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# Analysis of the Impact of Large Container Ships on Port Capacity

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**Abstract:** ***Facing the fierce competition in the shipping market, major container liner companies are constantly increasing the scale of container ship construction in pursuit of scale effect, and the trend of large-scale development of container ships is increasingly obvious. The enlargement of container ships not only intensifies the competition of shipping companies, but also brings profound changes to the port's facilities and equipment. This paper analyzes the development process, background and reasons of the large-scale container ships, as well as the future development trend of large-scale ships. The qualitative and quantitative method was used to analyze the current status of ship enlargement on the development status. Through the corresponding data and cases, combined with the current rise of international trade protectionism and the global spread of new pneumonia, the impact of ship enlargement on port development was analyzed with a view to the port Development provides corresponding theoretical references and suggestions.***

**Keywords:** Large-scale ships; Port development; Scale effect.

## 1. INTRODUCTION

Due to the increasing competition in the international shipping market, price fluctuations caused by the shortage of oil resources, and the slowdown in the growth of world trade volume, shipping companies are more inclined to order large-scale purchases in terms of reducing costs, obtaining economies of scale, improving market competitiveness, and protecting the environment. Container ship. According to incomplete statistics, there are more than 100 container ships with more than 18000TEU in the world, and a considerable number of orders are still being built in the shipyards of China and South Korea. After these large container ships are successively put into the shipping market, it will inevitably intensify the shipping companies. Competition. In order to meet the needs of the market, large-scale ships, relying on its excellent scale and environmental effects have brought new vitality to the shipping market. But at the same time, it also poses new challenges to port terminal facilities, port operation efficiency, port distribution system and port hub port competition. Under the trend of large-scale container ships, port water depth, loading and unloading capacity, supporting facilities for gathering and transportation are facing severe tests. Therefore, this article mainly discusses the impact of large container ships on ports and container transportation, and how ports should respond to the trend of large container ships.

Experts and scholars have conducted a lot of research and exploration on the impact of container ship enlargement on ports from different angles. H.Zhuang analyzed the process and trends of large-scale international container ships and the impact on the development of container ports, and proposed measures that my country's container ports should make in response to the trend of large-scale container ships [1]. J.S.Zhu discussed the scale effect of the large-scale container ship, analyzed the main limiting factors of the large-scale scale effect of several ships, and proposed that the port loading and unloading and management should have higher efficiency [2]. S.S.Huang analyzed the impact of container ship large-scale trends on port operations [3]. Starting from the current situation of large- scale container ships, Y.S.Li analyzed its main impact on the port and proposed measures that the port can take to deal with the trend of large-scale container ships [4]. H.Y.Li analyzed the countermeasures adopted by the port in the era of large container ships [5]. K.Sun mainly studied the frontier operation technology of container terminals to deal with the enlargement of container ships [6]. H.Zhen put forward the changes that should be made in terms of facilities and services in the future of container terminals under the trend of large container ships [7]. The above-mentioned scholars proposed countermeasures for ports under the trend of container large- scale from the aspects of port operation, terminal frontier facilities and equipment, etc., and also discussed and analyzed the main cause of ship large-scale effect-scale effect, and Limiting factors and other aspects of research.

In this paper, by querying a large number of materials and documents, the previous research results are summarized and analyzed, and the relevant research on the impact of container large-scale on ports and collection and transportation is mostly stayed at the level of qualitative analysis, mostly concentrated on the economic scale brought by the large-scale ships. At the level of benefits, there are relatively few studies on the challenges of large-scale ships to ports and the prospects and constraints of large-scale development. This article analyzes the

large-scale ships through the corresponding data and cases, combined with today's complex and changing trade situation. The impact on port development, with a view to providing corresponding reference for port development.

## 2. DEVELOPMENT HISTORY AND CURRENT STATUS OF LARGE-SCALE CONTAINER SHIPS

### 2.1 The background and development status of large-scale container ships

**Table. 1-1 Six stages of container ship development**

| Development stage | Time/year | Ship type | Length/m | Draft/m | Capacity/TEU |
|---|---|---|---|---|---|
| 1ST Generation | 1950 | Converted by tankers and freighter | 135-200 | 9 | 500-1000 |
| 2nd Generation | 1970-1980 | cellular containership | 215 | 10 | 1000-2500 |
| 3rd Generation | 1980-1988 | medium-sized container ship | 250-290 | 11-12 | 2500-4000 |
| 4th Generation | 1988-2005 | Panamax | 275-305 | 11-13 | 4000-10000 |
| 5th Generation | 2006-2012 | New Panamax | 300-350 | 13-15 | 10000-15000 |
| 6th Generation | 2013- | Post Panamax | 350-400 | 14-16 | 15000-24000 |

(1)With the continuous deepening of economic globalization and the continuous growth of container trade, large container ships are favored by the market for their excellent scale effect, environmental effect and energy effect. The scale effect brought about by it is also increasing step by step. Ship transportation companies continue to increase investment in large ships, chasing lower unit space costs to reduce transportation costs and improve competitiveness. In particular, the increase in maritime trade volume, the innovation of shipbuilding technology, and the strengthening of shipping alliances have caused the rapid growth of container ships.

(2)The Pan-Atlantic Steamship Company acquired by Marklin in 1956 placed containers on the deck of an oil tanker, opening a precedent for maritime container transportation. After decades of rapid development, the container shipping volume has ranged from the initial hundreds of TEUs to the current over 23,000 TEU. MSC GULSUN is currently the world's largest container ship, with a container capacity of 23,756 TEU and a length of 399.9 meters. With a width of 61.5 meters, a maximum draught of 16.5 meters, and a total ton of 232,618. The specific stages of container development are shown in Table 1-1 below. Figure 1-1 shows the growth trend of container ships in the past two decades.

Compared with the 13100 TEU container ship, the unit space cost of the 18000 TEU container ship is 26% lower, the average fuel consumption per container is 35% lower, and the carbon dioxide emissions are less, resulting in a significant reduction in operating costs. Compared with 9000TEU and 18000TEU container ships, the number of manpower is basically 22, each large container ship could save up to millions of dollars in shipping staff expense and also saves a lot of machinery maintenance costs.

### 2.2 Future development trends of large-scale container ships

Since the beginning of the new century, large-scale ships have developed rapidly, and mainstream shipping companies are competing to order super-large container ships. Fig2-2 is the comparison of the total size of newly built container ships in the world with the newly built ships above 8000TEU. It can be clearly seen that the proportion of large container ships in newly built ships has increased year by year and has occupied major share.

We also noticed that container large-scale has slowed down in recent years. Among them, the technical conditions are more restrictive, and the increase in the length of the ship will increase the total longitudinal strength of the ship, which may lead to the risk of bending deformation and fracture of the ship's steel plate, whether the ship is in a mid-arch or sagging state The largest bending stress is generated in the middle of the hull. The middle part of the hull is much more stressed or stressed than the bow and stern, so the possibility of damage is the greatest. This is why the maximum length of ultra-large container ships is maintained at 400 meters. In June 2013, Container vessel 'MOL Comfort' carried 7041 TEU and sank after breaking in the middle of the ship in bad weather. This was the most serious safety accident in the history of container ships and caused tens of billions of dollars in economic losses. The cause of the accident is largely due to the insufficient longitudinal strength of the ship.

Measures to resist the total longitudinal bending of the ship: (1) Increase the thickness of the ship's plate, strengthen longitudinal strength members and continuous members such as stringers and longitudinal keels. The increase in the use of steel will directly increase the cost of shipbuilding and increase the weight of the ship, which will affect the economy of the ship. (2) Research and development of new steel materials with higher fatigue resistance is one of the factors that affect the large-scale ship.

With the development of science and technology, the breakthrough of new materials and the application of high-performance green ship mainframes (LNG as power supply), the large-scale ships will continue to develop in the future.Measures to resist the total longitudinal bending of the ship: (1) Increase the thickness of the ship's plate, strengthen longitudinal strength members and continuous members such as stringers and longitudinal keels. The increase in the use of steel will directly increase the cost of shipbuilding and increase the weight of the ship, which will affect the economy of the ship.(2) Research and development of new steel materials with higher fatigue resistance is one of the factors that affect the large-scale ship.

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## 3. THE IMPACT OF LARGE CONTAINER SHIPS ON PORT DEVELOPMENT

### 3.1 Development status and trends of container ports

The enlargement of container ports has become an inevitable trend in the development of container transportation. Many countries pay great attention to the investment and construction of containerized deep-water terminals. Ports have the same economies of scale as container ships. The larger the scale, the lower the cost. The port's competitiveness and the scale advantage is more obvious. With the continuous development of large-scale container ships, it will also inevitably promote the enlargement of ports. For example, the Shanghai Yangshan Deepwater Port has rapidly increased container throughput after its completion. Container throughput has become the world's first for serveral years. The container throughput in 2019 reached 43.3 million TEU increased by 3.1% year- on-year. In October 2019, Singapore held a groundbreaking ceremony for Tuas Port. The total investment is expected to be 20 billion Singapore dollars. After completion, it will be the world's largest automated port, which will play an important role in consolidating Singapore's status as an international transit port. At the same time, the weak growth of global container trade has begun to show. In 2019, the growth of global container trade is only increase 1.8%; affected by the COVID- 19, Clarkson predicts that container trade will decline by 10.8% in 2020. This will bring great challenges to the development of container trade and ports. Figure 2-1 shows the trend of global container trade from 2011 to 2020.

### 3.2 The impact of large container ships on port facilities and equipment

**(1)Impact on berths, waterways and yards**

Large container ships have higher requirements for port berths and channel water depth. The water depth of the port restricts the use of large ships. With the trend of large-scale ships, the draught of ships continues to increase, and the water depth challenges of port terminals are also increasing. The safe navigation of ships requires sufficient surplus water depth. Insufficient water depth in the channel will prevent large containers from entering the port terminal. In the planning and design of some well- known ports in the world, a large number of deep water berths and waterways of more than 14 meters have been opened, and wide port areas and anchorages have been built to increase their capacity for large container ships and enhance their competitiveness.

The development of large-scale ships puts forward higher requirements on the yard. A large-scale 23000TEU container can be loaded and unloaded at the terminal by several thousand TEUs. This is a huge test for the load-carrying capacity of the yard. Efficient revolving containers are essential to enhance the throughput and competitiveness of the terminal. The expansion of the storage yard is not just a simple area expansion, but also involves the coordinated operation of the storage yard equipment, the reasonable planning of the storage yard layout, and the reasonable arrangement of container stacking and unloading.

**(2)Impact on loading and unloading equipment**

The container loading and unloading bridge is enlarged. Taking the 18000TEU as an example, the container loading and unloading bridge requires a front reach of more than 68-70M, and an on-rail lifting height of 50M. For example, the full-scale lifting speed of the mainstream large shore bridge is increased to 90M/min; the running speed along the track is increased by 240M/min. The new large- scale loading and unloading bridge can lift two or even four 20-foot standard boxes at the same time, greatly improving the operation efficiency. However, the cost of large container loading and unloading bridges is extremely high, requiring big amounts of capital and technical support. There is no matching loading and unloading equipment for large ships, which will seriously affect the loading and unloading efficiency of the port and increase the time the ship is in the port. Not only does it not bring scale benefits, but it will increase shipping costs and reduce timeliness, thereby affecting shipping quality.

Subject to the length of the ship, the large-scale development of container ships is constantly increasing the width of the ship, increasing the unit workload and load of container handling[8]. This requires improved efficiency and performance of the dock crane. In order to achieve this goal, the wharf will either increase the working time ratio of each wharf crane when a ship is docked at the port, or increase the number of hoistings per crane per hour. As the length-to-width ratio of ships decreases, the ship-to-shore workload becomes increasingly concentrated.

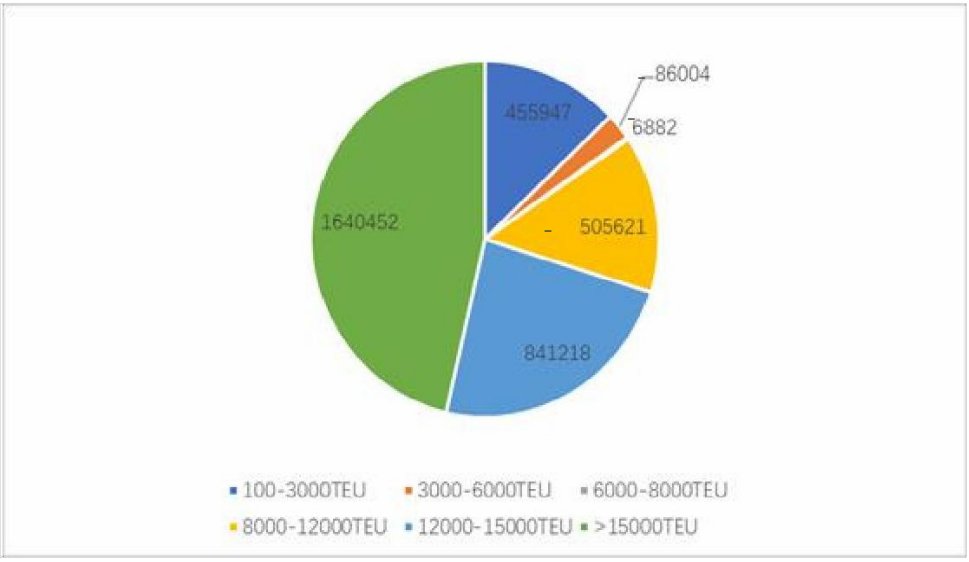


**Figure 1:** 2017-2019 Different types of containership deliveries in the world market

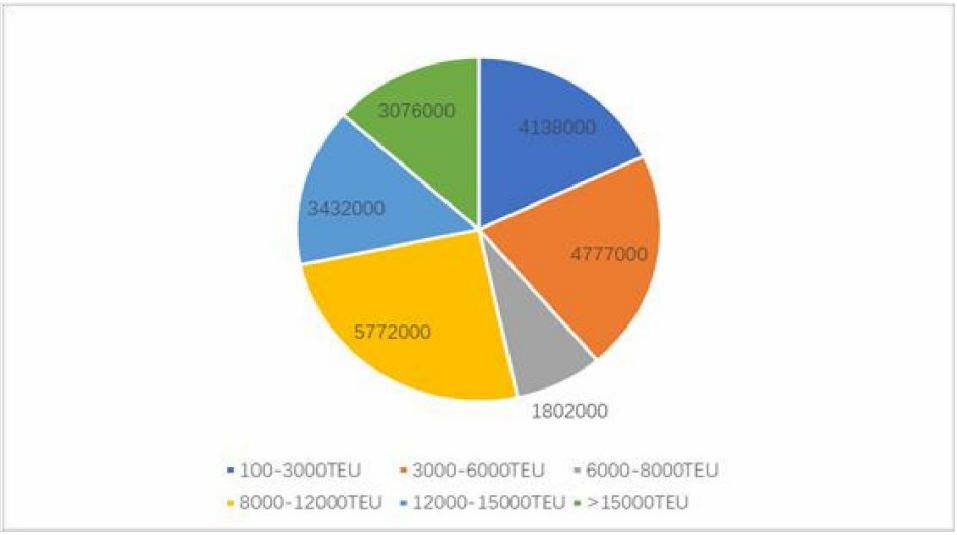


**Figure 2:** The world containership fleet size till 2019

It can be seen from Fig1 and Fig2 that in the new shipbuilding market in the past three years, the proportion of large ships above 8000TEU has reached 85%, and large container ships have occupied the absolute main position of the market; the trend of large-scale ships is becoming more and more obvious. It can be seen from the data that the

proportion of large container ships above 8000TEU in the existing container market accounts for 53%, which means that there are still quite small and medium-sized container ships operating in the market. Fig3 shows that the construction peak of 3000-8000TEU ships appeared in 2005-2010, and then fell sharply, and the current construction volume has been very small in the proportion of the global container ships.

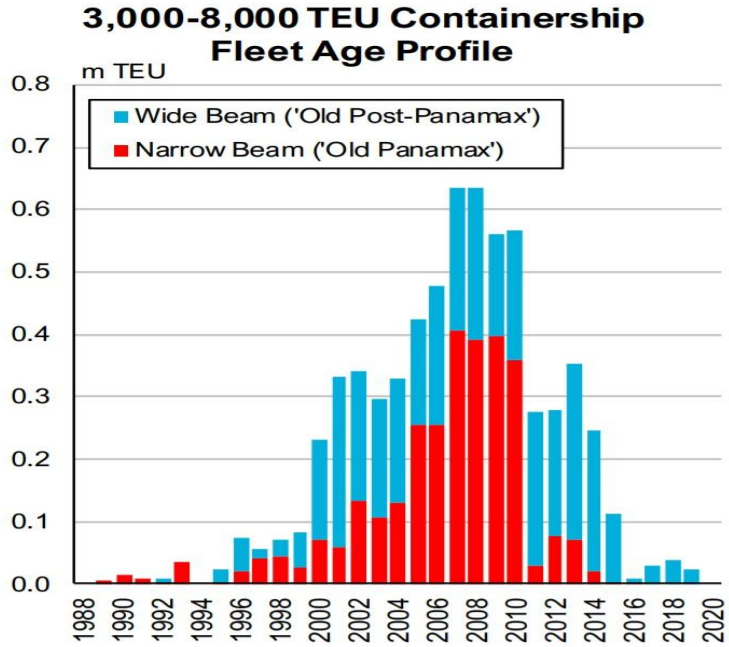


**Figure 3:** 3,000-8,000 TEU containership fleet age profile (Source:Clarkson)

Table 1 shown that 3000-8000TEU container ships with a ship age of more than 5 years currently account for 27.8% of the total carrying capacity, and this part of the capacity will gradually withdraw from the market in the next 10 years. Replaced by large newbuilding container ships. This will bring great challenges to traditional small and medium ports. Limited to port berths, yards, gathering and transportation networks, and terminal loading and unloading equipment, small and medium-sized terminals do not have the capacity to accept large container ships. Even if some ports have natural deep water channels and berths, the large-scale upgrading and transformation of the terminal and Equipment updates require huge amounts of funds.

**Table 1:** Containership fleet by size and age from 3000 to 8000TEU

| | 0-4year | 5-9year | 10-14year | 15-19year | over 20year |
|---|---|---|---|---|---|
| 3000-6000TEU | 167,000 | 1239,000 | 2003,000 | 1035,000 | 333,000 |
| 6001-8000TEU | 21,000 | 461,000 | 741,000 | 509,000 | 71,000 |
| Percentage of total containerships size(%) | 0.82 | 7.39 | 11.93 | 6.71 | 1.76 |

(remarks: The world total containership fleet size:22,997,000TEU)

Terminal operating costs mainly include berth costs, container loading and unloading bridges, yard cranes, container truck operating costs, maintenance costs for related equipment, depreciation costs, loan interest and idle costs. Limited to port berths, yards, gathering and transportation networks, and terminal loading and unloading equipment, small and medium-sized terminals do not have the capacity to accept large container ships. Even if some ports have natural deep water channels and berths, the large-scale upgrading and transformation of the terminal and The equipment renewal requires huge capital investment and high maintenance costs; the premise of the large-scale terminal is the scale effect brought by the container trade, which requires a stable growth of the terminal's throughput. Affected by global trade protectionism and New Coronary Pneumonia, global trade has declined significantly, and the prospects and extent of recovery are not clear; this requires that in a new situation, realistic and scientific design planning should be done in port planning to avoid Resource waste and economic loss caused by repeated construction.

The corresponding measures are as follows:

(1)For some high-quality medium-sized ports with good development expectations, large-scale transformation of the port can be appropriately carried out to create a hub port for container docking; optimize the resource allocation of the port, integrate the resource advantages of the port area, and radiate and stimulate the port area and hinterland economic development.

(2)For some ports with poor growth expectations or unsuitable for large-scale transformation, we must resolutely avoid the waste of funds and resources caused by repeated construction. According to our own conditions, the use of existing port facilities can be used as a branch port to strengthen and Hub port communication and coordination to achieve the benign development ofthe port.

## 4. CONCLUSION

Although global trade is affected by uncertain factors such as trade wars and COVID-19, the continuous development of large-scale container ships will continue to strengthen with the breakthrough of shipbuilding technology and the pursuit of scale effect by container liner companies to reduce operating costs; Large container ships will also become the absolute main force in the future market. In order to meet the future development needs of large-scale ships, the positioning of global container ports will also be adjusted accordingly, and the future port hub and branch ports will have more clear divisions.

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