Preface

The global COVID-19 pandemic put the world economy under challenge in 2020 and the trade growth of the world's major economies fell sharply. The European region was bogged down due to Brexit and the pandemic. Trade protectionism rose in some developed economies such as the United States, increasing the global trade barriers. In this context, the international maritime trade and port production growth rates declined, and the port and shipping industry faced many challenges for development. In view of this, we must keep an eye on the developments of global ports, analyze the new features and trends in the global port industry, and summarize and promote new concepts, technologies, methodologies and models emerging during port development to support sustainable advancement of the port industry.

Chapter 1 Overview of Global Port Development Environment in 2020

1.1 Overview of Global Economic Development

1.1.1 Global economy shrinks

The COVID-19 pandemic that broke out in 2020 threw the world economy into a deep recession. In 2020, affected by the pandemic—the most severe public health event in nearly a century—the global economy fell off a cliff. The *World Economic Outlook* report published in April 2021 by the International Monetary Fund (IMF) estimated that the global economic growth would slump by 3.3% in 2020, a record low since 2009. Overall, the world economy in 2020 featured a synchronous recovery after a deep recession.

After the 2008 international financial crisis, the global economy failed to fully recover in the as long as 11 years that followed, and the COVID-19 pandemic outbreaks in 2020 have further worsened the situation. Most of the economies in the world, from developed economies such as Europe and the United States to emerging markets such as South Asia and South America, have been hit hard by the pandemic. In contrast, benefited from the strict prevention and control measures, China has put its domestic epidemic situation under effective control quickly and actively promotes the resumption of work and production, with its national economy leading the steady recovery.

The European economy remained in deep recession, and the "second lockdown" slowed down the recovery momentum of the European economy. Although European governments have adopted stringent social distancing measures to prevent and control the outbreaks and introduced loose monetary and fiscal stimulus policies on a more extensive scale than those during the financial crisis, the effects have been limited due to the collective decision-making mechanism of the EU and Euro Area members. The annual economic growth of the Euro Area still shrank significantly (by -6.6%). In the second quarter, the Euro Area GDP fell sharply quarter-

on-quarter. After an extensive "lockdown" initiative, the pandemic situation in Europe was brought under control, and its economy also welcomed a rapid pickup. In the third quarter, the Euro Area GDP surged by 12.6% quarter-on-quarter. However, the relaxation of quarantine policies and the restart of the economy also caused the pandemic to rebound again. The GDP growth in the fourth quarter fell again (-0.7%) quarter-on-quarter. Due to the repeated outbreaks, the United Kingdom, France, Germany, Spain, and other economies successively re-implemented lockdown measures in November, significantly slowing down the economic recovery momentum in Europe.

1.2 Overview of Global Trade Development

In 2020, the COVID-19 pandemic spread across the world. Many industries were frustrated or shut down, factories stopped production, and cargoes failed to be transported smoothly. Economies adopted trade restrictions one after another in response to the pandemic. Global trade activities fell sharply, making the already sluggish global trade situation even worse. According to the World Trade Organization (WTO) estimates, the international trade volume in 2020 fell by 5.3% in 2020, and the growth rate dropped by 5.5 percentage points from 2019.

1.3 Overview of Global Shipping Market Development

In 2020, the COVID-19 pandemic weakened the trade demand and interrupted the logistics supply chain. Specifically, the annual seaborne trade volume fell by 3.6% year-on-year to 11.5 billion tons. Specifically, the global container trade volume saw a strong recovery after a plunge in the second quarter. The global iron ore trade volume recorded contrarian growth driven by China's strong steel demand. The seaborne coal trade volume fell at a higher rate due to China's import restrictions targeting Australia's coal. The supply-demand imbalance has led to the continued downturn in the global crude oil market.

1.3.1 Global container volume recovers strongly after a plunge

In 2020, the COVID-19 pandemic significantly impacted the global economy,

consumer activities, and supply chains, and led the trend of the container shipping trade. The seaborne container trade volume globally of the year is expected to drop by 3.0%, the largest decline in container trade since the global financial crisis.

1.3.2 Global major bulks trade shows differentiated trends

The global iron ore trade volume grew against the trend. In 2020, the global iron ore seaborne trade recorded a contrarian growth rate of 3.2%. On the demand side, China's increased iron ore imports were the main driver behind the significant global iron ore trade increase. On the supply side, Australia, Canada, and other economies recorded increased export volumes in 2020, driven by the strong recovery of major iron ore suppliers. The Vale tailings dam break put iron ore production under stress due to the stability problems. In addition, the COVID-19 pandemic has disrupted the operations of ports and railway facilities in southern Brazil, increasing transportation difficulties and weakening the recovery momentum of iron ore exports in Brazil.

The global coal shipping volume accelerated to decline. In 2020, the global coal demand remained sluggish, and the coal trade volumes of major importers and exporters all showed negative growth. On the demand side, China's coal imports at the beginning of the year remained robust. However, due to the impact of the pandemic coupled with the government's tightened control over imported coal in the later stage, China's annual coal imports fell sharply in 2020. Similarly, India's coal demand was weak due to the pandemic. Its domestic production plunged and its coal imports fell sharply from the high level at the beginning of the year. On the supply side, due to the worsening Sino-Australian relations, Australian coal customs clearance was restricted, which lowered Australia's coal exports.

1.3.4 Global liquid bulks market in a downturn

In 2020, the demand for oil products dropped sharply, refineries cut production on a large scale, and the annual crude oil trade volume decreased by 7.7%. In the first half of the year, international oil prices plummeted. On the demand side, due to the dramatic global economic recession, a large number of ships were suspended worldwide, the global industrial chain and supply chain were interrupted, and the

shipping volumes of both service-purpose oil and production-purpose oil fell sharply. On the supply side, due to the breakdown of negotiations between Russia and the Organization of Petroleum Exporting Countries (OPEC), Saudi Arabia lowered prices and increased production. The combined effect of the crude oil demand decline and the supply surge severely disrupted the international crude oil market. In the second half of the year, although the pandemic continued to be rampant, most economies worldwide tended to recover their trade activities, and market oil demand also tended to rebound, driving up the global crude oil trade volume slightly.

Chapter 2 Overview of Global Port Production in 2020

2.1 Overview of Global Port Throughputs

2.1.1 Overview of global port cargo throughputs

In 2020, the COVID-19 pandemic spread worldwide, throwing the world economy into a deep recession. The cargo throughput of major global ports[1] dropped by 1.3% year-on-year. The cargo throughput growth rates of about three-quarters of major ports around the world ranged from -10% to 10%, and the range expanded significantly compared with that in 2019. Specifically, the ports with positive growth rates were primarily located in China. In contrast, the ports with negative growth rates were primarily located in Japan, South Korea, and other Asian and European regions outside China.

In 2020, the growth rate of global cargo throughput followed an upward trend. In the first quarter, the COVID-19 pandemic spread in China, and the import and export trade between China and its major trading partners was restricted, inhibiting the port throughput growth. Although China was the first to resume work and production in the second quarter, as the pandemic spread globally, both supply and demand ran low in the cargo trade market. Coupled with the extensive lockdown which blocked economic activities, the global shipping supply chain was interrupted, resulting in a decline in the cargo throughput of major international ports. Starting from the third quarter, as various economies restarted their economic activities and community lockdown was gradually lifted, trade demand increased, and the port production situation warmed up significantly.

2.1.2 Rankings of the world's top 20 ports by cargo throughput

The world's top 20 ports recorded lower production in 2020 year-on-year, and multiple ports saw their year-on-year throughput growth fall sharply. However, the

[1] Major global ports refer to the ports with statistical data available, including major cargo ports in the world. The data can reflect the trade growth trend of global ports. Comparing the statistics by the United Nations and the World Bank and Clarksons analysis of international maritime trade data, this report primarily covers coastal ports for studying the port throughputs (totalling about 20.67 billion tons), accounting for about 62% of the global total throughput of coastal ports. See the attached table for the specific ports.

port production in the second half of the year picked up. In particular, the 15 Chinese ports on the list resumed production earlier, and their annual production performed well. This has driven up the cargo throughput of the world's top 20 ports by 1.1% against the trend in 2020. Specifically, Ningbo-Zhoushan Port promoted the recovery of its logistics chain and supply chain after the outbreaks at the beginning of the year, ranking first securely by recording a cargo throughput of 1.17 billion tons. Among international ports, Port of Hedland benefited from the strong growth in China-Australia iron ore trade volume and recorded cargo throughput growth against the trend. Port of Singapore, Port of Rotterdam, and Port of Busan were all affected by the pandemic, and their throughput growth rates fell to the negative range.

2.1.3 Cargo throughput analysis of ports in different regions

(1) Cargo throughputs of ports in Europe dipped

In 2020, European economies implemented strict lockdown measures, and the seaborne trade demand shrank sharply. Although the economic situation in Europe improved in the second half of the year, the repeated outbreaks, the lack of confidence in the market, and the increasing global uncertainties have caused the cargo throughputs of major European ports to plummet.

Among the major ports, the annual cargo throughput of the Port of Rotterdam fell sharply under the impact of the COVID-19 pandemic on energy demand and steel production. The bulks cargo throughput of the Port of Antwerp shrank by 16%, but its container shipping volume grew significantly, narrowing the total throughput drop of the port to 3.1% for the year. The Port of Zeebrugge benefited from the port infrastructure construction, and its gravel handling volume increased sharply. Because of the high-quality services at port terminals and the increased ship calls due to the congestion at British ports, the annual cargo throughput of the Port of Zeebrugge grew by 2.6% against the trend. The Port of Riga was affected by the sharp decline in dry bulks (grain, coal) and liquid bulks shipping demands and its cargo throughput plummeted by 27.7%.

(2) Throughputs of North American ports dropped slightly while throughputs of

South American ports increased against the trend

In 2020, the North American economy shrank sharply, and the port throughputs of major economies such as the United States, Mexico, and Canada were suppressed. The cargo throughput of North American ports fell by 2.8% year-on-year. South America witnessed a slump in the service industry and a severe economic recession, but its port operations remained normal. Coupled with the strong pull of dry bulks throughputs, the production situation of South American ports was better than expected.

In terms of North American ports, the annual cargo throughput of the Port of Long Beach grew by 1.1% against the trend as residents chose to work from home, which increased the demands for medical equipment, home decoration supplies, sports equipment, and office furniture. The cargo throughput of the Port of Montreal plummeted due to cargo overstock and delays caused by the strike of terminal workers. In terms of South American ports, thanks to the region's agricultural strength and port flexibility in maintaining cargo flows, the dry bulks and pulp shipping volumes of the Port of Santos exhibited a sound growth trend, which drove up its cargo throughput by 9.3% against the trend. The Port of Paranagua also benefited from China's import demand for Brazilian soybeans, and its cargo throughput maintained a high growth rate.

(3) Asian port throughputs declined slightly

In 2020, the growth rates of Asian economies slowed down. Thanks to its strict prevention and control measures, China recorded economic growth against the trend, and its port throughputs picked up with strong momentum. However, under the impact of the pandemic, Japan and South Korea's import and export demands remained sluggish, and their port production was depressed. The cargo throughputs of Southeast Asian ports such as those in Indonesia, Malaysia, and the Philippines declined year-on-year. However, the Southeast Asian region benefited from their close cooperation with China in the cross-border e-commerce sector during the outbreaks, and their import and export trade volumes recovered significantly in the second half of the year. In this context, the cargo throughput of Asian ports in 2020 declined

slightly by 0.6%.

In terms of major ports, except China which witnessed stable cargo throughput growth of ports due to its effective epidemic prevention and control measures and domestic trade policies, all other ports in Asia presented negative growth as a whole. Affected by the economic shrinkage of trading partners such as the United States and Japan, South Korea saw the export volumes of its major ports such as Port of Busan, Port of Gwangyang, and Port of Incheon decreasing, which lowered the port cargo throughput. The sluggish domestic manufacturing industry in Japan dampened the performance of ports such as Port of Tokyo and Port of Yokohama. In particular, the Port of Nagoya was negatively affected by the decline in iron ore trade, and its throughput dropped significantly. The economy of Southeast Asia was hit hard by the pandemic and its demand for import and export trade was weak. The cargo throughputs of major ports in the Philippines, Malaysia, and other economies showed a negative growth trend.

Cargo throughputs of ports in the Mainland China started low but grew. In 2020, China's port cargo throughput growth presented a strong recovery after bottoming out. The annual cargo throughput reached 14.55 billion tons, a year-on-year growth rate of 4.3%. Although the pandemic dampened the growth rate, which underperformed the 8.8% of the previous year, Chinese ports outside the Mainland China exhibited strong resilience against the general throughput slump.

Throughputs of South Korean ports suffered sharp declines. South Korean ports recorded 1.51 billion tons of throughput during the year, a year-on-year decrease of 9.6%. Except Port of Masan, all other major ports in South Korea fell to the negative growth range in terms of cargo throughput. The main reason is that the export value shrank sharply, especially the exports of automobiles, aircraft parts, auto parts, and other products, which affected the Port of Busan, the Port of Gwangyang, the Port of Incheon and other ports.

The throughputs of Southeast Asian ports dipped. In 2020, the declined demand for imported cargoes in the Philippines resulted in a sharp drop of cargo throughput by 13.3% at Philippine seaports. Major ports in Malaysia were affected by port

congestion and other factors, and their cargo throughputs declined. Regional lockdown measures, border closures, and economic sluggishness caused by the COVID-19 pandemic, combined with occasional international trade frictions, have severely impacted Singapore's manufacturing and export trade. In addition, the oil throughput plunged (by 11.4%), which also contributed to a cargo throughput decline of 5.7% year-on-year at the Port of Singapore.

Topic 1: COVID-19 Pandemic Exacerbates Port Production Situation

In recent years, challenges such as the "international trade frictions", "Brexit", "regional economic sanctions", and "geopolitical conflicts" have kept the global port production tepid. In 2020, the COVID-19 pandemic significantly impacted international economic and trade development and greatly affected the production activities at ports, leading to frequent problems, including global port congestion and port labor shortages. Although its impact was less than the financial crisis, it still set back the already poorly performing port production, "exacerbating" the situation. During the period, port authorities took countermeasures to reduce the impact of the COVID-19 pandemic. Some of these measures have played a positive role in improving the health incident safety systems at ports and promoting ports' intelligent development. As a result, the COVID-19 pandemic has, to a certain extent, promoted the high-quality development of ports. But undoubtedly the impacts of the COVID-19 pandemic on port production in 2020 were still dominated by negative ones.

1. Port production during the pandemic

1.1 The negative impacts of the COVID-19 pandemic on the port and shipping industry will continue for a long time

Based on the economic, trade, and port throughput growth data and by comparing the impacts of the financial crisis and the COVID-19 pandemic on the global economy and trade and port production, we can find that the pandemic has a smaller

impact on global trade and the port and shipping industry in the short term than the financial crisis had. The international trade volume in 2020 declined by 8.5%, and the container throughput fell by 2.1%. The declines are significantly smaller than the 11.3% and 8.5% drops during the financial crisis in 2009. The fundamental reason is that the economic crisis caused by the pandemic primarily focused on the service trade sector and that the impact on commodity purchase demand was relatively small. Therefore, although the cargo trade in 2020 declined faster, it recovered more quickly as well. However, in terms of long-term impacts, this pandemic will have a more enduring negative impact than the financial crisis. First, the economic downside risks remain prominent, including the possible aggravation and spread of the outbreaks and delays in vaccine procurement and distribution. All these risks can increase the economic recovery uncertainties in the coming years. Second, various government departments have introduced massive amounts to combat the impact of the pandemic. The world economy is currently experiencing the heaviest debt burden in modern history, and low economic growth will undermine debt repayment abilities. As a result, economies around the world will face new risks brought about by financial pressure. Finally, the shortage of anti-epidemic supplies such as masks, ventilators, and protective clothing after the outbreaks has made many economies aware of the importance of manufacturing. Therefore, many economies will invest more in the manufacturing industry after the pandemic situation is alleviated, which will result in a massive change in the global industrial layout and trade pattern.

2. Pandemic situation and port production performance are highly correlated in general

Port performance depends on the production and consumption demands of the hinterland areas on which the port relies. In 2020, China's pandemic prevention and control measures also embodied flexibility by tightening the measures when the outbreaks got severe, which has led to a decline in production and consumption demands and further to the sluggish port production. Due to the different priorities of economy and security, China also has different policy preferences for pandemic prevention and control. The COVID-19 pandemic situations in different global

economies showed different trends. Asian economies put the pandemic under control earlier. The infections in the United States grew rapidly and then fell, and the European economies witnessed repeated outbreaks that were less optimistic.

Therefore, if we select major economies around the world and compare their daily new infections with the cargo and container throughputs of major ports in the economies, we can find that the pandemic situation has a high correlation with port production performance, highlighting the following characteristics: **(1) Strict prevention and control measures were often adopted at the beginning of the outbreak.** Domestic production was halted, consumer demand dropped sharply, and cargo handling and transportation operations were greatly restricted. During this period, port throughput usually had a sharp decline. **(2) When the pandemic situation got controlled,** normalized prevention and control measures can sustain the normal port operations. Besides, as the number of daily new infections decreased, the throughput growth decline would stop or even pick up slowly or quickly. **(3) When the domestic pandemic situation improved significantly,** and production and consumption gradually resumed to normal levels, that is, when the number of daily new infections dropped significantly, cargo throughput, especially container throughput, might show retaliatory growth, as presented by the September trend in South Korea and the September-November trend in Brazil. **(4) When the pandemic situation recurred,** as the prevention and control mechanism had matured, port throughput had a weak correlation with the pandemic situation. At this time, port throughput was more sensitive to domestic economic stimulus policies. For example, although the pandemic continued to deteriorate in the second half of 2020 in the United States, its imports continued to surge due to multiple rounds of active domestic fiscal stimulus policies. **(5) In addition,** the container throughput growth had a higher correlation with the pandemic situation. This is because cargoes, consumables used by residents, other durable goods, and raw materials produced by enterprises are shipped in containers. The pandemic primarily dampened residents' consumption willingness, and major bulks throughputs often recovered quickly during the pandemic.

2. Impacts of the pandemic on port operations

2.1 Ports were prone to congestion during the early stage of outbreaks

Port congestion caused by the outbreaks usually occurred in two stages, the initial stage of the outbreak and the stage where the pandemic situation improved significantly. **In the early stage of the outbreak,** most economies around the world adopted strict prevention and control measures such as city lockdown, port lockdown, and restricting residents' activities. Ports also closed operations, prohibited ship calls, banned cargo clearance or adopted other measures to avoid the pandemic. Employees engaged in port-related industries such as terminal operations, warehousing, customs, and freight forwarding mostly worked from home. Besides, as land freight routes were blocked, truck drivers could not transport cargoes out of the port. This slowed down terminal operations, and a large number of containers were stranded at the port, leading to heavily congested depots. In April 2020 or so, the pandemic began to break out outside China and ports in at least ten economies, including the Philippines, Bangladesh, Italy, and Spain, fell into chaos and congestion. **When the domestic situation improved significantly and** prevention and control measures were moderately relaxed with operations normalized, the raw materials import demand from factory production resumption and the long-depressed consumer demand might usher in explosive growth. Therefore, the rapid increases in import and export demands in this period might make the port fail to meet the cargo handling capacity demand, and a large number of ships waited at anchorages and containers were stranded in the depots, resulting in congestion. Port congestion along the west coast of the United States in the second half of 2020 falls into this category. Driven by the U.S. economic stimulus, the import demand surge for consumer goods in the United States resulted in prolonged congestion at the ports of Los Angeles and Long Beach and other ports. **In addition,** the pandemic recurred due to the cold weather at the end of 2020, and the restocking demand at the end of the year and the Christmas increased. The Port of Felixstowe in the United Kingdom, the Port of Oakland in New Zealand, the Port of Bilbao in Spain, and many major ports in West Africa successively fell into severe congestion. Large shipping companies began to impose surcharges such as congestion surcharges, peak season surcharges, and lack of containers surcharges.

2. Shortage of front-line employees at the port led to a decline in port production efficiency

The port serves as a gateway to receive incoming supplies. Imported cargoes (especially cold chain goods) and crews are likely to carry novel coronavirus. Therefore, port employees, especially pilots and terminal stevedores, and other first-line workers such as onboard operators are exposed to high risk. Many ports such as the Port of Santos in Brazil and Hong Kong Port suffered from interrupted or even halted port operations due to the outbreaks. Therefore, port authorities in various economies attach great importance to preventing and controlling the COVID-19 pandemic for first-line personnel. They have formulated strict pandemic prevention and control procedures and operating standards and suspended overseas shifts of foreign crew members to strictly prevent novel coronavirus from entering the country through ports or waterways.

In addition, considering the high risk of port operations, some employees' temporary absence after they were confirmed or suspected of infection, and some employees' voluntarily giving up the job to avoid infection, ports faced severe labor shortages during the epidemic. According to the 16th Port Economic Impact Barometer released by the World Ports Sustainability Program (WPSP) and the International Association of Ports and Harbors (IAPH) in February 2021, the shortage of personnel and workers at all levels peaked out in early May (Week 18). Terminal workers, truck drivers, and port authority employees were greatly affected. Then the situation gradually improved and has now been maintained at a low level.

3. Long-term impacts of COVID-19 pandemic on global port development

During the COVID-19 pandemic, economies and ports worldwide adopted countermeasures to deal with the impacts of the pandemic. Some measures have solved the pandemic-caused problems at that time and changed to some extent the development environment of ports in the future.

3.1 The pandemic has changed the positioning of ports in the new global economic and trade landscape

In recent years, the rapid development of the global economy and trade has

slowed down significantly. The anti-globalization trend continued to rise, geopolitical tensions intensified, trade disputes were frequent, and other factors have become acute. The interruption of multiple industrial chain links has caused the global industrial chain to move toward regionalized and polycentric directions during the pandemic. It is possible to form an Asia-Pacific industrial chain cluster with China, Japan, and South Korea as the core, an American industrial chain cluster with the United States-Mexico as the core, and a Nordic industrial cluster with Germany, France, the United Kingdom, and Italy as the core. The three major clusters realize the division of roles across the entire industry chain in their respective clusters. Therefore, the region's bilateral and multilateral trade demands may further increase, the offshore routes will be boosted, and the ship upsizing trend may slow down.

Against this background, the positioning of ports in various economies around the world will change. Ports will no longer pursue a large size to accommodate large ships sailing on oceangoing routes. The importance of satisfying domestic and regional transportation needs will increase. Specifically, during the pandemic, China proposed a new development pattern of "focusing on the internal circulation and realizing mutual promotion of internal and external circulations". In this new pattern, the port supply system will be adjusted accordingly, including improving the internal circulation port infrastructure, optimizing the cargo collection, distribution, and transportation system, expanding and extending port service functions, and creating a hub network system of inland rivers, riverside ports, and coastal ports.

2. The pandemic promotes the health incident safety system development of global ports

In a port safety system, in addition to occasional accidents and natural disasters, the most hazardous should be health emergencies, especially global infectious diseases such as influenza A (H1N1), Ebola, and COVID-19. Such diseases can be spread via ships carrying mosquitoes and flies from epidemic areas and discharging ballast water and sediments globally. To this end, the World Health Organization prepared the *Handbook on Management of Public Health Events on Board* in 2016 to assist port authorities in assessing risks within the scope of the *International Health Regulations*

(IHR). However, due to the lack of corresponding prevention and control rules and practices worldwide, most port authorities in various economies have adopted strict "one size fits all" prevention measures to reduce the possibility of imported cases. After this pandemic, the IAPH and governments (ministries of transport) of all economies have formulated relatively complete port and ship pandemic prevention guidelines. In practice, they have formed a relatively mature pandemic prevention and control mechanism, which has promoted the health incident safety system development of ports.

3. The pandemic has accelerated the development of intelligent ports

In 2020, ports in various regions worldwide adopted strict prevention and control measures in response to the COVID-19 pandemic. Some physical isolation measures broke the original business model of the port, and most ports in the world had to re-examine their working procedures. They expanded the application of digital tools to restructure the port's working patterns. For example, some ports in Thailand promoted the application of "Internet of Things + technologies" such as electronic payments, mobile terminals, and mobile apps. Malaysia has strengthened its ports' digital infrastructure. Meanwhile, to improve future ports' responses to emergencies, they started to eye more intelligent ports to carry out construction and development.

Ports with a higher digital level, such as the Port of Singapore, continued to accelerate the establishment of a digital governance system with domestic public health and other departments during the pandemic and explored to set up a legal regulatory framework and governance system for port digitalization. They also strived to promote digital means to strengthen cooperation with ports in the region. For example, the Singapore Customs promoted the bilateral single-window interconnection plan of Australia, China, Indonesia, and the Netherlands, and expanded its digital strengths to cross-departmental and cross-regional digital governance. The port's digital co-governance solution has provided a model for all peers in the world.

2.2 Overview of Container Shipping Throughputs of Global Ports

2.2.1 Overview of global port container throughputs

The international container trade has maintained slow growth since 2018 due to the continued global trade frictions and weak consumer markets, among other factors. In 2020, under the impacts of the COVID-19 pandemic, both supply and demand in the container shipping market fell, and the container throughput growth of global ports entered the negative range.

2.2.2 Rankings of the world's top 20 container ports by throughput

In 2020, the production of the world's top 20 container ports was also stagnant compared with that in 2019. Multiple ports on the list recorded year-on-year throughput growth declines to varying degrees. However, most ports enjoyed a faster recovery in the second half of the year as global shipping demand rebounded. Most Chinese ports resumed growth driven by the resumption of work and production and related domestic policies, especially Ningbo-Zhoushan Port, Qingdao Port, and Tianjin Port, which demonstrated eye-catching performance. Among international ports, the freight demand surge at the Port of Los Angeles and the Port of Long Beach in the United States in the second half of the year offset the throughput decline in the first half of the year caused by international trade interruption. The continuous outbreaks of the COVID-19 pandemic in Europe caused the container volume on the Far East—Europe routes to fall by 5.2% year-on-year. For major ports in Europe such as the Port of Rotterdam and the Port of Hamburg, their challenge was the falling cargo shipping volume. Under such circumstances, the throughput of the world's top 20 container ports grew against the trend by 0.7% in 2020.

2.2.3 Container throughput analysis of ports in different regions

In 2020, the container throughput growth of all continents fell into a negative range. The European and American regions were more severely affected by the pandemic, with their container throughput falling by 4.6% and 4.4%, respectively. In the Asian region, as China led the resumption of work and production and achieved

"normalized pandemic prevention and control", its container throughput dropped only slightly by 0.6%. Oceania benefited from the promotion of Sino-Australian trade, and its decline of annual container throughput was narrower than that of the European and American regions.

Container throughput in Asia declined slightly. In 2020, Asian economies took prompt public health countermeasures when the virus infection rate was low and rolled out large-scale stimulating policies and measures, which led to the rapid production recovery of Asian ports.

The container throughput growth of the Mainland China started low but rose gradually. In 2020, ports in the Mainland China accomplished a container throughput of 264.3 million TEUs, with the growth rate slowed by 3.2 percentage points, being 1.2%. Quarter-specific, the growth in the first quarter fell sharply to -10.6% due to the pandemic. But the throughput growth picked up quarter by quarter with the resumption of work and production at home and abroad and the recovery of part of the consumer demand. It reached 8.8% in the fourth quarter, surpassing the level in the same period of the previous year.

Other major ports in Asia recorded negative growth in container throughput. South Korea's weak foreign trade demand and the growth slowdown of the transshipment container volume at Port of Busan led to a fall of the container throughput of South Korean ports by 0.8% year-on-year. Kaohsiung Port was affected by the continuous Sino-US trade frictions and the COVID-19 pandemic, and its annual container throughput plummeted. Although Port of Dubai's container throughput dropped by 4.4% year-on-year due to the pandemic, boosted by its investment in digital technology and automation, its throughput decline narrowed by one percentage point year-on-year.

Southeast Asian ports performed poorly. The foreign trade demand in Southeast Asia was weak, and the port container throughput dropped significantly. Benefited from its investment in new container handling equipment and channel dredging efforts, as well as the shipping demand pickup on Asia—Europe routes in the second half of the year, Port of Tanjung Pelepas saw an increase of its annual container throughput

against the trend by 8%. The Port of Singapore remained open during the pandemic and further strengthened its cooperation with ship enterprises such as Hyundai Merchant Marine (HHM). Its container throughput stayed relatively stable, registering a decrease of only 0.9%. Due to the global shortage of containers and container drops and order cancellations due to delays of trans-Pacific ships, the container throughput of Port of Laem Chabang dropped by 5.4%.

The container throughput of European ports rebounded after a steep drop. In 2020, due to the COVID-19 pandemic, European import and export trade demands dropped sharply in the first half of the year. As various economies gradually lifted their lockdown measures in the second half of the year, trade slowly picked up. Major European container ports showed different degrees of recovery, but the container throughput throughout the year didn't recover to the same period last year.

North American ports showed strong recovery following a "√" shaped curve. In 2020, domestic and foreign trade demands were weak, and the container throughput of North American ports fell sharply. In the second half of the year, driven by the domestic consumer demand surge in the United States and the strong demand for inventory replenishment of retailers, the container throughput of North American ports rebounded strongly.

The recovery of Latin American ports was weak. In 2020, the pandemic prevention measures of Latin American economies led to a decline in logistics capacity, which, together with the shrinking international trade, put pressure on the growth momentum of Latin American ports at the beginning of the year. In the second half of the year, the demands for consumer consumption, raw materials and manufactured products in Latin America gradually recovered. However, due to the weak economic foundation of the region, its container trade recovery momentum was far weaker than in other regions.

The growth rates of container throughputs of African ports plunged. In 2020, the pandemic situation in the African region was complex and severe. Besides, the unfavorable factors such as the international oil price plunge and the raging locust plague in East Africa also hit the African economy hard in the first half of the year, with

the large-scale suspension of shipping routes and a sharp drop in container trade. In the second half of the year, as the machinery and equipment trade among others picked up, the container throughput decline in Africa narrowed significantly.

Topic 2: Global Container Ports with the Fastest Growth in Investment and Size

In 2020, the global economy experienced a deep recession, and the container shipping trade was also hit hard. Affected by factors such as the economic and trade environment, location, investment intensity, and cargo source attractiveness of the economy where the port is located, global ports exhibited varying growth rates in container throughput. To assess the growth potential of international container ports, we have listed the top 100 global container ports in Lloyd's List in 2020 as candidates, and made statistics, analyzed, and calculated "container throughputs" and "import and export values" of these ports from 2017 to 2019 to rank the most potential container ports in our opinion, in a bid to offer some reference for industry insiders. The rankings are shown in the table below.

1. As the destination of the manufacturing industry shift, the Southeast Asian region posts robust growth.

Among the top 25 container ports globally with the fastest size growth rate in 2020, three ports based in Southeast Asia rank among the top five, demonstrating the region's strong development momentum. With the constantly enriched and expanded all-round exchanges and cooperation between China and Southeast Asian economies and regions, especially with the phased results of the "Belt and Road" initiative achieved, China and Southeast Asian economies will embrace more economic opportunities. The Port of Cai Mep, Port of Hochiminh, and Port of Hai Phong in Vietnam ranked second, third, and fourth, respectively, on the list of the world's fastest-growing container ports in terms of size in 2020. By virtue of its abundant labor resources and natural resources (oil, natural gas, and coal), the strong support from

the government and various departments, and successive signing of trade agreements with the Eurasian Economic Union, the European Union, South Korea, and the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), Vietnam enjoyed a much-improved business environment and faster industrial transformation. To cope with the anticipated growth in freight demand brought about by future industry shifts and various trade agreements, the Ministry of Transport of Vietnam is planning to invest heavily in constructing ports in its long-term development plan for 2050. A total of 6 to 8 billion yuan is planned in the first phase by 2030 with Port of Cai Mep and Port of Hai Phong as key investees.

2. Policies boost port throughput growth in South Asia and West Asia

As an emerging economy, South Asia has become a destination of a new round of global industry shift relying on its low land and labor costs. South Asia is located in the overlapped area of the "Belt and Road", the "Bangladesh-China-India-Myanmar Economic Corridor", and the "China-Pakistan Economic Corridor". Its ports are essential for transshipment between Southeast Asia and Arabic and African routes, playing a vital role for connecting to the eastern coastal areas of China, Southeast Asia, and African and European economies and regions along the routes. India's Mundra Port ranks 11th on the list and is the fastest-growing port in South Asia in terms of size. In recent years, Adani Ports, the terminal operator of the Mundra Port, has invested in the expansion of the Mundra Port's container terminal and port infrastructure, such as channel dredging, which has dramatically increased the capacity of the port and helped the port exceed Jawaharlal Nehru Port in terms of container throughput to become India's largest container port in 2020. The Port of Abu Dhabi in the UAE ranks 5th. In 2018, the second-phase container terminal of the COSCO Shipping Ports Khalifa Port in Abu Dhabi, a joint venture of COSCO Shipping Ports and Abu Dhabi Seaport Authority, was officially opened. This semi-automated advanced terminal capable of meeting the needs of different types of ships will help the Port of Abu Dhabi develop toward a major container gateway port and an important hub port in the Middle East, which is also the port's positioning.

3. Chinese container ports develop fast overall

In 2020, despite the impact of the COVID-19 pandemic, China's total import and export values for foreign trade still grew by 1.9% against the trend. The strong resilience and comprehensive competitiveness of China's foreign trade promoted the steady development of China's container ports. Specifically, Guangxi Beibu Gulf Port was the fastest growing port in China in terms of size. Guangxi strives to build new western land-sea corridor. The rapidly increasing sea-rail intermodal trains at the Beibu Gulf Port, frequent train lines, and high train space utilization have all injected a strong impetus into the rapid development of Beibu Gulf Port. The development momentum of Zhuhai Port cannot be underestimated. Zhuhai Port has developed rapidly in recent years, and its container throughput also surges. With its throughput continuing to rise, Zhuhai Port Group is also consolidating the port infrastructure. The 150,000-ton waterway in its Gaolan Port Area was completed and passed acceptance in early 2019.

4. With strengthened investment in construction, European container ports engage in win-win cooperation

The Port of Saint Petersburg, Russia, tops the list. Boosted by Russian trade with China, especially the sales of crude oil, refined copper and petrochemical products, Russia's import and export trade values grew at an average rate of 13.2% from 2017 to 2019. Since COSCO Shipping acquired a 67% stake of the Piraeus Port Authority (PPA) in 2016, the Port of Piraeus in Greece grew from severe losses and patchily operations into the 4th largest port in Europe and the largest port in the Mediterranean. The "China-Europe Land Sea Express Line" with the Port of Piraeus as the hub has covered nine countries, 1,500 nodes, and 71 million people. The Port of Gdańsk in Poland relies on its development positioning as an essential gateway to Central Europe and the Baltic states and has enjoyed rapid development in the container business in recent years. In 2020, the container throughput of the DCT Gdańsk - Deepwater Container Terminal Gdańsk - declined due to the pandemic. However, as the only port in the Baltic Sea area that supports direct calls of ships from Asia (including the world's largest ships), the port still has strong competitiveness.

2.3 Overview of Dry Bulks Throughputs of Global Ports

In 2020, the throughputs of global dry bulks ports showed divergent trends. Specifically, iron ore trade demand was strong, but coal demand was generally weak. The world's main dry bulks shipping volume registered 5.1 billion tons, decreasing by 2.9% year-on-year. Among the major ports, Port of Hedland benefited from China's strong demand for iron ore, and its iron ore throughput was on the rise. Affected by China's restrictive policy on coal imported from Australia, the coal throughputs of Qinhuangdao Port and Port of Hay Point declined faster. Boosted by the increasing supply of green energy and the reduced demand for coal and iron ore from the steel industry, the dry bulks throughput of the Port of Antwerp plummeted by 17%. Due to the declined steel production in Germany and the falling demand for energy coal, among other reasons, the dry bulks throughput of the Port of Rotterdam dropped by 14.3%.

2.3.1 Analysis of global iron ore ports

In 2020, Boosted by China's iron ore imports, the global iron ore trade volume increased by 3.2% to 1.5 billion tons. Specifically, major iron ore exporters showed divergence in trade growth. The dam disaster led to restrictions on mining activities. Vale's production in Brazil declined, and iron ore supply was tight. Brazil's iron ore exports fell by 2.0% throughout the year. Meanwhile, as China's import demand remained strong and Brazil's iron ore supply continued to be unstable, Australia's iron ore exports gained momentum. However, as China implemented a diversified strategy of iron ore imports by opening up other iron ore markets, especially the Indian market, the iron ore trade volume in India surged by 68.0%.

2.3.2 Analysis of global coal ports

In 2020, the import and export trade of major coal ports in the world shrank significantly. On the supply side, the global seaborne coal trade volume shrank. Besides, due to China's coal import restrictions, Australia's coal export volume declined. The continued restrictions to prevent the outbreaks in India and the Philippines dampened Indonesia's coal shipments. In addition, many Indonesian coal miners ceased

operations, further accelerating the decline in coal exports. On the demand side, due to Australian coal's repeated failures of environmental protection tests in 2019, China initiated strict control over customs declarations across the nation in 2020. In addition, many companies that used coal as energy gradually transformed to use clean energy such as water power and wind power, resulting in weak coal demand in the market. After the outbreaks, with the power demand declining, many power plants in Japan, South Korea, and the European Union were closed. Specifically, the production capacity of coal-fired power plants in the European Union was reduced by 2/3.

2.4 Overview of Liquid Bulks Throughputs of Global Ports

In 2020, the COVID-19 pandemic broke out globally, and all economies adopted isolation and lockdown measures to prevent the spread. Crude oil demand was severely hit, and the supply and demand in the crude oil market got imbalanced quickly. As all economies actively resumed work and production, crude oil demand improved but was hard to recover to the same level last year. According to Clarksons' statistics, the seaborne crude oil trade volume in 2020 dropped by 7.7% year-on-year.

2.4.1 Liquid bulks throughputs of Asian ports show divergent trends

In 2020, the overall demand for marine oil in Singapore declined, the international crude oil prices were turbulent, and the Singapore marine oil market was in a downturn. As a result, the supply of low-sulfur fuel oil arriving in Singapore remained low. In addition, the supply of high-sulfur fuel oil resources was also decreasing. In this context, the crude oil throughput of the Port of Singapore dropped sharply. Due to the refinery capacity expansion, China's crude oil imports bucked the trend and increased by 7.3% to 540 million tons. The commissioning of new facilities of the private enterprise Zhejiang Petroleum & Chemical Company Limited boosted the crude oil throughput of Ningbo-Zhoushan Port, which increased by 10.2% year-on-year. Qingdao Port launched China's first bonded crude oil mixing and blending business and mixed 1.2 million tons of bonded crude oil. Besides, Qingdao Port achieved breakthroughs in export tax rebates and bonded direct supply of domestic low-sulfur oil for ships, and launched the oil supply pilots for large vessels in outer

anchorages in Qingdao, with the oil supply throughput for ships increasing by more than 30%, promoting the growth of the port's crude oil throughput.

2.4.2 Liquid bulks throughputs of European ports plunge

In 2020, Europe implemented a large-scale lockdown, which undermined European crude oil demand to a large extent. Due to the pandemic, the kerosene demand of the Port of Rotterdam dropped sharply. The refineries reduced their production in response to the falling demand. The sulfur-containing oil was also restricted. As a result, the liquid bulks throughput at the Port of Rotterdam fell dramatically. Due to the reduction in refining activities, the crude oil throughput of the Port of Antwerp plummeted by 60%, resulting in negative growth in the liquid bulks throughput throughout the year.

2.4.3 Liquid bulks throughputs of American ports slump

In 2020, the drilling activities in the United States decreased, and ports were affected by hurricanes and low oil prices. As a result, the U.S. producers reduced the number of oil wells and cut the production, causing the crude oil production in the United States to plummet since April. As the U.S. refineries entered the autumn maintenance period and the pandemic showed signs of a rebound, the U.S. crude oil production remained sluggish at the end of the year, reducing the liquid bulks throughputs of major U.S. ports, such as Port of South Louisiana and Port of Long Beach. Due to the bumper harvest of soybeans and other agricultural-related products in 2020, the robust exports of grain seed oil at the Port of Santos, and China's demand for oil imports, the liquid bulks throughput of Port of Santos achieved contrarian growth of 11.4%.

Chapter 3 Overview of Global Port Operations and Management in 2020

3.1 New Developments of Port Logistics

In 2020, the COVID-19 pandemic broke out globally. The sudden outbreaks brought a significant impact to the global shipping and logistics industry. Economies around the world announced lockdown measures to deal with the pandemic. Port closures, shortage of container equipment, widespread delays of shipping schedules, short supply of spaces, and rising freight rates, among other negative factors, pushed the global logistics supply chain into trouble. In the face of the difficult pandemic situation, national and regional government departments and port, shipping, and logistics companies were all trying their best to unblock the global logistics supply chain, exhibiting new development characteristics amid the crisis.

3.1.1 Opportunities and challenges coexist for sea-railway intermodal transport under the pandemic

Affected by congestion, the U.S. West Coast ports suffered a shrinking scale of sea-railway intermodal transport. The Port of Los Angeles and the Port of Long Beach handled many imported cargoes for Sino-U.S. trade. However, the large-scale outbreaks in the United States caused retailers to stock up cargoes in large quantities in the second half of 2020, resulting in a concentrated influx of cargoes into Los Angeles and Long Beach ports, and the two major ports suffered severe congestion. The surging cargoes and the limited capacity of the infrastructure caused the average utilization of terminals and depots to stay above 80%. Many containers were stored in the depots, and the passage from the quayside to the container railway stations and depots was also occupied. The service levels of railway facilities were significantly compromised. As a result, the railway efficiency for cargo collection, distribution and transportation slumped, resulting in a sharp drop in the container volume for intermodal transport in the Alameda Corridor connecting the two ports with the hinterland. In 2020, the total container throughput of the ports of Los Angeles and

Long Beach increased by 2%, but the container volume for intermodal transport in the Alameda Corridor fell by 5.91% year-on-year to 4.73 million TEUs. In comparison, the Port of New York-New Jersey was driven by the increasing import demand due to the pandemic, and port congestion was not severe. This ensured a container throughput growth rate of 1.5% in 2020. The railway passage also played a significant role. The intermodal transport volume of the port railway increased by 6.2% year-on-year to 705,900 TEUs.

Due to the pandemic, the sea-railway intermodal transport frequency reduced. The Port of Hamburg, the Port of Bremerhaven, the Port of Duisburg and other ports in Germany have long attached great importance to the construction and development of sea-railway intermodal transport infrastructure. In the inland cargo collection, distribution, and transportation system of the Port of Hamburg in Germany, the share of railway, highway, and waterway transport was 50.7%, 40.3%, and 9.0%, respectively, and the share of the railway cargo collection, distribution, and transportation at the Port of Bremerhaven was as high as 48.2%. However, in 2020, due to the COVID-19 pandemic, the freight volume of the Port of Hamburg and the Port of Bremerhaven decreased to varying degrees, and the sea-railway intermodal transport volume also declined accordingly. The Port of Hamburg completed 2.58 million TEUs of sea-railway intermodal container transport volume throughout the year, a decrease of 4.7% year-on-year. The weekly frequency of sea-railway intermodal transport also dropped from 2,100 in the previous year to 1,726. The sea-railway intermodal transport volume of the Port of Bremerhaven dropped by a wider margin of 7.17% to 990,000 TEUs.

China's port sea-railway intermodal transport ushered in a development opportunity. In 2020, China's total sea-railway intermodal container transport volume reached 6.872 million TEUs, a high year-on-year growth rate of 29.6%. Specifically, Qingdao Port ranked first in the nation in terms of total sea-railway intermodal transport volume, while Shanghai Port led the nation in year-on-year growth. One of the reasons for the rapid growth lies in that under the influence of the global outbreaks in 2020, port congestion became prominent in maritime shipping. This has resulted in a short supply of empty containers and spaces and soaring seaborne shipping rates,

and the cargo transport duration and timeliness cannot be guaranteed. In this context, China-Europe trains became an essential supplement to the maritime trade passage between China and Europe. Besides, the policy guidance in the economies and the improving sea-railway intermodal transport facilities also brought about opportunities for the sea-railway intermodal transport development from the supply and demand perspectives. In 2020, the China-Europe trains gave full play to the unique advantages of international rail transport and became a green channel for transporting pandemic prevention materials. 12,406 trains were operated throughout the year, increasing by 50% year-on-year, being the first time to exceed the "10,000 trains" mark.

3.1.2 Cold chain logistics develop fast at ports

The pandemic drove up the cold chain logistics demand at the Port of Antwerp. The cold chain logistics system in Europe was well developed. In particular, the Port of Antwerp is a crucial cold chain logistics hub in Europe. It has the most advanced refrigerated warehouses, including 5.5 million cubic meters of liquid storage space and 5.5 million square meters of covered dry storage space. The capacity greatly exceeds its surrounding ports and can provide product-specific automated storage solutions. Almost every container terminal at the Port of Antwerp is equipped with reefer charging facilities and can support the power use by 8,000 reefer containers at the same time. In addition, the port area has ultra-modern checkpoints that provide efficient and fast customs inspection services. The digital electronic certificate pilot has further accelerated the customs clearance of cold chain cargoes. Meanwhile, relying on its developed, convenient, and efficient multimodal transport network, the port has guaranteed the efficient operations of the cold chain logistics. In 2020, clouded by the pandemic, the cold chain business brought a vast "thermal benefit" to the Port of Antwerp. The port's refrigerated container throughput recorded strong growth of 10.5% and exceeded the 1 million TEUs mark, accounting for 8% of its total container throughput.

The cold chain logistics infrastructure of China's ports was rapidly upgraded. In recent years, China's cold chain logistics market has continued to expand. During 2017-

2019, the annual compound rate reached 15.3%, and the cold chain logistics demand was also on the rise. In 2020, China overtook the U.S. and became the world's largest refrigerated container importer. China's major ports have successively built seaport cold chain logistics centers to promote cold chain logistics development. In 2020, the International Cold Chain Project of Guangzhou Nansha Port was officially topped out. It will develop into China's largest port-surrounding cold chain warehouse group and a comprehensive cold chain logistics distribution base with a warehousing capacity of 460,000 tons. However, in terms of transportation structure, the current cold chain logistics in China remain dominated by road transportation, which is still unreasonable. The operation modes such as direct delivery from the production area and multi-location coordination and new intermodal transport such as "aviation + high-speed rail + road transportation" are still in their infancy stage of development.

The United States vigorously promoted the development of cold chain projects at ports. The United States is China's largest supplier of refrigerated food. The cold chain logistics centers primarily include ports such as Los Angeles, Long Beach, Oakland, New York-New Jersey, Philadelphia, Savannah, and Northwest Seaport Alliance (NWSA). Specifically, the ports of New York-New Jersey and the ports of Los Angeles and Long Beach have been the largest gateways of refrigerated cargoes in the United States, while the Philadelphia/Wilmington/Gloucester port group is the most active area of refrigerated container business in the United States. The share of reefer containers at the Packer Avenue terminal of Port of Philadelphia even exceeded 50%, much higher than the average level of 5%. Compared with large-scale cold-chain logistics hubs, some small ports in the United States invested more in developing specialized cold-chain logistics in recent years, and their development was faster. In 2020, the refrigerated container import volume of the Port of Miami increased by nearly 13% to 64,000 TEUs. At the beginning of the year, the U.S. Department of Transportation allocated US$44 million to the Port of Miami for building cold chain processing centers and cold storage to improve the processing capacity of refrigerated food and medicine. The first phase of the cold chain logistics project costing US$14 million at the Port of Wilmington was also put into operation this year, and the second

phase of the refrigerated container depot expansion project is also under construction.

Topic 3: Western Europe Gateway in Adversity - Port of Antwerp

In 2020, the COVID-19 pandemic broke out globally, and the cumulative number of infections in Europe skyrocketed. The pandemic brought considerable challenges to port production, including the shrinking trade volume and the prevention requirements which impacted port production. Figure 1 reflects the container throughputs of the top eight major European ports and the cumulative numbers of infections in the country of the port in 2020. Although the container throughputs of the major ports were hit hard by the pandemic, the severity of the pandemic was not inversely proportional to the port production and operation performance. Specifically, the United Kingdom recorded the largest number of infections, and its main port, Port of Felixstowe, was severely hit by the pandemic. In comparison, the Port of Antwerp in Belgium outshone its peers, maintaining positive growth in production among all ports. In addition, the two ports of Antwerp and Zeebrugge in Belgium will explore integrated development in 2021 to strengthen their competitiveness in northwestern Europe. The battle for the gateway of the European region will become more intense, and the status and role of the Port of Antwerp will be further elevated.

1. Diversified cargo structure enhances risk resilience

In 2020, the Port of Antwerp recorded a cargo throughput of 230 million tons, a year-on-year decrease of 3.1%, and a container throughput of 12.03 million TEUs, a year-on-year increase of 1.4%. The sound performance of the port can be attributed to many factors. On the one hand, the port handles a diversity of cargo types in its businesses, including automobiles, steel, coal, fruits, grain, timber, fertilizers, paper, and containers, which translates to its low dependence on a specific market segment, hence its more robust resistance to market fluctuations. On the other hand, the port has a sufficient supporting infrastructure capacity, with as large as 12 million square meters of storage spaces in the port area. This forms a cushion of the port in the case

of external environment impacts and ensures the normal flows of cargo logistics while supporting the rapid recovery of industry and consumer sectors in Belgium and other parts of Europe. Furthermore, the Port of Antwerp, as the world's second-largest maritime chemical and petrochemical center, has industrial zones which house BASF and Bayer, among many other large-scale multinational companies. The port and the industry rely on and support each other. The freight volume generated by industrial companies in the port area accounted for as high as 23% of the total cargo volume of the port. Such cargoes did not require long-distance transshipment and were not much affected by the pandemic as a result.

The Port of Antwerp connects the world's most extensive sea routes and the production and consumption centers across Europe. It is the main import and export gateway for Belgium, the Netherlands, Luxembourg, Germany, and France. 60% of Europe's purchasing power is concentrated within 500 kilometers of Antwerp. Nearly half of the port throughput comes from the transit and re-export trade of neighboring economies. Compared with its adjacent ports, the Port of Antwerp is located inland. Although it is farther from the seaward waterways of international maritime routes, it guarantees the fastest and the most reliable accessibility with the inland.

In addition, the cargo collection, distribution, and transportation network system of the Port of Antwerp is very developed. Externally, the Port of Antwerp has established trade ties with more than 100 countries and regions in the world. The port has more than 300 liner routes, including 325 weekly routes and 50 daily routes, which can reach more than 800 ports globally. Internally, the water and land transportation within and outside the Port of Antwerp extends in all directions. The port is connected with three European highways, 12 international railway lines and the Rhine River and other inland water transport networks. The port area has more than 1,000 kilometers of railways, eight multimodal transport terminals, and the annual freight volume of its port railways approaches 30 million tons, with the inland water transport volume exceeding 85.69 million tons. Through the dense "road-rail-water" multimodal transport network, incoming cargoes can reach Belgium and the Netherlands within 18 hours, get the lower reach of Rhine within 24 hours, and reach northern France

within 36 hours. In addition, the cargoes can reach Brussels Airport within 1 hour and Liège Airport within 2 hours by road. Currently, containers at the Port of Antwerp are still primarily collected, distributed, and transported by road and waterway, accounting for 58% and 34%, respectively, but the proportion of railway transport in and out of the port is relatively low, at only 8%.

3. "Efficient and cheap" integrated port logistics services

The reasons for Port of Antwerp maintaining its strong competitiveness for a long time include its convenient inland transportation network and efficient and fast customs clearance services, and its relatively cheap integrated logistics and transportation costs. Taking a 20-foot general container as an example, compared to the Port of Rotterdam, the Port of Bremerhaven, the Port of Hamburg and the Port of Le Havre, the Port of Antwerp offers the lowest rates for handling and transporting cargo containers to an inland area whether it is by road, rail or barge. The Port of Antwerp has the lowest terminal handling fees in the European Union, namely, about 200 euros, while other ports such as Rotterdam, Hamburg, and Le Havre charge 215 euros, 230 euros, and 211 euros respectively. In addition, the port storage fees of the Port of Antwerp are also very attractive, with only 147 euros per TEU charged for a one-month storage period. In comparison, this charge is as high as 706 euros at the ports of Bremerhaven and Hamburg in Germany.

4. Future strategic development direction of the Port of Antwerp

As the largest port in Belgium, the Port of Antwerp contributed 4.8% of the national GDP and created job opportunities for 143,100 people, being an important engine of the Belgian economy. In recent years, the container cargo volume of the port has been on the rise. To support further growth in the future, the local government and port authority have launched an expansion plan, namely ECA (Extra Container Capacity Antwerp), striving to build new terminals and expand the existing ones. After the project is completed and put into production, the Port of Antwerp will increase its container handling capacity by 7.2 million TEUs.

However, compared with the port throughput growth, the Port of Antwerp emphasizes improving port resilience, clean energy, smart transformation, and

sustainable development in its future development strategies. In recent years, the Port of Antwerp has also launched CLean INland SHipping (CLINSH), Smart Ports Entrepreneurial Ecosystem Development (SPEED), ePIcenter logistics integrated alliance and other projects, aiming to optimize the port and city environment, improve the port operation efficiency and increase the port accessibility. To help the port and the shipping industry with their energy-saving and emission reduction initiatives, the Port of Antwerp has invested 35 million euros in promoting the transition from marine fuels to clean energy. Its strategic goal is to transform and develop into a "multi-fuel" port before 2025, providing green and clean energy, including LNG, hydrogen, and electric power for ships arriving at the port.

The Port of Antwerp continues to lead the world in smart digital port construction. It has introduced a series of innovative measures such as developing autonomous unmanned probe ships, pilot applications of blockchain, the construction of smart terminal sensor walls and digital 3D maps of the port. However, these are not its final goals. The Port of Antwerp's strategic vision is to build a digital ecosystem at the port to meet the development needs of the future supply chain. In addition, the Port of Antwerp is also increasing its investment in inland hinterland connectivity. It has launched a plan jointly with a Belgian railway infrastructure management company to improve the accessibility of railway lines in the port area and further optimize the port's cargo collection, distribution, and transportation system. Besides, it also strives to increase its sea-railway intermodal transport to 15% by 2030.

3.2 New Developments of Port Operations

3.2.1 Deepened integration of port resources

Europe promoted the integration of port authorities under the landlord port model. European port competition has turned white-hot, and ports in the region have begun to explore substantial integration. The three major ports in France, namely Port of Rouen, Port of Le Havre, and Port of Paris, have established the HAROPA Port Alliance as early as 2012. Their cooperation was concentrated in port authorities. Their

collaboration was dominated by scattered, project-based initiatives in the past nine years, without a uniform port authority operational body through thorough integration. However, they did have a unified brand for promotion to the external parties. The integration of the HAROPA Port Alliance has been advancing despite many oppositions. However, under the new situation, HAROPA has also begun to explore in-depth integration further. It is expected that by June 2021, the three ports will be wholly integrated to form a single port authority and be listed as a unified whole. After the integration, a French economic stimulus plan will support port development, allocating 71 million euros to promote green ports. Meanwhile, the ports of Antwerp and Zeebrugge in Belgium will begin to explore substantial integration in 2021 after nearly two years of negotiations. The Port of Antwerp Authority and the Port of Zeebrugge Authority will be integrated into "Port of Antwerp-Bruges" Authority. In the integration plan of the two ports, port production scale is not a future focus. Instead, they will focus more on integrating multimodal transport networks to improve port logistics efficiency and flexibility. The two ports will also invest in the low-carbon economy to seize a leading position in the energy transition and digital development fields.

Ports in Mainland China used capital as a link to integrate investment, construction and operations. Unlike the operation and management modes of European ports, most public terminals in Mainland China feature integrated functions of port operators, including port investment, construction, and operations. Since 2014, Mainland China has been promoting the integration of public port operators in each province so that one province has one public port investment and operation enterprise. Currently, almost all coastal provinces such as Zhejiang, Jiangsu, Liaoning, Shandong, Anhui, Sichuan, Jiangxi, Hunan, Guangxi and Hainan have established a provincial-level port group. In addition to the integration by province, the cross-province port resource cooperation is also constantly strengthened. In August 2020, Shanghai International Port Group (SIPG) subscribed for a 5% stake of Ningbo-Zhoushan Port, becoming the second-largest shareholder of Ningbo-Zhoushan Port. As a result, the port features cross-shareholding by two major port groups.

3.2.2 Beirut explosion sounds the alarm of port security

On August 4, 2020, the Port of Beirut in Lebanon's capital experienced two consecutive large explosions due to the ignition of more than 2,700 tons of ammonium nitrate stored in the port area. The port area was razed to the ground, leaving about 200 killed and more than 300,000 homeless. The economic losses exceeded tens of billions of U.S. dollars. The explosions were considered one of the most powerful non-nuclear and man-made explosions in human history and have sounded an alarm for ports worldwide, implying that port security management cannot be ignored.

Learning the lessons of the major explosions at the Port of Beirut, ports around the world have begun to investigate the operational risks of hazardous chemicals and introduced related policies to improve port safety. From the investigations, the ports in some regions still have major safety management risks, especially in some developing countries in South Asia. After the explosions in Port of Beirut, the Indian government issued a warning requesting all ports across the nation to verify any explosives in their warehouses. They then found 37 containers containing nearly 740 tons of ammonium nitrate shelved for five years at Chennai Port, and the containers were only 700 meters away from the residential area. Bangladesh also set up a relevant committee organization to eliminate dangerous goods that have been stored at Port of Chittagong for 28 years and unclaimed.

Since the 9/11 attacks, the United States has attached great importance to the security of its homeland and ports. Ports in the United States all have corresponding safety centers and relevant regulations to limit the amount of dangerous goods stockpiled at ports. In 2020, the Federal Emergency Management Agency (FEMA) of the U.S. Department of Homeland Security launched the Port Security Grant Program (PSGP) to improve port maritime security risk management further, providing 30 U.S. port authorities with US$100 million in funding to further improve and consolidate port security. China is also very vigilant about port security. After the Beirut explosions, it immediately rolled out special security rectifications in key areas such as ports, terminals, logistics warehouses, and chemical parks and carried out inspection and

supervision of more than 22,000 major hazards. It also issued the *Notice on Further Strengthening the Safety Management of Dangerous Goods during Port Operations*, which puts forward strict requirements and prohibitions on the safety management of dangerous goods during port operations.

Chapter 4 Comment on Global Terminal Operator Development in 2020

In 2020, the COVID-19 pandemic outbreaks allowed global terminal operators to witness the fragility of the fragmented logistics resources. Their investment willingness is gradually shifting to the integration of logistics supply chains. Investment continues to flow to seaborne shipping services, inland warehousing, logistics, and other upstream and downstream sectors of ports. Full-process integrated logistics services are gradually becoming the shared target of more global terminal operators.

4.1 Overview of Global Terminal Operator Development

4.1.1 Productivity changes of global terminal operators

In 2019, global terminal operators controlled about 62% of terminal capacity, which ran flat with that in 2018. According to the forecast of the British shipping consulting agency Drewry, the capacity expansion rate of global terminal operators will remain at 1.7% in the next five years, slightly lower than the global average growth rate of 2.1%. Under the influence of the pandemic, the production environment of major global ports further deteriorated. Global terminal operators further increased cost management and monitoring and adopted more stringent and prudent investment strategies. Therefore, it is expected that in 2020, Drewry may further tune down its expansion expectations of global terminal operators' production capacity.

4.1.2 Market share changes of global terminal operators in different regions

In 2019, the share of global terminal operators in terms of container throughput accounted for 66.2% of the total global throughput, a slight increase from 2018. In terms of regional proportions, Europe and the Middle East and the Indian subcontinent were the regions with the highest proportion of global terminal operators in terms of throughput, at 78.4% and 73.3%. The share of global terminal operators in Asia was also significant, accounting for 64.4% of the market's total. In

addition, in the context that public institutions in Africa accounted for 35%, global terminal operators still occupied half of the African market and more than 61% of the market share in Latin America, highlighting global terminal operators' favor of emerging markets.

4.1.3 Profitability of global terminal operators

In 2019, except DP World and APM Terminals, the single-container revenue of the world's major terminal operators all showed a declining trend. Specifically, supported by the ancillary revenue from the signing of service contracts with shipping companies and the dividends of new terminals, ICTSI enjoyed a robust revenue throughout the year. However, subject to the depreciation of major currencies such as the pound and the euro, CK Hutchison recorded a minor increase in profit margin at only 0.6%. In addition, DP World achieved substantial growth in operating income through acquisitions. However, as some of these acquisitions were not included in the port's business scope, its Earnings Before Interest, Taxes, Depreciation, and Amortization (EBITDA) margin declined slightly. In 2020, the global economic downturn further intensified, and global terminal operators' profitability also faced huge challenges. In the Drewry sample survey, 80% of terminal operators reported a decline in revenue in the first half of 2020, and the total revenue of all the samples fell by 2% year-on-year.

4.2 Analysis of Business Performance of Global Terminal Operators

4.2.1 COSCO Shipping Ports business growth falls

In 2020, affected by the global COVID-19 pandemic, especially the repeated outbreaks outside China, the total throughput of COSCO Shipping Ports was basically the same as the previous year. Its total container throughput reached 123.83 million TEUs, and its equity throughput fell by 3.1% year-on-year to 38.46 million TEUs. In terms of profitability, the performance of COSCO Shipping Ports in 2020 was affected by the pandemic, with the company's annual operating income falling by 2.6% year-on-year to US$1 billion.

4.2.2 China Merchants Port business develops steadily

Owing to the container volume increase from the newly acquired terminals and the opening of new routes at domestic ports, China Merchants Port posted the best growth among the global terminal operators covered in this report in 2020, with a total container throughput of 120 million TEUs, up by 7.9% year-on-year, and an equity throughput of 46.638 million TEUs, up by 11.9% year-on-year.

In terms of profitability, as port throughput in the second half of 2020 gradually picked up, China Merchants Port recorded an annual operating income of HK$8.95 billion, an increase of 0.5% year-on-year. Due to the non-recurring disposal income of HK$4.2 billion in 2019, its profit attributable to equity holders decreased by 38.4% year-on-year to HK$5.151 billion.

4.2.3 DP World enjoys sound business performance

In 2020, DP World Port Group's maritime and logistics businesses were severely challenged. However, the group kept strengthening its global network layout, actively integrated acquired companies to promote synergy, put costs under control to enhance profitability, and managed expenditures to maintain a smooth cash flow. Meanwhile, it also accelerated business expansion and diversified investment to improve the group's competitiveness in the industry. The group maintained stable business performance overall, and its container throughput ran flat with that in the previous year.

In terms of profitability, DP World benefited from the acquisition of the pan-European logistics platform P&O Ferries, the marine logistics operator Topaz Energy & Marine, and Canadian terminal Fraser Surrey Docks and the TIS Container Terminal in the Port of Yuzhny, Ukraine, as well as the revenue from new customers. As a result, the operating revenue of DP World Port Group in 2020 increased by 11.0% year-on-year to US$8.53 billion. The group's EBITDA was US$3.32 billion, an increase of 0.4% year-on-year and its full-year EBITDA margin fell by 4.1 percentage points to 38.9%.

4.2.4 APM Terminals' business volume declines

In 2020, the global container business of APM Terminals experienced an extensive

decline. Except the narrow positive growth of container throughput in Asia, the company posted negative growth in all other regions. However, in terms of profitability, APM Terminals' single-container revenue recorded a favorable figure once again, which to a certain extent reflected its sound cost control. The improvement of APM Terminals' profitability was closely related to its parent company's (A.P. Moller-Maersk) development strategy of logistics supply chain integration. In recent years, AP Moller-Maersk has continued to strengthen vertical integration, integrating and controlling more upstream and downstream resources on the supply chain through integrating shipping, port ancillary services, inland logistics services, and other elements to cut the total operating costs. Terminal business, as its key sector, also benefited a lot.

Generally speaking, compared with the acquisition of new terminals, APM Terminals currently prefers the expansion and upgrading of terminal facilities. In 2020, APM Terminals acquired only one terminal—the container terminal of the Aarhus Logistics Center in Denmark, but it also made a lot of moves in terminal expansion. For example, it spent seven billion rupees to expand its Pipavav terminal in India, formulated an expansion plan for Port of Poti in Georgia, and co-developed a container terminal at Port of Abidjan in Côte d'Ivoire with the terminal operator Bolloré. In addition, APM Terminals also paid great attention to the smart upgrading of the port. In 2020, it launched smart projects in succession, such as a standardized container intelligent tracking system and a truck digital appointment system (API) to help further elevate the terminal operating efficiency.

4.2.5 ICTSI business volume grows slightly

In 2020, against the unfavorable economic and trade environment, ICTSI's port production was greatly affected, and its container terminal business only recorded a minor increase of 0.2% throughout the year. Despite the sharp decline in its terminal business growth, ICTSI has secured a 2% year-on-year growth rate in port business revenue through strict cost control and diversified product portfolios.

In terms of profitability, ICTSI's full-year revenue in 2020 was basically the same as the previous year. Boosted by the economic benefits created by tariff adjustments

and new terminal services, ICTSI's annual revenue increased by 2% year-on-year to US$1.51 billion, with the single-container revenue steadily rising to US$148 and the EBITDA standing at US$880 million, an increase of 6% year-on-year.

4.2.6 PSA International's growth rate drops

In 2020, affected by the COVID-19 pandemic, PSA International Port Group recorded a total container throughput of 86.6 million TEUs in the year, an increase of 1.7% year-on-year, and the growth rate further declined. The group's annual operating income was S$4.18 billion, an increase of 2.5% year-on-year. However, due to the decrease in other income and the increase in operating expenses caused by the pandemic, the group's profit margin narrowed. Its overall net profit fell by 6.2% year-on-year. Its operating profit margin also decreased compared with 2019.

4.2.7 CK Hutchison posts weak business performance

Compared with other terminal operators, CK Hutchison posted the weakest performance. Its global terminal network layout was the most fragmented. The global outbreaks of the pandemic also dealt the heaviest blow to its network. In addition, CK Hutchison has been eliminating its terminal assets in recent years, reflecting the overall attitude of Hutchison Whampoa Limited towards terminals. In 2020, the annual container throughput of CK Hutchison dropped by 2.7% year-on-year to 83.7 million TEUs.

In terms of profitability, CK Hutchison sold a 20% stake in Shanghai Mingdong Container Terminals, which led to a decrease in the contribution of its Shanghai business. In addition, the low warehousing revenue in Mexico led to a decline in operating income. Overall, the operating income of the group's port and related service sectors in 2020 dropped by 7% year-on-year to HK$32.87 billion, and its EBITDA fell by 19% year-on-year to HK$10.91 billion.

Chapter 5 Overview of Global Terminal Investment and Construction in 2020

Under the influence of the pandemic, some port construction projects have been postponed to even several years later. Coupled with the impact of the pandemic on the economy, port construction funds will experience a shortfall in the next few years, and the port construction cycle may be extended. In 2020, most of the demands for port construction and expansion aimed to improve handling efficiency, cut the economic costs and pursue information-based development. Region-specific, due to the global COVID-19 pandemic, the port trade growth in Asia slowed down, and port construction demand decreased. Southeast Asian ports continued to advance container terminal construction, vying to become the regional hub. Ports in the Americas delayed or put aside the plans of construction projects last year due to the pandemic and restarted construction in the second half of 2020. The European region continued to expand infrastructure to cope with the economic downturn to stimulate regional economic and trade growth. The port construction projects in Africa and South America were relatively scarce, with insufficient construction momentum.

5.1 Construction of Container Terminals

5.1.1 Construction of automated terminals in Asia gains speed

1. Automated terminals favored in East Asia under the pandemic

Clouded by the global pandemic in 2020, automated terminals which feature less human participation have attracted attention. Government departments and port companies have constantly strengthened feasibility assessment for terminal automation transformation and construction, and port automation technologies were also applied in East Asia one after another. Specifically, China's Qingdao Port took the lead in piloting the "air-rail" cargo collection, distribution, and transportation system, which can achieve an annual transportation capacity of 1.5 million TEUs in cooperation with the Qingdao automated terminal. Meanwhile, Xiamen Port planned to build a 200,000-ton-class automated container berth. The project will use remotely operated

intelligent bridge cranes, with all the gantry cranes in the depot being automated rail cranes and container trucks using the unmanned driving technology. The automated terminal is designed to provide a throughput capacity of about 910,000 TEUs a year.

2. Southeast Asia re-launches port construction projects

As the pandemic situation was put under control gradually in Asia in the second half of the year and the compensatory trade rose, which boosted shipping service renewals, port construction projects in Southeast Asia quickly picked up in the second half of the year. The enthusiasm for port construction in Singapore, Malaysia, Indonesia, Thailand, and other regions rose again. In 2020, in addition to Tuas Mega Port Phase II in Singapore and Port of Tanjung Pelepas and Port of Kelang in Malaysia which were carrying out phased construction, Indonesia also accelerated the construction of Port of Tanjung Priok and Port of Patimban to vie for the status of Southeast Asia's transshipment center. Meanwhile, the Malaysian government also supported the Port of Sabah to develop a new terminal in Sepangar Bay. The construction project will include land reclamation, transportation equipment upgrading and extension of the terminal shoreline. After completion, the annual throughput of the port will increase from 500,000 TEUs to 1.25 million TEUs. In addition, the Myanmar government also vigorously promoted the construction of port facilities, and the project funds primarily came from the investment of China and Japan, among other economies. In 2020, the Japan International Cooperation Agency funded 6.03 billion yen in Myanmar to build a modern container port in Mandalay. After completion, the Port of Mandalay will have container handling machinery, depot warehouses and other facilities.

3. Port construction in South Asia and West Asia slowly gains speed

The port infrastructure in South Asia and West Asia was relatively backward. With the trade development, there exists a greater demand for port upgrading. In 2020, the Indian government approved the construction of a greenfield, deepwater port at Wadhavan. The port cost about US$9.16 billion and can receive and unload container ships of 25,000 TEUs, exceeding the current largest container port in India, Jawaharlal Nehru Port. The Port of Colombo in Sri Lanka also planned to invest US$32 million for

the fifth-phase expansion of the terminal to improve the port's efficiency. Port construction in West Asia also maintained a slowly accelerated trend. Specifically, PSA International Port Group's subsidiary Saudi Global Ports reached an agreement with the Saudi Arabian Port Authority to invest US$1.87 billion in the construction of two container terminals in King Abdul Aziz Port in Dammam. The investment will focus on automation technologies to increase the port's operating capacity to 7.5 million TEUs. In addition, the expansion of the Port of Abu Dhabi was still ongoing. It is expected to increase the cargo handling capacity by providing deep water channels and enhancing infrastructure. After the completion in 2021, the container terminal's capacity may increase by 5 million TEUs.

5.1.2 Americas restart the last round of suspended projects

1. The United States continues to upgrade its port facilities

In the first half of 2020, the COVID-19 pandemic got rampant across the nation and severely curbed economic development. In this context, the U.S. ports suffered a shortage of labor, which coincided with the concentrated arrival of cargoes, resulting in severe ship congestion on the west coast of the United States. In the second half of the year, as the government took intervention measures, the originally congested trade demand was gradually recovered. Port cargo volume rose rapidly, and port production capacity ran slightly short. In this environment, the U.S. government restarted the port upgrading projects before the outbreaks, and the U.S. Department of Transportation planned to invest additional US$1 billion in infrastructure construction to improve the port supply chain. In addition, the U.S. Department of Transportation also approved a new port infrastructure development plan in the second half of 2020, allocating more than US$280 million to improve coastal port infrastructure, covering 15 coastal ports in the United States to improve the efficiency of transportation and supply chain networks.

2. Canada follows suit to improve port operational capabilities

With the restart of the U.S. port expansion projects, Canada followed suit and actively promoted the construction of port facilities. Specifically, the Port of Halifax

was expanded to meet the berthing operations of large ships of above 14,000 TEUs. It planned to build the second container terminal and another container operation area on the other side of the original terminal. Meanwhile, the Canadian government provided 55 million Canadian dollars to the Montreal Port Authority to start the new terminal construction. The new terminal will include two berths and one container handling area. It is estimated that the container terminal can handle 1.15 million TEUs per year. In addition, the Port of Vancouver in southwestern Canada was also undergoing expansion, primarily at the Centerm Container Terminal and the Vanterm Container Terminal. The project will increase the storage capacity by approximately 200,000 TEUs. The Port of Prince Rupert's ongoing renovation plan is expected to be completed in 2021 when its port capacity will be increased to 1.6 million TEUs. It is worth noting that western ports such as Port of Vancouver and Port of Prince Rupert are trying to compete for Asian routes from the Seattle-Tacoma Seaport in the United States through increased production capacity to expand their geographic advantages.

5.1.3 Europe expands port construction to promote the development

The COVID-19 pandemic has exerted a significant impact on the European economy and trade. But as the economic downside pressure increased, many infrastructure construction needs were put on the agenda to alleviate the impact of the economic downturn. With the gradual increase of the share of large ships on the Eurasian routes, many European ports still fail to meet the development needs for large-scale vessels, so European ports are also more inclined to build larger berths. The deep-water container terminal jointly developed by Stockholm Container Port in Sweden and Hutchison Whampoa was officially completed in 2020, becoming the only port of call for large container ships on the east coast of Sweden. The Port of Antwerp is also actively cooperating with PSA International to expand the Europa Terminal at the Port of Antwerp. After the completion of the project, the terminal can handle two ultra-large container ships simultaneously. Montenegro announced that it would invest up to 2.5 billion euros to build a new container terminal at Bar Harbor of the Adriatic Sea. The project covers about 140 hectares and can handle ships of more than

22,000 TEUs, and is expected to be completed by 2025. After that, the port may become the first port of call to use the Adriatic Sea as a gateway to Europe. The United Kingdom not only re-established a free trade port after announcing its "Brexit" but also announced an investment of US$11 million in port construction to stimulate the domestic economy and port trade. However, the COVID-19 pandemic has put a halt to the British port construction campaign. According to the British Ports Association (BPA), the COVID-19 pandemic has suspended 64% of the UK's port construction projects, while another about 15% of the construction projects were progressing slowly.

5.1.4 Terminal construction intensity in Africa eases

Due to environmental, folklore, inland infrastructure and other reasons, investors' enthusiasm for Africa was cooled. The port trade demand also exhibited weak growth, which retarded international capital investment in African ports. Currently, only Hutchison Whampoa and the Egyptian Navy signed a long-term agreement, planning to invest about US$730 million in a new container terminal in Abu Qir, Egypt, aiming to connect the Port of Alexandria as well as the capital Cairo and other major cities. The terminal will have a handling capacity of two million TEUs and is expected to start operations in 2022. DP World, a global terminal operator, also signed an agreement with the Senegalese government to invest US$837 million in the Port of Dakar to develop a new container terminal and a five-kilometer channel, which move will enable the port to accommodate the world's largest container ship. In addition, affected by the pandemic and the decline in trade, the second container terminal construction of the Port of Damietta, jointly developed by Egypt and China Harbour Engineering Company Ltd (CHEC), had to postpone. The terminal project cost US$500 million and will increase the port's annual container handling capacity to 1.8 million TEUs after completion.

5.2 Construction of Bulks Terminals

The COVID-19 pandemic has shocked the global manufacturing industry, and the economic and trade growth has slowed down, which caused a significant impact on the international dry bulks market. The freight rates of dry bulks fluctuated

dramatically, the raw materials ran short of supply, and the construction of bulks terminals progressed slowly.

5.2.1 Europe continues to promote bulks terminal construction

In 2020, the pandemic situation in major European economies ran out of control, and the economic recovery was under bigger pressure. European governments aimed to restore economic development through the construction of port facilities. Specifically, the Port of Barranquilla in Colombia planned to expand the port to increase its bulks handling capacity. The terminal operator Compas invested US$30 million to expand the port infrastructure. After the expansion, the port can accommodate four ships at the same time on the existing shoreline. Equipped with modern "coal-mine-purpose belt loaders", the port can shorten the operating hours of vessels at the terminal. Meanwhile, other European economies were also actively building new bulks terminals to cope with larger dry bulks carriers. Specifically, the new bulks terminal at the Port of Muuga, Estonia, covers about 4.4 hectares and has a designed capacity of approximately 500,000 tons. In 2020, the new bulks terminal in Esbjerg, Denmark, was basically completed. Its four warehouses can store about 17,000 cubic meters of cargoes, such as sand, gravel, detritus, and granite.

5.2.2 China's bulks terminals implement smart upgrading

Compared with container terminals, bulks terminals started earlier in terms of automation application. For bulks terminals, automation technology is more important. In 2020, Zhanjiang Port went all out to build an intelligent bulks terminal, completing projects including horizontal spiral feeders and flexible bucket wheels, the centralized control room for intelligent bulks terminals, and the fully automatic intelligent bucket wheel stacker-reclaimers. In addition, Yantai Port also "armed" operating machinery with advanced industrial automation, testing, surveying and mapping, computer image and graphics and communication technologies, and has formed chained operations.

5.3 Construction of LNG Terminals

Economies worldwide are paying increasing attention to environmental protection and sustainable development and have introduced relevant policies and augmented capital investment to promote LNG energy. According to the International Gas Union (IGU) statistics, from 2020 to 2025, 19 LNG projects were approved or under construction. After these projects are put into operation, the global total natural gas liquefaction capacity will reach 553 million tons/year. LNG-powered ships also embraced rapid development in the past two years, which has stimulated the growth of the LNG bunkering market, and LNG terminal construction has become a major trend.

5.3.1 China steadily advances its LNG terminal construction

China's natural gas market has entered a golden period of rapid development, with annual natural gas consumption increasing year by year. LNG accounts for an increasing market share, and natural gas-related policies are introduced one after another. LNG receiving stations, which progressed slowly previously, have also seen rapid development. Private capital gradually tapped to this field, and the numbers of LNG receiving stations newly built and expanded increased sharply. Guanghui Qidong LNG Terminal, Shanghai LNG Terminal Expansion Project, PetroChina Tangshan LNG Terminal, Zhejiang Ningbo LNG Terminal Expansion Project were all put into operation in 2020. Meanwhile, the rapid development of LNG-powered ships has also boosted the growth of LNG bunkering stations at ports. In June 2020, China's first offshore international LNG bunkering center settled in Yantian Port, Shenzhen. Yantian Port hence becomes one of the pioneers in the construction of LNG bunkering centers in the world. In addition, China's "Yangtze River Gasification" project was implemented in 2020. With this project, LNG handling and refueling stations will be set up along the Yangtze River to promote the oil-to-gas transformation of ship engine fuels and build a green shipping channel on the Yangtze River.

5.3.2 LNG terminal construction in the United States in a jam

Influenced by the pandemic, nine LNG terminal projects in the United States were delayed due to financial difficulties and pandemic risk prevention, including the third-

phase expansion of the Corpus Christi LNG terminal in Texas, which was postponed until after 2022, and the Driftwood LNG export project planned by the Louisiana state, which was delayed to 2021. Sempra Energy has completed the LNG supply transaction, postponing its Port Arthur LNG export project in Texas to 2021. The construction of the Venture Global LNG's 10-mtpa Calcasieu Pass LNG terminal in Louisiana is ongoing to upgrade the LNG storage tank capacity. The Golden Pass LNG terminal may increase the authorized export capacity of the LNG terminal under construction in Texas from 15.6 tons/year to 18.1 tons/year. The COVID-19 pandemic didn't delay the project, which is expected to be completed as planned in 2024.

5.3.3 LNG terminal construction in Southeast Asia progresses quickly

The rapid economic growth of Southeast Asian economies has stimulated the huge demand for new energy. Given the massive increase in energy demand, Southeast Asian economies have launched LNG terminal construction initiatives. In 2020, both Vietnam and the Philippines accelerated the construction of receiving stations to ease the pressure on the local power supply. In September 2020, the planned LNG floating storage and regasification facilities project in Batangas, Philippines, was officially launched. The project was jointly undertaken by Tokyo Gas and a power generation company (First Gen) under the Lopez Group and planned to introduce LNG to the Philippines in the second half of 2022. SAMSUNG C&T signed a contract with the Tiwai Wharf in Vietnam to build 180,000 cubic meters of liquefied natural gas tanks, regasification facilities and berth facilities at the wharf. The project is scheduled to be completed in October 2022. In October 2020, the Hai Phong City of Vietnam formally approved the ExxonMobil LNG power generation integrated project. The project includes the power generation power enhancement of the power plant, the construction of an LNG storage warehouse, and a storage capacity of six million tons of LNG per year. The project is expected to be officially put into operation in 2026.

Chapter 6 Overview of Global Port Technology and Information in 2020

In 2020, when the COVID-19 pandemic dealt a heavy blow to port production and operations, it also enhanced terminal operators' awareness and willingness to develop smart ports and prompted them to accelerate the application of advanced technologies such as the 5G technology, blockchain, edge computing, artificial intelligence, and computer vision to speed up the transformation and upgrading of traditional terminals. According to the relevant research of the Dutch consulting company Royal Haskoning DHV, a smart port generally goes through five development stages before maturing, namely data acquisition, collaborative sharing, decision support, reinforcement learning, digital transformation.

6.1 Automated Port Development

6.1.1 Single-point technology optimization and upgrading of port automation

Since the emergence of the first batch of automated terminals in the 1990s, automated terminal technologies have continued developing and innovating. From gate systems to depot cranes and further to terminal cranes, automation technologies gradually cover the entire port operation process, and now fully automated terminal operations are also realized. The automation technologies are constantly innovated, and breakthroughs were made in 2020 in the cargo collection, distribution, and transportation system for multimodal transport in the port area and the terminal handling and production operations.

Qingdao Port proposed an intelligent air-rail system for cargo collection, distribution, and transportation to improve the collection, distribution, and transportation efficiency at ports. The intelligent air-rail system upgrades the port container collection and distribution from plane operations to three-dimensional operations by establishing rails in the air. The system is immune to bad weather and road traffic congestion and breaks the safety and environmental protection

bottlenecks of plane operations such as intersections and congestion. It also connects up the "one kilometer in the middle" of containers from the railway station at ports to the depots. The project will be promoted at the fully automated terminal of Qingdao Port. The first phase of the project will use the intelligent air rail system to interact with AGVs, IGVs, and trucks to accurately connect eight types of port operations, including sea-railway intermodal transport, transshipment operations, and customs inspections. With 5G, artificial intelligence, big data, Beidou positioning, machine vision, laser scanning and other high-tech technologies used comprehensively, the system can achieve breakthroughs in smart port automation.

Currently, the automated terminal port equipment is already capable of remote automatic operations. However, due to the diversified lock types and the complicated unlocking processes, no mature equipment or technology is available to replace manual disassembly and assembly during container lock disassembling and assembling. To address this issue, Tianjin Port installed ground unlocking stations for containers and replaced manual labor at the unlocking stations with mechanical arms to avoid operations under the quay cranes and reduce the manual labor intensity. This can reduce workers' operations and minimize safety risks while increasing the handling speed of container locks. With the help of six fully automatic intelligent robots, it takes only 20 seconds to assemble and disassemble a container truck.

6.1.2 Automation transformation technologies for traditional terminals evolve

Due to the relatively high cost and challenging transformation of fully-automated terminals, semi-automated terminals have become the primary trend in the current upgrading and transformation of traditional terminals. The quay crane automation transformation technology mainly involves the STS automation management system, the truck positioning system, the built-in optical identification system OCR, and the container collision avoidance system. Due to the complexity of quay crane operations and the difficulty of full automation, quay crane automation is usually not the first option in the automation transformation of the traditional terminals. The automation

upgrading and transformation of horizontal transportation equipment involves using unmanned AGV technology, SC technology or automated trailers. For example, Tianjin Port employed unmanned electric container trucks in full-process real ship operations, and Xiamen Port Hairun Terminal upgraded and transformed the unmanned horizontal transport, intelligent guidance of trailers and other parts.

The automation transformation of traditional container terminals still faces many challenges. First, traditional terminals take longer for renovation and construction, with higher costs and energy consumption. For example, to build a medium-sized automated terminal with an annual throughput of two million TEUs generally requires more than RMB 1 billion; to create a horizontal container transport method by using AGVs, tens of thousands of magnetic nails need to be buried underground. Second, the technical standards for the transformation of traditional terminals are not in place. The existing technical solutions of automated terminals are difficult to meet the fully automated transformation requirements of traditional manual terminals. The reliability and stability of the next-generation automated terminal technologies need to be tested. Automated terminals have sophisticated and complex structures, and the cost of trial and error is high. Third, port operators have different roles and needs. Automation transformation of traditional terminals requires the coordination of multiple management entities to balance the demands of all parties. Fourth, limited by the overall connection of the terminal's horizontal transport system and the quayside and depot equipment systems, full automation of terminals still has challenges.

Compared with cargoes shipped in standard containers, bulks' cargo forms and ship types are different, which sets more stringent technical requirements on the automation upgrading and transformation of bulks terminals. Dry bulks terminal automation technologies primarily involve unmanned operations of large-scale equipment such as loading, unloading, container stacking and reclaiming, and fully automatic control of bulks operation processes. In terms of technological transformation, 3D laser scanning technology can be used to scan the stockpiles during cargo handling from ships and trucks in real time; GPS technology can be used to locate

the container position accurately; simulation technology can be used to simulate the dynamics of the equipment in the operation process to realize real-time monitoring of stacker-reclaimers and stacking-reclaiming dynamics. In the operation process, 3D laser scanning technology can be used to realize full-process automation of cargo unloading from ships, horizontal transport, stacking and reclaiming, loading to trunks, mixing, and loading to vessels at the terminal.

6.2 Digital Port Development

6.2.1 Port data coordination mechanism and platform construction

The smart port information system enables interactions between the port and logistics companies via advanced technical means and achieves connections between different information platforms by establishing an information-sharing mechanism and a unified data interaction standard for the information platform. With the information of all parties integrated into a port information system platform that encompasses all the information and data and provides services to all participants, the solution can ensure the accuracy, reliability and timeliness of data information. The European Port Community Systems Association (EPCSA) established a port platform. Setting up a cross-regional single window has established a port alliance containing six major port operators in Germany, the United Kingdom, the Netherlands, Spain, Italy, Latvia, Belgium, Ukraine, and Israel. The convenient and standardized information-sharing mechanism has promoted the efficiency of port operations.

In 2020, the information platform systems of various ports were constantly upgraded and improved. Specifically, the "E-Logistics Yantian" one-stop integrated port information service platform of Yantian Port District of Shenzhen Port was launched. The Port of Abu Dhabi achieved the digital transformation of truck logistics through Maqta Gateway's digital logistics solution platform MARGO. In March 2020, China Merchants Port built a smart port logistics platform that connected customs, ports, carriers, shippers, freight forwarders, financial institutions and other related parties based on blockchain technology.

6.2.2 Paperless port documents develop quickly

By virtue of blockchain technology's traceability and trustworthy technical characteristics, ship enterprises and ports have realized data interconnection and intercommunication between systems and the collaboration and mutual trust of processes. This allows customers to complete operations throughout the ship enterprise and the port in the supply chain, with a paperless process throughout the imported cargo release. The paperless import documents and the paperless container equipment handover orders, bills of lading, packing lists, and other documents have greatly improved the informatization level of the port logistics system and accelerated the port customs clearance. The fully electronic port operation documents, on the one hand, provide all-around and multi-angle protection for data flows, and on the other hand, greatly enhanced the business efficiency via business processing modes such as online business authorization, online container pickup appointment, and verification code for paperless container pickup. In addition, during the global COVID-19 pandemic, the paperlessness of port documents greatly reduced offline contacts and set up a security line of defense for various port operations.

Currently, the paperless application of port documents has been widely promoted in global ports. With the help of blockchain technology, most ports have comprehensively adopted paperless port operation documents, and the port logistics efficiency has been dramatically improved. For example, in June 2020, Qingdao Port and COSCO Container Lines Co Ltd jointly launched a digital, contactless import pickup solution based on blockchain technology. By the end of the current month, COSCO Container Lines Co Ltd has completed the imported cargo release of nearly 500 containers at Qingdao Port through the blockchain paperless imported cargo release model. On average, almost 24 hours of pickup time per container is saved for the customer. The paperless operations of Xiamen Port documents can save more than 10 hours of operation time for each import and export container pickup operation, saving about RMB 200 million of cost every year.

6.3 Intelligent Port Development

6.3.1 Global ports enter the 5G era

The pandemic has stimulated the demand for 5G applications at ports. The global 5G network market has exceeded US$10 billion. Many ports worldwide invested and deployed 5G infrastructure construction to lay the foundation for smart ports. A smart port needs to rely on 5G networks to build a unified wireless access network and a unified business platform to realize ubiquitous broadband access and enable multiple business access scenarios such as environmental monitoring, customs operations, and remote control. 5G technology is primarily used to carry out research and application of remote control of large port machinery based on a 5G network, realize remote control of bridge cranes and gantry cranes, improve container operation efficiency and safety, and empower routine production. The 5G high-definition video back transmission + AI visual analysis technology can support research and application of intelligent tallying and real-time automatic collection and identification of container numbers, damage, and other information to improve port accuracy and efficiency tallying. The research and application of unmanned container trucks and IGVs in closed ports can realize the horizontal transport automation of container terminals and improve transport efficiency and safety. Based on the 5G network, the research and application of multi-channel video back transmission, intelligent identification and positioning technology for port scene monitoring can be carried out to improve the port security level.

6.3.2 AI technology boosts smart upgrading of ports

In 2020, AI chips, supercomputers, and cloud computing enhanced computing power. Supported by the Internet of Things and big data technologies, artificial intelligence stepped out of laboratories to enter commercial applications. The artificial intelligence technology is currently in its initial stage of application at ports, primarily in the first line of port production operations. The AI technology primarily empowers the container circulation and transport processes at ports and is used to realize single-point technical solutions such as full-process identification of containers, the horizontal transport of containers, and the vertical transport of gantry cranes and quay

cranes. For example, machine vision technology can be used to identify and collect data during container circulation and transport. Leveraging the machine vision technology, the port can intelligently identify the container number, container type, handling and pickup status of the container, and the degree of damage to the container during the process from container unloading to stacking, tallying, pickup, and loading to ships. Such solutions can be used in gates, gantry cranes, quay cranes and other scenarios. From quay cranes to gates to container depots, artificial intelligence is accelerating the intelligentization of traditional terminals in all aspects.

In 2020, the world's first portal crane AI tallying system for ports was launched at Zhuhai Port. The system uses AI technology to achieve front-end video capturing, image capturing, ballhead-camera linkage capturing and automatic recognition of characters, and ultimately realizes intelligent production of portal cranes. During the trial operations, the portal cranes' identification rate of container numbers and container types reached 98%. In 2020, the container integration system and the intelligent tallying system of Tianjin Port were fully integrated. The Tianjin Port intelligent tallying system was used at all container terminals to accurately identify handled container numbers, trailers, and ship loading locations. Specifically, the one-time identification accuracy rate of vehicle numbers and container numbers exceeded 95%, which effectively enhanced the efficiency of cargo handling and tallying operations of the terminal companies

Topic 8: Evaluation of Comprehensive Service Time Efficiency of 20 Major Container Ports in the World Based on AIS Big Data in 2020

To strengthen life safety at sea and improve navigation safety and efficiency, the International Maritime Organization (IMO) requires ships that meet specific requirements to be equipped with an automatic identification system (AIS). As a result, the AIS system has been widely used worldwide. The AIS data can objectively reflect

the trend of the port and shipping market promptly. The Port Development Department of Shanghai International Shipping Institute began to measure and evaluate the service efficiency of container ports from ship arrival to departure based on AIS data in 2015. In 2020, we selected 20 major container ports in the world to continue the follow-up study and calculate the rules of ship arrivals and the characteristics of service time at the port, in an aim to directly reflect the development characteristics of the port and shipping market in 2020 and the impacts of significant events on the port and shipping industry. Key statistical indicators included the numbers and types of ships arriving at the port, the berth operation time after berthing, and the auxiliary operation time after ship arrived at the port. Auxiliary operations include tugging, pilotage, waiting for berthing, and port inspections. After calculation and statistics, the following characteristics were identified.

1. Overview

(1) The total number of ships arriving at the port drops significantly

The calculation results showed that the number of ships arriving at the world's 20 largest container ports in 2020 dropped by 10.7% compared with 2019. The decrease was much wider than the corresponding throughput decline of the 20 largest container ports, which was 0.3%. The year-on-year decline in the number of ships arriving at the port was primarily attributed to three reasons. First, the global pandemic outbreaks in the first half of the year. With the tightened pandemic prevention requirements, the number of ships calling at ports decreased. Second, ship enterprises adopted slow steaming or suspended some ships to improve ship loading rates to control their operational costs. This has lengthened the operating cycle of ships and reduced the frequency of calls at ports. Third, after most ports resumed normal operations in the second half of the year, many ports experienced congestion and ships' stay at the port increased. This also lengthened the operational cycles of ships. Month specific, after the outbreak of the COVID-19 pandemic in China at the beginning of 2020, the number of vessels arriving at the port plummeted in February, followed by the global outbreaks in April and May when all economies took measures to prevent the viral spreading and the number of ships arriving at the port stayed low. May registered the largest decline

of ship arrivals year-on-year. After June, as the ports of various economies resumed normal operations, the number of ships arriving at the port began to pick up. However, due to port congestion in September, the number of arriving ships decreased slightly but maintained a stable level overall.

(2) Share of 4,000-TEU ships or above in vessels arriving at the port decreases

According to the analysis of the statistical results, in 2020, except for the 0-4000TEU ship type, the proportion of arrival ships of other types will decrease to varying degrees. According to the analysis, possible reasons are as follows. 1) Ship enterprises suspended much of their capacity to cope with the plummeting freight volume during the pandemic. Most of the active carriers were large container ships to avoid low loads caused by the insufficient cargo volume, which may undermine the operational benefits. The proportion of total idle capacity of container ships increased rapidly from 6.1% at the beginning of the year to a relatively high level of 11.6% in June. 2) In 2020, the global container fleets prolonged their speed-down cycle, and the average sailing speed continued to decline. The average speed index of the global container fleet stood at 73.79, a decrease of 1.4% year-on-year, which marked a drop of 26.2% from 2018. 3) To comply with the pandemic prevention and control requirements, trunk route ships reduced calls at ports, reducing the call frequency of large ships at ports to a certain extent.

(3) Growth of ship detention time increases slightly

According to statistics, the detention time at the world's 20 major container ports increased in 2020, with the average time of ship stay at the port increased by 8.8%. Specifically, berth operation time and auxiliary operation time increased by 6.9% and 17.9%, respectively. The increase in non-berth operation time was greater than that of the berth operation time, which can be attributed partially to the additional inspection and quarantine measures at port calls to prevent the pandemic spread and partially to the longer waiting time for berthing due to the port congestion. It is worth noting that month specific, the berth operation time showed a significant year-on-year increase at the end of the year, while the auxiliary operation time was relatively stable. This was primarily due to the increase in container cargo volume at the end of the year after

the pandemic was brought under control compared with the end of last year. As a result, the laytime of ships at the berth was lengthened.

II. Overview of 20 Major Ports in the World

1. Structure analysis of arriving ships at the world's 20 major container ports

(1) The number of ships arriving at each port declines across-the-board

In 2020, 17 of the world's 20 major container ports registered year-on-year decreases in the number of ships arriving at the port. Specifically, the decreases of five ports were between 0% and -10%, and that of 11 were between 10% and 20%. Dalian Port was the only port with the growth rate falling by more than 20%, and the COVID-19 pandemic has greatly impacted the port and shipping industry. The statistical data has reflected several features worthy of note. 1) Port of Antwerp (1.0%), Port of Hamburg (2.2%) and Port of Long Beach (0.6%) were the only three ports with an increase in the number of ship arrivals. Port of Antwerp and Port of Hamburg, located in Europe, benefited from the resilience of trade demand within the European Union, which increased the number of small and medium-sized ships calling at the port. The Port of Long Beach on the west coast of the United States benefited from the increasing number of large and medium-sized ships (4,000—12,000 TEUs) arriving at the port. (2) The numbers of ships calling at ports such as Singapore, Hong Kong, and Busan, which had higher shares in the international container transshipment business, dropped significantly. This is primarily due to the suspension of trunk route capacity and the fewer calls at transshipment hubs.

(2) The decline rate of ships arrivals higher than that of container throughput

The above section mentioned that the drop of ship arrivals at the world's 20 largest container ports in 2020 was much higher than that of the corresponding throughput. By focusing on and analyzing the breakdown of the ports, we can find that this phenomenon was general across all ports, except Port of Hamburg and Dalian Port. Based on the data of several ports that had published the data on container ship arrivals, such as the Port of Singapore, which recorded 15,613 container ship arrivals in 2020, we can see that its container ship arrival decline was 10.9% year-on-year, but its container throughput only dropped slightly by 0.9%. The figures in 2019 were 2.2%

and 1.6%, respectively.

(3) The ship upsizing trend slows down at US West ports but persists at US East ones

Boosted by the scaled effect from the ship upsizing trend at US West ports and the Panama Canal expansion, which benefited the US East ports, the upsizing trend of ships arriving at the US West and US East ports developed to higher levels in succession. According to IHS Markit, the shares of new Panamax carriers (10,000 TEUs < Capacity < 15,000 TEUs) at ports on the west coast and east coast of the United States reached about 18% and 15%, respectively. In particular, the east coast of the United States has enjoyed rapid development since the Panama Canal expansion, with its share rapidly increasing from 3% to 14.5% in 2020. Based on the AIS data, more than half of the ships calling at Port of Los Angeles and Port of Long Beach on the west coast of the United States had a capacity of more than 8,000 TEUs. The share of the Port of New York-New Jersey on the east coast of the United States was also close to 40%, exceeding the average level of the 20 major ports. However, under the influence of the COVID-19 pandemic in 2020, the ship upsizing trend on the west coast of the United States slowed down due to port congestion. The ship structure on the east coast of the United States further developed to larger sizes. In particular, after the port congestion on the west coast, some larger ships chose to call at the port on the east coast instead. The data results showed that the share of vessels calling at the ports of Los Angeles and Long Beach with a container capacity of more than 8,000 TEUs decreased to varying degrees, down by 2.0 and 2.5 percentage points, respectively, to 50.2% and 48.3%. At the same time, that of the Port of New York-New Jersey increased by 2.1 percentage points to 39.2%.

2. Operational efficiency evaluation of the world's top 20 container ports

(1) Reasons for the longer berth and auxiliary operation time vary among ports

As discussed above, the ship detention time at the port increased by 8.8% (berth operation time and auxiliary operation time were extended by 6.9% and 17.9%, respectively) in 2020. In other words, the time of ship stay at the port increased by 1.7 hours, and the berth operation time and the auxiliary operation time increased by 1.1 and 0.6 hours, respectively. The berth operation time at Dalian, Singapore, Long Beach, and Los Angeles ports was extended significantly. Dalian Port was undergoing container business adjustments and showed broader changes of its container business data. Port of Long Beach and Port of Los Angeles had a longer operation time due to the port congestion. Port of Singapore' longer operation time was primarily due to the route withdrawal of shipping companies, which increased the load per ship. Specifically, the auxiliary operation time of the Port of Antwerp and the Port of Singapore increased significantly. In the Port of Antwerp case, the increase was due to the larger share of small and medium-sized ships that serve domestic trade driven by the relatively brisk internal trade in the EU. In the Port of Singapore case, it was due to the increased service content brought about by pandemic prevention inspections and ship bunkering at the port.

(2) U.S. port berth operation time still much longer than average

Compared with other ports where ship berth operation time ranged from 10 to 20 hours, the berth operation time of the three ports in the United States was much longer, especially the two ports of Los Angeles and Long Beach on the west coast where the average ship berth time ranged from 40 to 60 hours, much higher than the around 25 hours of the Port of New York-New Jersey on the east coast of the United States. The reason was that the ports on the west coast of the United States primarily served large container ships on trans-Pacific routes, with a single ship capable of handling about 8,000—12,000 TEUs, while the east coast ports served small and medium-sized vessels from across the Atlantic, Latin America, Africa and the Middle East, with a single ship capable of handling about 2,500—4,500 TEUs. However, due to the hybrid structure of ship sizes, the berth operation time was relatively high. Comparing the performance of the three ports in 2020, we can find that the two ports

on the west coast had longer ship stay time to varying degrees. This can be attributed to the strict quarantine measures, and long-term high loads under the influence of the pandemic as imports from Asia continued to increase significantly in the second half of the year, which led to a shortage of skilled workers. The Port of New York-New Jersey benefited from the gradual implementation of the infrastructure investment of US$2.9 billion, enjoying a higher port operation efficiency. In 2020, its average berth operation time was reduced by 2.5 hours, making the port the second largest container port in the United States.

(3) The trends of berth operation time and auxiliary operation time opposed to the ship size trend

According to Figure 8, the average berth operation time and auxiliary operation time of the 20 major container ports increase with the increase of ship size, and the auxiliary operation time is relatively short. The reason is that in the process of ship berthing operations, part of the fixed operation processes such as ship mooring won't cause longer additional operating time as the ship size grows. Ships with a higher container capacity can produce higher time and economic benefits. Larger vessels entering the port have a higher priority, so the greater the container load of the ship, the shorter the auxiliary operation time. Moreover, ships with a larger container capacity have a higher number of containers to handle at the berth, hence the longer berth operation time. It is worth noting that, according to the changes in 2020 and 2019, the service time in 2020 was higher than that in 2019, and the port service efficiency of various ship types fell in 2020. As the ship size became larger, the berth operation time gap widened, and the auxiliary operation time decreased, indicating that large ships were less affected in the gate-in and gate-out processes, but the single-ship operation time increased. On the contrary, small vessels needed to spend more time in gate-in and gate-out processes.

Chapter 7 Overview of Global Green Port Development in 2020

7.1 Connotation of Green Port Development

In recent years, green port development has received close attention worldwide, especially since January 2020 when the IMO's MARPOL Annex VI that stipulates the sulfur content of marine fuels to be less than 0.5% came into effect. The world is paying more and more attention to the development of green shipping and green ports. In response to the ship fuel emission reduction, the demand for the construction of shore power, LNG receiving stations and other facilities has also increased, and ports are also attaching increasing attention to air pollution. Air quality, dust pollution, and other metrics enjoy a growing status in green port development year by year. Therefore, the connotation of green ports is also constantly updated and diversified.

In addition, apart from being a scientific development concept, the green port also refers to the construction of an ecological industry system. Its development can be divided into four dimensions. (1) From the perspective of resource intensification, it can maximize the rate of return of input resources, and form a benign development pattern featuring efficient utilization of resources through industrial foundation and policy guidance; (2) From the perspective of scaled development of ports, on the one hand, green port development can fully utilize the value of port infrastructure to reduce resource waste caused by repeated investment, and on the other hand, with the support of a high cargo volume, it can facilitate the arrangement of large-capacity collection, distribution, and transportation systems such as railways to promote environmental improvement; (3) From the perspective of port modernization, it can continually improve the green environmental protection facilities during port infrastructure construction, improve the technical content of green ports, and create safe and efficient ports; (4) From the perspective of port ecology, it can continuously improve the awareness of ecological environment under the guidance of policies and systems and accelerate the realization of environmentally friendly ports.

7.2 Green Port Evaluation System

7.2.1 North America expands green port and shipping certification system

The "Green Marine Certification" in the United States is a green port evaluation system launched by the Green Port and Shipping Association established by shipping companies, ports, and terminal operators related to the Saint Lawrence River shipping. However, now the scope of Green Marine Certification has been expanded across the United States and Canada, and the recognition of the certification has been on the rise. From the perspective of the certification system scope, it includes not only ports, terminals, waterways and other enterprises, but also ship enterprises, shipyards and other institutions, and its performance indicators highlight a wide range covering invasive species, impacts on the community, underwater noise, and others. This demonstrates that North America has a comprehensive definition of the scope of green ports. More than 130 member units of the Green Port and Shipping Association have applied for or received the Green Port and Shipping Member Certification. With the increasing number of certified members, the greenness of the port and shipping industry chain in North America is also improving.

7.2.3 European ports adjust green priorities

Despite the major challenges posed by the COVID-19 pandemic, European ports still adhere to the requirements of green development. At the end of 2020, the European Sea Ports Organisation (ESPO) released its fifth annual environmental report, which analyzed the environmental performance of EU ports in 2020 and pointed out the priority levels of port ecological issues. Specifically, air quality has ranked first on the list of essential items for five consecutive years. It is believed that air quality has become a key factor for sustainable port activities (whether air quality management meets standards is linked to port operating permits). Following air quality are climate change and energy efficiency. The climate change item has been elevated by one place on the priority list and become the second top priority for ports in 2020. 70% of

European ports will consider the impacts of climate changes when developing new terminals, and 65% of ports have even taken measures to enhance existing infrastructure's adaptation to climate changes.

7.3 Green Port Governance Policies

7.3.1 Port of Singapore carries on the Maritime Singapore Green Initiative

In terms of green port development, the Port of Singapore usually adopts economic subsidies and tax exemptions among other means to promote the development of related upstream and downstream enterprises and help reduce environmental pollution caused by ports, ships and related activities. The Port of Singapore Authority has funded the Maritime Singapore Green Initiative (MSGI, valid until 2024) to promote the decarbonization of the shipping industry further. With the policies and technologies constantly enriched and improved, the initiative now covers four aspects: green ports, green ships, green energy technologies, and green awareness, to guide the green development of ports from different perspectives. With the support of the initiative, Jurong Port has been building a solar-based smart grid and LNG refueling facilities. In the future, various green technologies such as electric port operation ships, ship oil spill detection and monitoring systems will continue to develop.

7.3.2 Europe promotes the transformation of the port distribution system

As a leader in sustainable development, Europe shows ingenuity in the green ecological construction field. The President of the European Commission proposed a "European Green Deal". The deal is a policy that will guide the profound transformation of the European economy in the future. It is clearly stated that the European Commission will begin to transfer most of the current 75% of cargoes transported via inland roads to railways and inland waterways in 2021 and control the entry of heavily polluting ships to EU ports. Ships forced to dock at the ports can only

use shore power. In addition, the European Union will also invest nearly 142 million euros to support the use of green fuels in transportation. The project includes the transformation of ships and the installation of the corresponding infrastructure at ports to enable them to use liquefied natural gas and the installation of shore power at the ports to reduce emissions from docked ships.

7.3.3 Carbon tax levied to encourage the development of "zero-carbon" technologies

Currently, IMO member states are working to achieve full decarbonization as soon as possible after 2050. The IMO Marine Environment Protection Committee (MEPC) will discuss shipping "decarbonization" at a relevant meeting at the end of 2020, including imposing carbon charges. The governments of the member states have agreed to consider further the US$5 billion research and development plan proposed by the industry and evaluate the possible impacts of the mandatory fee of US$2 per ton of fuel on the economy of various countries. With the gradual implementation of the global energy transition and low-carbon "emission reduction" plans, it is expected that the "zero-carbon" technologies will be introduced in 2030 to accelerate the achievement of emission reduction goals.

7.4 Green Port Technology Innovation

7.4.1 Full-process dust prevention technologies of bulks terminals

The new "dust suppression technology" is an automatic sprinkler and control system combined with the vibrating feeder at the bottom of the wagon tipper. The tipper room marks the beginning of the cargo loading and unloading process at the port. During the tipping process, the tipper enables the coal and water to be evenly mixed so that the dust emission is kept at the minimum when the coal passes through the belt conveyor, transfer room, stacker, reclaimer, ship loader, and other processes. The new "dust suppression technology" is designed to have nozzles, solenoid valves and other sprinkling dust suppression equipment installed on the vibrator feeding

funnel and chute at the bottom of the wagon tipper so that the coal and water are evenly mixed during the vibrating feeding process. PLC realizes automatic closed-loop control. The sprinkler control system can adjust the amount of sprinkling water according to different coal types. The online moisture monitor is installed at the outlet of the vibrating feeder to detect the moisture content of the coal after sprinkling in real time, and the detection results are sent back to the control system. The control system automatically adjusts the amount of sprinkling water according to the detection results to minimize the dust at each transfer point during the coal handling process. The above process resolves the coal dust problem in the whole process by spraying water once, completely suppressing the generation of coal dust from the source.

7.4.2 Application of underwater noise monitoring technologies

To reduce the shipping industry's impact on underwater organisms, the Port of Vancouver Authority has added a new ship reward program to its original EcoAction Program, which aims to reduce the effects of underwater noise on marine life when ships are sailing. Canada became the first economy in the world to set up an incentive plan for reducing ocean noise. The International Fund for Animal Welfare is also working with shipping companies and ports to reduce ocean noise pollution by encouraging the operations of quieter ships. To reduce the hazards to marine mammals from underwater noise, the British Baker Consultants company and German offshore wind power plant developers worked together to install automated Passive Acoustic Monitoring (PAM) Systems near the base of the power plant to measure the noise level, record the ocean animal activities, and use acoustic deterrent devices (ADDs) to drive away marine animals.

7.5 Green Port Clean Energy

7.5.1 Promote sustainable energy development and utilization

In the medium and long term, ports need to turn their eyes to new sustainable energy sources to achieve emission reduction goals. In December 2020, the *Energy White Paper* issued by the British government elaborated on the green recovery after

the COVID-19 pandemic and proposed an energy transition plan. Specifically in the port sector, the Port of Helsinki, Finland, will use solar energy in place of onshore power supply from fossil fuels and promote renewable solar energy by substantially increasing the number of solar panels at the port. Liquefied natural gas (LNG) is also a viable and clean transitional marine fuel. The Port of Singapore actively promotes LNG bunkering services. The Maritime and Port Authority of Singapore (MPA) has jointly formulated bunkering standards and procedures with the industry to enable LNG bunkering operations from trucks to ships. It also actively supports the Singapore Maritime Institute (SMI) to launch the Biofuel Compatibility Study for Singapore Harbour Craft, which aims to study biofuels' environmental, technical, and economic feasibility. In 2020, the Fidelis Infrastructure Investment Company of Houston, USA, invested RMB 9.2 billion in the research and development of renewable diesel at the Port of Baton Rouge. It is expected to produce 60,000 barrels of low-carbon renewable diesel per day, and ships can choose to use non-fossil raw materials, including soybean oil, corn oil, and animal fat, to produce renewable fuels.

7.5.2 Promote energy conversion of port facilities

In 2020, the nine ministries and commissions of the Chinese government jointly issued the *Guiding Opinions on Building a World-Class Port*, which encourages the addition and replacement of port operation machinery, port vehicles and tugboats, among other facilities, to give priority to the use of new and clean energy and accelerate the increase of clean energy ratio in port operating machinery and vehicles. It is estimated that 15 new-energy-powered heavy trucks can reduce carbon dioxide emissions by about 1,000 tons per year and reduce diesel consumption by 600,000 liters per year. The CTA container terminal at the Port of Hamburg in Europe has put in six new green-energy charging stations and 16 battery-powered AGVs. It is estimated that by the end of 2022, nearly 100 unmanned container transport vehicles will be fully converted to the fast-charging battery drive, which will reduce approximately 15,500 tons of carbon dioxide emissions and about 118 tons of nitrogen oxide emissions per year. The Port of Antwerp built the world's first hydrogen-powered

tugboat. The "hydrogen-powered tugboat" is driven by an internal combustion engine that burns hydrogen in combination with diesel. This dual-fuel technology ensures that the hydrogen-powered tugboat has ultra-low emissions.

Chapter 8 Global Port Development Trend in 2021

8.1 Global Port Development Trend

8.1.1 Global economy and trade to show recovery growth

After the global outbreaks of the COVID-19 pandemic in 2020, the trade demands of various economies fell across the board. With the development and promotion of vaccines, the year 2021 is likely to witness the restart of the international economy and trade as a marker of the new stage of the "anti-pandemic campaign". According to the latest forecast issued by the International Monetary Fund (IMF) in January 2021, the global economic growth rate in 2021 will rise from -3.3% in 2020 to 6.0%. The growth rate of international trade volume will also increase from -5.3% to 8%, showing a recovery growth trend in the "post-pandemic" era, and the growth rate will decline year by year after 2022.

Most international agencies are optimistic about the economic and trade environment outlook for 2021, and regions with better pandemic control, such as East Asia and Southeast Asia, have gradually achieved industrial recovery and economic growth in the second half of 2020. However, in Europe and the United States, due to their inadequate pandemic prevention measures in the earlier stage, the outbreaks continued to ferment, and the economy is still in a deep quagmire. The global promotion and application of the COVID-19 vaccine can control the spread of the pandemic on a large scale, and help industries and economy and trade pick up. However, the suspension of industries and the decline in the purchasing power of residents under the influence of the pandemic will make it difficult to support the rapid recovery of consumer trade in the short term. The game of great powers in the "post-pandemic" era is quietly happening. Economies around the world are not hesitating to intensify international contradictions to protect their interests, intensifying the problems including "international trade frictions", "regional economic sanctions", and "geopolitical conflicts". Therefore, as the global pandemic is brought under control, the world economy and trade have gradually begun to recover growth. However,

despite the low economic base in 2020, it is comprehensively predicted that a substantial increase as predicted by international institutions may be difficult though global economic and trade growth in 2021 will recover.

8.1.2 Global ports to enter a period of steady growth

In 2021, the global economic growth and trade pattern will be in a period of recovery. However, due to unpredictable "black swan" events such as regional international relations, trade protectionism, and canal congestion, the recovery of international trade and world shipping will still be subject to some negative impacts. This will further slow down the recovery growth rate of port throughput, resulting in a stable port production situation or starting a period of steady growth. According to the port production statistics over the years, the cargo throughput growth of major global ports from 2017 to 2020 is 5.2%, 2.9%, 1.7%, and -1.3%, respectively, showing a downward trend year by year. Despite the expected recovery growth after the pandemic, the growth rate may remain in the 3%—5% range, and the growth rate may drop significantly after 2022. Meanwhile, the growth of global port container throughput in the years from 2017 to 2020 is 6.2%, 5.2%, 2.1%, and -2.1%, respectively, the growth rate being better than that of cargo throughput for long. However, in 2020, the decline of global port container throughput growth was greater than that of cargo throughput growth, fully demonstrating that the container shipping trade is more closely related to production and consumption as well as the economy. Supported by a low base, it is estimated that the recovery of global port container throughput growth in 2021 may be slightly stronger than that of cargo throughput growth to reach about 5%. With the recovery of the cargo collection, distribution, and transportation systems at ports in the second half of 2020, many container trade activities gradually recovered, international shipping demand rebounded sharply, and container freight rates doubled. It is expected that in 2021, with the recovery of international economic and trade demand, international liner companies will gradually resume the routes that were suspended earlier under the pandemic and release more capacity and containers. This will gradually balance the shipping supply and demand to meet more trade and

shipping needs.

From a long-term perspective, governments of various economies have gradually begun to implement industrial chain system restructuring and localized manufacturing strategies under the impact of the pandemic. On the one hand, from the perspective of physical industry safety, it is necessary to maintain the basic commodity manufacturing capabilities and large-scale production systems in their countries. On the other hand, they also need to possess basic product manufacturing capabilities and large-scale production systems after the pandemic to promote domestic economic development and increase employment through the real economy. Therefore, although it will not have a significant impact on international trade in the short term under the current environment, the governments of various economies will actively guide the industry to return to their own countries, which may shock the international maritime trade and port production in the medium and long term. Even if the pandemic is over, the international trade growth and the scale of transportation will be hard to return to the original growth track.

- **Asian ports gradually stabilize and pick up, North American ports may stop the decline**

In 2021, the impact of the COVID-19 pandemic on the global economy and international maritime trade will continue to weaken, and global shipping and ports will enter a recovery growth phase (represented by the lift of 14-day detection of ships at the port for observation and other measures). However, following the China-US trade frictions, a small number of national organizations represented by the United States and commercial organizations once again provoke disputes on the grounds of "human rights protection", vainly imposing international sanctions to hinder international economic cooperation. The trade between China and the United States and related economies may be affected to a certain extent. However, under the new development pattern of accelerating the "grand domestic circulation, international and domestic dual circulation", Chinese ports will maintain their general trend of trade recovery. Meanwhile, Japanese and South Korean ports have been heavily hit by the pandemic, especially the trade in commodities such as bulk commodities and auto

parts which cannot recover quickly in the short term. As a result, their growth may slow down. Relying on the stable trade with China and other regions, Southeast Asia and other regions are expected to maintain certain growth momentum. In addition, while provoking international disputes, the United States will also gradually augment efforts in attracting the industrial return. Based on the low base from the continuous declines in the previous two years, North American ports may stop the decline in 2021, but the possibility of their further rapid expansion is low.

- **European ports maintain low growth, while Australian ports slow down growth**

In Europe, due to different government prevention and control efforts, the spread and impact of the pandemic are more serious. In addition, the mutation of the virus in the United Kingdom has forced all economies to enhance their lockdown measures. As a result, the overall economic and trade environment in Europe is relatively weak. In 2020, the cargo throughput growth of major European ports plummeted to -5.9%, which was much lower than other regions. Although vaccines will effectively alleviate the pandemic situation in Europe, the economic downturn may be hard to see effective control in the short term. In addition, the manufacturing industry has suffered heavy losses, and the market consumer confidence is insufficient in the region. Even if various economies return to the regular track of economic development, their market consumption power has not yet recovered. The port trade is expected to pick up but to a limited extent. In addition, relying on the relatively stable commodity trade, Australian ports still maintained sound growth during the outbreaks. However, the current development focuses of various economies may be shifted from infrastructure construction to the consumer market and manufacturing industry development. The energy demand such as coal and ore may slow down. However, with international trade agreements such as RCEP taking effect, tariff reductions between trading partners may drive up the strategic reserve demands. Therefore, it is expected that the Australian port trade growth may decline, but the overall growth trend will remain.

- **Container trade to usher in a rebound, and Asian ports continue to lead the world**

In recent years, the container trade growth of global ports has kept falling, especially in Europe, America, and Africa. In the Americas, trade protectionism has resulted in the return of manufacturing industries, and the frequent multilateral economic and trade disputes have led to slow growth in trade demand. In Europe, a series of internal problems of the EU have been triggered since the Brexit, leading to increased tariff uncertainties and a weakened industrial base. At the same time, African ports, which initially had strong growth potential and vitality, also experienced weak growth due to the pandemic and other external factors, and their overall performance was lackluster. On the contrary, the Asian region represented by China has actively promoted the economic and trade growth of the region and partner countries by establishing pilot free trade zones and signing international free trade agreements, and is expected to lead the recovery of global container trade.

In the future, the complementary pattern of economic globalization and regional industries may be impacted to a certain extent. While various economies prioritize the security of their production and consumption, they will re-plan the international industrial chain system based on cost and market advantages. With economic development and increasing labor costs, emerging economies such as the Asian region are gradually changing from the "world factory" role. The international trade flows and the port network patterns will also change quietly, coupled with closer cooperation and trade exchanges between regional economies.

8.1.3 Port investment market to continue the slump

- **Asian countries remain important support for port construction**

Due to the sufficient capacity of global ports, economies with large-scale maritime trade have shown significantly lower enthusiasm for port construction. For example, the ports in Mainland China, Asia, have had sufficient production capacity after years of construction. The Ministry of Transport of China decided to suspend the collection of port construction fees. The port and other water transport infrastructure investment also slowed down, with port construction tending to ease. However, Singapore, South Korea, and other economies in Asia are still actively promoting the

construction of port facilities and actively expanding their trade scale to compete for the status of transit hubs. The construction of Tuas Port with a capacity of 65 million TEUs continues, and South Korea also launched a US$6 billion port reconstruction plan. The Busan North Port and the Inner Incheon Port have started construction, expected to cover 19 port construction projects. Overall, although Asia won't see large-scale construction of ports as in Mainland China, the port construction plans implemented by economies such as Southeast Asia, Japan, and South Korea will still be an important force to promote port construction in the world.

- **North America will restart the once shelved port construction projects**

The low port efficiency and terminal workers' strikes, among other incidents, have long plagued the logistics industry development of North American ports, which in turn affected the economic growth of North American economies. As early as before the pandemic, the U.S. Department of Transportation had formulated a port development plan which was later shelved due to the outbreaks. The funds were partially allocated in the second half of 2020. It is expected that North American port construction projects will restart in succession, but the extent of project renovation and expansion will be limited, dominated by renovation initiatives. As a result, the construction period will be short. In 2021, a batch of ports will complete renovation or expansion and put to production in succession. Meanwhile, the Canadian government will also promote a number of port expansion projects in response to the ship upsizing trend. Part of the start-up funds was allocated in 2020. The production capacity of several ports, including Halifax and Vancouver, will be further increased.

- **Enthusiasm for LNG terminal construction may continue**

With the increasing requirements of the IMO on emission control zones, many ship enterprises began to use LNG and other new energy sources and build LNG-fueled ships, which has boosted the construction demand for LNG terminals and receiving stations. In particular, to gain an edge in LNG bunkering, ports in China and Southeast Asia are actively deploying LNG terminals and LNG bunkering facilities. Many LNG receiving stations along the coast of China will be put into operation in 2021. Southeast Asia is also actively developing LNG receiving stations to reduce power consumption.

Such facilities can serve ship bunkering and make up for the gap of domestic electricity supply. In addition, the United States government is also actively promoting LNG receiving stations. However, due to the impact of the pandemic, the United States prioritize the construction of container terminals required for the supply of people's livelihood and industrial development when earmarking transportation construction funds, and some LNG terminal construction projects have temporarily slowed down.

8.1.4 Global terminal operators resume a wave of integration

- **Terminal operators actively transform into logistics service providers**

Given the sluggish shipping market, most global terminal operators chose to sell their non-performing assets and accelerate integrating resources in the same industry to "survive the hard times together". However, under the pandemic test, global terminal operators have increasingly discovered that apart from the horizontal integration of resources in the industry, what's more important is to connect up logistics resources, from ship enterprises to ports, ports to logistics collection, distribution, and distribution systems, and logistics to inland warehouses and cargo owners' integrated logistics systems. They are more critical in the event of emergencies and for enhancing customer service capabilities and customer loyalty. Maersk Group established the logistics company Damco and actively expanded the European port rear logistics system and park resources with APM Terminals as the player, resulting in its growing share in the entire supply chain. As a result, Maersk Group can improve the stability of the entire logistics system by controlling the resources and better serve customers and guarantee the transportation system compared with other global terminal operators at different stages. It is believed that more and more global terminal operators will participate in the integration of resources of the entire logistics system and transform to full-logistics-supply-chain service providers.

Topic 9: Analysis of Congestion in US West Ports Clouded by the COVID-19 Pandemic

In 2020, amid the COVID-19 pandemic, the ports of Los Angeles and Long Beach on the west coast of the United States experienced a slump in business performance in the first half of the year, followed by a surge of imported containers in the second half of the year. This caused severe port congestion and a chain reaction which had a significant impact on global shipping. During this period, the two ports also adopted countermeasures to alleviate the congestion. With the decline of imports in the United States, the congestion was expected to ease at the end of the summer in 2021 gradually.

1. Congestion on the west coast of the United States has lasted for more than half a year

In recent years, ports in North America have experienced frequent port congestions due to terminal worker strikes and the impact of the Sino-US trade frictions, drawing global attention. In 2020, the ports of Los Angeles and Long Beach on the west coast of the United States again experienced large-scale port congestion. The severity and duration of the congestion both exceeded the previous levels. The following analysis will approach from two perspectives: port waters and landside areas.

Congestion in port waters is reflected in the increase in the ships waiting to be berthed and the time of ship stay at the port. Due to the substantial increase in the number of vessels calling at the port, the port's handling capacity cannot meet the demand, resulting in many ships queuing at anchorages. According to statistics from the Marine Exchange of Southern California, data of major ports in the San Pedro Bay area, dominated by the ports of Los Angeles and Long Beach, showed that as the port berth utilization rate increased from June 2020 and gradually saturated in November, the number of ships waiting at anchorages soared, reaching more than 50 by February 2021. The average waiting time for ships at anchorages also increased to 7.3 days, indicating that the congestion failed to be alleviated in the short term.

The congestion of the landside areas of the port can be reflected by the detention

time of containers at the port, that is, the time from when the container is unloaded from the ship to the time when it leaves the port. Under normal circumstances, import containers will be picked up out of the port within the 4-day free storage period provided by the Port of Los Angeles to avoid paying additional demurrage. However, because the demand for cargo collection, distribution, and transportation exceeded the port's capacity, the containers could only prolong the storage time at the port, waiting for container trucks to evacuate the cargoes from the port. According to the Pacific Merchant Shipping Association (PMSA) data, the average stay time of containers at the port has been on the rise since June 2020, and it has been longer than four days for six consecutive months since September. The proportion of containers whose detention time was longer than five days exceeded 20% for consecutive months, implying the considerable pressure on the port evacuation system.

2. The decline in port operation efficiency cannot meet the surging import demand is the leading cause

Despite the port congestion all year round due to labor disputes, the low production efficiency and other issues at the ports on the west coast of the United States, the causes of congestion in this round differed from the past. In the context of the COVID-19 pandemic, the surging imports in the second half of the year and the low port efficiency due to labor shortage were the main causes of this congestion.

(1) The surging imports to the United States in the second half of the year generate pressure on the US West ports

In 2020, the COVID-19 pandemic spread rapidly in the United States. The U.S. government has implemented rounds of economic stimulus bills to increase personal disposable income and consumption willingness by directly issuing subsidies and shopping vouchers to support economic recovery. However, in the second half of the year, the U.S. government had to adopt strict prevention and control measures in the face of an increasingly difficult pandemic situation. Besides, as residents' anti-pandemic awareness rose, the consumption of catering, tourism, and other services was curbed, and American consumers were more inclined to purchase durable goods

such as motor vehicles and furniture and consumables such as personal care food and beverages. Apart from that, the end of the year was a traditional time for manufacturers to replenish inventories. Affected by these factors, the import demand in the United States continued to rise in the second half of the year. Specifically, China is the largest trade importer of the United States. In 2020, China's exports to the United States increased by 8.4%, and most of them were transported by ships. The ports of Los Angeles and Long Beach on the west coast of the United States are the main gateways for Sino-U.S. trade. Among the containerized cargoes imported from China, about 47% in tonnage were handled by the two ports. In particular, the anti-pandemic supplies imported from Asia during the outbreaks (masks, disinfectants, ventilators and others) all entered the United States from the two ports. Therefore, the two ports were directly subject to the pressure brought by the surging Sino-US trade, which was the main cause of port congestion.

(2) The labor shortage caused by the pandemic leads to a decline in port efficiency

In 2020, with the wide spread of the COVID-19 pandemic in the United States, port workers such as terminal workers and truck drivers were also severely affected. In January 2021, nearly 700 workers at the ports of Los Angeles and Long Beach were infected, accounting for approximately 4.7% of the total workers at the two ports. Besides, about 1,800 workers chose to leave the port temporarily in fear of infection, and the severe shortage of labor has compromised the efficiency of terminal operations. However, since most of the anti-pandemic supplies entering the United States came from Asia, the two ports shouldered the critical mission of ensuring the import of such materials. Therefore, the port authorities have adopted a series of measures to keep the ports in operation at all times. It has become a complex problem for the port authorities to protect the labor force from infection while maintaining port operations.

In addition, with the imports surging and the labor resources in shortage, the two ports prolonged port operating hours to alleviate port congestion, temporarily recruiting terminal workers to increase the scheduling rate. However, the new workers

were relatively less proficient due to insufficient training time, making it hard to address the labor shortage. Meanwhile, although ports still maintained operations, they also implemented strict prevention and control measures, which compromised ports' operational efficiency to a certain extent. Therefore, unless the COVID-19 pandemic in the United States improves significantly or the port authorities get the qualifications for vaccinations for all terminal workers, labor shortages will continue to be a significant factor in port congestion.

3. Measures taken by ports of Los Angeles and Long Beach to cope with port congestion

(1) Temporary countermeasures adopted to improve the port's throughput capacity

The current round of port congestion was primarily caused by the surging import demand exceeding the port's handling capacity, which declined due to the pandemic. Therefore, expanding the port's handling capacity in a short period is an effective means to alleviate the congestion. To this end, the ports of Los Angeles and Long Beach have adopted a series of countermeasures. For example, 1) The port authorities increased the operating hours of ports by urgently recruiting terminal operators and implementing multiple shifts, and strengthened the training for equipment operators; 2) The Los Angeles Port Authority provided terminal operators with an incentive of US$7.5 million and a certain amount of reward per container for terminal operators who shortened truck turnaround time. To increase the two-way utilization of container trucks, they also offered financial rewards for truck drivers who immediately unloaded the containers shortly after they entered the port area and took another loaded container; 3) They strengthened the efficient management of trucks through digital construction. The Port of Los Angeles successively launched three versions of truck management tools during the congestion, which can monitor truck dynamics in real time to help operators better predict and manage cargo flows. For example, the empty containers recovered by truck drivers were reduced when empty containers were excessive at the port.

(2) Ship enterprises adjust routes to distribute cargoes to other ports

Given the large-scale delays of cargoes caused by congestion at Southern Californian ports, ship enterprises actively sought other routes. They guided cargo owners to choose different routes by adjusting routes and charging congestion surcharges at specific ports to keep the U.S. import supply chain unblocked. Specifically, the options available primarily included the following: 1) First, Oakland, Seattle and other ports on the west coast of the United States became the top choices of ship enterprises after the route adjustments due to their locations on the east coast of the Pacific Ocean, just like the Southern Californian ports. In particular, the Port of Oakland is investing much money to strengthen port infrastructure construction. 2) Second, the ports on the east coast of the United States and the Mexico Gulf Coast. As the throughput capacity of other ports on the west coast of the United States gradually gets saturated, the routes of ship enterprises calling at ports on the east coast of the United States will rise. The throughput growth of the Port of New York-New Jersey, the Port of Houston, and the Port of Savannah in the fourth quarter was the same as that of the ports on the west coast. This route change will also accelerate the ship upsizing trend on the east coast. In the fourth quarter, the number of container ships passing through the Panama Canal gate recorded a more than two-digit growth rate. 3) Finally, for the routes on the west coast of Canada, the option of unloading the ship at the Port of Montreal or the Port of Prince Rupert in Canada, and then transferring the cargoes to the inland areas of the United States by rail is also an alternative to address the congestion of Southern Californian ports. However, due to the strikes in labor agreement negotiations in 2020, the two ports as mentioned earlier have been suspended for some time. Therefore, many containers have been accumulated, and congestion was also seen in the rear collection, distribution, and transportation processes. For this reason, choosing this route is also subject to greater uncertainty.