Quantitative analysis of the relationship between Port and city in China

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Abstract. By introducing the concept of Relative Concentration Index (RCI), this paper quantifies the relationship between port function and city function, and determines the degree of interdependence between port and city. By analyzing the status and evolution of the relationship between 26 major port cities in China since 1990, this paper summarizes the general rules for the development of the relationship between port function and city function in China, which is unbalanced. The evolution of relationship between port and city is a gradual process, different port cities have different evolution cycles, port cities with different development scales have their own balance. Finally, this paper puts forward how to realize the new development stage of “Port flourishing with city”.

1. Typical stage model of port city

The general path for Port Development is Setting – Expansion – Specialization – Regionalization (as shown in Figure 1). With the development of port and city, the types of port cities can be grouped into 9 categories according to large, medium-sized, small ports and cities (as shown in Figure 2). In the world, the relationship between port and hinterland is different. World class port cities such as New York, Hong Kong, Tokyo and Singapore have large cities and large ports. The port city has developed the city function, but the function of the port is small, such as Cape Town and Buenos Aires. When port functions continue to decline and urban functions are equally developed, they can be called coastal cities, such as Stockholm, Baltimore and Tunisia. On the contrary, in some examples, the port size is far greater than the city, and can become the main port city, such as Rotterdam, Le Havre and Genoa, the main port towns, such as the free port, Gioia Tauro and Lamchabang port. The general development path of the port city is Small coastal port - Regional port city – World class port city, and other possible path, such as the big city small port and the small city big port.
Figure 1. The development path of the port

Port developing with city: Port as a natural trade hub, the formation and prosperity of which led to...
the formation and development of the city. At this stage, the relationship between port and city shows that the city is built because of the port, and the port is the basis for the establishment of the city. With the development of transportation, storage, processing and other business, it has led to the gathering of industry, population and trade activities around the port, and the port city has gradually formed and developed.

Port prospering with city: With the development of the hinterland economy and trade, the improvement of the collection and distribution system, the port scale is expanding day by day. Port as the window of international trade, convenient traffic conditions and regional advantages, attract heavy industry and processing industry gathering, port industry has gradually developed. At this stage, the port city participates in the regional and international division, the city status and influence has been continuously promoted, the port and the city are more closely linked, and the industrial port city is formed. At the same time, the port has strengthened the demand and dependence of the urban land space and the industrial layout.

Port flourishing with city: With the development of the hinterland industry and the support of the collection and distribution network, the port space is becoming larger and larger, the service extends to inland hinterland, the logistics Park gradually built in the port, the port functions tend to be diversified, the influence of internationalization is increasing, the international influence of port cities' economy, trade, finance and shipping has been enhanced. Large port cities have gradually become regional international shipping centers. At this stage, due to the port demand for more land resources, with the expansion of the port business, the contradictions of collection and distribution, transportation and environmental impact and gradually emerged. The relationship between port and city is more focused on the development of mutual coordination and balance. According to the needs of urban development, the port will expand new functional areas and transform coastal waterfront lines into urban functional areas. The port and the city have development space, to achieve prosperity.

2. Quantification of the relationship between port and city based on RCI index

2.1 RCI index
RCI (relative concentration index) is an index to measure the relative importance of port to city. Vallege uses the RCI index to reveal how the port area and human settlement in the Mediterranean are organized, the average population division with average throughput in the whole region, the values obtained are very high in the areas with trade and low in densely populated areas. The area ratio of the port function and city function is close to 1. Traditionally, RCI proposed by Vallege was used to assess this dynamic relationship in 1979. RCI proposed by Vallege is a concept that reflects the relationship between port economic scale and port city economic activities. The ratio of the throughput of a port in the area to the ratio of the urban population to the total population of the port is taken as the basis for evaluation.

First, the throughput of port i in the area is calculated as follows: \( \sum X_i \) (1), the \( X_i \) is the throughput of port I, \( \Sigma X \) is the sum of the throughput of all ports in the region. The port city's population proportion of the total population of the city area, the following formula: \( \sum Y_i \) (2), the \( Y_i \) is the population of port city I, \( \Sigma Y \) is the sum of the population of all port cities in the region. The relative concentration index for type (1) and (2) the ratio is as follows:

\[
\frac{\sum X_i}{\sum Y_i} \Rightarrow RCI = \frac{\sum X_i}{\sum Y_i} \frac{\sum Y}{\sum Y} \tag{3}
\]

If RCI>1, it indicates that the port city that has been evaluated has the position of pivotal; If RCI<1, this port city is more similar to the general inland city, but has no obvious characteristics of the port city; When RCI is close to 1, the development level of port and port city is the same.

2.2 Quantitative analysis of the relationship between port and city in China
Based on RCI, we make an empirical analysis of China's port cities. In order to facilitate data collection and analysis, this paper selects data consistency of the 26 major coastal port cities as the
research object. Time series data from 1990 to 2017, every 5 years to choose a time point, in this way, the relationship between port functions and urban functions of 26 port cities is analyzed. Because of the limitation of space, no statistical data are enumerated here.

By calculating the RCI of 26 port cities, according to the quantitative results, we can see that 6 of the port cities (RCI between 0.75 to 1.25), Shanghai, Tianjin, Yantai, Lianyungang, Zhanjiang and Haikou, are in a state of port and city function balance, the ideal state of interaction has been reached between the port and the city. There are different degrees of imbalance between the other 10 port functions and urban functions: (1) There are 2 port cities whose port function and urban function belong to the serious imbalanced type. The relative importance of port function and city function in these ports is more than 2.5 times. The level of port development in Ningbo and Zhoushan is far ahead of the city, and the city cannot provide sufficient support for the further development of the port, thereby limiting the development of the port to a certain extent. Yingkou port has no strong driving effect on the city and don’t give full play to the advantages of the port. (2) The port function and urban function is slightly unbalanced inc: The port functions of these 3 port cities Jinzhou, Fuzhou, Zhongshan are slightly more important than their urban functions; The 7 port cities such as Weihai and Wenzhou have slightly stronger urban functions than their port functions. From the above analysis, we can see that most port cities in China are in an unbalanced state between port function and urban function, once this imbalance increases, it will probably lead to the stagnation or even decline of some port cities. Therefore, the local government should formulate corresponding policies, timely adjust the relationship between port function and city function, the port city into a healthy development track to interact.

Figure 3. RCI of the 26 ports

Analyzing the evolution of ports since 1990, we can get the characteristics of the evolution of functional relationship in port and city.

(1) RCI of port city presents a rising trend: Such as Dandong, Yingkou, Tianjin, Xiamen and Zhuhai belong to this type. This is because as a result of economic globalization, the function of the port has been paid more and more attention. A lot of port city has to enhance the port function as a target, Port plays a very important role in the development of cities, and cities depend heavily on ports.
(2) RCI of port city presents a downward trend: It shows that the urban strategies of these port cities have always been a priority. As the city enters the stage of diversified economic development, urban development depends largely on the self growth effect. Although the port has a considerable scale, it has no obvious effect on urban development, 4 port cities such as Shenzhen have similar development trends.

(3) Functional relationship of port and city remains stable and constant: Dalian, Qingdao, Shanghai, Guangzhou, RCI of which change is very small. Port and city develop synchronously, are all in a faster stage of increasing returns to scale. Ports and cities show a positive interactive development trend.
The RCI of port cities such as Jinzhou, Weihai, Beihai and Wenzhou has been less than 0.75 since 1990, has been in an unbalanced state with weaker port functions than urban functions. The concrete manifestation is the disjunction of the development of the port and the development of the city. The port is not the main growth point of the city's economy, has a lower pull on the city's economy. Port and city did not achieve effective interactive development.

3. The new development stage of “Port flourishing with city”
With the continuous development of economy and society and the improvement of people's living standard, port and city of our country has experienced the early “Port developing with city”, the mid “Port prospering with city”, and “Port flourishing with city” today. Request port realizing transformation and upgrading, integrating deeply with the city, and the throughput of high-speed growth, to improve the resource efficiency, environmental friendly and economic benefits of high quality transition.

(1) Development and plan of resources comprehensively. One is the natural resources. Making proper planning, with the city function upgrading, promoting the port shoreline, land and water resource intensive development, overall planning the development of new port functions and relocation of old port, and promoting the coordinated development of port and city. Encouraging enterprise technological innovation and management innovation, popularization and application of new technologies for energy-efficient, water-saving, materials-saving at ports, comprehensive utilization of solid wastes such as dredged soil and sludge to promote recycling of resources and improve utilization efficiency of port resources. Two is the data resources. More than 90% of China's foreign trade goods are transported through port, which is the gathering place of massive data. Shipping data resources and financial services, and the industrial cluster to realize ecological integration, enhance the port service. Three is leisure tourism resources. Unified planning and layout of port and city life, the shoreline of ecological environment protection and waters, To build beautiful ports and beautiful cities.

(2) Pilot demonstration and improvement of laws and regulations. The port industry involves many stakeholders cross depth fusion, and difficulties in the reform of laws and regulations, standards, system and mechanism etc. Ports and modern Internet, big data, cloud computing, urban functions and other new formats are more prominent. So, it is difficult to through the systematic plan and measures in the short term. The most feasible path is to select key issues and links in key areas and through pilot demonstration to make a breakthrough, raise the success to regulations, standards, etc, in order to form the base of law suited to national conditions.

(3) Safety and green development. Forming a perfect regulation system of dangerous chemicals transportation, establishing standard system for safety production and emission standard system with mandatory national standards as the main body, fully implementing the supervisory responsibility of the government and enterprise's main body responsibility. Orderly promoting of the port emission.
control area, increasing the use ratio of clean energy and renewable energy in port. Establishing and perfecting the emergency system of accident. Actively promoting the ecological protection and restoration projects of the port.

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