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Research on the (positive) externality of ports

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Research on the (positive) Externality of Ports

by

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Declaration

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

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

(Signature):

(Date): 20th June 2020

Supervised by: Prof. Wang Xuefeng

Supervisor's affiliation: Shanghai Maritime University

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Abstract

Title of Dissertation: **Research on the (Positive) Externality of Ports**

Degree: **Master of Science**

The dissertation is a research on the summary and analysis of positive externalities of ports. Principal Component Analysis (PCA) is employed to summarize key indicators and to measure the positive externality of port cities. SPSS software is used to calculate the model and to create a final rank. Then, port management systems are evaluated to examine how they influence port positive externalities, and which operation mode should be adopted after comparing different modes. The study finally concludes with suggestions for what kind of management policy the government should introduce, which may counteract the port positive externalities. Also, some suggestions in terms of certain key indicators are presented to Shanghai.

A brief review of the literature is provided, including the definition and overview of externality, the overview of port externalities and evaluation methods, and the review of port management and operation models.

In the methodology section, the general assessment method is summarized and additional background is provided to explain why Principal Component Analysis (PCA) is used to assess selected indicators. Then, evaluation indicators reflecting port positive externality are summed up and some specific indicators are quantified, and the way those indicators demonstrate the port positive externality is analyzed as well. Moreover, the rank of ports based on positive externality is yielded, indicating that London has the strongest port externality. Singapore, Athens, Shanghai come next. Shanghai ranks only fourth as a result of a less developed government management system, compared to London and Singapore, in terms of specific indicators and shipping service of port. Also, how the port management system counteracts the port under port positive externality and which operation mode the port should adopt after comparing different operation modes are explored.

In the conclusion, suggestions for management policy are presented for regulators so as to maximize the positive externality for Shanghai as a port city.

KEYWORDS: Externality, Management system, Operating models, Policy

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LIST OF ABBREVIATIONS

ICBC	Industrial and Commercial Bank of China
H&M	Hull and Machinery
IUA	International Underwriting Association
IG	International Group
SSA	Singapore Shipping Association
MPA	Maritime and Port Authority of Singapore
NYSE	New York Stock Exchange
R&D	Research and Development

Chapter 1 Introduction

1.1 Research Background and Research Purpose

Research Background

With the development of global economic integration, ports not only have an increasing impact on the economic and social development of cities, but also play an ever more important role in improving global trade development. Ports are gradually becoming functional center of comprehensive logistics and a main growth point for economic development in urban areas.

The economic development of port and logistics also highlights its externalities, such as ripple effects of rapid urban development brought by ports, offshore pollution, ecological damage, ports congestion and reduced shoreline resources. The container port has entered a period of exponential growth. However, its negative externalities have gradually emerged, such as the pollution of coastal water near the port. Moreover, the drastic development of the city brought by the port and the following ripple effects have also been affirmed by all circles.

The development of global economic integration and the backwardness of the management mode make the port innovation development imperative. Throughout the port development and management, under the traditional management mode based on the government control, there are imperfections in the management mechanism. Some defects and loopholes are obvious, especially under the influence of market economy, the reform and development of port management mode has become a must.

Port, as an important form of logistics in the trade industry, promotes regional economic development; meanwhile, port constantly improves itself, and the logistics model also continually innovates. In recent years, with the continuous development of economic globalization, higher demands have been placed on the port logistics supply chain.

Research Purpose

The study on the externality of port economic development helps the sustainable development of the port and society, and assists the port governments formulating relevant policies to strengthen management and enhance the competitiveness of the port.

The existence of these externalities has a critical influence on the growth of port and social economic development, to which should be paid great attention by every port, shipping enterprises and even the whole society. During the process of port development, given its own economic effects, its external effects should be given full consideration, so that social resources can be used reasonably and fully.

The concept of externality originated in the field of economics. Research in the field of port production and services is still lacking. Therefore, it serves as a crucial research topic of theoretical value and practical significance to explore how to apply scientific theoretical systems and methods to the analysis and studies on the externality of port economy. This kind of research aims to ensure that the port in normal production and operation can create huge economic benefits, and at the same time produce as little negative impact as possible so as to herald the road of sustainable development of the port. First, theoretically speaking, the concept of externality in economics is further expanded to fill the research gap of externality in port economic development and its impact. Second, the study contributes to the evaluation of indicators of port positive externality and generates the rank of it. Third, the research guides the government to formulate relevant policies and regulations to strengthen management based on those specific indicators, enhance the international competitiveness of ports and boost the overall and coordinated development of ports. The results of the research provide a good reference to managers of both government decision-making departments and port enterprises.

It is very necessary for the studies of port externality. It is important to do research on this topic and solve the problem of the externality of ports. It is of profound theoretical and practical significance to the sustainable development of ports and society, improvement of the international competitiveness of ports, and the rational distribution of port resources and national resources.

1.2 Research content and dissertation structure

Research content

The first chapter of the dissertation presents the background and purpose of the whole research. The second chapter is literature review, discussing an externality overview, externality of ports, evaluation methods, and port management and operation. The third chapter introduces the methodology, including general assessment method for port externality analysis, selection and analysis of evaluation indicators of port positive externality and how key indicators are quantified. The fourth chapter demonstrates the result and discussion. Then, some recommendations for Shanghai port are made concerning these indicators on management and operation.

Dissertation structure

Figure 1 shows the whole structure of the dissertation.

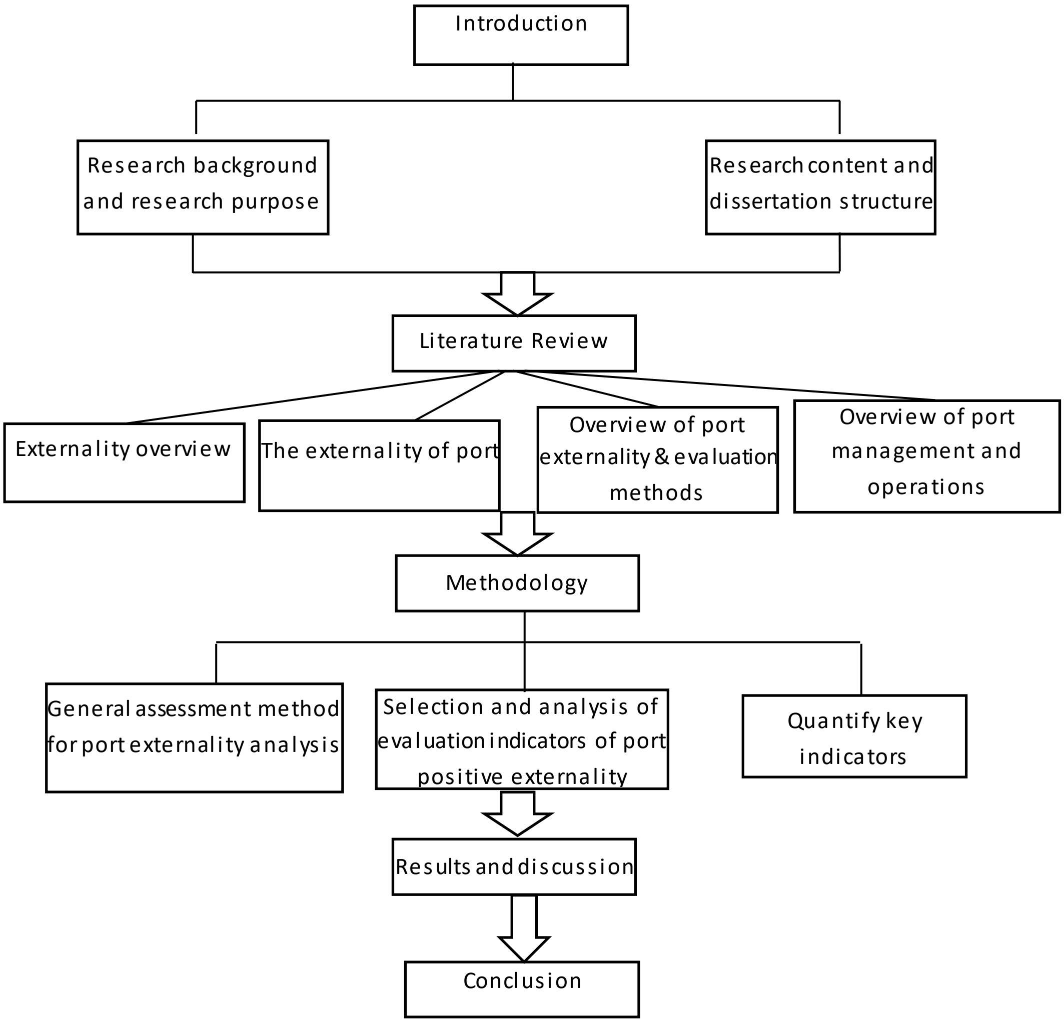

Figure1. Dissertation structure

Chapter 2 Literature Review

2.1 Externality Overview

Related Research on Externality Theory and Internalization Methods

The concept of externality was first proposed by Alfred Marshall (1890) of the Cambridge School. In his book *Principles of Economics*, he wrote "For the expansion of the scale of production appearing in the economy, we can distinguish it into two types. The first type is the expansion of production depending on the general development of the industry. The second type is the expansion of production coming from the efficiency of the organization and management of a single enterprise's own resources. The former is called the 'external economy'. The latter is called the 'internal economy'."

Marshall's student Pigou (1920) further studied and perfected externalities in his famous book, “The Economics of Welfare”. He put forward the concepts of "internal diseconomy" and "external diseconomy". Moreover, from the perspective of optimal allocation of social resources, he applied marginal analysis methods, proposed the value of the marginal social net product and marginal private net product, and finally created the externality theory. It was his belief that in economic activities, if an enterprise causes losses to other enterprises or the whole society without paying a price, it is external diseconomy. At this time, the marginal private cost of the enterprise is less than the marginal social cost.

Ellis and Fellner (1943) believed that "external diseconomy" is related to property rights. Yet, they paid more attention to "external diseconomy" in real life than their predecessors, and linked the issue of pollution to "external diseconomy".

Although Coase (1960) did not define "externalities", the category of "transaction costs" in his thesis "The Problem of Social Cost" seemed to have left room for Ellis and Fellner's discussion of "externalities". Coase thought that Pigou discussed externalities on the wrong lines. He proved that Pigou was completely wrong under the condition that the transaction cost was zero. Because no matter how the initial rights were allocated, ultimately, resources were put to their most valuable use. The rational subject would always consider the spillover costs and benefits. The issue of social costs would no longer exist. According to Coase, welfare economists such as Pigou did not draw correct conclusions on externalities. It was not simply a deficiency in analytical methods, but it rooted in the fundamental flaws of methods in welfare economics.

Bi Leqiang (2011) investigated the nature, classification and performance of the external effects of regional economy on the basis of organizing the externality theory and related theoretical research. He then proposed relevant countermeasures to deal with external effects of regional economy.

Wang Qian (2012) systematically analyzed the connotation of economic externality and the development and evolution of its theory. Based on this analysis, the harm from economic externality was elaborated and the countermeasures for economic externality were presented.

Fu Yuanyuan (2015) examined the definition of economic externality and the history of its theoretical development, described hazards of economic externality, and pointed out related governance countermeasures of economic externality. Based on Pigou's theory, Coase's theorem, government regulation, and market mechanism analysis, some shortcomings and problems are discovered. Also, more operational theories are advanced and put into practical implementation to solve the danger caused by externalities.

Definition of externality

As Buchanan et al. (1962) claimed, an externality is the cost or benefit that affects a third party who did not choose to incur that cost or benefit.

Mankiw and Nicholas (1998) argued that externalities often occur when the production or consumption of a product or service's private price equilibrium cannot reflect the true costs or benefits of that product or service for society as a whole.

Externality is usually expressed in terms of spillover effects, externalities, externalization, exogenousity, etc. Externalities can be either positive or negative. However, the effect of externalities is not reflected in the process of a market transaction by cost or price. As a result, externality is one of the main causes of "market failure." Market mechanisms alone often fail to achieve optimal allocation of resources and maximize social welfare. Figure 2 shows the externality is a subset of market failure, according to Jia Lihong(2003).

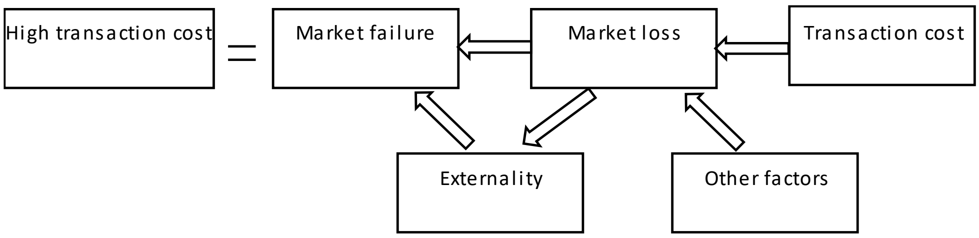

Figure2. Externality is a subset of market failure**.** From "A New Probe into the Relationship between Externality Generation Mechanism and Market Loss", by Jia Lihong, 2003, p.53. Copyright 2020 by CNKI.

Generation of externalities

Since negative externalities place additional burdens on society and individuals, and the unit imposing the burdens did not bear the responsibilities, people may be more concerned about the causes of negative externalities. The emergence of negative externalities can be attributed to the following main causes:

(1) Hanley et al. (2019), Nick, Hilary Kirkpatrick, Ian Simpson, and David Oglethorpe suggested that externalities arise from shared resources. Many people prefer the existence of shared resources as the root cause of externalities. Due to institutional and technical reasons, the value attributes of shared resources cannot be effectively classified as private, so it is difficult to

avoid the generation of negative externalities.

(2) Dahmen (1999) claimed that externalities result from decentralized economic activity. Externality stems from the decentralization of economic activities, and each has its own independence regarding benefits. Therefore, producers cannot consciously incorporate external diseconomy into costs for profit and loss.

(3) Hives alleged that externalities are induced by flaws in market mechanisms. Externalities are caused by defects in the market mechanism. In most cases, the market can operate effectively; yet, it cannot solve all problems, and it should not be expected to do it. The market cannot incorporate the negative effects produced in the production process into costs, thereby creating externalities. Under the laissez-faire economics, externalities are often neither known nor compensated by producers and consumers responsible for them, and are therefore transferred to the public in the form of declining environmental quality.

(4) For Coadse, et al. (1994), externalities are caused by unknown definition of ownership. Externality arises from the unclear definition of ownership. If ownership can be determined, then the power transaction between the parties involved in the externality or external effects will eliminate the externality and produce an efficient result and equilibrium.

(5) Meade, J. (1952) viewed externalities as results generated by monopoly conditions. As long as there is a monopoly in the market, the output level of the product will be limited, so that the price of the product or service is higher than its marginal cost. Monopoly may create institutional or legal obstacles, or may also produce economies of scale production, making it difficult for new competitors to enter the market, and impossible to generate a large number of competitors in the market. Therefore, negative externalities are incurred.

2.1.1 Classification of externality

Positive externality and negative externality

A positive externality is any difference between the private benefit of an action or decision to an economic agent and the social benefit. A positive externality is anything that causes an indirect benefit to individuals.

Conversely, a negative externality is any difference between the private cost of an action or decision to an economic agent and the social cost. In simple terms, a negative externality is anything that causes an indirect cost to individuals.

Positive externality means "external economy", while negative externality "external diseconomy". The external economy represents the additional benefits or benefits that economic activities of the subject bring to other entities. External diseconomy refers to the extra cost or loss caused by the economic activities of the subject to others without corresponding compensation.

Production externality and consumption externality

The externality of production is the externality caused by production activities, and the externality of consumption is the externality brought by consumption behavior. In the past, economic theory focused on external issues in the field of production. After the 1970s, the scope of research on externality theory expanded to the field of consumption. In the two-person externality model, when the performer B of the externality behavior is a producer, the externality implemented by B is called production externality, that is, the externality originates from the production field. When B is a consumer, the externalities implemented by B is called consumption externality, originating from the field of consumption. Whether it is the externality of production or that of consumption, its impact may be either "positive" or "negative" for A, and A may be the producer or the consumer.

Technological eternality and pecuniary externality

The classification of technological externality and pecuniary externality was proposed by Viner (1931). His distinction of externalities is based on the effects of externalities reflected by price signals and the influence of the real variable of total social output, that is, whether externality will affect the efficiency of resource allocation.

Pecuniary externality affects others or the economy only through changes in prices. In a market economy, pecuniary externality does not affect the efficiency of resource allocation, which means it does not impact the real variable of social output. The influence of technological externalities cannot be reflected by price signals. technological externality can affect others or the economy with non-price factors, and further change the total output of society. The effect of technology on effectiveness of resources configuration are shown in Figure 3.

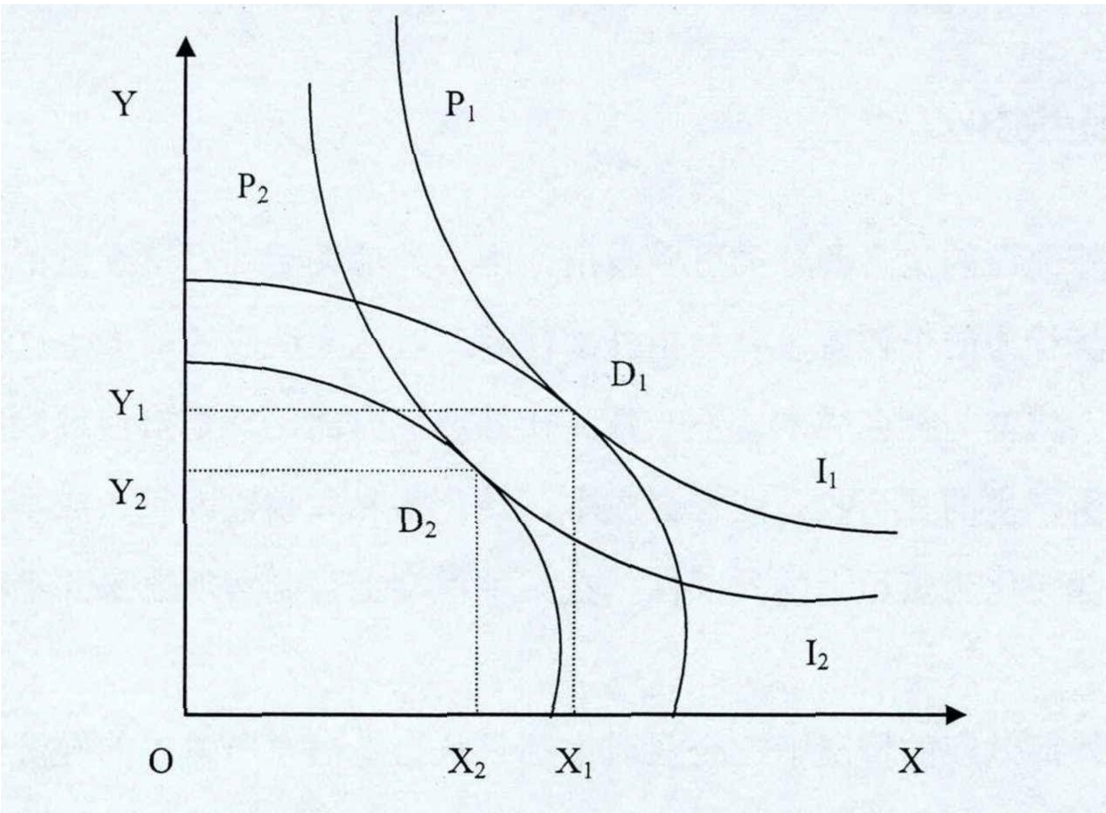

Figure3. The effect of technology on effectiveness of resources configuration. From "Research on Externality of Port Economy Based on System Dynamics", by Han Liang, 2011, p.9. Copyright 2020 by CNKI.

Simple externality and complex externality

Simple externalities are also called unidirectional externalities, and complex externalities are also known as interactive externalities. In the two-person externality, when B exerts external influence on A and A does not do the same on B, the externality is a simple and unidirectional one. When B exerts external influence on A, and A on B, it is described as complex externality, which is bidirectional and multiple. A large number of externalities belong to simple externalities. Figure4 shows the simple externality and complex externality.

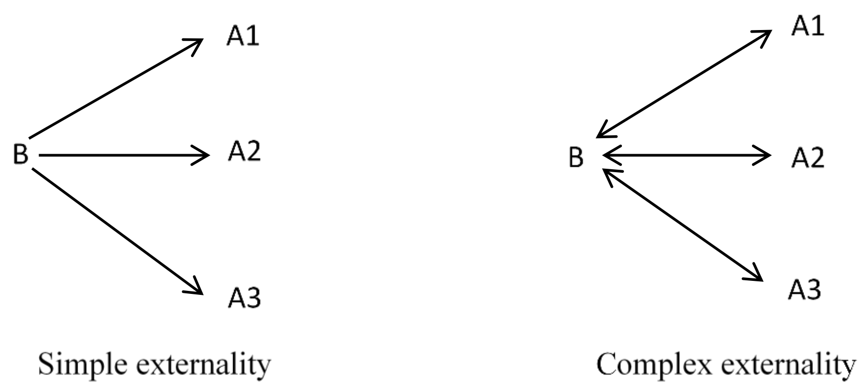

Figure4. Simple externality and complex externality. From "Research on Externality of Port Economy Based on System Dynamics", by Han Liang, 2011, p.10. Copyright 2020 by CNKI.

2.1.2 Internalization of externality

Pigou's tax and subsidy policy

Pigou (1920) claimed that state must intervene and state power of taxation must be used to levy taxes and grant subsidies to achieve the Pareto optimality. Pigou's idea is that the national macro-control issues need to be flexibly mastered and applied in practical problems.

Coase equity transaction

Coase (1937) maintained that externalities can be managed through the coordination of private contracts to avoid more serious damage from both sides of the economic subject. In Coase's view, as long as the property rights are clearly defined and the transaction costs are zero, no matter who owns the property rights, an efficient allocation of resources will be ensured. The shortcomings of the theory of property rights trading are that it lacks consideration of the efficiency and fairness between generations. Since the total amount of social resources is limited, the excessive use and exploitation of people will deplete resources.

Direct government intervention

As the market mechanism cannot automatically achieve Pareto efficiency and optimal allocation of social resources, it is necessary to supervise the entire trading market through government macro-policy control. In order to achieve the goal of government regulation, no matter what method is adopted, a basic focus must include reducing the behavior level of negative production externality, or increasing the behavior level and benefits of positive externality-producing enterprises. Direct government intervention must make full use of the power of relevant national laws and policies.

2.2 The externality of port

With the development of global economic integration, the construction of port infrastructure and the development of port service industry are in the ascendant. As a hub of various modes of transport and information flow, ports play an increasingly critical role in the growth of international trade and the revitalization of the world economy. However, while bringing great economic benefits for countries and regions, ports also witness changes, which has brought about a certain negative impact on social development. For example, the construction and daily operation of the port occupies a large amount of land, marine and other natural resources, and the environmental pollution caused by waste discharge. These positive and negative effects on the city are externalities of port.

In this section, the positive and negative externalities brought by the port development are analyzed. The specific effect factors are proposed. At last, the usual evaluation methods of port externalities are introduced.

Transportation Externalities and Internalization Methods

The American ULI (2003) suggested that joint development is a real estate development activity in which the transportation system can be used to gather high-density populations, reduce time and costs of transportation, and maximize the benefits.

Johansson (1995) established the external cost model of traffic congestion based on his research. The model of social net income of various road users was obtained, and the model of congestion tax was created under the condition of maximizing net income.

Mishan (1971) analyzed the external costs of traffic accidents, establishing the Mishan model, and formulated MEC =MSC=MPC.

Mark A. Delucchi (1998) and the research team of Transportation Research Institute of the University of California distinguished the monetized cost of accidents and the non-monetization cost (external cost of the technology). All property damage, medical, legal, traffic police, and administrative costs led by the accident were external monetized cost, which was calculated based on the data from 1990 to 1991. The cost of these was 13.1-49billion US dollars. The cost related to pain, suffering, mental injury, death, and non-marketable productivity loss was the external cost of technology, and the cost of which was 10.2-120 billion US dollars. To be precise, only this part needed to be internalized.

Han Liang (2011) summarized several externality internalization methods in the Research on Externality of Port Economy Based on System Dynamics.

2.2.1 The positive externality of port

As a hub of sea and land, a port encourages the flow of material, information, talents, and other factors between the hinterland and overseas regions, and its powerful agglomeration and diffusion effects turn itself into a growth pole for regional economic development. Ports serve as a key part of urban development in terms of industrial development, spatial structure, regional division of labor, and social formation. Meanwhile, the economic development of cities has become "boosters" for port functions, scale, and hinterland expansion.

The impact of ports on agriculture is mainly due to the trade of agricultural products by ports. As for the industry, after the World War II, the development of maritime transport, has changed the industrial production location. Needs of raw materials and resources of industrial department reduced, and market demand and cost increased. Developed countries or regions established the production enterprises in the economically developed coastal areas, and transported commodities, such as ore, crude oil, raw coal, raw salt, pulp, wood and other raw materials via ports. Thus, it has promoted a number of cooperative industrial areas, boosted the development of the port industry, and changed the industrial structure of the city. For the international trade, countries establish an economic and trade network through ports, which act as the node of trade center network. As a regional gateway to a country, a port has been of great political and military significance. In the context of international politics nowadays, economic and military struggle is becoming increasingly complex and local conflicts and emergencies occur from time to time. Ships provided by a military port can respond to combat plans, emergency or rescue. At the same time, shipping companies can employ their ships around the world via the important port nodes to rapidly deliver major goods and personnel, protect national security interests, minimize national losses as much as possible, and enhance the international prestige of sovereign states.

The following Table1 introduces the influences on city development from the port in different stages.

Table 1

Influences to city development from the port of different stages

	Primary stage	Intermediate stage	Advanced stage
Name	Business Transportation	Port industry	Diversified development
Dominant factor	Port location	Port agglomeration	Multiplier effect
Type of port industry	Co-production industry: maritime industry, transportation and warehousing industry closely connected with the port loading and unloading industry	Dependent industry: processing industry, manufacturing industry and heavy-chemical industry formed by port's resource endowment	Relevant industries: finance, insurance, commerce and other service industries related to the above two types of industries
The external space structure of the port	Single-core and point-based	Multi-core supply chain	Networked structure

Note: Adapted from "Research on Externality of Port Economy Based on System Dynamics", by Han Liang, 2011, p.16. Copyright 2020 by CNKI.

The Primary Stage of the Impact of the Positive Externality of the Port on Urban Development

During this period, the positive externality of the port originates from the port's transit function. At this time, the port functions are relatively single, with freight forwarding and commercial trade as the core. The impact of a port on a city corresponds to the port's function at this stage, which is mainly based on the activities of the port affairs and distribution departments. The economy of a port city depends on the transit of goods and commercial trade as well. At this stage, the location advantage of the port matters a lot, for good location and environment can facilitate the formation and development of the city.

From the perspective of the internal layout of a port city, commercial banks are densely distributed along the port, and residential areas are adjacent due to the influence of the port's commercial and transportation functions. As for the development of external layout, a port city remains in the stage of single-core and point-based development. Along with the gradual accumulation of capital, technology, labor and other factors, the city tends to spread outward.

Intermediate Stage of Impact of Positive Externality of Port on Urban Development

As mentioned above, the impact of a port on a city stems from the port's transport transit function, and the port's cargo distribution and transit function has induced the emergence of the port-vicinity industry. However, the development of the port industry is not the natural tendency of a port. Only when the transportation volume provided by the port to the port industry becomes large enough for the scale economy to take shape, the port-vicinity industry can be created. With the expansion of the port scale and the formation and development of port-vicinity industries, profound changes have taken place in the urban industrial structure, and thus speeded up the industrialization.

Judging from the internal space structure of a port city, affected by profit margins, the dependent industries in the industrial zone and the high-tech zone are densely distributed along the port, and the residential area in the vicinity of the port is squeezed and forced outward (away from the port area). Under the influence of the hyper-cyclic evolution mechanism of urban space development, the urban CBD and road construction also spread outward.

As for the external space structure, the regional groups of ports based on the industrial chain initially form, and the “corridor-like” city belt of coastal ports gradually develops.

Advanced Stage of Impact of Positive Externality of Port on Urban Development

The positive externality of a port is gradually diversifying. The port is shifting from the initial cargo transportation and transit center to a comprehensive port, integrating tourism, integrated logistics, and information technology development. The city's industrial structure has also been further optimized and upgraded. Influenced by the multiplier effect, related industries such as finance, insurance, commerce and trade continued to develop, and urban functions therefore expanded. The port economy is no longer regarded as a single point of economic growth and it shows the trend of diversification.

For the internal space of a port city, urban development has moved from the coast to the inland in a networked model, and new gathering areas (residential areas) and towns have formed. The radiating effect of related industries spreads inland along transportation routes and improves the location of some inland cities and suburbs, thereby stimulating the establishment of new economic growth points and fostering the urban-rural integration. In terms of external space development, the proliferation of industries has strengthened the inter-regional connection. It has gradually formed the networked development model of the port city group based on the industrial chain, and thus drove the development of more port cities.

2.2.2 The Negative Externality of Port

Port Congestion

Port congestion is one of the significant contents of negative externalities of ports. Externalities can be assumed to arise whenever there is a waiting for a ship. With the continuous increase of international trade volume, the throughput of the port grows. Especially, as the volume of containers entering and leaving the container port terminal goes up, the congestion of the port becomes inevitable. The congestion of the port first extends the external cost of time. Due to the great cost of ships and the high operating costs, once the port is overcrowded, heavy losses will be incurred. Compensation such as port demurrage may occur. Yet, there is an externality for the entire social system. The time cost of this ship is not only caused by the port, but is generated by the entire system, including the port side and the ship side. That is to say, the demurrage fee should not be borne by the port. The cost to bear is part of the externality of the port congestion.

Environmental Pollution

Water Pollution

There are many sources of pollutants in the water around the port. The sources of pollution can be divided into two categories: natural and anthropogenic, according to the causes of formation. Water pollution can worse the sensory properties of water, including color, taste, turbidity, floating matter, sediment, physical and chemical properties temperature, conductivity, pH scale, radioactivity, chemical composition inorganic matter, organic matter, biological composition type, quantity, state, and quality etc. Pollution also obstructs the normal function of the water body and reduces the quality of the water environment.

The pollution of the water around the port mainly comes from the washing and ballast water of the oil tanks. Also, the bilge water generated by the berthing ships during the driving process is a key source of pollution as well. Ballast water generally refers to the seawater or fresh water injected into the tanker to maintain the normal navigation of the hull. When the oil tanker is unloaded during the navigation, or after the vessel is unloaded, the seawater or freshwater must be discharged before the ship reaches the loading port, then the ship can be refueled. As the amount of crude oil in the tank cannot be completely drained after it is unloaded, about five thousandths of the amount of oil will still remain in the tank. Crude oil tankers in particular, the actual residual amount far exceeds this data. After ballast water is injected into the tank, a large amount of oil will be mixed. Therefore, ballast water tends to be the largest volume of oily water in a ship's oily sewage.

Tank washing water refers to the oily sewage, which flushes out residual oil during repair or cleaning in oil tankers. In addition, tanks are also normally washed when they are diverted to other types of oil. In the cleaning process, the oil content in the sewage is relatively high, and the general oil content is between 1000-30000mg/l. Normally, tank washing water has a higher degree of emulsification, which will definitely multiply the difficulty of processing. The volume of tank washing water is generally 400-800t per tank of 10,000-ton tanker, but the total amount of these discharges is much less than that of ballast water.

Air Pollution

The main sources of pollution impacted by the port on the atmospheric environment are dust and polluted particles generated during the loading and unloading of bulk cargo. The contaminants include ore, coal, and ore powder at the port frontier and during the storage at the port yard, polluting gases volatilizing during the transportation of crude oil and liquid chemicals at sea and during the transshipment and storage at ports, exhaust emissions from fuel oil during port handling machinery work.

Sound Pollution

As modern industry has continuously developed, environmental pollution may occur. Noise pollution is a kind of environmental pollution and has become a major hazard to human beings. During the daily production and operation of the port, various large-scale machinery and equipment are widely used, especially at night, which brings massive amounts of noise pollution to the surrounding environment.

Port noise mainly comes from port loading and unloading, transportation operations, and ship entry operations. Port noise emanates from the production and operations of large loading and unloading machines, auxiliary machine, and repair equipment. Noises also originate from transportation vehicles such as trucks, trains, and ships during transportation, mainly concentrated in the frontier areas of the port. When a large ship enters a port, the ship's main engine, propeller, system power machinery, and pressure pump emit much noise, in addition to hydrodynamic noise.

It is generally stipulated that the frontier operation area of the port is not less than 200m from the rear residential area. Various noises of the port seriously affect the acoustic environment around the port area. Furthermore, the entry of ships into the port has caused damage to the acoustic environment along the route, threatening the health and quality of life of the residents around the port area.

2.3 Overview of Port Externalities & Evaluation Methods

Cherdvong Saengsupavanich pointed out that the existence of a port will erode the coast and affect the living habits of local residents, which can be considered as the externality of the port. Port operators and shipping companies are considered to be held accountable.

R. O. Goss (1979) pinpointed the dangers of the port monopoly effect and discussed the externality of the port, including maritime safety and pollution.

Han Liang (2011) remarked the significance of ports and the research on them. He also proposed several classifications of externalities and different kinds of positive and negative externalities of ports in his *Studies on Port Economic Externality based on System Dynamics*.

Zhang Huaqiang (2009) mentioned in the *Study on Externality of Container Port* that the externality of ports has gradually become prominent and the existence of externalities exert a substantial impact on ports and socio-economics; therefore, it is necessary to analyze port externalities.

Liu Hongyue (2011) advanced the term "port external effect" and further defined its connotation. The spatial scale of the study is considered to be different. The external effect of the port can be divided into the external effect of the port on the city and the external effect of the port on the region.

Nathaniel Baum-Snow (2000) selected data from 5 major cities with updated rail transit systems from 1980 to 1990, applying regression analysis to estimate the impact of updated rail transit on real estate values. He emphasized the external benefits of the new rail transit, indicating how commuting patterns, beneficiary groups, and rental house prices are affected.

David R. Bowes (2001) believed that rail transit stations have a large negative externality. He proposed negative factors brought by rail transit stations, such as noise, pollution, high crime rates near stations. Then, he used the characteristic price method to build a standard price model, and two auxiliary regression models (representing the correlation between commercial and crime rates and rail stations respectively).

CVM is based on the principle of utility maximization. As CVM is a method becoming widely adopted in non-market value, it can be used in questionnaires to fully simulate market behavior to reflect people's preferences for changes in public products. CVM is an effective research method for deriving people's willingness to pay on the basis of imaginary conditions, and ultimately obtaining the total economic value of public goods.

The land price and transportation cost model (TCM) and urban activity and transportation cost model (TUM) were proposed by a Japanese scholar Aoki. Urban rail transit based on the theory of transportation cost and land price can help evaluate the value-added of land along the line.

2.4 Overview of Port Management and Operations

Yang Geng (2017) conducted a comparative analysis of port management systems of

Shenzhen Port and Shanghai Port regarding investment construction and operation modes of domestic and foreign ports.

Su Rui (2019) introduced the port management system of Liaoning Province in the *Research on Government Promotion of Port Resources Integration in Liaoning Province*.

Ji Lei (2018) demonstrated the port management systems of different western countries in the Research on the reform of Jiangsu port management system.

Gu Jing (2018) showed several port supply chain models in the *Research on Port Logistics Operation Mode Based on Supply Chain Management*.

Fan Baowen (2019) suggested the construction goal of the intelligent logistics information system for the port in the analysis of the status and development of the intelligent application of the port terminal system.

Xu Ronghua (2018) pointed out that port logistics provides basic logistics services and derivative value-added services as an important link in supply chain logistics. Famous ports, including Singapore Port, Antwerp Port and Rotterdam Port each took advantage of their convenient geographical locations and adopted suitable port logistics management and operation modes, which have brought them great success. The researcher thus gained experience and inspiration: the government should attach great importance to port construction. Based on the port situation, the government should formulate and implement differentiated strategies, adopt the correct port management mode and port logistics operation mode, introduce policies to promote the development of port logistics, and continuously enhance service quality and level.

Zheng Jun (2019) started with port operation and management work. Based on understanding the current status of port operation and management, he built a set of modern port operation and management models, indicating that the role of the government and society in the modern port operation and management model should be brought into full play. The management system and management path should be improved, so as to comprehensively raise the level of port operation and management.

Dai Rongxin (2019) elaborated on the background, necessity of construction and the status and future development of the intelligent application of the port terminal system.

Ji Fei (2018) expounded the actual work experience of intelligentization of ports and terminals.

Wang Jingmin (2014) designed an integrated port supply chain collaborative management model, collaborative management platform, and countermeasures according to an analysis of the concept of collaborative management of an integrated port supply chain based on the Internet of Things.

Liu Lidong (2017) conducted a detailed study of the integrated port logistics service supply chain system, and analyzed the characteristics of the modern port logistics supply chain.

Li Liming (2019), based on empirical research, analyzed the port and regional economy, and set up an in-depth discussion on the interaction mechanism between the two.

Huang Heng (2017) took Shanghai Port as an example to explore how super-large container hub ports can realize the sustainable development by building an intelligent operation model.

Guo Yifei (2017) adopted a combination of macro analysis and micro analysis to examine the current status of Qinhuangdao Port and the development status of the port based on relevant theories of port economics and port management system. Along with a comparative analysis, a series of measures such as the reform of the port management agency were proposed to optimize the port management system of Qinhuangdao Port.

Wu Aicun (2015) introduced the management model of foreign ports, and explored how the port industry development can transform from a low-level industrial agglomeration into an industrial cluster with a high degree of division of labor and cooperation.

Sun Chao (2019) analyzed the internal operation mode of the port group.

Zhao Xu (2019) elaborated on the prerequisites, organizational structure, management system and operation process of the outsourcing management model based on partnering. The feasibility of this model is demonstrated by an example using Huanghua Port comprehensive port area project.

Chapter 3 Methodology

3.1 General Assessment Method for Port Externality Analysis

There are a lot of methods to analyze port externality, and this topic refers to many aspects. In general, the following methods will be adopted: Location quotient, Input-output model, Empirical description method, Gravity model. Pros and cons of those basic principles are introduced in Table 2.

Table 2

Methods of studying port externalities

Method	Location quotient	Input-output model	Empirical description method	Gravity model	Principal Component Analysis
Principle	Compare the economy and employment density of port area based on country averages	Use liner calculation and other methods	Analyze social benefits according to regional economic structure and related experiences	Evaluate port social benefit and dependence quantitatively by examining different locations	Evaluate a port's development effect
Pros and cons	Pros: Easy operation; data available in the statistical yearbook Cons: Such analysis only refers to big scale industry, but cannot reflect the social benefit of ports	Pros: Analysis of different industry multipliers, especially for indirect effects. These multipliers are sensitive and accurate. Cons: More data, time, cost and technology are required	Pros: Smaller port's material is available; easy operation. Cons: Inaccuracy; easily influenced by interviewee's feelings	Pros: Equation built by cargo flow and people flow for calculating the relationship between surrounding area and port Cons: Incapability of reflecting the economy unit which have few	The explanation and meaning of principal component are ambiguous in contrast to original variables

		when building an input-output table		activities related to locations	

Note: Adapted from "Research on Externality of Port Economy Based on System Dynamics", by Han Liang, 2011, p.25. Copyright 2020 by CNKI.

Principal Component Analysis (PCA) – The first study is about how the development of Shanghai port reflects the degree of the development of cities or country. A number of related indicators and the multi-statistical method are used to conduct the PCA. This analysis is an attempt to make the best comprehensive simplification of the multi-variable cross-sectional data table under the principle of minimizing the loss of data information. That is, to reduce the space of high-dimensional variables. When the economic variables selected in the analysis have different volumes, the variable levels vary greatly. The PCA based on the correlation coefficient matrix should be selected. Assuming that there are p indicators in the current problem, the p indicator is viewed as p random variables, which are recorded as X1, X2, X3, Xp. PCA can change the p-indicator problem into a discussion of the linear combination of p indicators. Besides, these new indicators F1, F2, …, Fk (k≤p), in accordance with the principle of retaining the main amount of information, fully reflect the information of the original indicator, and are independent of each other.

That is the very reason why this model is chosen. Since there are so many indicators available to evaluate the positive port externality, an indicator system can be built to assess the port externality, and rank the port based on those indicators. Yet, it is no easy task to get the result from so many indicators. A way to simplify the evaluation of indicators and minimize the loss of data is required to obtain the port positive externality rank based on the port comprehensive index.

The conclusion can received by a liner program, if A is the real symmetric matrix of P, then orthogonal matrix U can be retrieved to make the.$U^{-1}AU = \begin{bmatrix} \lambda_1\, 0 \ldots 0 \\ 0\, \lambda_2 \ldots 0 \\ M\ M\ O\ M \\ 0\, 0 \ldots\ \lambda_p \end{bmatrix}$ p × p.

If the corresponding unit feature factor of characteristic root of former matrix is u1…up, make the $\mathrm{U} = (u_1, \dots, u_p) = \begin{bmatrix} u_{11}\, u_{11} \dots u_{1p} \\ u_{21} u_{22} \dots u_{2p} \\ M\ M\ O\ M \\ U_{p1} U_{p2} \dots U_{pp} \end{bmatrix}$. Then, the corresponding unit feature factor of real symmetric matrix A belonging to different characteristic root is orthogonal. Then, U'U=UU'=I. Assume the covariance matrix of X is $\sum_{x}$, because $\sum_{x}$ is nonnegative definite symmetric matrix, then there must be an orthogonal matrix U to make $\mathrm{U}\sum_x U = \begin{bmatrix} \lambda_1 0 \\ O \\ 0\ \lambda_p \end{bmatrix}$ with the knowledge of linear algebra. And U is just the orthogonal matrix composed by corresponding feature vector of characteristic root. $\mathrm{U} = (u_1, \dots, u_p) = \begin{bmatrix} u_{11}\, u_{11} \dots u_{1p} \\ u_{21} u_{22} \dots u_{2p} \\ M\ M\ O\ M \\ U_{p1} U_{p2} \dots U_{pp} \end{bmatrix}$. Linear combination of original variables composed by elements of U fist row has the maximum variance, which is $F1=u_{11}X_1+\dots u_{p1}X_p$, Var ($F_1$) $=U'_1\sum_x U_1 = \lambda_1$. Principal component 1 can be retrieved according to the maximum variance λ_1. Since the first principal component is not enough, second principal is required. The proportion of variance of i-th principal component of total is called contribution rate, which reflects the amount of original information and the overall ability. As the proportion of top k principal component variance is used to show the comprehensive ability of top k, it is known as cumulative contribution rate. PCA is adopted here for the sake of replacing original p indicators with principal component F_1, F_2, …F_k ($k \leq p$), as little as possible. However, an actual amount of Principal Component selected depends on those can reflect 80% information of original variance. When cumulative contribution is higher than 80%, the number of Principal Component is enough.

3.2 Selection and Analysis of Evaluation Indicators of Port Positive Externality

Indicators system serves as the basis to evaluate the port positive externality, and it is vital to design indicators system for a multi-index evaluation method. Therefore, three groups of first-level indicators (maritime finance and law, maritime technology, logistics and trade services) are chosen to show the degree of effects port can bring synthetically, which means port produces positive effects on the city or even on the country. There are 12 subdivided second-level indicators under the first-level indicators. The specific indicators system is shown as Table 3.

Table 3

Qualitative indicators system

First-level indicator	Second-level indicator
Maritime finance and law	Shipping finance and banks
	Maritime law
	Marine insurance
Maritime technology	Shipbuilding
	Classification societies
	Market value of ships built at shipyards
	Patents by maritime companies
	Maritime education institutions
Logistics and trade services	Port volume
	Port operators
	Size of ship owners' fleet and management of fleet
	Value of city-controlled fleet

Maritime Finance and Law

Maritime finance and law are major indicators to assess the port positive externality. Port daily operation and development encourage the trade of city and increase the trade value of the city. More attention paid by international finance institutes and stock institutes to the port can stimulate more shipping banks relocate or set their branch banks in the city. In addition, the trade related to port such as charter, import and export, sailor employment and so on may lead to a series of dispute, which can facilitate the formulation and improvement of local law. These are the positive externality for the city or the country.

London, Singapore, Oslo and New York perform better in this field. London, an old port city, has a special position in the global financial industry and is widely recognized for its law-related and maritime insurance services. London is home to world-leading institutions, such as Lloyd's Insurance, and English law is the most widely applied in shipping disputes. New York, Hong Kong and Singapore together with London, are considered the four leading global financial cities according to the Global Financial Centres Index.

In terms of the number of listed maritime companies on their local stock exchanges, the number in Hong Kong, Tokyo and Shanghai has increased since 2017, which means that the places are becoming attractive destinations for registering new stocks. New York is by far the largest equity market in the world for maritime stocks, both in number of tradable stocks and market capitalization of companies. As shown in Figure 5, the number of New York greatly surpasses other port cities.

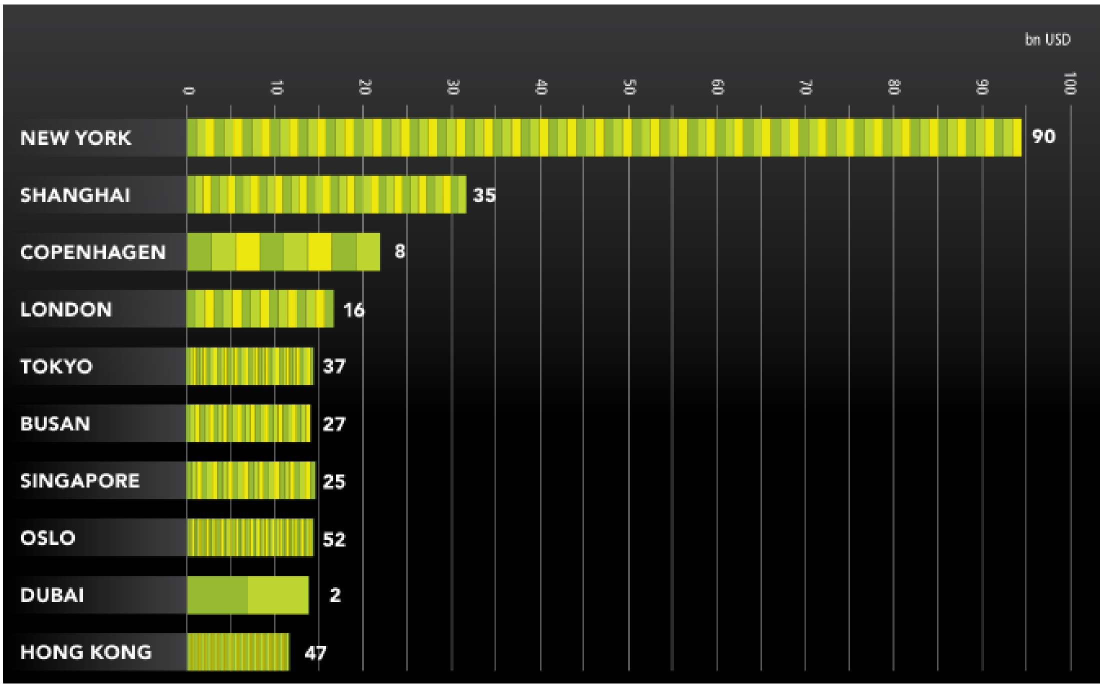

Figure5. Market value and number of listed maritime companies on local stock exchange. From "The leading maritime capitals of the world 2019", by A Menon Economics and DNV GL Publication, 2019, p.26. Copyright 2019 by A Menon Economics and DNV GL Publication.

The following Figure 6 shows the top stock exchanges. The number of new orders in Shanghai seems to be much smaller than that of in Korea, Singapore, and Tokyo, which means positive externality brought by ports in terms of new orders in stock exchange is not significant.

Stock Exchanges	No. Builders	New Orders 2019			Orderbook May 2020			Scheduled Delivery,'000 CGT			
		No.	'000 dwt	'000 CGT	No.	'000 dwt	'000 CGT	2020	2021	2022	2023+
1 Korea	4	212	23,177	9,476	408	46,230	20,299	6,536	9,499	4,010	254
2 Italiana	2	16	45	1,098	51	130	4,188	405	810	866	2,108
3 Singapore	9	38	2,327	589	118	6,863	2,319	1,036	1,016	209	58
4 Tokyo	6	44	2,614	844	92	5,870	1,737	832	698	166	41
5 Hong Kong	5	16	133	794	49	476	1,663	457	500	203	503
6 Shanghai	3	15	172	147	52	1,757	707	255	278	173	
7 Taiwan	1				14	673	303	235	68		
8 NSE India	2	4	32	27	11	40	124	77	47		
9 Zagreb	1				6	124	120	65	55		
10 PINK (OTC)	1				2		92	92			
Other (9)	14	17	11	32	65	84	198	167	31		
Total Public Yards (19)	**48**	**362**	**28,512**	**13,008**	**868**	**62,247**	**31,750**	**10,156**	**13,001**	**5,628**	**2,964**

Figure6. Total Public Yards. *From Clarksons Research "Capital Market Monthly", by Clarkson Research Services Limited, 2020, p.11.Printed on FSC/PEFC certified paper.*

Figure 7 reveals the stock exchanges in terms of publicly listed shipping fleets. The number of Shanghai also seems smaller than that of NYSE of New York and Tokyo, which means positive externality brought by ports is not so remarkable in this aspect.

Stock Exchanges	No. Owners	No Vessels, end				Million GT, end				Apr-2020	
		2016	2017	2018	2019	2016	2017	2018	2019	No.	m.GT
1 NYSE	59	2,265	2,328	2,327	2,286	101.9	107.1	109.6	110.0	2,293	110.7
2 Tokyo	37	1,875	1,853	1,839	1,847	90.9	91.8	93.4	95.3	1,853	95.8
3 Shanghai	36	805	912	1,086	1,169	31.0	36.6	50.4	55.0	1,163	54.4
4 OMX Copenhagen	7	900	890	929	918	26.4	29.5	31.8	32.4	921	32.6
5 Oslo	39	917	969	1,077	1,078	22.7	25.7	28.1	28.9	1,082	29.2
6 Taiwan	20	644	664	673	649	24.4	25.7	26.3	25.4	644	25.2
7 Hong Kong	33	1,002	1,022	1,063	1,093	19.4	20.6	21.9	23.3	1,100	23.5
8 NASDAQ	16	395	427	407	368	15.0	17.3	16.2	14.6	367	14.6
9 Frankfurt	5	187	218	236	238	8.5	13.4	13.6	13.7	238	13.7
10 Korea	28	501	434	368	373	21.5	17.1	12.3	13.6	373	13.5
Others (53)	223	4,565	4,618	4,527	4,623	87.5	88.6	95.1	98.9	4,547	99.6
Total Public Listed Fleet (63)	**503**	**14,056**	**14,335**	**14,532**	**14,642**	**449.2**	**473.4**	**498.7**	**511.2**	**14,581**	**512.6**
Share of World Fleet		***14.9%***	***15.0%***	***15.0%***	***14.9%***	***35.6%***	***36.3%***	***37.1%***	***36.6%***	***14.8%***	***36.5%***

Figure7. Top Publicly Listed Shipping Fleets - Stock Exchanges. From Clarksons Research "Shipping Review & Outlook", by Clarkson Research Services Limited, 2020, p.176.Printed on FSC/PEFC certified paper.

Figure 8 exhibits the Top 10 Shipping Stock Exchanges. It can be noticed that top 10 shipping stock exchange do not gather in those big port cities. A weak correlation between port externality and shipping stock exchanges can thus be inferred.

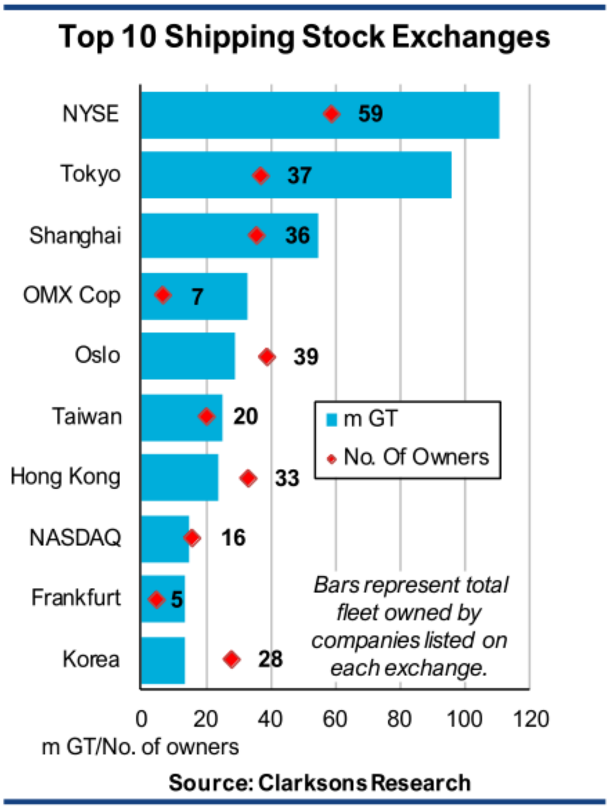

Figure8. Top 10 Shipping Stock Exchanges. From Clarksons Research "Shipping Review & Outlook", by Clarkson Research Services Limited, 2020, p.107.Printed on FSC/PEFC certified paper.

Shipping Finance and Banks

There is no doubt that New York is the biggest shipping financial center of the world. In Europe, Oslo and Rotterdam perform better.

Asian banks (particularly Chinese banks) have emerged in ship finance. As of today, three out of global top ten banks are Chinese banks: Bank of China, ICBC, China Exim. Figure 9 indicates that Beijing owns the most shipping banks portfolio. However, it is well known that Beijing is a political center rather than a port city. Also, some other cities in the rank are not port city, which means the positive externality brought by ports is not pronounced in terms of shipping banks.

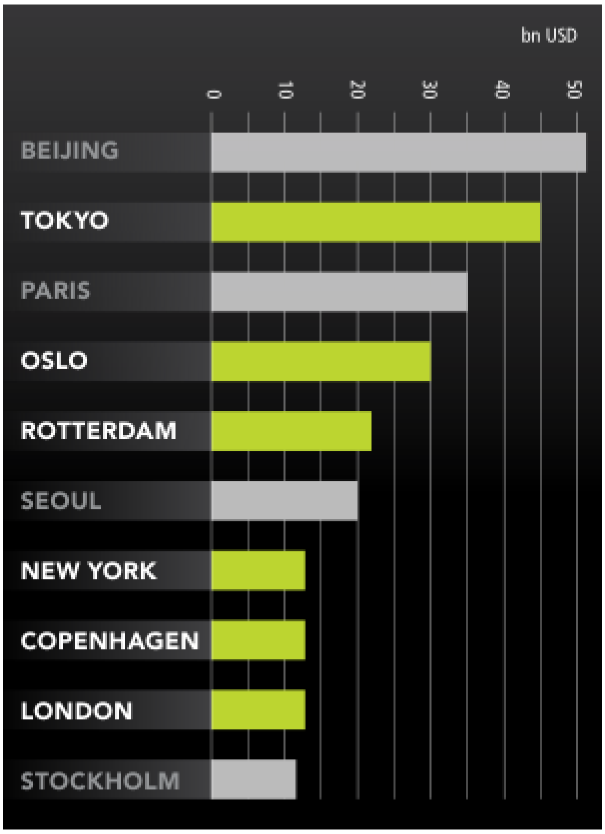

Figure9. Shipping banks portfolio. From “The leading maritime capitals of the world2019”, by A Menon Economics and DNV GL Publication, 2019, p.26. Copyright 2019 by A Menon Economics and DNV GL Publication.

Figure10 exhibits the Leading Bank Maritime Portfolios.

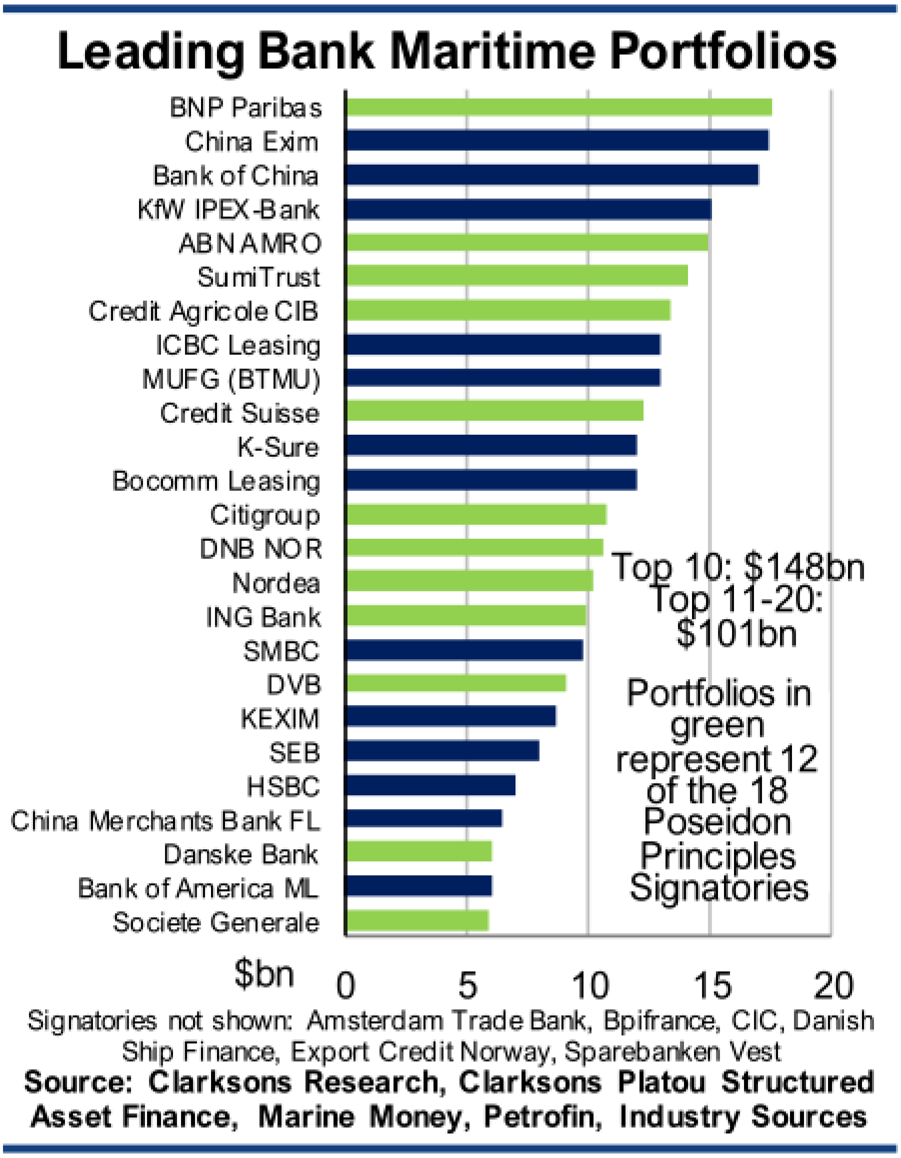

Figure10. Leading Bank Maritime Portfolios. From "Shipping Review & Outlook", by Clarksons Research, Clarksons Platou Structured Asset Finance, Marine Money, Petrofin, Industry Sources, 2020, p.103. Printed on FSC/PEFC certified paper.

Figure11 presents the top syndicated shipping loan book runners of 2019.

Rank	Bookrunners	Value ($bn)	No.
1	Nordea Bank	2.5	17
2	ABN AMRO Bank	1.6	10
3	Bank of America	1.6	5
4	BNP Paribas	1.4	8
5	DNB	1.1	11
6	Credit Agricole	0.9	9
7	Wells Fargo	0.8	3
8	Citigroup	0.7	4
9	BMO Capital Markets	0.7	3
10	Mizuho Financial	0.6	3

Figure11. Top Syndicated Shipping Loan Book runners 2019. From “Shipping Review & Outlook”, by Clarksons Research, 2020, p.178.Printed on FSC/PEFC certified paper.

Maritime Law

The report of Menon pointed out that London has the most leading legal experts in maritime law. Hamburg, Singapore, New York and Hong Kong have an average of 20 such legal experts. According to statistics, London also has the largest number of maritime lawyers, followed by New York and Athens. Since English law has been widely used in shipping disputes, London seemed to be the best location to settle maritime disputes and international marine arbitrations.

Marine Insurance

Concerning port functions, a series of insurance such as vessel insurance, sailor insurance and cargo insurance are demanded; thus, insurance industry in the city has gradually come into existence. London owns the first marine insurance company, Lloyd’s of London, in the early 18th century. The city was further complemented by the International Underwriting Association (IUA), continuing to be an unrivalled port city for marine insurance with more than 50% of International Group (IG) of P&I clubs covered gross tonnage served by UK-based clubs. Over 30% of global cargo and H&M premium are collected by UK-headquartered insurance companies and the city has the largest number of representation offices among all clusters.

Singapore has improved thanks to its efforts to encourage marine insurance activities by introducing its own Singapore War Risk Mutual supported by its industry association (SSA).

Maritime Technology

Maritime technology is the second indicator chosen to evaluate the port positive externality. The presence of port directly or indirectly refines the infrastructure of port, berth and terminal. More branch institutes of classification society are founded there. And the constant expansion of port and terminal supply the motion for the ship enlargement. As the result, as the ship building industry is accelerated, the market value of shipyards will grow. Besides, there will be more related shipping patents, with a rising demand of shipping talents, which enriches the local education resources.

Oslo is advanced in this indicator. One of the most important technology companies in the Norwegian clusters is DNV GL, whose head office is located in Oslo. In the respect of environmentally sustainable technologies & solutions for the oceans, Oslo also maintains a strong and collaborative partnership with key players to focus on ocean technology and sustainability. London performs well because of its prestigious maritime education institutions. Besides, London possesses the oldest classification society, Lloyd’s, with a history from 1760. London’s is recognized for being the port city of excellent educational and R&D centers. Hamburg has been home to the center for maritime technologies since 1965, and has been the hub for R&D in the German maritime industry, whose goal is to promote cooperation among various players in the industry, the academic circles, universities and government agencies. Busan, as the center for Korean shipbuilding, boasts its big fleet size delivered by its shipyards. Tokyo, with the presence of classification society ClassNK, is the world’s second largest classification society. There are large parts of research and development activities located in Tokyo.

In the respect of maritime technology and equipment, the performance of Singapore is outstanding due to the fact that the city acts as a market place where buyers and sellers can meet, even without shipping companies producing equipment and technology products there. The Maritime and Port Authority of Singapore (MPA) has hugely invested in R&D and advanced maritime technology as one of their core pillars with an aim to support Singapore to be a global port and shipping center.

Shanghai technical capacity in the country is rising these years, but it still has a long way to go. Shanghai’s low ranking as per the World Bank’ Quality of Port

Infrastructure index pushes it far behind leading port cities such as Rotterdam, Singapore, Hong Kong and Dubai. Yet, regarding specialized logistical services, Shanghai takes the lead in offering the best port-related logistics services.

Shipbuilding & Infrastructure

The region surrounding Busan, offering deep waters free from sand-banks, is the heart for Korean shipbuilding cluster. Although China is the world's second largest ship manufacturer in CGT, it is not yet as technologically advanced as the Korean shipyards.

The Figure 12 reveals the rank of countries/regions of new building orders ownership. China ranks high on the list, but the gap with others is little, which means the positive externality brought to those countries by port development is not obvious compared with others.

Top Countries /Regions[9]		$ bn.[7]		New Orders				in ,000 GT			Vessel Contracting		
		2019	2020*	2017	2018	2019	2020*	2017	2018	2019	2020*	This Year	
1	China P.R.	8.5	2.7	314	192	184	68	10,255	5,956	8,488	3,312	*UP BY....*	*17.0%*
2	Japan	8.5	1.3	288	405	276	39	7,460	14,598	7,422	1,102	*DOWN BY.....*	*-55.5%*
3	Greece	6.0	0.4	157	122	76	7	8,816	10,031	5,763	646	*DOWN BY.....*	*-66.4%*
4	Malaysia	4.4	0.5	16	27	25	7	164	440	1,021	547	*UP BY....*	*60.8%*
5	South Korea	4.9	0.4	71	73	90	8	5,560	7,597	5,439	351	*DOWN BY.....*	*-80.6%*
6	Hong Kong	0.2	0.3	36	29	7	3	794	398	184	319	*UP BY....*	*420.5%*
7	Singapore	2.7	0.2	87	99	51	6	3,789	3,305	2,721	234	*DOWN BY.....*	*-74.2%*
8	Norway	1.7	0.5	82	89	42	7	2,950	4,408	1,152	157	*DOWN BY.....*	*-59.2%*
9	Germany	0.5	0.2	23	59	22	12	561	1,855	618	136	*DOWN BY.....*	*-33.8%*
10	Denmark	0.5	0.1	23	26	11	3	1,246	960	248	125	*UP BY....*	*51.7%*
Total Top-10		**37.9**	**6.6**	**1,097**	**1,121**	**784**	**160**	**41,595**	**49,549**	**33,057**	**6,930**	***DOWN BY.....***	***-37.1%***
Share of World Total		*49%*	*66%*	*54%*	*58%*	*56%*	*72%*	*70%*	*76%*	*68%*	*91%*		
11	Brazil	0.0	0.8	12	9	0	1	36	4	0	100	*UP BY....*	
12	Turkey	0.2	0.1	88	55	14	2	450	617	229	82	*UP BY....*	*7.0%*
13	Finland	0.4	0.1	1	2	4	1	63	1	175	61	*UP BY....*	*5.0%*
14	Russia	3.9	1.6	31	30	28	7	836	671	961	57	*DOWN BY.....*	*-82.1%*
15	United Kingdom	1.0	0.1	31	27	14	1	1,367	1,751	301	52	*DOWN BY.....*	*-48.1%*
16	Portugal	0.0	0.3	1	5	0	4	36	55	0	37	*UP BY....*	
17	Sweden	0.8	0.1	9	6	17	2	106	209	409	16	*DOWN BY.....*	*-88.4%*
18	United States	10.0	0.1	81	75	44	5	3,805	3,568	1,634	8	*DOWN BY.....*	*-98.5%*
19	U.A.E.	0.6	0.0	16	21	14	2	61	99	301	8	*DOWN BY.....*	*-92.2%*
20	Indonesia	0.0	0.0	155	107	39	1	412	207	23	7	*DOWN BY.....*	*-6.4%*
Total 11-20		**16.9**	**3.1**	**425**	**337**	**174**	**26**	**7,174**	**7,183**	**4,033**	**429**	***DOWN BY.....***	***-68.1%***
Share of World Total		*22%*	*31%*	*21%*	*17%*	*12%*	*12%*	*12%*	*11%*	*8%*	*6%*		

Figure12. Ownership of Newbuilding Orders. From Clarksons Research "World Fleet Monitor", by Clarkson Research Services Limited, 2020, p.17.Printed on FSC/PEFC certified paper.

Selected public designers and manufacturers of engines and maritime machinery/equipment as Table 4 shown. It can be seen that those companies locate mostly in Europe, US, Korea, which indicates that positive externality of China in this aspect is not so noticeable.

Table 4

Selected Public Designers & Manufacturers of Engines & Maritime Machinery/Equipment

Company	Selected Key Products	Country
Alfa Laval	Engine room equipment, BWTS, scrubbers	US
Caterpillar	Diesel & gas engines, turbines	US
Doosan Infra core	Diesel engines - 2 & 4 stroke & generators	Korea
General Electric	Diesel engines - 2 stroke & gas turbines	US
HSD Engine	Diesel engine licensee: MAN B&W, Wartsila	Korea
MAN Energy Solutions	Diesel engine - 2 & 4 stroke	Germany
Wartsila	Engines, propulsion, BWTS	Finland
Rolls-Royce Plc	Diesel engines - 4 stroke, gas turbines	UK
ABB	Propulsion, electric & digital solutions	Switzerland
Japan Engine Corporation	Diesel engine - 2 stroke	Japan
Kongsberg	Technology and digital solutions	Norway
Furuno	Navigation & communication equipment	Japan
Dresser-Rand	Gas engines, turbines, compressors	US
GTT	LNG storage and containment systems	Paris
Inmarsat	Mobile Satellite Communication	UK

Note: Adapted from "Capital Market Monthly", by Clarkson Research Services Limited, 2020, p.11. Printed on FSC/PEFC certified paper.

Classification societies:

In terms of the size of classified fleets, DNV GL is at the first place, and thus elevating Oslo in the port city ranking. Lloyd's Register headquartered is in London with a history from 1760. Figure 13 shows the rank of Class Society Fleets. Figure 14&15 introduce the top classification societies by fleet.

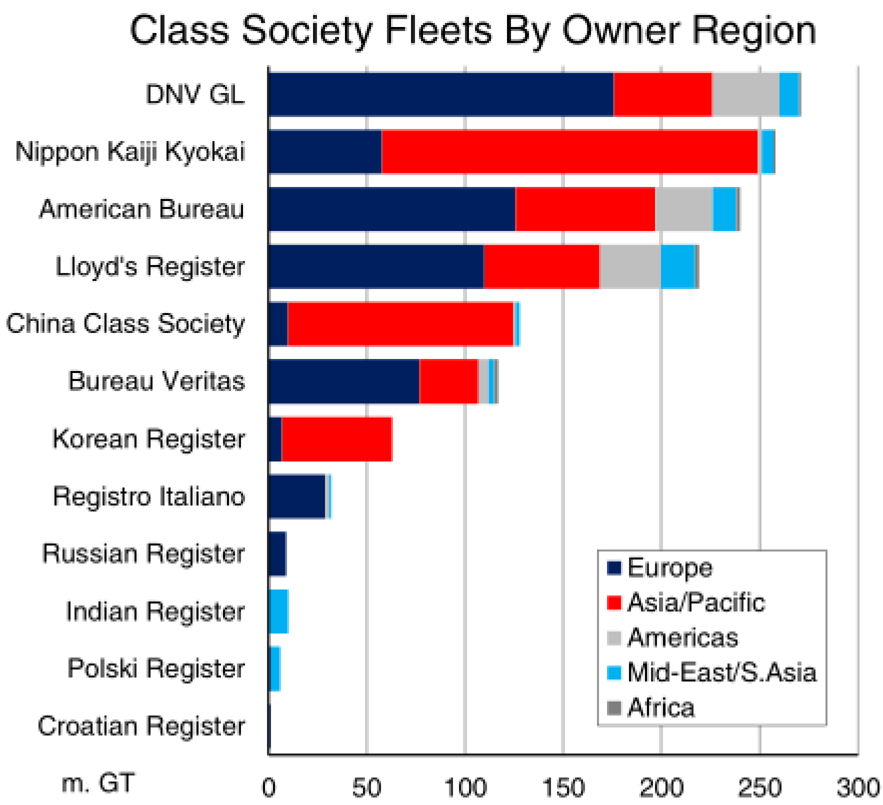

Figure13. Class Society Fleets By Owner Region. From Clarksons Research "World Fleet Monitor", by Clarkson Research Services Limited, 2020, p.10.Printed on FSC/PEFC certified paper.

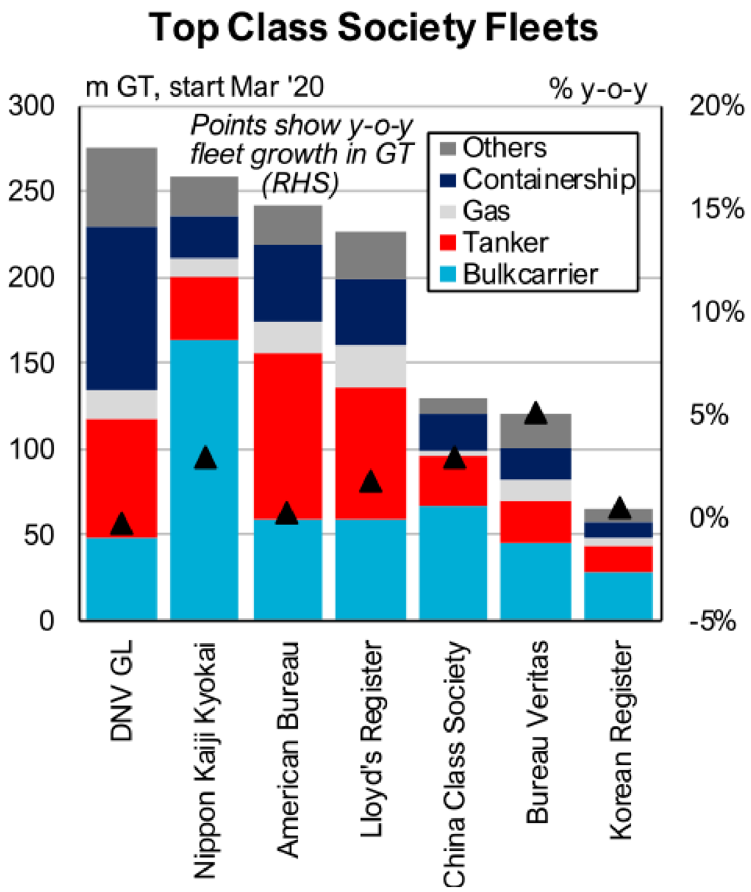

Figure14. Top Class Society Fleets. From Clarksons Research "SHIPPING MARKET OVERVIEW", by Clarkson Research Services Limited, 2020, p.39. Printed on FSC/PEFC certified paper.

Class Societies	Current Fleet, number						Current Fleet, m.GT					
	Tanker	Bulkcarrier	Containership	Gas	Others	TOTAL	Tanker	Bulkcarrier	Containership	Gas	Others	TOTAL
IACS Members												
DNV GL	1,604	1,120	1,888	329	3,732	8,673	69.5	48.8	94.7	16.5	46.0	275.5
Nippon Kaiji Kyokai	1,521	4,137	605	405	1,825	8,493	36.4	164.0	24.2	11.2	24.0	259.8
American Bureau	1,749	1,121	612	225	3,499	7,206	97.0	59.3	44.1	18.2	23.5	242.1
Lloyd's Register	1,541	1,270	603	373	3,071	6,858	77.3	59.5	38.5	23.8	27.7	226.8
China Class Society	1,120	1,610	441	112	2,011	5,294	28.4	67.0	21.6	2.9	10.6	130.6
Bureau Veritas	1,235	1,134	464	303	4,628	7,764	24.9	45.4	19.5	11.4	19.9	121.1
Korean Register	646	502	253	136	869	2,406	15.1	29.0	8.1	4.9	8.6	65.6
Registro Italiano	616	353	120	38	2,579	3,706	9.1	12.3	3.5	0.4	16.5	41.9
Russian Register	455	36	20	21	1,836	2,368	3.4	0.7	0.2	2.5	5.3	12.1
Indian Register	175	76	28	22	1,111	1,412	5.5	2.7	0.6	0.9	1.7	11.4
Polski Register	45	79	12		234	370	3.3	1.8	0.6	0.0	0.9	6.6
Croatian Register	25	19	2		260	306	0.9	0.6	0.2	0.0	0.2	1.8
Total IACS Member	**10,397**	**11,221**	**4,929**	**1,859**	**25,401**	**53,807**	**349.2**	**475.9**	**242.5**	**83.5**	**181.7**	**1,332.8**
Share of World Total	*67%*	*93%*	*92%*	*90%*	*40%*	*55%*	*96%*	*97%*	*98%*	*99%*	*82%*	*95%*

Figure15. Top Classification Societies by Fleet. From Clarksons Research "Shipping Review & Outlook", by Clarkson Research Services Limited, 2020, p.162.Printed on FSC/PEFC certified paper.

Market Value of Ships Built at Shipyards

Another parameter to understand the port city is the factor in the market value of the ships built at the shipyards. Thus, the purchasing price of vessels built at different shipyards from 2017 to 2019 was considered and shown in Figure16.

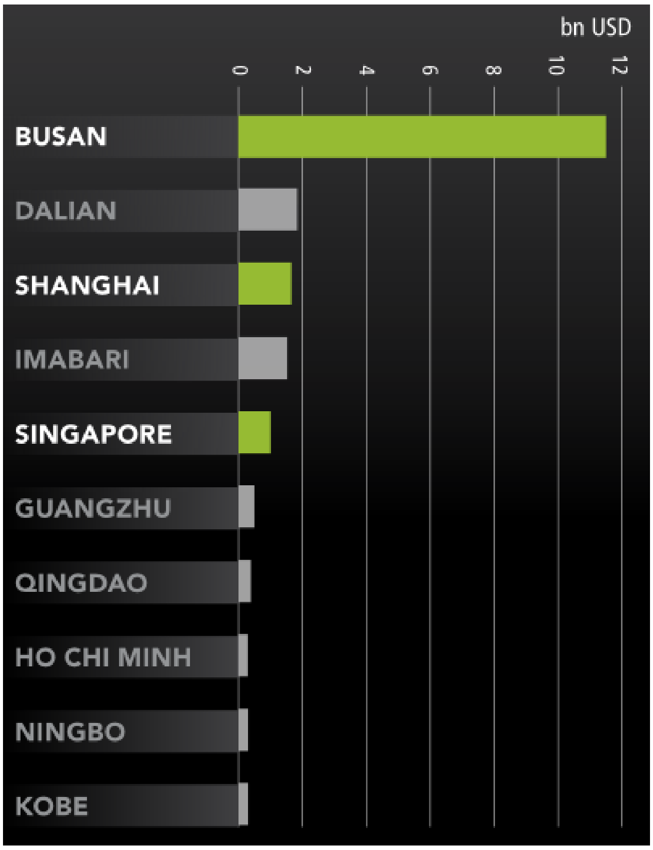

Figure16. Market value of listed shipyards and technical service providers (by year-end 2018). By city headquarter (value in bn USD). From "The leading maritime capitals of the world 2019", by A Menon Economics and DNV GL Publication, 2019, p.31. Copyright 2019 by A Menon Economics and DNV GL Publication.

Patents by Maritime Companies

Busan scored the largest number of patents in 2018 as shown in Figure17, followed by Tokyo. Daewoo Shipbuilding and Marine Engineering Co. Ltd. holds almost 80% of the patents in Busan. In Tokyo, the segment of "building of ships and floating structures" accounts for 93% of its total patents, held entirely by Mitsui E&S Holdings Co. Ltd.

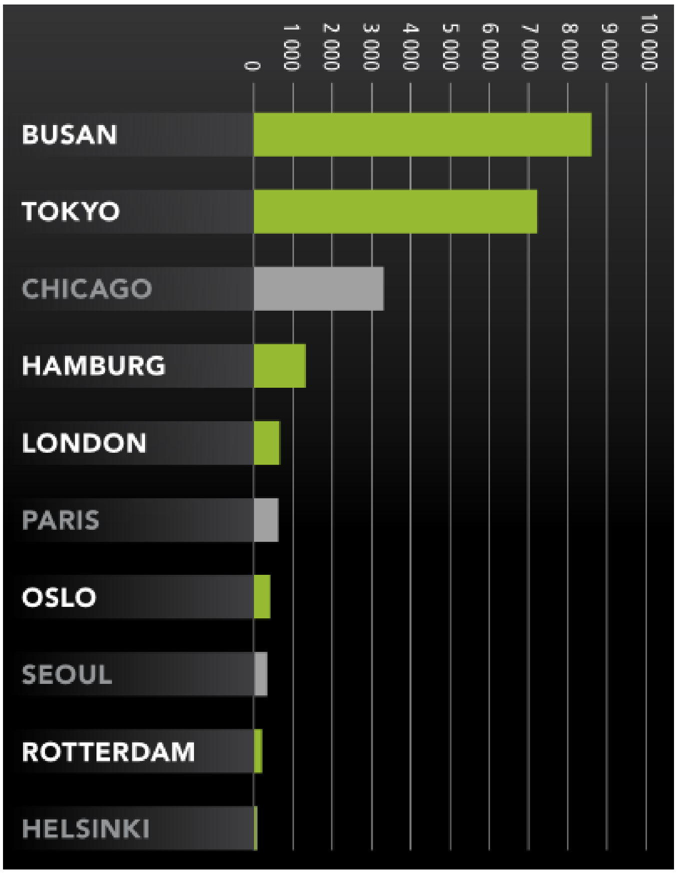

Figure17. Number of patents developed by maritime firms per city. From "The leading maritime capitals of the world 2019", by A Menon Economics and DNV GL Publication, 2019, p.32. Copyright 2019 by A Menon Economics and DNV GL Publication.

Maritime Education Institutions

London is the leading port city in respect of maritime education as shown in Figure18 and home to prestigious maritime academies such as Cass Business School and London Shipping Law Centre.

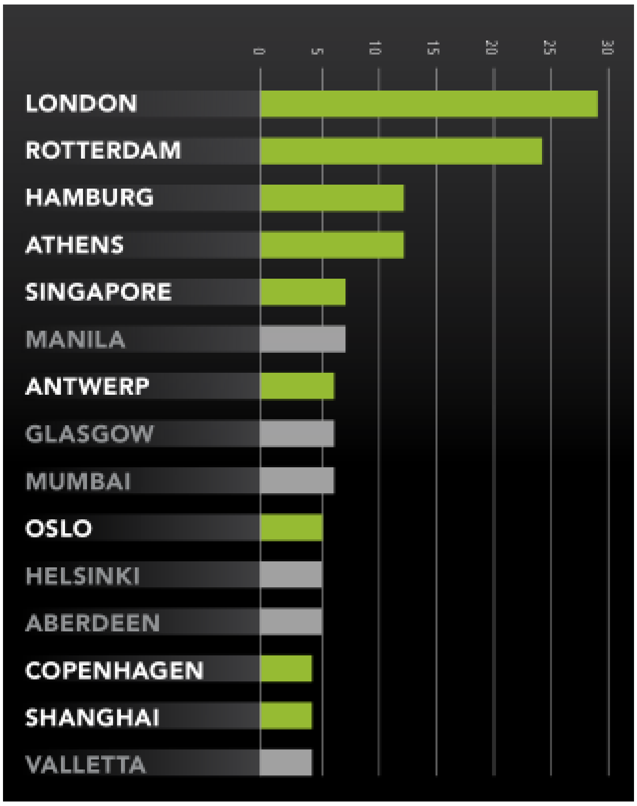

Figure18. Number of maritime Education Institutions per city. From "The leading maritime capitals of the world 2019", by A Menon Economics and DNV GL Publication, 2019, p.32. Copyright 2019 by A Menon Economics and DNV GL Publication.

Logistics and Trade Service

Logistics and trade service serve as the third indicator to evaluate the port externality. First, logistics level reflects the port level directly. For instance, a developed port has greater port volume. Port development improves the shipping environment and development. As more and more operators, owners, brokers and cargo companies pop up in the port cities, there will be more fleets, whose value is owned or managed by owners in the local area. Meanwhile, port development boosts the local logistics and trade service, which make a port city more attractive and competitive.

Port Volume

Shanghai has ranked top these years in terms of container throughput, playing a key role in supporting the manufacturing industry in the port region.

Seven of the world's top 10 container ports are found in China. Table 5 indicates the major container port throughput from 2011-2019, m TEU.

Table 5

Major container port throughput, m TEU

Region/Port	2011	2012	2013	2014	2015	2016	2017	2018	2019
Busan	16.2	17	17.7	18.7	19.5	19.5	20.5	21.6	21.9
Guangzhou	14.4	14.5	15.3	16.2	17.6	18.6	20.1	21.6	22.8
Hong Kong	24.4	23.1	22.4	22.2	20.1	19.6	20.8	19.6	18.4
Ningbo	14.7	16.2	17.3	19.5	20.6	21.6	24.6	26.4	27.5
Qingdao	13	14.5	15.5	16.6	17.3	18	18.3	19.3	21
Shanghai	31.7	32.5	33.8	35.3	36.5	37.1	40.2	42	43.3
Shenzhen	22.6	22.9	23.3	24	24.2	24.1	25.3	25.7	25.8
Singapore	29.9	31.6	32.6	33.9	30.9	30.9	33.7	36.6	37.2
Tianjin	11.5	12.3	13	14.1	14.1	14.5	15	16	17.3
Tokyo	4.6	4.8	4.9	4.9	4.6	4.7	5	5.1	4.9
Antwerp	8.7	8.6	8.6	9	9.7	10	10.5	11.1	11.9
Bremen/Bremerhaven	5.9	6.1	5.8	5.8	5.5	5.5	5.5	5.5	4.9
Hamburg	9	8.9	9.3	9.7	8.8	8.9	8.8	8.7	9.3
Rotterdam	11.9	11.9	11.6	12.3	12.2	12.4	13.7	14.5	14.8
Los Angeles	7.9	8.1	7.9	8.3	8.2	8.9	9.3	9.5	9.3
New York/New Jersey	5.5	5.5	5.5	5.8	6.4	6.3	6.7	7.2	7.5
Dubai	13	13.3	13.6	15.2	15.6	14.8	15.4	15	14.1

Note: Adapted from "Container Intelligence Quarterly Second Quarter 2020", by Clarkson Research Services Limited, 2020, p.34. Printed on FSC/PEFC certified paper.

Port Operators

In Figure19, Hong Kong almost tops the list. This record is contributed to Hutchison Port Holdings, which also shows that port of Hong Kong has brought the strongest positive externality in terms of operators.

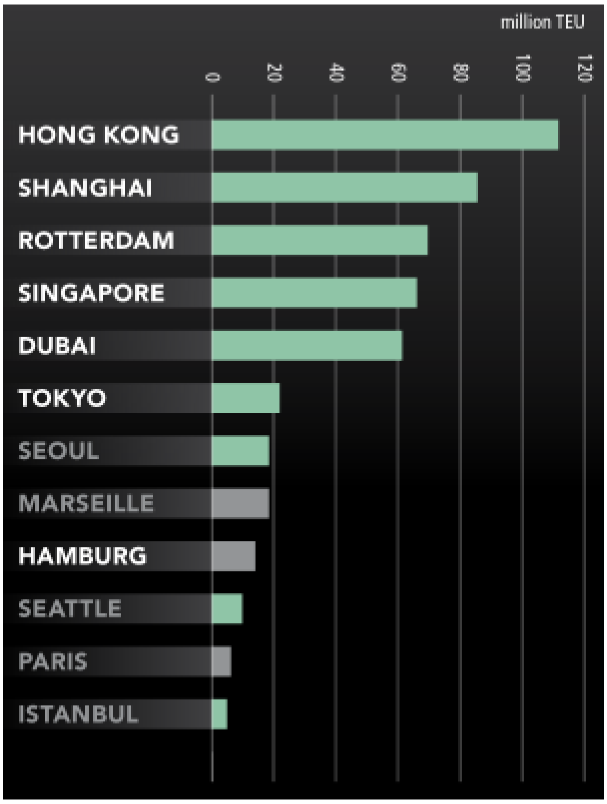

Figure19. The largest port operators in the world by headquarters (million TEU). From "The leading maritime capitals of the world 2019", by A Menon Economics and DNV GL Publication, 2019, p.37. Copyright 2019 by A Menon Economics and DNV GL Publication.

Size of Ship Owners' Fleet and Management of Fleet:

In Figure20, cities are ranked by the total fleet in compensated gross tonnage (CGT) based on owners located there. Athens ranks in the first place, indicating that its positive externality in this aspect is stronger than others.

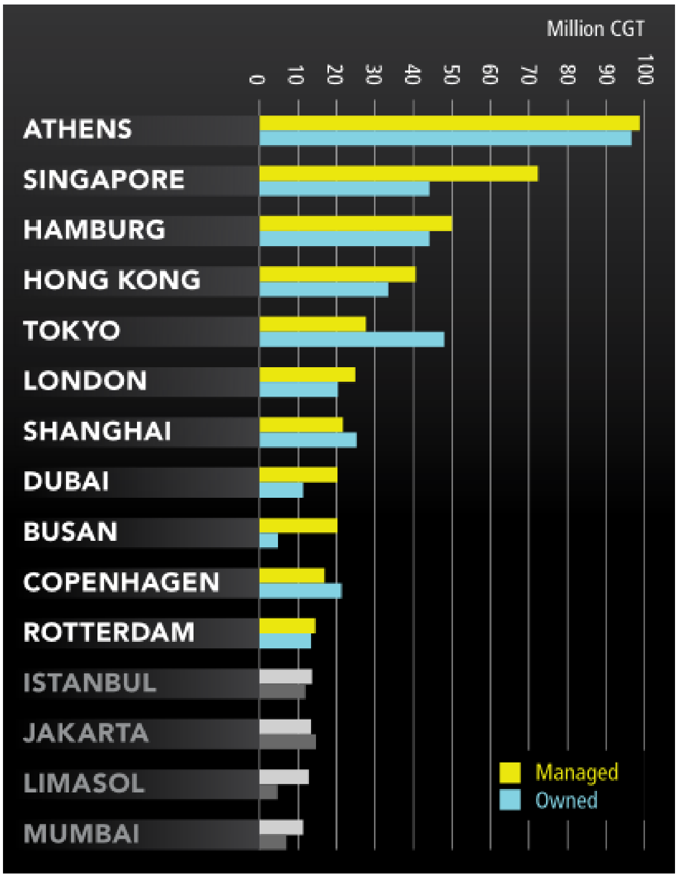

Figure20. CGT owned by ship managers registered in the city / Size of fleet (CGT) controlled by ship owners registered in a city. From "The leading maritime capitals of the world 2019", by A Menon Economics and DNV GL Publication, 2019, p.22. Copyright 2019 by A Menon Economics and DNV GL Publication.

Value of City-controlled Fleet:

Another segment indicator is the value of the fleet controlled by these port cities. This evaluation is based on data from Clarksons.

Europe currently remains as a pivotal center for shipowners, with roughly 40% of the world fleet value controlled by owners based there. Fleet in Tokyo is well-diversified. In Figure21, it can be found that Athens, Tokyo and Hamburg rank the top three, which means the positive externality is more significant.

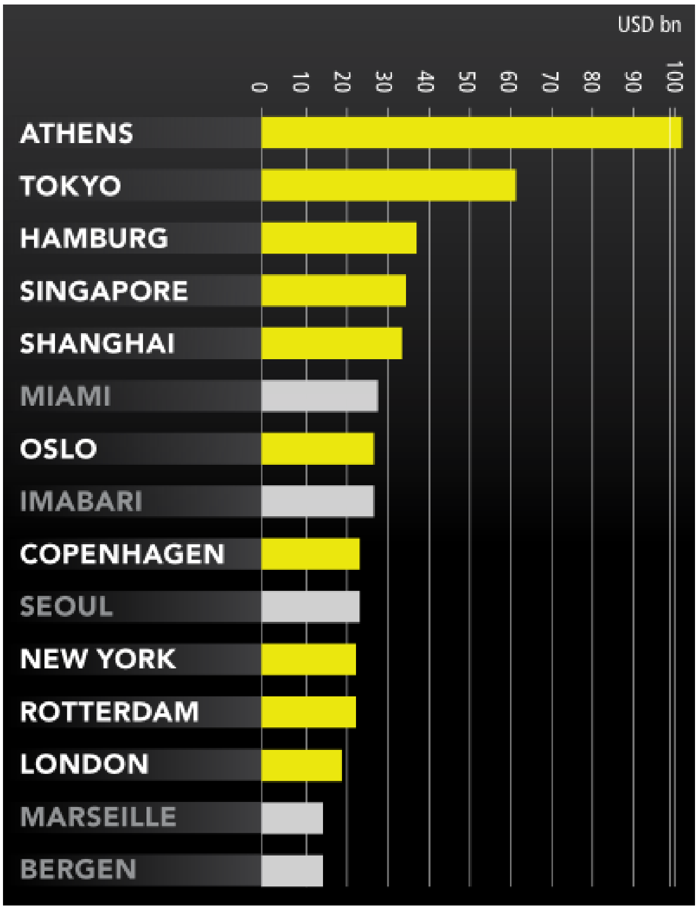

Figure21. The 15 most valuable fleets in the world. Value in Bill USD of the fleet controlled by companies with headquarter in the city. From "The leading maritime capitals of the world 2019", by A Menon Economics and DNV GL Publication, 2019, p.22. Copyright 2019 by A Menon Economics and DNV GL Publication.

3.3 Quantify key indicators

This paper is analyzed based on port positive externality. As many specific foreign port data are not accessible, it took a long time to obtain them. Due to the lack of certain data, so the assumption and approximate value is drawn according to the overall situation, previous data, and some data received from the figures of the report. Finally, the relevant port rank is generated to showcase the positive externality based on these indicators.

Selection and Analysis of Indicators

10 indicators are selected to easier quantify and evaluate the port externality, see appendix 1. These indicators come from the first level, including market value of

listed maritime companies on local stock exchange, number of maritime arbitrators, number of classification society branches, port volume, number of top 100 bulk companies, number of public listed owners, number of broker companies, fleet (CGT) owned by ship managers registered in the city, fleet (CGT) controlled by ship owners registered in a city, and value of city-controlled fleet. Also, these 14 advanced port cities in the world, including Shanghai, Singapore, Tokyo, Busan, Oslo, Houston, Hamburg, Athens, London, New York, Rotterdam, Copenhagen, Dubai, and Hong Kong are analyzed for the PCA. Table 6 below describes the evaluation indicators system for the Principal Component and factors analysis.

The data market value of listed maritime companies on local stock exchange, fleet (CGT) owned by ship managers registered in the city, fleet (CGT) controlled by ship owners registered in a city and value of city-controlled fleet are obtained from Menon. Number of maritime arbitrators, number of classification society branches, number of top 100 bulk companies, number of broker companies are collected from Baltic. Port volume and value of city-controlled fleet are retrieved from Clarksons. Specific of public owner information are gathered from Clarksons and the number of public listed owners of every port city are calculated by the author.

Table 6

Quantitative indicators system

First-level indicator	Second-level indicator	Corresponding Variable
Maritime finance and law	market value of listed maritime companies on local stock exchange	P_{11}
	number of maritime arbitrators	P_{12}
Maritime technology	number of classification society branch	P_{21}
Logistics and trade services	port volume	P_{31}
	number of top 100 bulk companies	P_{32}

	number of public listed owner	P_{33}
	number of broker company	P_{34}
	fleet (CGT) owned by ship managers registered in the city	P_{35}
	fleet (CGT) controlled by ship owners registered in a city	P_{36}
	value of city-controlled fleet	P_{37}

The Process of Principal Component Analysis (PCA)

In this process, statistical software SPSS was applied to a series of operational analysis, such as dimensionality reduction, factor analysis. The results are shown in the following Table 7 correlation matrix, which explains the correlation between those indicators. The closer the number is to 1, the higher the correlation between two indicators is.

Table 7

Correlation Matrix

		market value of listed maritime companies on local stock exchange	Number of maritime arbitrators	Number of classification society branch	Port volume	Number of Top 100 bulk companies	Port City Owner Number	Number of broker company	fleet (CGT) owned by ship managers registered in the city	Size of fleet (CGT) controlled by ship owners registered in a city	Value of city-controlled fleet
Correlation	Market value of listed maritime companies on local stock exchange	1.000	0.065	-0.381	0.019	0.039	-0.211	-0.008	-0.245	0.020	-0.134
	Number of maritime arbitrators	0.065	1.000	0.134	-0.177	0.731	0.014	0.923	-0.046	-0.118	-0.142

Number of classification society branch	-0.381	0.134	1.000	0.473	0.239	-0.184	0.225	0.475	0.127	0.208
Port volume	0.019	-0.177	0.473	1.000	0.282	-0.075	-0.044	0.049	-0.254	-0.184
Number of Top 100 bulk companies	0.039	0.731	0.239	0.282	1.000	0.369	0.885	0.289	0.059	0.006
Port City Owner Number	-0.211	0.014	-0.184	-0.075	0.369	1.000	0.275	0.308	0.398	0.490
Number of broker company	-0.008	0.923	0.225	-0.044	0.885	0.275	1.000	0.187	0.059	0.026
Fleet (CGT) owned by ship managers registered in the city	-0.245	-0.046	0.475	0.049	0.289	0.308	0.187	1.000	0.841	0.754
Size of fleet (CGT) controlled by ship owners registered in a city	0.020	-0.118	0.127	-0.254	0.059	0.398	0.059	0.841	1.000	0.908
Value of city-controlled fleet	-0.134	-0.142	0.208	-0.184	0.006	0.490	0.026	0.754	0.908	1.000

Table 8 exhibits the total variance interpretation. The proportion of first four principals is 86.478%, so first four principals can be extracted to evaluate the positive externality.

Table 8

Total variance interpretation

composition	Initial eigenvalue			Extract the sum of squared loads		
	total	Variance percentage	Grand total %	total	Variance percentage	Grand total %
1	3.259	32.593	32.593	3.259	32.593	32.593
2	2.657	26.567	59.160	2.657	26.567	59.160
3	1.698	16.978	76.137	1.698	16.978	76.137
4	1.034	10.341	86.478	1.034	10.341	86.478
5	.944	9.442	95.921			
6	.246	2.461	98.381			

7	.106	1.060	99.442			
8	.029	.289	99.731			
9	.016	.156	99.887			
10	.011	.113	100.000			

Extraction Method: Principal Component Analysis

Table 9 is a composition matrix.

Table 9

Composition Matrix

Composition Matrix[a]

	Component			
	1	2	3	4
Market value of listed maritime companies on local stock exchange	-.234	.135	-.397	.866
Number of maritime arbitrators	.364	.839	-.228	-.065
Number of classification society branch	.422	.092	.812	-.013
Port volume	-.023	.183	.770	.361
Number of Top 100 bulk companies	.613	.721	.018	.128
Port City Owner Number	.573	-.110	-.336	-.243
Number of broker company	.600	.771	-.158	-.044
Fleet(CGT) owned by ship managers registered in the city	.841	-.361	.212	.120
Size of fleet (CGT) controlled by ship owners registered in a city	.751	-.552	-.202	.229
Value of city-controlled fleet	.747	-.576	-.114	.074

Extraction Method: Principal Component Analysis

a. Four ingredients were extracted.

Since the units of principal component vary, standardizing the data becomes a must. Series of analysis, description statistics, description and degeneralization processing through specific data of each indicator are conducted to obtain the original data after reunification as shown in Table 10.

Table 10

Original data after standardization

	ZMarket value of listed maritime companies on local stock exchange	ZNumber of maritime arbitrator	ZNumber of classification society branch	ZPort volume	ZNumber of Top 100 bulk companies	ZPort City Owner Number	ZNumber of broker company	ZFleet(CGT) owned by ship managers registered in the city	ZSize of fleet (CGT) controlled by ship owners registered in a city	ZValue of city-controlled fleet
Shanghai	0.56392	-0.2359	0.92594	2.28353	0.12975	-0.34306	-0.09373	-0.45346	-0.30016	0.13228
Singapore	-0.18171	0.12504	0.67176	1.79462	2.23689	1.57807	1.03752	1.5813	0.47169	0.21109
Tokyo	-0.22557	-0.39833	-1.1075	-0.79423	-0.16089	2.41857	-0.22948	-0.24999	0.68609	1.23555
Busan	-0.22557	-0.37126	0.41758	0.56832	-0.88749	-1.06348	-0.77249	-0.53485	-1.15778	-0.77398
Oslo	-0.18171	-0.32614	-1.1075	-1.16292	-0.88749	0.37737	-0.22948	-0.33138	0.34305	-0.10414
Houston	-0.62031	-0.39833	-1.36168	-0.44157	-0.23355	0.37737	-0.22948	-0.73833	-0.94338	-0.97099
Hamburg	-0.62031	-0.32614	0.41758	-0.44157	-0.66951	-0.94341	-0.77249	0.68601	0.47169	0.28989
Athens	-0.62031	-0.37126	1.18012	-0.78621	-0.23355	0.49744	0.13252	2.63938	2.74437	2.85106
London	-0.09399	3.41867	0.41758	-0.87438	2.23689	0.01715	3.07379	-0.33138	-0.51457	-0.41936
New York	3.28326	0.03481	-1.36168	-0.58824	-0.16089	-0.70327	-0.22948	-0.53485	0.34305	-0.30115
Rotterdam	-0.62031	-0.37126	0.67176	-0.00074	-0.74217	-0.10292	-0.63674	-0.77903	-0.85761	-0.30115
Copenhagen	0.12532	-0.37126	-1.36168	-0.07288	-0.37887	-0.70327	-0.77249	-0.69763	-0.42881	-0.30115
Dubai	-0.26943	-0.39833	0.92594	0.23169	-0.30621	-0.70327	-0.18423	-0.53485	-0.90049	-0.77398
Hongkong	-0.31329	-0.01031	0.67176	0.28459	0.05709	-0.70327	-0.09373	0.27905	0.04288	-0.77398

The Conclusion of Principal Component Analysis (PCA)

The data in the component matrix are divided by the characteristic value according to the principal component. Then, after being squared, coefficients corresponding to each of the Principal Component can be obtained. Table 18 introduces the data in composition matrix and coefficients of each component.

Table 11

Data in composition matrix and coefficient of each component

Data in composition matrix	Coefficient of component 1	Data in composition matrix	Coefficient of component 2	Data in composition matrix	Coefficient of component 3	Data in composition matrix	Coefficient of component 4
-0.234	-0.12987522	0.135	0.082820527	-0.397	-0.30458551	0.866	0.851643081
0.364	0.201564587	0.839	0.51471424	-0.228	-0.175300388	-0.065	-0.063922402
0.422	0.23384364	0.092	0.056440656	0.812	0.622985613	-0.013	-0.01278448
-0.023	-0.012857853	0.183	0.112267826	0.770	0.590620409	0.361	0.355015188

0.613	0.339491909	0.721	0.442322964	0.018	0.014007744	0.128	0.125877961
0.573	0.317250106	-0.11	-0.067483393	-0.336	-0.257601008	-0.243	-0.238971442
0.600	0.332205973	0.771	0.472997234	-0.158	-0.121091244	-0.044	-0.043270549
0.841	0.465843217	-0.361	-0.221468225	0.212	0.16259522	0.12	0.118010589
0.751	0.416116836	-0.552	-0.338643934	-0.202	-0.155083696	0.229	0.22520354
0.747	0.413901912	-0.576	-0.353367583	-0.114	-0.08776512	0.074	0.072773196

Chapter 4 Results and Discussion

$F1 = -0.1298ZX1 + 0.2015ZX2 + 0.2338ZX3 – 0.0128ZX4 + 0.3394ZX5 + 0.3172ZX6 + 0.3322ZX7 + 0.4658ZX8 + 0.4161ZX9 + 0.4139ZX10$

$F2 = 0.0828ZX1 + 0.5147ZX2 + 0.564ZX3 + 0.1122ZX4 + 0.4423ZX5 - 0.0674ZX6 + 0.4729ZX7 – 0.2214ZX\ 8 + 0.3386ZX9 + 0.3533ZX10$

$F3 = -0.3045ZX1 - 0.1753ZX2 + 0.6229ZX3 + 0.5906ZX4 - 0.0140ZX5 - 0.2576ZX6 - 0.1210ZX7 + 0.1625ZX\ 8 - 0.1550ZX9 + 0.0877ZX10$

$F4 = 0.8516ZX1 - 0.0639ZX2 – 0.0127ZX3 + 0.3550ZX4 + 0.1258ZX5 - 0.2389ZX6 – 0.0432ZX7 + 0.118ZX\ 8 + 0.225ZX9 + 0.0727ZX10$

Comprehensive index:

$F= (32.593/86.478)F1 + (26.567/86.478)F2 + (16.978/86.478)F3 + (10.341/86.478)F4$

The following Table 12 is the result of Principal Component Analysis.

Table 12

Ranking of port positive externality by weighing selected indicators

	F1	F2	F3	F4	F	Rank
London	2.054092876	4.515256599	-1.109513862	-0.655367546	1.865096989	1
Singapore	2.807820963	1.077846575	1.176483514	0.633549856	1.696089178	2
Athens	3.965926069	-2.859693663	0.130725911	0.18423581	0.783087646	3
Shanghai	-0.310940795	0.425449779	1.857888134	1.28507425	0.5319257	4
Hong Kong	-0.215345653	0.264166243	0.983775719	-0.0081404	0.192154891	5
Dubai	-1.1642385	0.372703784	1.185378119	-0.318328587	-0.129642869	6
Hamburg	-0.029227969	-1.257211795	0.585591089	-0.286661183	-0.316557121	7
Rotterdam	-1.177732937	-0.257773953	0.798064262	-0.861663764	-0.469427626	8
Tokyo	1.017107064	-1.331883199	-1.873490759	-0.807816407	-0.490234745	9
Busan	-1.901786269	-0.024550802	1.245175856	-0.176276743	-0.500929813	10
New York	-1.315276244	0.123391414	-2.108906902	2.752475892	-0.542681512	11
Houston	-1.48666812	0.205960057	-0.811563863	-1.122071239	-0.790542729	12
Copenhagen	-1.645021357	-0.34512599	-0.615541775	0.074977831	-0.837893412	13
Oslo	-0.598703443	-0.908533528	-1.444079164	-0.693995096	-0.871245835	14

By extracting only new four principals from original 10 indicators and calculating comprehensive index F, the final rank of port externality degree was obtained based on those specific indicators according to F. First, worth noting, the number of F represents relative value, so it is normal if F is a negative value.

As the Table12 shows, London, Singapore and Athens take the top three spots in the total ranking of evaluation indicators. Shanghai ranks fourth, and Hong Kong, Hamburg and Rotterdam come next. The result shows the positive externality of port. The higher the ranking, the stronger the positive externality. That is, London port has the strongest positive externality according to those specific indicators, followed by Singapore, Athens and Shanghai. It can be found that the comprehensive performance of Shanghai still lags behind compared with that of London, Singapore, Athens. Therefore, suggestions concerning government policy, port management and operation model are put forward to enhance Shanghai port's positive externality.

Moreover, the values of London and Singapore are very close, which are 1.865 and 1.696 respectively. That means the port positive externality of both cities is relatively close. However, the gap between second and the third place (Athens) is very huge. The cause might be the fact that F2 of the second principal component extracted is very low compared with the first few port cities. On the contrary, the value of second principal component London is much higher than others, thus increasing the overall rank among the samples. That indicates all positive externalities performed by London port are not uniform, which is a similar case for Athens.

Although Singapore ranks second, the value of every principal component extracted is positive, and there is no negative index. Singapore's positive externality is relatively uniform, which explains why Singapore is widely accepted as a top international shipping center.

Even though Shanghai ranks only after London, Singapore, Athens, the index of last three Principal Components are high. Hong Kong bears the similar situation with Shanghai. From the sixth place (Dubai), the index of F is negative, but there is no special meaning, because F just represents a relative level. As can be seen, Rotterdam, Tokyo, Busan, New York are at a level, the F fluctuates between -0.6 and -0.4. While Houston, Copenhagen, Oslo are at a level, the F fluctuates between -0.7 and -0.9.

4.1 How does the Port Management System and Policy Affect the Port Under the Port Positive Externality

Port generates a series of positive and negative externalities. Meanwhile, the economic development of a city also influences to the port and has become "boosters" for port functions, scale, and hinterland expansion. Therefore, it is essential to explore how the port management system affects the port. This section mainly introduces and compares the present management systems and provides advice to Shanghai port on specific government management in order to increase the positive externality and the rank.

1. From the perspective of shareholding structure, the major management systems of the port can be divided into private management, government or state-owned enterprise management, joint management of government or state-owned enterprises and private enterprises.

Private management refers to the port shares fully allocated to the private person. The person is responsible for the construction, operation and management of all matters by himself, such as Hong Kong and the Phillipston Port. However, such management system is rare among international large and medium-sized ports. Some countries, such as Japan, Korea, and some ports of China consider ports having fundamental effects and strategic value are not suitable for complete private operation, and adopt direct state administration or indirect management through state-owned enterprises. Now, the most common systems in the world is a mode jointly managed by governments, state-owned enterprises and private enterprises. According to the world port statistics, about 75% of the ports around the globe (2700 main ports) adopt this mode.

2. As for the ownership of management rights, there are centralized management and decentralized management. The former refers to the direct central control and management of ports, and major decisions on port development are largely decided by port authorities subordinate to the central government. Such management can be found in countries with single major port, such as Singapore, Sri Lanka, Kenya, Morocco, Nigeria and some countries in South America. The latter refers to the transfer of management power to local governments, giving full play to the autonomy and initiative of local governments. Decentralized management is classified into two types: one is the Port Authority and/or the Port Council, formed by the local government, such as the United States, Australia (whose port managed by the state government), Antwerp, Rotterdam, Hamburg, Bremen and other well-known European ports (managed by port committee organized by local city government). The other is the establishment of an independent port authority not affiliated to any local governments. The autonomous port is a public trust port model adopted by countries such as Marseille, Le Havre and London, Dover and Teesport. The choice of ownership of a country's port management is related to the country's judgment on the economic status of the port industry. Some countries, such as Japan, Italy, Spain, Greece, take the port as a critical public service industry, they emphasize its public nature, and therefore adopt centralized management methods. Some countries such as the United Kingdom and the United States think the port as an ordinary business entity. As there is nothing special compared with other industries, these countries advocate decentralized management model. In the real economic activities, the two management models have their own advantages and disadvantages.

3. Judging from the establishment and function of administrative agencies, there are three modes: large-scale traffic management, independent management and composite

management. All the three models are categorized according to the port authority's affiliation and infrastructure maintenance responsibility. As there are 2 types of port administration, the port administration agency is split into the port authority responsible for administration and the port group company formed according to the modern enterprise system.

4. As for the management agency's mode of regulation, it mainly includes port planning, shore line use management, handling company management, port rate setting, and port’s usage fee collection.

Port planning is an critical function of the Port Authority. In no matter which management system, the institutions of every national Port Authority have a full-time department responsible for this work, for instance Japan, in order to ensure the overall coordination of port development capacity. The central government is accountable for the formulation of the national port five-year development plan, specific planning standards and technical standards. The U.S. federal government does not interfere with port planning, but the Port Authority do. Yet, important projects should be approved by the local government. Shore line use management refers to the government in charge of the development and maintenance of shore lines. As port shore line is a valuable land resource, most western ports of shore line are maintained by the Port Authority, which acts according to market demand for berth construction and other facilities. Most of the world's ports are outsourced to other companies, and operating companies are determined by the Port Authority or the Port Board through tenders. Ports Authorities have the right to set port rates, which are based on two principles: one treats ports as an industry. In addition to the recovery of construction investment, a certain profit should be yielded, such as in the United Kingdom and the United States. The other treats ports as an infrastructure. With rates set to recover investments, port usage fees are generally collected by the Port Authority.

At present, public service supplied by the management department cannot keep up with economic and social development. In the face of insufficient public service supply, uneven public distribution, and asymmetric information of public service Public service system needs to be improved. The government KPI system of Shanghai port management department is unscientific.

First, higher tax burden affects shipping talents and enterprises gathering in Shanghai. According to Paid Taxes (2018), published by the World Bank, Singapore, Hong Kong and London have a total tax burdens including profits tax and labor tax of 20.3%, 22.9% and 30.7% respectively, while Shanghai has a total tax burden of 67.1%. Although Yangshan bonded port area has implemented a series of preferential tax policies related to shipping enterprises, compared with international prestigious shipping centers, the degree of tax concessions is still relatively limited. Second, the enormous cost of shipping finance. Singapore and other leading overseas port cities have almost no foreign exchange control. Foreign exchange there is relatively free, and many financing institutions enjoy higher internationalization with low financing costs.

The government should be devoted in shaping policies in this area. If the government can reduce the tax burden on shipping enterprises, introducing certain preferential policies on foreign exchange control, the regulatory environment will become more convenient. In order to simplify the entry and exit procedures of shipping enterprises and that of goods import and export, strengthen the integrity, coordination and operation of China's shipping legal system, the local government should introduce policies to encourage the development of talents and increase the attraction of international outstanding shipping talents.

4.2 What Kind of Operation Model Should the Port Operate After the Management System

Under different management systems, what kind of operation mode should the port adopt is a fundamental issue. Although there is a classification statement, landlord port model, tool port model and service port model, our first concern should go to an operation model based on the supply chain management.

Segmented Operation Model of Port

The organization and implementation of segmented operation model:

(1) Identify the two entities and clarify their separate responsibilities. Each business segment (market center) takes total responsibility for the market development and maintenance of the category as the sole market development subject for a single category in the entire group. The main functions of each business segment (market center) are that it is accountable for the organization and management of the supply of the corresponding goods in the entire group, the collection and arrangement of the supply of goods, and the analysis of the supply market. It should also record the annual task index of this cargo and be in charge of the allocation of supplies to related terminal companies (cost centers) in stages and in a planned way throughout the year. Other tasks, including visiting and keeping customers, developing the market vigorously to achieve the goal of indicators, ensuring the security management and control of related terminal companies (cost centers). The main functions of the relevant terminal company (cost center) are as follow: it is held responsible for the daily production organization and management of the unit and the collection of supply information. Also, it should cooperate with the market center to complete the annual task indicators, ensure safe production, improve operational efficiency, and enhance service quality.

(2) Unified business price management. Each business segment (market center) must strictly implement relevant national policies and regulations. At the same time, based on the production cost and the income and profit assessment standards, it should conduct a systematic analysis and calculation of the source market according to the principle of "mutual protection of volume and price, progressive discount", offer preferential treatment to relevant customers, and sign price agreements and implement them after relevant decision-making procedures.

(3) Each business sector (market center) puts forward the overall indicators for the next year and draws up an indicator allocation plan. Major work is as follows: Under the premise of ensuring the maximization of revenue and the optimization of services, each business segment (market center) communicates and coordinates with relevant terminal companies (cost centers) based on factors such as operating costs, processes, routes, terminal resources, and customer service. And then, it should prepare the total supply plan for the next year and submit to the competent department of the group for approval.

Outsourcing Operation Model of Port

Outsourcing operation model was formed mainly to alleviate the fierce competition among ports. It should be noted that although the outsourcing port supply chain model has many advantages, the connection between suppliers in various transportation processes exerts a decisive effect on the overall situation of material transportation. Thus, in order to complete it better and efficiently, seamless connection between relevant companies throughout the supply chain is necessary.

The cooperation model for shipping companies:

For port operations, cooperation with shipping companies can bond investment risks with the interests of shipping companies. Via cooperation, companies not only share the pressure caused by a considerable one-time investment, but also maintain the utilization rate of the terminal and the punctuality of ships on berth, safety and efficiency. The liner company can also effectively control the berthing time at the terminal to ensure the schedule and schedule rate and achieve a win-win situation for both parties. However, after some foreign shipping group companies invest in terminals, the terminals they invest will give priority to providing services to their ships. The quality of their terminal services to other local regional shipping companies cannot be guaranteed.

The cooperation model for professional terminal operators:

For port operations, the cooperation with professional terminal operators can reduce the financial pressure on investment and construction. In terms of operation management, these global terminal operators own mature experience, technology and excellent professional management teams. They can also better the standardization, marketization and internationalization of terminal enterprise management. Besides, terminal operators can effectively support terminal companies' cargo supply and route development with stable resources of customer relationship. However, since professional terminal operators mainly aim at obtaining controlling shares and high returns, they tend to slightly overlook the strategic positioning and regional impact of the terminal.

Strategic alliance model for shipping companies and shippers:

Strategic alliance model for shipping companies and shippers can further consolidate the cargo base and route support for port companies and promote the sustainable port development. Meanwhile, the model can help boost a comprehensive development of information management, obtain a perfect information connection of three parts (ship, port and cargo), enhance the quality and efficiency of port operations, and achieve a multi-win situation.

Integrated Operation Model of Port

The integrated model of alliance port supply chain is formed by the dynamic combination of the internalized port supply chain model and the outsourced port supply chain model. It has become a direction of the development for modern port models.

In the integrated port logistics service supply chain system, it is more important to achieve the extended function of port logistics regarding the vertically integrated supply chain method, It mainly reflects in the following two aspects: First, the staff should comprehensively expand the port's logistics park based on the integration of the port area. That is, the staff should strengthen the construction level of free ports and dry ports, realize the development of the import and export processing zone and bonded logistics zone in stages to further fulfill the construction of the free trade port area. By building a port logistics system in the hinterland, the port's shipping functions, trade functions, and corresponding tax reporting functions can be effectively extended to other inland areas. Second, the staff should encourage the links and cooperation between the port and shipping companies and logistics companies to further strengthen the development of the supply chain.

The port logistics service supply chain is horizontally integrated largely through the main body of logistics transactions with global or representative regional shipping centers, and with regional ports as a link of transmission. Professional and hierarchical positioning of logistics services should be achieved to further build the "port alliances" and "combined ports". The supply chain of horizontally integrated port logistics service can make reasonable use of the terminal's shoreline resources through the connection and cooperation of airlines and flights. At the same time, it can carry out a hierarchical development strategy to ensure a rational allocation of port resources.

By constructing an integrated network system for the supply chain of port logistics service, the overall benefits of the network will become apparent. The competitiveness of the port service supply chain network is closely related to the development of the hinterland economy. Take Rizhao Port as an example. Based on customer needs, the port has fully integrated upstream and downstream resources of the port logistics chain. Starting from the two levels of production, the system can handle service support, build and improve an integrated service system with an industrial chain centered on the port, provide customers with agents, purchasing, sales, supply chain finance and other businesses, and strive to build a transaction service system with complete functions, services, and sound management. Also, it can customize a complete set of logistics transportation system from the origin of the goods to the production line of the enterprise and the finished product collection port. The "door to door" of trade cargo transportation is realized to effectively fulfill the "integrated" service requirements of the entire industry chain such as modern logistics. Therefore, the implementation of "port-city integration" is significant and conducive to the development of the port economy and the urban economy.

Intelligence Operation Model of Port

The intelligent application of the port or dock system is achieved mainly through computer technology, communication technology, mechanical automation and other high technologies. Based on the terminal operation of big data management and control, a terminal operation efficiency index system is constructed, the terminal operation efficiency and external service situation are objectively evaluated, and the bottlenecks of terminal operation efficiency and improvement methods are analyzed. Also, terminal resource planning & decisions support system is built based on the cost and efficiency of big data. By doing so, the intelligentization and automation of key resource allocation of dock berths, quay bridges, storage yards can be realized, and the unification and coordination of terminal operation efficiency, cost and resources can be achieved.

Main performance of intelligence operation model of port:

The realization of port logistics services and intelligent system management is the basis for an intelligent port and the systemization of logistics and related information. The major manifestations are as follow: First, to improve the electronic, network, digital information, and automation aspects of the port intelligent service systemization. In order to relieve the burden of needs for labors, reducing the economic cost of the port terminal during its operation and improving economic efficiency should be prioritized. Second, a better contact and development with related enterprises in various fields should be achieved by keeping in touch with related companies such as vessels, railways, highways, stations, warehouses and other companies to foster the transportation, storage and management of cargo. Besides, the flows of information between businesses should be ensured by recording their information, and completing the sharing and collection of platform information. Third, the level of management and decision-making among ports should be improved. For example, in some control and management processes, accurate and good judgments on the use of relevant information digitization and the use of human and material resources should be done to improve the organization and production of ports in their work, and make port-related service business more effectively. Fourth, departments should be united by achieving the unification of information of logistics transportation among ports and its related traffic management, customs inspection and other management departments. By doing so, it can make the cargo flow smoother and more effective, increase the transportation efficiency, and facilitate the improvement of port logistics services. Fifth, a logistics information service platform among ports should be created. The platform can improve the digitalization and information technology among ports and the record of related data, ensure the cargo transactions among ports, effectively reinforce the security of transportation and reduce risks.

The benefits of the construction of an intelligence operation model: The model can improve port services. The volume of information generated and exchanged by the shipping industry is tremendous, especially in the case of multimodal transport or special cargo transportation (such as the transportation of dangerous goods). Due to the large number of transport participants and regulatory authorities, the exchange of transport information becomes even more complicated. Therefore, the establishment of an efficient and comprehensive information service platform and the application of an unified information exchange standard system will support various types of logistics and transportation companies in Shanghai Port to carry out efficient information exchange based on the Internet. More, it helps improve the collaborative operation efficiency of upstream and downstream enterprises in the logistics industry, and encourage an effective management and integration of logistics supply chain. Also, this model can help build efficient ports. As there are various evaluation indicators of terminal handling cost, in terms of the relevance and comparability of equipment operation management, single-case cost (i.e., total cost of single box or unit container throughput) serves as one of the key performance indicators. For different terminals, the single-box cost is a key index to evaluate and compare its cost management, which, together with the volume and rate of the box, constitutes the determining factor for the profit of the terminal. In addition, single-box cost is also a crucial indicator for the terminal to develop and implement market competition strategy. In short, the formulation of cost control plans for most port and dock enterprises in China and the world lacks rationality, and their resource planning is mainly based on manual compilation, which makes it difficult to maximize the efficiency of dock machinery operations. Based on terminal operation big data, the intelligence operation model conducts cost control and efficiency analysis, and it can provide decision support for terminal operations. Under the intelligence operation mode of the port, Shanghai Port is expected to break through the status quo, where domestic ports largely take throughput as the performance measurement index and overlook the cost control.

The model can lighten the urban traffic pressure as well. Most of the large container hub ports are located in central coastal cities, and these cities usually face heavy traffic pressure. Urban traffic congestion not only causes painful inconvenience to citizens, but also affects urban economic development adversely. By improving the service level of container river-sea transportation, promoting the joint construction of ports and cities, and strengthening the information sharing between ports and transportation management departments, the contradiction between port economic development and urban traffic congestion can be alleviated in some degree. Advantages of different operation model as Table13 shows.

Table 13

Advantages of different operation model

Operation mode	Advantages

Segmented Port Operation Model	Unified pace and consistent goals; reducing cost and increasing efficiency; improving market efficiency and reducing market cost; highlighting functions of the supply chain platform; carrying out supply chain services; realizing the "logistics, finance and trade" model and new profit points; enhancing customer stickiness; promoting the transformation of port groups
Outsourcing Port Operation Model	By outsourcing the entire activity of material distribution to specialized companies, the model alleviates competition among ports, while satisfying different needs of customers, saving the internal resources of port logistics enterprises, improving the efficiency and professionalism of the entire supply chain; thereby, it promotes the development of port logistics.
Integrated Port Operation model	The model possesses the capability of high information technology and an efficient information management platform. It helps the reorganization of enterprise and their internal structures. While achieving better cooperation among port enterprises, it can effectively restructure the internal organization of the enterprise and foster the overall professional level and innovation ability of port logistics, which can realize the effective use of capital resources.
Intelligence Port Operation Model	The model can first reduce the cost of work and achieve the purpose of saving resources. Also, it encourages the port terminal enterprise to implement better management strategies, optimizing the port terminal's working process, and dispatch engineering information conveniently at any time.

4.3 Discussion

The final rank of port positive externality based on the specific indicators seems to be a bit different from a traditional port rank. Unexpectedly, Athens ranks the top, and Shanghai ranks fourth. That result arises from the fact that not all indicators could be quantified, which is also the disadvantage of this dissertation. In respect of the design of indicators, those indicators are regarded to be able to reflect different aspects of port positive externality. Yet, the number of indicators is not sufficient enough. As the data accessible are very limited, assumptions are made based on the present data and previous data. For future’s research, the output will be better and more convincing if more indicators can be quantified. Even so, in this dissertation, certain ideas about how to evaluate the port positive externality are provided, and advice is offered for the government in terms of management system and operation model so as to increase the port positive externality of Shanghai.

Let’s take a closer look at why Shanghai ranks fourth in the final classification by observing the original data. The following result is just what the port positive externality reflects. If the problems are solved, it can thus increase the port positive externality.

Shanghai's shipping service function is basically sound, and its shipping service level has been improved; however, problems such as strong homogeneity, insufficient service depth and professionalism, low degree of internationalization still exist. In the provision of shipping service products, an obvious gap with London, Singapore, Hong Kong and other international port cities still remains as to the service level. While the function of the headquarter economy has not yet been played, some of the introduced decision-making and capital operation is still carried out abroad.

Although the "Xinhua News Agency Baltic Index" and "Menon" report have given a high evaluation of Shanghai port’s conditions, in the sub-index, the logistics service level of Shanghai port remains low. Besides, the two evaluation indicators of the two reports did not inspect the use of resources at the hub port and the construction of a collection and distribution system.

At present, the main problem of the construction of Shanghai port is limited available land, coastal lines, air space and other resources. For example, container berth utilization rate is low, ports, anchorages are in the state of overload operation, available port shore line and port-to-port land resources are seriously scarce. Especially, the shortage of deep-water shore line resources, limited hub port function, delayed development of international transit and consolidation services. Also, there is much room left for improvement in the efficiency of port terminal services. Given the poor collection and distribution method, the system integration capacity needs to be strengthened. In order to create a sustainable development climate for the city of Shanghai, container throughput should not be the sole focus.

Shanghai shipping service personnel remains insufficient with low overall quality. The port has unreasonable structure and other problems, particularly the shortage of high-level talent familiar with the port, shipping and supply chain, maritime law, shipping financial leasing, and free trade zone rules. The rapid expansion of port function has led to a huge talent gap in a short period of time, a lack of training and gathering mechanism for high-end shipping talents, and insufficient attraction to high-end shipping talents at home and abroad.

Shanghai policy makers should consider to take a less prominent role and prepare a further opening up policy. According to the status quo, the whole market is not open enough, which does little good to the development of modern shipping service industry. More, the development system of high-end shipping service industry, such as finance and insurance, is not flexible enough, which reduces the efficiency of high-end shipping service and restricts its development. Given an inadequate shipping and port policies, market demand, tax support, financial supervision, talent introduction, market opening and other supporting policies, the current condition has restricted Shanghai's comprehensive competitiveness, and the existing policies are required further complement. In addition, the level of tax burden of Shanghai shipping enterprises lags behind the world, for the efficiency and costs of customs clearance cannot adapt to the actual needs of the development of the international shipping industry. Compared with Singapore and Hong Kong, for the sake of encouraging transit preferential policies, Shanghai's policy lacks innovation. The port fees is still high, and transit efficiency and services still need to be improved.

Although the reform of Shanghai's financial system is gradually advancing, problems remain intact. For example, uncontrollable short-term large-scale capital risk after the opening of the capital account, the incomplete marketization of exchange rates and interest rates, the lack of experience in capital market supervision, and the absence of awareness and ability of financial institutions to provide services to the shipping services industry. In addition, Shanghai's capacity in the field of information services, such as international shipping rules and standard-setting, is undersupplied.

Therefore, in the face of the present problems, it is essential to take measures to increase the positive externality of Shanghai port and upgrade the rank of Shanghai.

The government should establish a comprehensive supervision system to strengthen process and afterwards management: the focus of the comprehensive supervision system includes innovating the way of government management, encouraging the government to implement the first-question responsibility system, changing the government management from prior approval to the process and afterwards supervision, raising the degree of supervision and participation, and boosting the formation of administrative supervision, industry self-discipline, social supervision, and public participation of the comprehensive regulatory system. In the process of comprehensive supervision, the government should further integrate administrative resources, establish information sharing and comprehensive law enforcement mechanism between different departments, and realize the integration and systematization of industry management.

Shanghai Port mainly operates joint ventures with terminal operators in certain port areas. At present, Shanghai's port unit information sharing and joint inspection are confronted with insufficient efforts. Port trade, logistics transparency and pass efficiency cry out for reform, and port logistics compliance costs are growing higher. Due to changes in trade demand and mode, the freight shipment shows the trend of being small, single, and rapid, and puts forward the requirements for a more convenient, safe and efficient export and the optimization of the supervision procedure of transit goods. Such changes require continued upgrade of Shanghai port shore business, so that customs clearance and logistics operations can achieve "parallel." On the basis of paperless and integrated construction port logistics operations, it is necessary to further overlay information such as logistics, government supervision and commercial trade to shape a big data platform that collects all data information.

Chapter 5 Conclusion

Although the indicators may resemble those in the international shipping center report, seeming to be used only for evaluating the international shipping center, the very subject in this paper is the port positive externality. This concept originates from economy. As port externality is showed on external things, the performance of international shipping center just demonstrates the positive externality. Thus, the indicators may appear similar. However, those evaluation indicators are completely different from evaluation indicators of port itself or from an international shipping center.

Port externality is reflected in many aspects, including maritime finance and law, maritime technology, logistics and trade services. After calculation, the conclusion suggests that London port has the strongest positive externality, followed by Singapore, Athens, Shanghai, which means these ports bring more benefits to the port area than others. It is essential to optimize the management system and operation model and refine the government policy to elevate the rank of Shanghai.

Still, there are limitations in the dissertation. The number of quantifiable indicators is contained due to the absence of data. For the future research, the result will be better and more convincing, if more indicators can be quantified. Besides, more attention should be paid on negative externalities for the sake of further optimizing and improving port positive externalities. What's more, certain research and innovation can be introduced in terms of management system and operation model of port in order to enhance the positive externality.

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Appendix 1

The original data of indicators

	Market value of listed maritime companies on local stock exchange	Number of maritime arbitrator	Number of classification society branch	Port volume (mTEU)	Number of Top 100 bulk companies	Port City Owner Number	Number of broker company	Size of fleet (CGT owned by ship managers registered in the city	Size of fleet (CGT) controlled by ship owners registered in a city	Value of city-controlle fleet
Shanghai	32	20	11	43.3	16	8	20	22	25	33
Singapore	15	60	10	37.2	45	24	45	72	43	35
Tokyo	14	2	3	4.9	12	31	17	27	48	61
Busan	14	5	9	21.9	2	2	5	20	5	10
Oslo	15	10	3	0.3	2	14	17	25	40	27
Houston	5	2	2	9.3	11	14	17	15	10	5
Hamburg	5	10	9	9.3	5	3	5	50	43	37
Athens	5	5	12	5	11	15	25	98	96	102
London	17	425	9	3.9	45	11	90	25	20	19
New York	94	50	2	7.47	12	5	17	20	40	22
Rotterdam	0	5	10	14.8	4	10	8	14	12	22
Copenhagen	22	5	2	13.9	9	5	5	16	22	22
Dubai	13	2	11	17.7	10	5	18	20	11	10
Hongkong	12	45	10	18.36	15	5	20	40	33	10