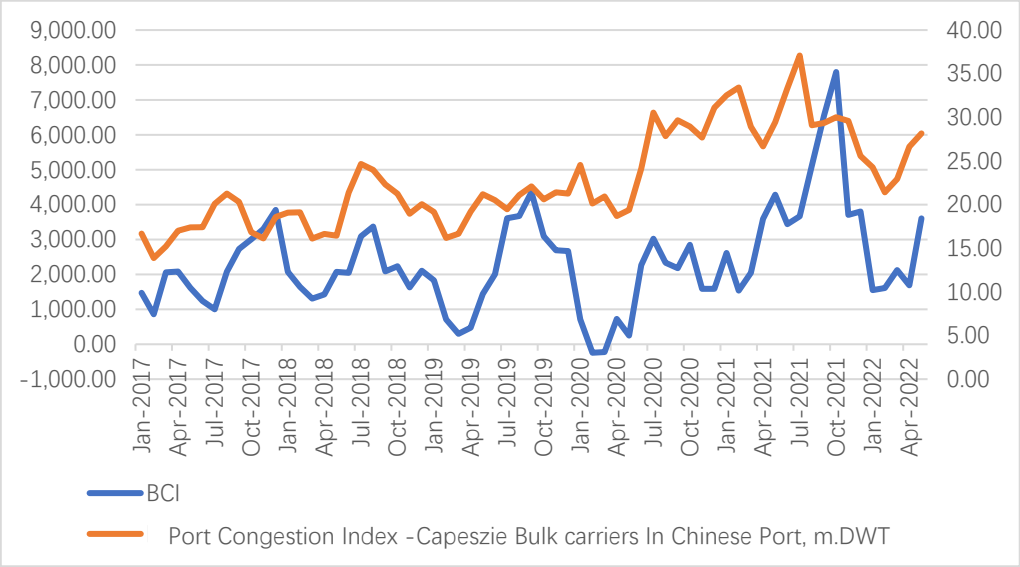


Figure 14 China BCI-Port congestion chart

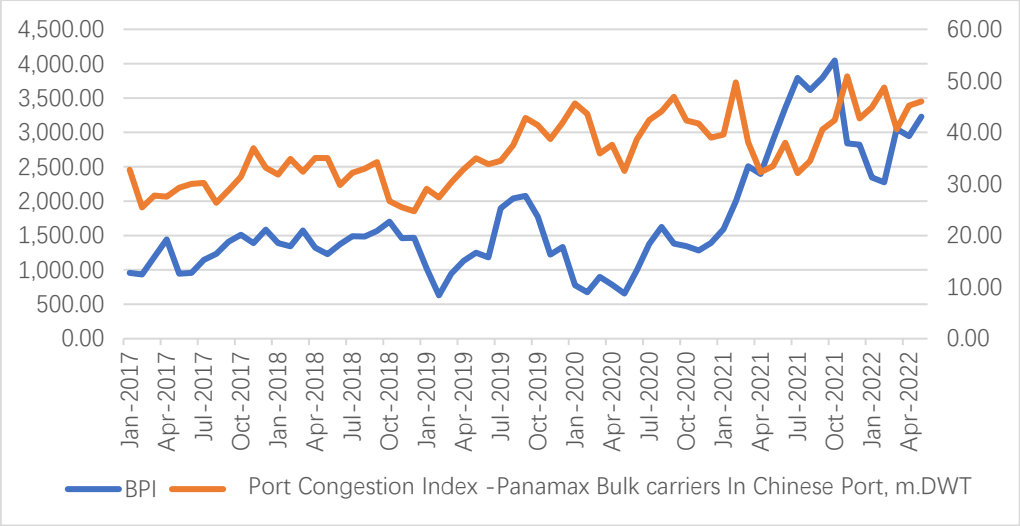


Figure 15 China BPI-Port congestion chart

Source: Clarksons Shipping Intelligence

There is no doubt that the problem of port congestion is caused by the Covid-19. The spread of the Covid-19 forces governments to take strict inspection and quarantine measures against the epidemic. According to the safety notice from the U.S. Coast Guard on February 2, 2020 , the U.S. requires that ships and crew members who have been to China within 14 days can berth at U.S. ports if the crew members are not sick, but the crew members must stay on board unless special activities are required.

However, the USCG believes that if the ship has crew on board at a Chinese port within 14 days, it is a dangerous ship and should be reported to the U.S. Coast Guard immediately.

MPA Singapore maritime and Port Authority issued a port maritime notice on February 1st, 2020, prohibiting the entry of passengers and crew members with recent travel history to Chinese Mainland in the past 14 days, as well as ships that have docked at ports in Chinese Mainland in the past 14 days. That is to say, the increase of various quarantine procedures for people and ships will inevitably increase the non productive berthing time and affect the normal operation plan. The busy Singapore port encountered a large proportion of ships berthing in Chinese Mainland port, which also caused congestion in Singapore transit port. As one of China's largest coal importers, the Australian Border Defense Department announced on February 3 that it would implement strict quarantine measures for ships arriving from China from February 1. If the crew does not report any disease, the ship will work normally. If a crew member reports illness, the ship will be re quarantined for 14 days.

On February 3, 2020, the Philippine Ministry of Health issued a notice saying that the right of ships from China and other countries with a high incidence of Covid-19 to directly berth at the dock was canceled in all ports. Crew members from vessels of the affected ports or countries are prohibited from disembarking. If a ship that has docked in China within two weeks will call in the Philippines, the crew shall issue a maritime health certificate and declare when entering the next local port.

In contrast, the port policy of Brazil, another major iron ore importer of China, is much looser, because the average sailing time between China and Brazil is 45 days, far exceeding the 14 day incubation period of the new coronavirus. The ship only needs to correctly fill in the "maritime health declaration" for the purpose of relevant assessment and Free Pratique.

3.4.2. Newbuilding contracts

For the supply of dry bulk shipping, the new shipbuilding orders and second-hand ship trading volume are also noteworthy data. Due to the sharp contraction of global trade, the dry bulk ship orders decreased significantly in 2020. Affected by the epidemic, investment sentiment in all fields has been severely hit. In 2020, the demand for new dry bulk carriers has reached the bottom, and the number of new orders is the second lowest in the past decade. This decline is largely determined by the supply-demand relationship caused by the Covid-19. The following figure shows the tonnage and shipbuilding price of new orders for dry bulk cargo from 2017 to 2022. It can be observed that at the early stage of the outbreak, there was a significant decline in the volume of new shipbuilding orders, but it was not lower than that in the same period of 2017. Since then, the new shipbuilding orders in 2020 have been slowly decreasing. New shipbuilding orders began to rise in 2021 and began to decline slowly in June. It can be seen from this that the order volume of new shipbuilding has been at a low level during 2020. Even if all countries begin to resume production and dry bulk shipping demand starts to recover, as the shortage of transport capacity is caused by low turnover rate, ship owners will not build new ships on a large scale, and the imbalance between supply and demand of dry bulk carriers still exists in the short term.

Another point is the shipbuilding price. It can be seen from the combination chart that the trading volume of new shipbuilding has matched the volume of new shipbuilding in the past five years. This shows that the unit deadweight price of dry bulk shipbuilding industry has not changed much. However, since 2021, the unit deadweight shipbuilding price has increased significantly. The reason for the increase is likely to be related to the price change of second-hand ships.

The new shipbuilding of dry bulk cargo takes a long time. As can be seen from the figure below, the new shipbuilding cycle of dry bulk cargo is 3 to 4 years, which

also makes the income of dry bulk cargo ships lag behind. Even if the ship owner places an order, it is impossible to get a new ship immediately. The second-hand ship will be favored by the urgent ship owners, which is the same as the shipping market in 2007.

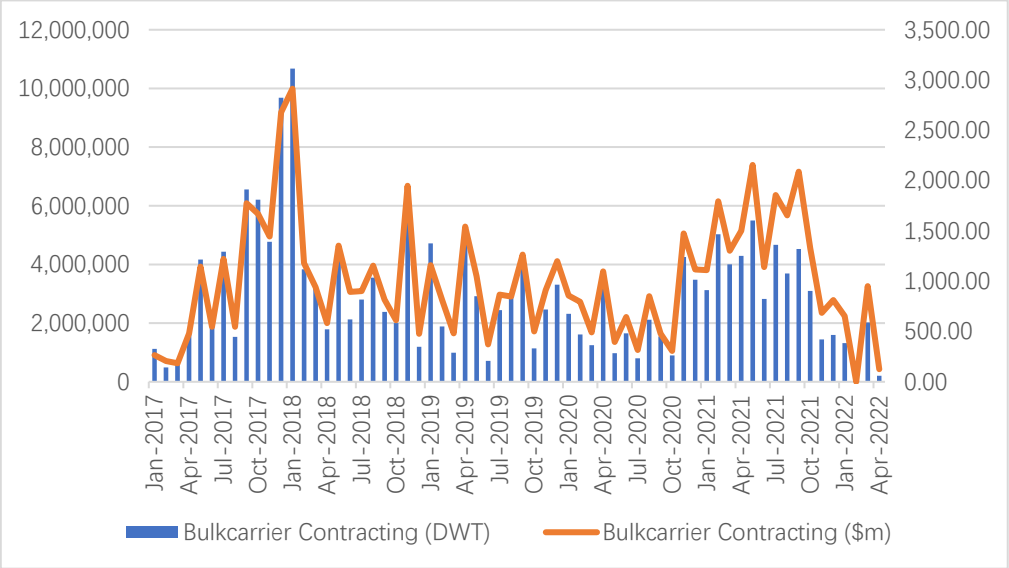


Figure 16 Bulkcarrier contracting

Source: Clarksons Shipping Intelligence

Compared with the long cycle of shipbuilding, it is a better choice to buy second-hand ships and immediately invest in profits. The figure below shows Bulk Carrier Secondhand Price Index and 2 kind of major dry bulk carriers second hand prices. In 2020, the price of second-hand bulk carriers did not change much. Since 2021, the freight rate of dry bulk carriers has soared, which has promoted the significant appreciation of second-hand dry bulk carriers. The price of second-hand dry bulk cargo ships has increased rapidly, and some ship types have even doubled. The weekly report of Xclusiv Shipbrokers showed that, compared with December 2020, the dry bulk carriers with the largest appreciation in December 2021 are those with 15 years of age, among which Capesize ships increased by 70%, Panamax ships increased by 100%, handy ships increased by 110%, and super handy ships increased by 130%. The sharp

rise in the price of second-hand dry bulk carriers is mainly due to the rising demand for dry bulk cargo caused by the resumption of work and production, and the shortage of ships. The port congestion and crew shift change caused by the Covid-19 have further exacerbated the shortage of ship supply. However, if further observation is made, the second-hand ships still have a strong upward trend from 2022, which can no longer be attributed to their freight rate performance, because both BCI and BPI have experienced a sharp decline since September 2021. According to the latest weekly report of Allied Shipbrokers, the shipping brokerage company, the Panamax and Capsize second-hand markets show signs of overheating, which is more likely to be the market foam, The uncertainty of the global economy and Global trade in recent months further supports this view.

Figure 17 Secondhand dry bulk carriers market

Source: Clarksons Shipping Intelligence

4. Quantifying the impacts of Covid-19 on shipping prices by AR-X models

4.1. Description of data and statistical properties

4.1.1. Data Selection

First, we need to study the change of BDI. The cumulative number of weekly confirmed Covid-19 cases in the global was selected as an indicator of the fluctuation of Covid-19. These data are collected from various countries and regions by the novel coronavirus research project of Johns Hopkins University in real time. As a well-known research institution in the field of global medicine and public health, Johns Hopkins University has long carried out interdisciplinary research on social and health problems, and has continued to track Zika virus, measles and so on in recent years. The reason for choosing weekly data is that the Baltic Airlines exchange is closed on weekends. Using weekly data is more conducive to data alignment and improve the accuracy of model regression. In order to deeply explore the impact of the Covid-19 on the international dry bulk market, daily data are selected. Eviews (Economic Views) software is selected for analysis, which is an econometric software package, which can analyze and evaluate time series data scientifically.

And, in order to get more accurate conclusions, the sub index should be modeled again. Therefore, the sub index AR-X model is established based on BCI, BPI and BSI. Previously mentioned, the data of the whole sample is from January 24, 2020 to March 2022. Since the outbreak of the epidemic, all parts of the country have successively initiated the first-class response, including work shutdown, business suspension, production activities shutdown, village closure, road closure and community closure.

The sudden outbreak of Covid-19 is rampant, and China's economy and manufacturing industry are nearly shut down, resulting in a sharp decline in the demand for dry bulk cargo shipping. The suspension and shutdown continued until May 2020. The epidemic situation is sporadic in China. There were concentrated epidemics caused by sporadic cases in some areas. The imported cases from abroad were basically controlled. The positive trend of the epidemic situation continued to consolidate, and the national epidemic prevention and control entered normalization.

With regard to the resumption of work and production, the Chinese government has scientifically divided the risk level of the epidemic into three categories: low, medium and high according to the comprehensive study and judgment of the regional population and the incidence of the disease. Since the second quarter, GDP has changed from negative to positive, making China the first major economy in the world to regain positive economic growth. There is no doubt that the rise and fall of China's manufacturing industry is related to the dry bulk market. Although the BDI decline caused by the initial outbreak of the epidemic is only a few months, it interferes with the model results. Therefore, the epidemic period will be more meaningful after the sub index AR-X model is discussed

Therefore the data from May 2020 to March 2022 were selected. Such sub samples defined as COVID2 were originally excluded from the epidemic raging in China before May and the highly transmissible variation of Omicron virus in 2022.

The statistical data of the Covid-19 in Johns Hopkins University began on January 24, 2020. The weekly data from January 24, 2020 to March 21, 2022 (so far) are selected as the sample interval for regression analysis. The missing data is processed by linear interpolation. BDI, BCI, BPI, BSI data comes from Clarksons, and the global epidemic data are compiled from the data release of John Princeton University (JHU) and the National Statistics website Worldometer.

4.1.2. Data Processing

In order to reduce the fluctuation of weekly data of time series and the influence of orders of magnitude between different sequences, logarithm processing is taken for Baltic indices and Covid-19 data, namely dlnBDI, dlnBCI, dlnBPI, dlnBSI and dlnCOVID. The subinterval named as dlnCOVID2.

Table 2 ADF test

	t-Statistic	10% level	5% level	1% level	Prob.*	Null Hypothesis
lnCOVID	-4.453028	-2.580046	-2.886290	-3.487046	0.0004	reject
lnBDI	-2.240591	-3.486064	-2.885863	-2.579818	0.1933	accept
dlnBDI	-7.086516	-3.486064	-2.885863	-2.579818	0.0000	reject
lnCOVID2	-3.887905	-2.579708	-2.885654	-3.485586	0.0029	reject
lnBCI	-3.318891	-2.580908	-2.887909	-3.490772	0.0163	accept
dlnBCI	-5.684008	-2.581041	-2.888157	-3.491345	0.0000	reject
lnBPI	-2.030842	-2.579818	-2.885863	-3.486064	0.2734	accept
dlnBPI	-9.143107	-2.579818	-2.885863	-3.486064	0.0000	reject
lnBSI	-1.394788	-2.579818	-2.885863	-3.486064	0.5828	accept
dlnBSI	-6.794166	-2.579818	-2.885863	-3.486064	0.0000	reject

Table 1 shows that the t-statistic of COVID time series is -4.453028, which is less than the confidence level of 10%, 5% and 1%. The Null Hypothesis that there is a unit root can be rejected at the level of 1%, and "McKinnon's approximate p value" is 0.0004. Therefore, COVID is considered to be a stationary series without unit root. The t-statistic of lnBDI time series is -2.240591, which is greater than the confidence level of 10%, 5% and 1%. The Null Hypothesis that there is a unit root cannot be rejected at the level of 1%. Moreover, the "approximate p value of McKinnon" is

0.1933, so lnBDI is considered to contain a unit root. The t-statistic of dlnBDI time series is -7.086516, which is less than the confidence level of 10%, 5% and 1%. The Null Hypothesis that there is a unit root can be rejected at the level of 1%, and "McKinnon's approximate p value" is 0.0000. dlnBDI is considered to be a stationary series without unit root. lnCOVID2, dlnBCI dlnBPI and dlnBSI after the first-order difference are stationary sequences. The null assumption that there is a unit root is rejected and can be used as the input variables of the model.

To reduce the fluctuation of weekly data of time series and the influence of orders of magnitude between different sequences, logarithm processing is taken for BCI, BPI, BSI and Covid-19 data, namely dlnBCI, dlnBPI, dlnBSI and dlnCOVID2.

Table 3 Descriptive stats

Variable	Observations	Mean	Std. Dev.	Minimum	Maximum
DLNCOVID	122	0.1058	0.2435	0.0042	2.1255
DLNCOVID2	111	0.0549	0.0574	0.0071	0.3809
DLNBDI	122	0.0132	0.1210	-0.2767	0.4785
DLNBCI	111	0.0277	0.3635	-2.0734	1.5116
DLNBPI	122	0.0120	0.1038	-0.2115	0.2397
DLNBSI	122	0.0133	0.0744	-0.2446	0.2717

4.1.3. Model Demonstration

This model is devoted to exploring the correlation between Covid-19, BDI. The traditional regression model is based on the clear causal relationship between explanatory variables and explained variables. In this model, the epidemic situation is added as an exogenous variable x. The AR-X model is established as follows:

$$dlnY^{BDI} = \sum_{i=1}^{m} a_i dlnY^{BDI}{}_{t-i} + \sum_{j=1}^{n} b_j dlnX^{COVID}{}_{t-j} + \varepsilon_t \quad (4-1)$$

$$dlnY^{BCI} = \sum_{i=1}^{m} c_i dlnY^{BCI}{}_{t-i} + \sum_{j=1}^{n} d_j dlnX^{COVID2}{}_{t-j} + \varepsilon_t \quad (4-2)$$

$$dlnY^{BPI} = \sum_{i=1}^{m} e_i dlnY^{BPI}{}_{t-i} + \sum_{j=1}^{n} f_j dlnX^{COVID2}{}_{t-j} + \varepsilon_t \quad (4-3)$$

$$dlnY^{BSI} = \sum_{i=1}^{m} g_i dlnY^{BSI}{}_{t-i} + \sum_{j=1}^{n} h_j dlnX^{COVID2}{}_{t-j} + \varepsilon_t \quad (4-4)$$

Table 4 Variable interpretation

Symbols	variable	Variable type
$dlnY^n$(n=D, C, P, S)	First order difference after logarithm of BDI, BCI, BPI, BSI	Explained variable
$dlnX^m$(m=COVID,COVID2)	Cumulative number of confirmed cases per week of COVID-19, The interval of COVID2 is from May 2020 to December 2021	Explanatory variable
$dlnY^n{}_{t-i}$	Baltic indices with order lag i	Lag term
$dlnX^m{}_{t-j}$	Covid cases with order lag j	Lag term
ε_t	White noise sequence	Parameter

$dlnY$, $dlnX$, respectively represents dlnBDI, dlnBCI, dlnBPI, dlnBSI, lnCOVID,

lnCOVID2, $dlnY_{t-i}$, $dlnX_{t-j}$ represent lag order i, j; ε_t, is Constant term; a_i, b_i, is the regression parameter.

4.1.4. Empirical results

For the BDI model. Through Akaike info criterion (AIC) and Schwarz criterion (SC), we can select the first lag order and second lag order of the explained variable and the first lag order of the explanatory variable, and the following results are obtained:

Table 5 Model result for BDI model

Variable	Coefficient	Std. Error	t-Statistic	Prob.	significance
DLNBDI(-1)	0.689209	0.104479	6.596626	0.0000	***
DLNBDI(-2)	-0.275918	0.104686	-2.635685	0.0100	***
DLNCOVID(-1)	0.177657	0.163655	1.085559	0.2807	

$$dlnY^{BDI} = 0.689dlnY^{BDI}{}_{-1} - 0.276dlnY^{BDI}{}_{-2} + 0.178dlnX^{COVID}{}_{-1} \quad (4-5)$$

Further, the test of autocorrelation and heteroscedasticity of the residual sequence of the regression equation shows that the model has no autoregressive phenomenon, heteroscedasticity and arch effect, indicating that the model can fit the sequence well.

Q-statistic probabilities adjusted for 2 dynamic regressors

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	-0.050	-0.050	0.2315	0.630
		2	0.003	0.000	0.2323	0.890
		3	-0.067	-0.067	0.6489	0.885
		4	-0.047	-0.054	0.8590	0.930
		5	-0.137	-0.144	2.6488	0.754
		6	-0.149	-0.176	4.8059	0.569
		7	0.112	0.084	6.0345	0.536
		8	0.074	0.066	6.5791	0.583
		9	0.042	0.017	6.7595	0.662
		10	-0.129	-0.158	8.4428	0.586
		11	0.010	-0.040	8.4541	0.672
		12	-0.057	-0.047	8.7882	0.721
		13	-0.116	-0.093	10.198	0.678
		14	0.161	0.166	12.982	0.528
		15	0.064	0.040	13.424	0.570
		16	0.206	0.155	18.077	0.319
		17	-0.105	-0.082	19.296	0.312
		18	-0.222	-0.287	24.864	0.129
		19	0.051	0.085	25.164	0.155
		20	-0.169	-0.093	28.493	0.098
		21	-0.061	-0.049	28.934	0.116
		22	0.031	0.022	29.053	0.143
		23	0.160	-0.025	32.173	0.097
		24	-0.048	-0.101	32.456	0.116
		25	-0.027	-0.048	32.548	0.143
		26	-0.021	0.003	32.602	0.174
		27	-0.035	-0.006	32.764	0.205
		28	0.037	0.040	32.945	0.238
		29	-0.063	-0.029	33.481	0.259
		30	0.195	0.010	38.692	0.133
		31	-0.012	-0.061	38.713	0.161
		32	-0.056	-0.034	39.154	0.180
		33	-0.064	-0.035	39.738	0.195
		34	-0.168	-0.108	43.860	0.120
		35	-0.021	-0.068	43.925	0.143
		36	-0.009	0.002	43.938	0.171

Figure 18 Autoregressive test for BDI model

Table 6 ARCH test for BDI model

Heteroskedasticity Test: ARCH			
F-statistic	1.071456	Prob. F(1,85)	0.3036
Obs*R-squared	1.083015	Prob. Chi-Square(1)	0.2980

For the BCI model. Through Akaike info criterion (AIC) and Schwarz criterion (SC), we can select the second lag order, the third lag order and the fourth lag order of the explained variable and the first lag order of the explanatory variable, and the following results are obtained:

Table 7 Model result for BCI model

Variable	Coefficient	Std. Error	t-Statistic	Prob.	significance
DLNBCI(-2)	0.429965	0.090353	4.758733	0.0000	***
DLNBCI(-3)	-0.242469	0.087748	-2.763254	0.0070	***
DLNBCI(-4)	-0.463170	0.088642	-5.225195	0.0000	***
DLNCOVID2 (-1)	0.634578	0.494946	1.282116	0.2033	

The R-square is 0.3701 which fits well, the Akaike info criterion is 0.492, the Schwarz criterion is 0.605. Further, the test of autocorrelation and heteroscedasticity of the residual sequence of the regression equation shows that the model has no autoregressive phenomenon, heteroscedasticity, and arch effect, indicating that the model can fit the sequence well.

$$dlnY^{BCI} = 0.430dlnY^{BCI}{}_{-2} - 0.242dlnY^{BCI}{}_{-3} - 0.463dlnY^{BCI}{}_{-4} + 0.635dlnX^{COVID2}{}_{-1} \quad (4-6)$$

Q-statistic probabilities adjusted for 3 dynamic regressors

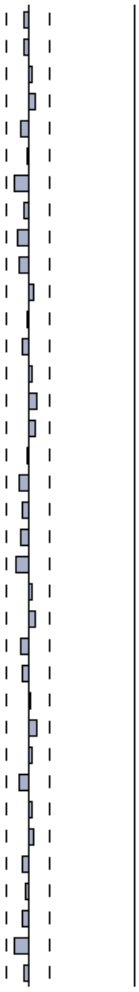
Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	-0.049	-0.049	0.2195	0.639
		2	-0.049	-0.051	0.4361	0.804
		3	0.042	0.037	0.6030	0.896
		4	0.070	0.073	1.0713	0.899
		5	-0.080	-0.069	1.6779	0.892
		6	-0.004	-0.007	1.6797	0.947
		7	-0.124	-0.140	3.1926	0.867
		8	-0.038	-0.052	3.3346	0.912
		9	-0.099	-0.109	4.3194	0.889
		10	-0.098	-0.113	5.2941	0.871
		11	0.056	0.055	5.6154	0.898
		12	-0.008	-0.020	5.6218	0.934
		13	-0.058	-0.042	5.9749	0.947
		14	0.035	0.004	6.1092	0.964
		15	0.089	0.052	6.9777	0.958
		16	0.079	0.079	7.6720	0.958
		17	-0.004	-0.020	7.6735	0.973
		18	-0.098	-0.120	8.7533	0.965
		19	-0.057	-0.115	9.1265	0.971
		20	-0.076	-0.128	9.8054	0.972
		21	-0.113	-0.125	11.324	0.956
		22	0.044	0.038	11.554	0.966
		23	0.070	0.103	12.145	0.968
		24	-0.071	-0.006	12.767	0.970
		25	-0.051	-0.055	13.097	0.975
		26	0.019	-0.063	13.145	0.983
		27	0.085	0.008	14.079	0.980
		28	0.040	-0.002	14.289	0.985
		29	-0.084	-0.114	15.228	0.983
		30	0.043	-0.015	15.483	0.987
		31	0.052	-0.011	15.853	0.989
		32	-0.065	-0.060	16.452	0.990
		33	-0.030	-0.028	16.583	0.992
		34	-0.055	-0.084	17.032	0.993
		35	-0.139	-0.132	19.923	0.981
		36	-0.044	-0.075	20.213	0.984

Figure 19 Autoregressive test for BCI model

Table 8 ARCH test for BCI model

Heteroskedasticity Test: ARCH			
F-statistic	3.271532	Prob. F(1,85)	0.0740
Obs*R-squared	3.224406	Prob. Chi-Square(1)	0.0725

For the BPI model. Through Akaike info criterion (AIC) and Schwarz criterion (SC), we can select the first lag order and second lag order of the explained variable and the first lag order of the explanatory variable, and the following results are obtained:

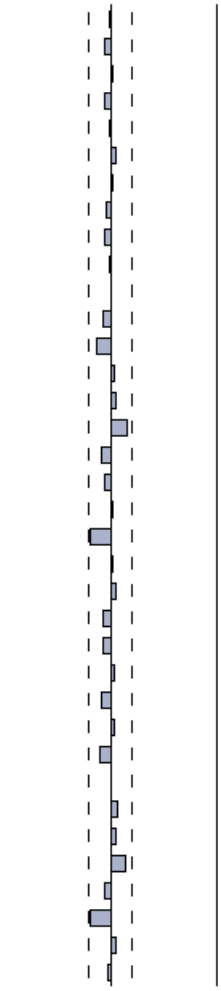
Table 9 Model result for BPI model

Variable	Coefficient	Std. Error	t-Statistic	Prob.	significance
DLNBPI(-1)	0.339627	0.094049	3.611149	0.0005	***
DLNBPI(-2)	-0.289459	0.093774	-3.086772	0.0026	***
DLNCOVID2(-1)	0.252591	0.150546	1.677829	0.0964	***

The R-square is 0.225 which fits well, the Akaike info criterion is -1.984, the Schwarz criterion is -1.900. Further, the test of autocorrelation and heteroscedasticity of the residual sequence of the regression equation shows that the model has no autoregressive phenomenon, heteroscedasticity and arch effect, indicating that the model can fit the sequence well.

$$dlnY^{BPI} = 0.340 dlnY^{BPI}{}_{-1} - 0.289 dlnY^{BPI}{}_{-2} + 0.253 dlnX^{COVID}{}_{-1} \quad (4-7)$$

Q-statistic probabilities adjusted for 2 dynamic regressors



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	-0.010	-0.010	0.0097	0.921
		2	-0.062	-0.062	0.3655	0.833
		3	0.019	0.018	0.3986	0.941
		4	-0.050	-0.053	0.6298	0.960
		5	-0.004	-0.003	0.6317	0.987
		6	0.053	0.047	0.9061	0.989
		7	0.021	0.023	0.9475	0.996
		8	-0.043	-0.039	1.1269	0.997
		9	-0.063	-0.064	1.5211	0.997
		10	-0.007	-0.009	1.5263	0.999
		11	0.000	-0.004	1.5263	1.000
		12	-0.077	-0.083	2.1450	0.999
		13	-0.125	-0.139	3.8026	0.993
		14	0.040	0.029	3.9734	0.996
		15	0.061	0.059	4.3756	0.996
		16	0.162	0.174	7.2618	0.968
		17	-0.089	-0.103	8.1516	0.963
		18	-0.060	-0.047	8.5656	0.969
		19	0.025	0.029	8.6350	0.979
		20	-0.202	-0.202	13.409	0.859
		21	0.025	-0.016	13.482	0.891
		22	0.065	-0.001	13.992	0.902
		23	-0.071	-0.053	14.612	0.908
		24	-0.076	-0.072	15.332	0.911
		25	0.033	0.018	15.468	0.930
		26	-0.093	-0.110	16.580	0.921
		27	0.036	0.065	16.753	0.937
		28	-0.102	-0.122	18.138	0.923
		29	0.012	0.021	18.157	0.941
		30	0.068	0.007	18.785	0.944
		31	0.055	0.043	19.212	0.951
		32	0.145	0.117	22.203	0.902
		33	-0.064	-0.106	22.790	0.909
		34	-0.190	-0.176	28.072	0.753
		35	0.050	0.043	28.452	0.775
		36	-0.021	-0.006	28.517	0.808

Figure 20 Autoregressive test for BPI model

Table 10 ARCH test for BPI model

Heteroskedasticity Test: ARCH			
F-statistic	0.945623	Prob. F(1,85)	0.3336
Obs*R-squared	0.957224	Prob. Chi-Square(1)	0.3279

For the BSI model. Through Akaike info criterion (AIC) and Schwarz criterion (SC), we can select the first lag order and second lag order of the explained variable and the first lag order of the explanatory variable, and the following results are obtained:

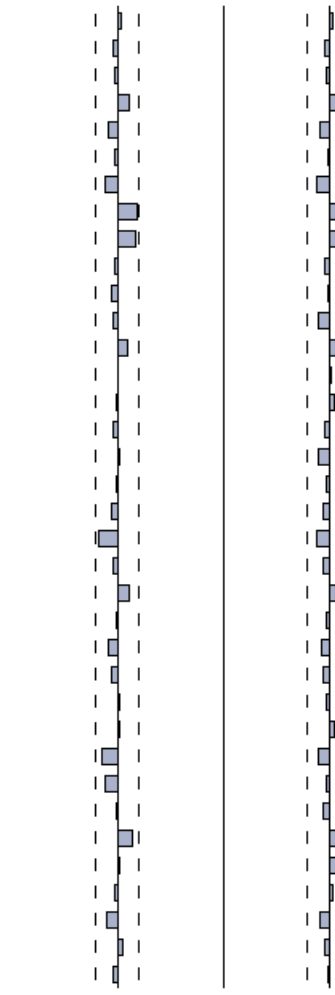
Table 11 Model result for BSI model

Variable	Coefficient	Std. Error	t-Statistic	Prob.	significance
DLNBSI(-1)	0.670294	0.092431	7.251866	0.0000	***
DLNBSI(-2)	-0.286708	0.091327	-3.139359	0.0022	***
DLNCOVID2(-1)	0.227444	0.088126	2.580906	0.0112	***

The R-square is 0.345 which fits well, the Akaike info criterion is -3.046, the Schwarz criterion is -2.961. Further, the test of autocorrelation and heteroscedasticity of the residual sequence of the regression equation shows that the model has no autoregressive phenomenon, heteroscedasticity and arch effect, indicating that the model can fit the sequence well.

$$dlnY^{BSI} = 0.670 dlnY^{BSI}{}_{-1} - 0.287 dlnY^{BSI}{}_{-2} + 0.227 dlnX^{COVID}{}_{-1} \qquad (4-8)$$

Q-statistic probabilities adjusted for 2 dynamic regressors



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	0.037	0.037	0.1247	0.724
		2	-0.036	-0.037	0.2443	0.885
		3	-0.030	-0.028	0.3299	0.954
		4	0.121	0.123	1.7180	0.787
		5	-0.083	-0.096	2.3763	0.795
		6	-0.032	-0.016	2.4722	0.872
		7	-0.115	-0.114	3.7733	0.805
		8	0.197	0.194	7.6307	0.470
		9	0.183	0.186	10.976	0.277
		10	-0.023	-0.039	11.029	0.355
		11	-0.052	-0.011	11.304	0.418
		12	-0.033	-0.105	11.420	0.493
		13	0.105	0.112	12.579	0.481
		14	0.001	0.029	12.579	0.560
		15	-0.006	0.053	12.583	0.634
		16	-0.039	-0.033	12.747	0.691
		17	0.026	-0.103	12.824	0.748
		18	-0.010	-0.018	12.834	0.801
		19	-0.061	-0.061	13.266	0.825
		20	-0.178	-0.109	16.975	0.655
		21	-0.043	-0.059	17.191	0.699
		22	0.114	0.079	18.748	0.661
		23	-0.008	-0.028	18.756	0.715
		24	-0.086	-0.076	19.676	0.715
		25	-0.058	-0.057	20.106	0.741
		26	0.027	-0.017	20.198	0.782
		27	0.030	0.064	20.315	0.817
		28	-0.152	-0.101	23.367	0.714
		29	-0.121	-0.031	25.330	0.661
		30	-0.002	-0.062	25.330	0.709
		31	0.144	0.108	28.195	0.611
		32	0.022	0.091	28.265	0.656
		33	-0.022	0.042	28.332	0.699
		34	-0.105	-0.097	29.959	0.666
		35	0.060	-0.049	30.505	0.685
		36	-0.034	-0.004	30.686	0.719

Figure 21 Autoregressive test for BSI model

Table 12 ARCH test for BSI model

Heteroskedasticity Test: ARCH			
F-statistic	14.09229	Prob. F(1,85)	0.3230
Obs*R-squared	12.37260	Prob. Chi-Square(1)	0.3263

4.1.5. Result Analysis

In BDI model the coefficient before the lag of explanatory variable is 0.178, but the P value of this coefficient is 0.28, which is not statistically significant. The coefficient of the explained variable before the first lag order is positive and the coefficient before the second lag order is negative, which is statistically significant. Therefore, COVID-19 has no significant impact on BDI in the whole sample range. This conclusion does not mean that the epidemic has no impact on BDI, but due to a variety of complex factors, the impact of the epidemic on BDI shows dynamic changes, especially the factor of China's resumption of work and production. China's important position in the global dry bulk cargo market has also been mentioned many times in the previous analysis. Due to the differences in China's anti epidemic measures, there was basically no epidemic in China after May 2020. This year, the powerful Omicron virus swept China again, causing shutdown again.

In addition, due to the different types and haul distances of the three main ship types of dry bulk cargo, Capesize, Panamax and Supramax, the impact of the epidemic on the three constituent indicators of BDI, which is the BCI, BPI and BSI may also be different. Therefore, we must optimize the above BDI ARX model and re-establish a new model to analyze the impact of the epidemic on the dry bulk market of specific ship types in a specific period of time.

In the BCI model, the coefficient before the lag of explanatory variable is 0.634, but the P value is 0.2033, which is not statistically significant. However, T statistic is much larger than 1 which can not be ignored in econometrics. Therefore, this lag term can also be regarded as significant. This result shows, when the number of confirmed cases lags behind the first phase and increases by one unit, BCI will also increase by 0.63% units. This is enough to show that the growth of the epidemic has a great impact on BCI. In other words, with the increase of the number of people infected with novel

coronavirus, the freight rate of bulk cargo such as coal and iron ore will also rise. As mentioned earlier, most of Capesize vessels are loaded with Iron ore, coking coal, thermal coal, which is important industrial raw materials just like vessels. Similar laws can be found on BPI.

According to the AR-X model, it can be seen that the capsize ship is greatly impacted by the epidemic. Because iron ore and coal account for the largest proportion in dry bulk transportation. After China returns to work in May 2020, the increase in the number of infected people has a positive impact on BCI freight rates. The growth of BCI is mainly due to the impact of supply. On the one hand, it is the lack of transport capacity caused by the epidemic, on the other hand, it is the port congestion caused by the epidemic prevention policy. As for demand, the strong demand after the resumption of work has indeed driven the demand for dry bulk shipping, but the Sino Australian trade dispute has a more significant impact on the freight rate of dry bulk.

In the BPI model, the coefficient before the lag of explanatory variable is 0.442, the P value is 0.0001, which is statistically significant. The coefficient of the explained variable before the first lag order is positive and the coefficient before the second lag order is negative, which is statistically significant as well. The results of the model show that when the number of confirmed cases lags behind the first phase and increases by one unit, BPI will also increase by 0.25% units, which means after the resumption of work and production in China until March 2022, the Covid-19 has a significant impact on BPI , and the impact is positive. Panamax ships are mainly used to transport people's livelihood, grain and other bulk materials. This shows that the demand for grain shipping in the post epidemic period is growing. In addition, Panamax ships also need to transport resources such as thermal coal, which is mainly used for near ocean transportation between some neighboring countries. Therefore, Panamax ships also have the same increase in coal transportation demand as Capesize ships.

The situation of Panamax ships is similar to that of Capsize ships. However, because some Panamax ships still need to transport grain, they are not as driven by the demand side as Capsize ships. Although they are also affected by the port congestion caused by the epidemic, in the second quarter of 2021, the problem of Panamax ships' congestion in Chinese ports was that they could not berth due to the trade conflict between China and Australia. On the other hand, With the surge in demand for Panamax vessels, charter rates rose in 2021. This led operators to increase sailing speeds on laden as well as ballast legs. However, due to the GHG emission specification, the speed cannot be significantly increased. This will also lead to the failure of timely dispatch of transport capacity.

In BSI model, the impact of the Covid-19 is also positive. the coefficient before the lag of explanatory variable is 0.233, the P value of this coefficient is 0.0116, which is statistically significant. The coefficient of the explained variable before the first lag order is positive and the coefficient before the second lag order is negative, which is statistically significant as well. This also means that the epidemic is also contribute to dry bulk shipping demand to grow by 4.6% in 2021 on account of surging grain and minor bulk trades. The impact of the epidemic on the Supramax ship is also positive, In 2021, Supramax bulkers demand increased by 4.4%.China’s woodchip imports from Vietnam, Australia, Thailand and Chile inflated in 2021. Two-third of the global trade of woodchips and wood pulp is shipped on Supramaxes; hence, any expansion in demand would generate demand for these vessels on long haul routes.

Moreover, port congestion also increased in 2021. Congestion at Brazilian grain load ports has been seasonal, usually seen in the first half of every year. However, the waiting days in 2021 were more, hampering vessel supply in the Pacific. The congestion at the Japanese and Chinese discharge ports was also high in 2021 mostly due to Covid-related measures. The waiting period increased at Chinese ports, particularly in South China.

From the middle of 2020 to the end of 2021, the overall growth of the dry bulk cargo transportation market is as follows: large ships take the lead and small ships take the lead. Since China's economic recovery, China’s iron ore and coking coal imports due to the expanding crude steel production in the country. Huge stockpiles have started to recede from Chinese steel mills, which had soared initially when the spread of coronavirus was limited to China. Therefore, it is not surprising why China will have such a large demand for dry bulk shipping after May. Although many countries have resumed their economic activities, it was still hard to make production centres return to normalcy.

On the other hand, the ongoing pandemic-induced lockdowns and low availability of workforce at the discharge ports in China are decelerating port activities, leading to record-high congestion which will squeeze effective availability of vessels. Covid-19-related precautionary measures have also brought in disruptions while discharging cargoes, adding to the overall congestion. This factor also led to the rise of BCI.

Moreover, due to the unprecedented rates of containers, some container cargo has been diverting to dry bulk vessels. Some shippers have hired bulk carriers to carry containers, in turn, fueling the positive market sentiments for dry bulk vessel demand. This is also the indirect reason for the increase of BPI caused by the epidemic

5. Suggestions and conclusions

5.1. Suggestions

5.1.1. Suggestion for ship owners

For the ship owners, the current profit situation is really good. Take things as they come. The dry bulk ship owners should reasonably allocate transport capacity to meet the import and export demand of dry bulk cargo as soon as possible. In addition, dry bulk shipping enterprises should cooperate with each other to actively deal with possible lease disputes and legal risks. While making plans for possible contract disputes, we should make good use of the relevant epidemic provisions of the Baltic shipping union to reasonably protect the contractual interests of dry bulk shipping enterprises; In addition, dry bulk shipping enterprises should strengthen transparency, further share cargo information, reduce communication costs, and jointly do a good job in risk prevention and control. Not only do a good job in centralized procurement when the fuel price is favorable, but also share information when soliciting goods to jointly prevent the risk of freight funds.

What's more, since the transport capacity of dry bulk carriers is insufficient, ship company should reduce the unreasonable business of loading containers on dry bulk carriers

5.1.2. Suggestion for ports

At present, the global trade in goods continues to recover strongly from the impact of

the COVID-19, and the port transport volume and price rise simultaneously. It is particularly important to smooth the port hub. Port container transportation system is an organic whole composed of multiple departments and links. To solve the problem of port congestion involves multi-party game. At present, in order to increase profits during the period of high freight rates, dry bulk shipping enterprises are purchasing a large number of second-hand ships, and the new shipbuilding orders have also increased. In the future, the probability of port congestion will still increase. In this regard, the port authority and the transport department must make design changes to the harbor basin and channel and build a stronger collection and distribution infrastructure; The terminal operator must replace the handling equipment and purchase more reliable cranes. However, these renovation projects have huge investment and long payback period, which makes it difficult to implement. In the absence of unified coordination, port congestion often becomes a cyclical problem of mutual prevarication. It is noteworthy that due to the severe epidemic situation in Shanghai. SIPG is strengthening the cultivation of market players in multimodal transport, strengthening the connection with surrounding ports, reducing the pressure of collection and distribution by sacrificing part of the benefits through the water-to-water transfer mode, and resolving the risk of port congestion through comprehensive logistics solutions.

In addition to serving as the node of cargo circulation, ports also bear the important responsibility of national and regional epidemic prevention and control. This attribute determines that the port enterprises cannot take the maximization of shipping efficiency as the fundamental principle of operational policy-making. Port enterprises themselves do not have much say in the import and export rules and regulations of goods trade under the control of the government. As far as China is concerned, there are a large number of state-owned enterprises operating at each node of China's shipping industry. The Chinese government can also formulate policies to strengthen

cooperation between ports and cooperation between ports and shipping enterprises. Accelerate the digital transformation of the port, integrate the data of industrial production, market procurement and port and shipping logistics, realize the sharing of information across departments, optimize and balance port resources by using big data analysis, and carry out early warning and assessment of market fluctuations caused by uncontrollable factors such as epidemic.

5.2. Conclusions

First of all, the impact of the epidemic on the dry bulk shipping market is obvious, which can be proved by both quantitative and qualitative analysis. The impact of the epidemic on dry bulk shipping mainly affects demand and supply. As the country with the largest dry bulk import and export, China has the greatest impact. In terms of demand, at the outbreak stage of the COVID-19, China suffered the most serious impact. In the first two months, China's industry almost stopped, and the dry bulk shipping industry also suffered a heavy blow.

With the resumption of work and production in China, the demand for iron ore and coal is growing, and the demand for dry bulk cargo shipping is rising rapidly, but the increase is limited. Unlike the order return phenomenon of containers, most of the processing and production of dry bulk cargo are carried out in China. There is no change in the shipping structure of dry bulk cargo transportation, and there is no problem of empty container turnover. In terms of supply, the dry bulk market has been in short supply since China resumed production. The sharp increase in the trading volume of second-hand ships can explain the serious shortage of dry bulk ship capacity. In addition, the port congestion caused by the epidemic is very serious, which can almost be regarded as the main reason for the rise in freight rates. The impact of the epidemic on oil prices is not significant, and the biggest factor affecting oil prices is

still due to the negotiations among oil producing countries. Although the oil price is an important component of the freight rate of dry bulk cargo, the influence of the oil price on the freight rate is very limited in the market where the supply exceeds the demand. In conclusion, the supply shortage caused by the epidemic has a greater impact on the dry bulk market than the increase in demand, and the biggest bottleneck in supply is port congestion.

According to the ARX model and BDI trend chart, we cannot deny that although the dry bulk shipping industry was severely damaged in the outbreak stage, since China resumed work and production, the black swan incident has become a major positive for the dry bulk shipping enterprises, and it can even be said that the outbreak has led to the revival of the entire shipping industry. The post epidemic stage has aroused people's demand for shipping all over the world. At first, in order to cope with the impact of the epidemic, the dry bulk carrier company reduced the input of transport capacity to maintain the freight rate, and the dry bulk port also controlled the cost by reducing workers. However, with the recovery of trade demand, dry bulk cargo transportation has changed from supply exceeds demand to demand exceeds supply. However, the epidemic prevention policies of various countries are still effective in ports, which inevitably leads to the growth of ship berthing cycle.

On the other side of the port, affected by the epidemic, the flow of people is restricted, the operation efficiency is reduced, and the collection and distribution of land transportation is also greatly affected. However, some ports in some countries have exposed the problem of aging equipment due to overload operation. A number of factors eventually lead to congestion. To sum up, strong demand, port congestion, lack of transport capacity and shortage of port equipment have led to a sharp rise in freight rates. The trend of the global epidemic determines the congestion of the port to some extent. If the global epidemic is not effectively controlled, crew exchanges will continue to be limited, and the port will continue to operate at full capacity for a long

time, which will continue to aggravate port congestion and shipping delays. For shipping companies, the profit is only short-lived. The high cost of dry bulk shipping will act on the real economy, causing a series of chain effects, and may eventually trigger a major crisis at the national level. In other words, the rising freight rate of dry bulk cargo is not the normal growth of international trade volume, which is harmful to the global manufacturing industry and economic development. In addition, the outbreak of Omicron virus in China in the second quarter of this year once again had a negative impact on the dry bulk shipping industry. It is precisely because the epidemic is constantly generating a series of uncertain variables.

In the long run, the threat of the epidemic to the shipping industry is far greater than the opportunity. There is no need for the government to intervene in the freight rate. Because for the dry bulk market, which is a completely competitive market, the freight rate is the market result of the bidding game between all parties. However, governments of all countries should cooperate and devote themselves to how to thoroughly solve the epidemic as they did with H1N1 and SARS in those years, instead of politicizing the epidemic and allowing the virus to mutate. Vaccines alone cannot do it once and for all. The dry bulk shipping enterprises should accurately grasp the trend of epidemic development, reasonably develop business, organize transport capacity, and strengthen cooperation to deal with potential risks. The port should be committed to upgrading the technical level to alleviate the low efficiency of the port caused by the Covid-19. Countries and relevant governments should accelerate the improvement of shipping inefficiency caused by crew isolation and travel restrictions, promote the implementation of relevant policies, and help the manufacturing industry and the global economy survive the cold winter.

Port congestion led to a significant increase in average non sailing days, which unexpectedly boosted the strong recovery of the dry bulk market last year. Conversely, the speed of congestion relief in the future will also be an important factor affecting

the future direction of the dry bulk market. Next, we should all pay more attention to the further impact of Omicron novel coronavirus, including the impact on demand, quarantine restrictions and port congestion.

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