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The co-evolution of seaports and dry ports in Shandong province in China under the Belt and Road Initiative

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Abstract

Nowadays, Belt and Road Initiative (BRI) has been prosperous for a long time and brings plenty of opportunities to every aspect of China. As a coastal province with lots of port resources, Shandong province has implemented port integration, and there are some operation problems arising, too. In order to make the seaports and dry port reach their full potential, it is very crucial to explore the evolution trend of the ports, which can offer more chances for future development. Based on related theory, this article analyses the evolution of seaports and dry ports in Shandong Province, combined with the background of BRI. After showing the trend of port evolution, this paper points out the co-evolution mechanism of seaports and dry ports and describe a dry port-seaport logistics network in Shandong Province, which results from the mutual influence of seaports and dry ports. Finally, considering the influence of the BRI, this article points out that Shandong Province should take the inland cities as the basis and consider the various costs of the ports to fully take part in the Belt and Road Initiative, when constructing a logistics network.

Keywords: Belt and Road Initiative, Dry port-seaport, Network evolution

Introduction

In order to build a moderately prosperous society, China has actively promoted common development and prosperity with all countries in the world. It has been eight years since the joint construction of the Belt and Road Initiative (BRI), which has become the widest and largest international cooperation platform, and fruitful results have been achieved from concept to action. The BRI has provided unlimited vitality for the seaports and dry ports. The increasing frequency of international cargo transportation not only has a good impact on the trade but also brings certain promotion to the port itself. Ports in the Belt and Road region maintained steady growth. The container throughput of ports along the route reached 259 million TEU in 2014, which is the second year after the BRI was proposed; the throughput of Southeast Asia, the Middle East and North Africa, and the European was 93.798 million TEU, 60.963 million TEU and 83.118 million TEU, which increased 5.1%, 4.6% and 4.8% respectively. In 2015, the world's most promising container seaports rank shows that there were 14 seaports in the Belt and Road region,

including Shanghai Port in China, Ho Chi Minh Port in Vietnam, Durban Port in South Africa, Algeciras Port in Spain, etc. It can be seen that the BRI provides many opportunities for the development of seaports.

Shandong Province is one of the largest coastal provinces in China, of which imports and exports to countries along the Belt and Road reached 660.82 billion yuan in 2020. Despite the impact of the epidemic, it still increased by 9.1% than in 2019. As an important logistics economy pillar in Shandong Province, seaports are giving full play to its prominent role. Some basic geography information and seven major seaports of Shandong province are shown in Fig. 1. In 2020, there are more than 1,200 for “Qilu” Eurasian train, ranking fourth in the country. A sea-rail combined transport network has been built to reach 42 cities in 14 countries along the Belt and Road route. In 2019, Shandong Port Group has been set up, with nearly 300 sea routes, ranking first in the northern of China, not only in number but also in density.

However, with the improvement of port integration, its existing problems have gradually emerged. Some integrations are simply superimpositions of port construction scale and throughput. Each port is still in charge of their own things at the level of port operation and management. Thus, it is difficult to achieve optimal allocation and coordinated development of port resources in the Shandong Province. In addition, the sea-rail combined transport in Shandong province has developed rapidly in recent years, but the interface capabilities of the multimodal transport at the conversion node are not matched, resulting in the incomplete release of the effect of logistics resource integration. From the previous analysis, the BRI brings great opportunities for China-world trade. Moreover, inland logistics network system based on dry port has been formed in China under the Belt and Road Initiative. Therefore, the co-evolution of seaports and dry ports can bring fresh changes to improve the status of ports, especially with the characteristic of Shandong Province and the BRI.

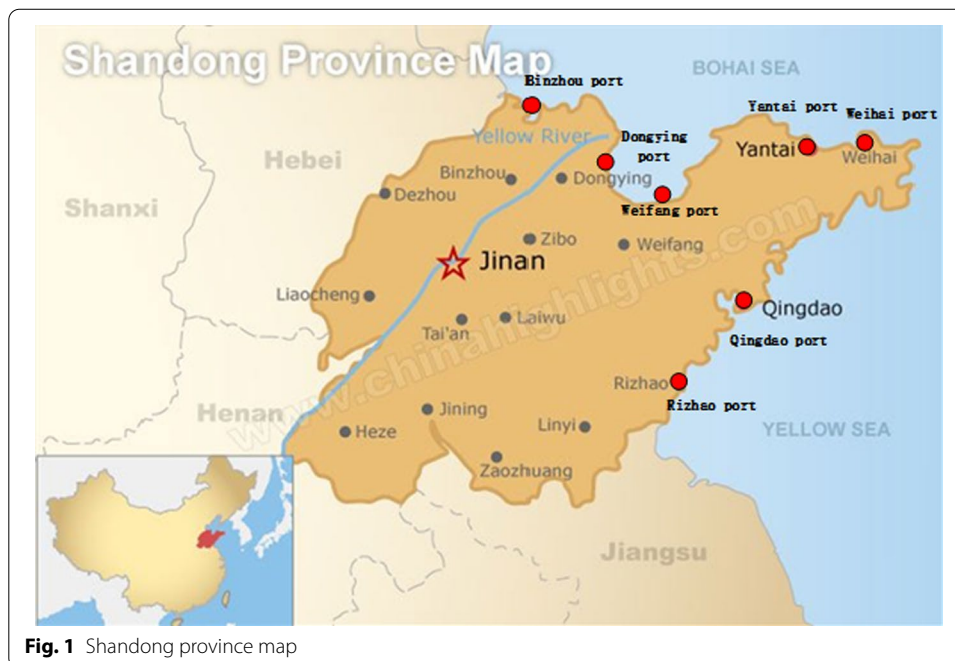


Fig. 1 Shandong province map

This paper focuses on the evolution relationship between seaports in Shandong Province and the dry ports in the inland cities. To further explore the evolution relationship between seaports in Shandong Province and the dry ports in the inland cities, the paper will make a comparative analysis of Shandong dry port affected by Belt or Road. This paper is going to discuss the co-evolution of seaports and dry ports in Shandong Province, leading to a dry port-seaport logistics network, which results from the mutual influence of seaports and dry ports. In addition, some policy discussions are provided for improving the inland logistics network under the Belt and Road Initiative.

The remainder of this paper are as follows. “Literature review and theory” section introduces theory and literature review. “Port evolution mechanism” section analyses the evolution of the seaport in Shandong Province, and shows the information about the dry port development in China. We discuss the evolution of Shandong’s dry port and seaport mechanism in the “Case study: the evolution of seaports and dry ports in Shandong province” section and adding the Belt and Road Initiative to the discussion in the “Discussion” section. At the end, “Conclusion” section gives conclusion and the key findings.

Literature review and theory

Belt and Road Initiative

The Belt and Road is the abbreviation of Silk Road Economic Belt and 21st Century Maritime Silk Road. In September and October, 2013, the Chinese President Xi Jinping put forward the cooperation proposal to build the New Silk Road Economic Belt and the 21st Century Maritime Silk Road, respectively, aiming to promote regional integration between China and other countries in Africa, Europe and Asia by strengthening infrastructure construction and institutional connections. BRI is centered on the establishment of an efficient logistics infrastructure and transportation network. The BRI runs through the continents of Asia, Europe and Africa, with an active East Asian economic circle on one side and a developed European economic circle on the other. The vast hinterland countries in the middle also have huge economic development potential. The key direction of the 21st Century Maritime Silk Road is from China’s coastal ports across the South China Sea to the Indian Ocean and extending to Europe or from China’s coastal ports across the South China Sea to the South Pacific. In accordance with the BRI trend, relying on major international corridors on land, and central cities along the route, China will jointly build a number of international economic cooperation corridors such as the New Eurasian Continental Bridge. With key ports as nodes at sea, a large, unobstructed, safe and efficient transportation channel will be formed.

From a long-term perspective, the construction of the Belt and Road aims to promote the development of the world economy in the twenty-first century, practice the concept of openness and tolerance, and create broad prospects for economic globalization. In the short term, the advancement of the Belt and Road construction can bring concrete and practical benefits to the employment and economic development of countries in the post-international financial crisis period. With the efforts of countries and regions along the route, the Belt and Road construction will connect the booming Asian and the European economic circle, which will stimulate huge economic potential and market demand, and create a new engine for world economic development. The construction

of the Belt and Road is the inheritance of the classics of China's ancient Silk Road, and it is also an inevitable requirement to build an all-round development pattern. At the same time, BRI is bound to become an inevitable choice to promote the economic development of China and the common prosperity of Asian and European countries (Yuan 2014). The successful realization of this strategy is inseparable from the concerted efforts of countries and regions along the route to create a new situation of win-win cooperation. BRI is a combination of opportunities and challenges. Zhang (2015) pointed out that the implementation of the construction of internal logistics infrastructure is imperfect, and there are still certain obstacles and barriers between trade entities. Therefore, to follow the strategic deployment of BRI, it is necessary to continuously improve the logistics infrastructure along the road and build a logistics system. Lee et al. (2018) gave a detailed introduction to the core building elements of the BRI, including transportation corridors, urban clusters, dry ports, free trade zones, etc., and analyzed the benefits of the Belt and Road for trade and logistics. Lam et al. (2018) believe that the new Maritime Silk Road is expected to have a long-term and multifaceted impact on logistics management and practice, which is mainly reflected in the construction of logistics network and performance. Wang (2016) integrated logistics facilities, logistics capabilities, logistics services, and government participation to build a modern logistics system under the Belt and Road Initiative, pointing out that cloud computing and big data are important support for the construction of this logistics system.

Seaport evolution

With the development of the modern transportation system, as the supplier of modern transport services, the port is continually extending its function and role. There are plenty of researchers focusing on this field. Bird (1963) puts forward an "Any port" model, which has a deep impact on the later studies. Taaffe et al. (1963) put forward six-phased transportation development. Hoyle (1968) makes some modification of the Bird's model and Rimmer (1967) introduces a new five-stage models for the port evolution. Hayuth (1981) illustrates a five-phased model of the container port system. Notteboom and Rodrigue (2005) study on the port regionalization phase and related functional focus. Other papers are more focused on different aspects of the ports evolution, such as services, concerted development of ports and cities, financial activities and so on Beresford et al. (2004), Bichou and Gray (2005), Sánchez and Wilmsmeier (2010), Boulos (2016), Lam (2016), Zhang and Lam (2017), Debie and Raimbault (2016), Davarzani et al. (2016), Bergqvist and Egels-Zandén (2012), Loh et al. (2017), Chen et al. (2019). All the references make significant contribution to the seaport evolution and this paper may introduce the concept mentioned by The United Nations Conference on Trade and Development (UNCTAD), which divides the evolution of ports into five stages, and is shown in Table 1. The first stage refers to that prior to 1960, the port served as a platform connecting the sea to land, which was independent of the trade. Seaport was loosely connected with the industry and commerce in the city, and only provided primary transport services; the second stage refers to the years between around 1960 and around 1980. Functions of the harbor were extremely expanded, providing "value-added services" for the goods, existing as a center for transport and industrial and commercial services. Combined with the industrial and commercial development, the hinterland

Table 1 Port evolution stage

Stage	Time	Location of the port
Phase 1	Before 1960	Connect to the platform
Phase 2	1960–1980	Center for transportation and industrial and commercial services
Phase 3	1980–2000	Comprehensive logistics center
Stage 4	2000–2007	Global resource allocation hub
Stage 5	Since 2007	Co-operated hub-and-spoke network

port had also been expanded; the third stage refers to the years between around 1980 and around 2000. Change in this period was regarded as a product of the development of containerization and multimodal transport. The port developed into an integrated logistics center and the service forms were also more specialized and diversified. Modern equipment took place of traditional tools, with more information services for transportation and trade added. The fourth stage refers to that with the development of Internet enterprises, traditional industry has developed towards the direction of being personalized and flexible. The port has become a global resource allocation hub and an indispensable part of the global supply chain. In recent years, experts have proposed the fifth-generation port, a co-operated hub-and-spoke network formed by large seaports as transit ports and regional ports as feeder ports.

Based on this theory, an increasing number of studies focus on the port evolution, especially for individual ports. Wilmsmeier and Monios (2013) analyses the evolution of container port in UK and the de-concentration trend, proving that the ports in UK are gradually becoming as transshipment hubs. Liu et al. (2013) show the port system evolution of the Pearl River Delta, examining the relationship between Hong Kong, Shenzhen and Guangzhou ports. Wilmsmeier et al. (2014) present the factors that influencing the evolution of a port system which transits from a concentrated system to a de-concentrated system. Notteboom (2010) aims to find the trends of the European container port system and strong market-related factors affect the relatively high cargo concentration level. Monios et al. (2019) establish the dynamics of second-tier hubs' emergence and the results suggest the role of the port stakeholders in some situations. Jiaoe et al. (2014) present the evolution process of the border ports in China and put forward four development modes. Wilmsmeier and Monios (2016) do some researches on the decentralisation of port governance and de-concentration of port traffic intersection, using case study to show the relation between short-term gains and long-term loss. Wang et al. (2017) choose several important adjacent ports to figure out the evolution trend of the China port system development. Xu et al. (2021) use the rank-size rule to prove port rank-size rule evolution and take the costal port of China as an example. Among the plenty of studies, there is few research about the port evolution in China, especially under the Belt and Road Initiative. Hence, it is valuable to make a deep exploration of the port evolution about the seaports in China and figure out what kind of influence the BRI brings to this process.

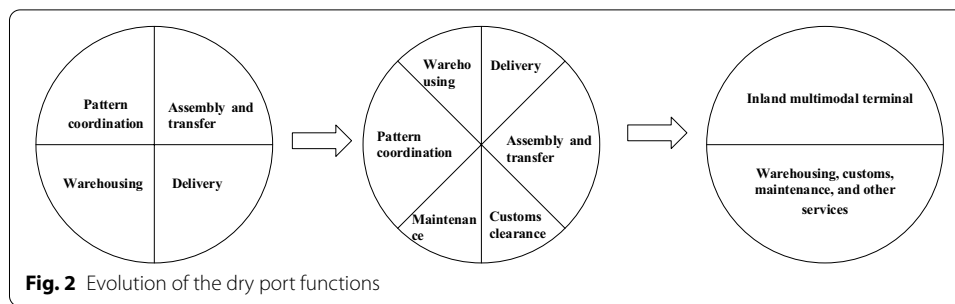
After 1990, with the deepening of economic globalization and regional co-operation, it was believed by UNCTAD that the function of certain seaports were beyond the

third generation of seaports, featuring as inter-port alliances and development of supply chain, which provided more refined and differentiated services. In addition, some scholars pointed out that smart ports and “green” ports are the development directions in the future from the perspective of technology and environmental protection. After the twenty-first century, globalization, alliance further developed, especially the popularization of multimodal transport, promote and inspired the horizontal development of port enterprises. In China, since the twenty-first century, the port developed its own system, port group in inland area branched or cooperated with inland areas, providing services for the overall transportation. Particularly, the improvement and planning of the multimodal transport system under the “Belt and Road” initiative has gradually shifted the focus of the entire transportation system to the inland areas. As an important link of the port, the port is giving full play to its subjective initiative and actively expanding its service scope to inland areas, resulting in “waterless port” and “land port” (collectively called dry port), thus creating a new role and functions of the port under the transportation system.

Dry port evolution

Generation of dry ports

As dry ports can allow many companies to operate at the same location, Hanappe (1986) first called the inland multi-function logistics center dry ports. Later, these multi-use logistics centers emphasized connections to the port and specify services offered in the port, and made very specific provisions on their ownership and services. Later, with the development of the global economy, these logistics centers realized the need to simplify customs clearance procedures and other functions to really different from inland freight village, inland customs clearance station, so they promoted the transfer of goods from the source to the destination without customs inspection, the so-called through transportation, thus forming the current dry port. Cullinane et al. (2012) reviews the concept of dry ports. He points out that although scholars in different countries have given different definitions, some of the basic characteristics and functions of dry ports are the same. This is to combine dry ports with other freight stations or logistics, pointing out the basis of the difference between the centers. For example, dry ports are usually in inland areas and have the functions of a port and facilitate customs clearance. This is the biggest difference from other logistics centers. Roso also points out that dry ports must have customs clearance functions to meet customer needs (Roso 2009). Besides convenient customs clearance functions like seaports, dry ports usually need to have efficient logistics channels to connect with the seaport (Notteboom and Rodrigue 2012). In dry ports, in addition to loading on ships, other activities of inland import and export goods can be completed. Activities that need to be completed at seaports, such as inland loans or transportation agents, can also be implemented at local dry ports (Crainic et al. 2015). It simplifies the cargo operation process from inland to coastal ports, improves operation efficiency, and reduces the environmental cost of transportation. Witte et al. (2019) give a systematic review of dry port studies and present the evolution of the dry ports.



Evolution of the dry port function

The evolution of the dry port functions can be summarized in Fig. 2. At first, the dry port usually owned four functions: two modes coordination of goods transport; assembly of goods for transfer; storage of goods to be picked; delivery and control of logistics. In addition to the functions above, other dry ports can also conduct container maintenance, customs clearance and other value-added services in the dry ports according to the needs of the customers, which is the second evolution stages of the dry port functions. Through years of evolution, the present dry port has served as an inland multimodal terminal directly connected to the harbor with high capacity transport, usually with rail transport, where customers can transport goods as directly in and out of the seaport. In addition, dry ports can be divided into long, medium and short dry ports (Roso 2008), depending on their function and location, with each category having its own characteristics.

Dry ports are more widely used than traditional inland terminals, aiming to improve the impact of the increase of container traffic and focus on security control through information and communication systems. Regular and reliable large volume transport to and from the harbor is crucial, which determines the performance of dry ports. Therefore, the dry ports can serve as a buffer zone to ease the seaport accumulation area. However, the application of dry ports is not necessarily the best solution in reducing transportation costs, mainly because of government policy and the dry port's inability to provide the value-added services that the shippers require.

Dry port-seaport logistics network

At present, the dry port-seaport network has become a key factor in the port competitive advantage. Robinson (2002) proposes several spatial layout forms by considering the functions of seaports and dry ports, while Veenstra et al. (2012) expand the concept of port portals by integrating dry ports. Rahimi et al. (2008) use the location-allocation method to establish a new dry port-based transportation network, which reduced congestion and pollution in the city to a certain extent. Henttu and Hilmola (2011) study the impact of the number of dry ports in the network on economic benefits and find that the use of logistics networks can reduce carbon emissions and save costs. Wang and Nguyen (2017) use FTOPSIS and fuzzy quality function deployment methods to discover the possibility of closing existing dry ports and opening new dry ports to optimize the location of dry ports, and then constructing a new network. Wei and Dong (Wei and Dong 2019) focus on cross-domestic dry port network

efficiency under the background of the Belt and Road Initiative. Using two-objective integer programming and adaptive genetic algorithms to prove that the connection of dry ports is the key to improving logistics networks. Tsao and Thanh (2019) use a robust multi-objective hybrid linear programming model to explore how to build a dry port-seaport logistics network under the government’s environmental protection policy requirements. Wei et al. (2018) design an OWA-based logistics network evaluation model to enable dry ports to fully play the key role of a sustainable logistics network under the BRI, and provide cargo distribution plan with Anhui Province as the research object.

Thus, progress only in the maritime part of the transport chain, rather than improving the hinterland through dry ports, is not sufficient to make the entire transport network. In the example of Fig. 3, it shows that in the past, the dry port and seaport are two independent units in the whole transportation process. While in recent years, the connection between seaports and dry ports are becoming more and more closely. So the implementation of the concept of dry port can create a seamless dry port-seaport logistics network. However, in order to be effective, coordination between all parties is required. In the process of establishing such a logistics network, besides the regular and reliable railway operation guarantee, the safety inspection of dry ports is also crucial, especially the handling of customs clearance procedures, which actually increases the implementation cost of invisible dry ports. Therefore, dry ports must be suitable for a complex system in which the infrastructure should be provided as support, while ensuring maintenance and legislation, designing appropriate institutional mechanisms to optimize the participation of the public and private sectors.

Research gap

In conclusion, there are two research gaps for the port co-evolution. For starters, there are few systematic research about the port co-evolution in China or in other areas around the world. Most of the papers usually focus on seaports or dry ports, which leave the discussion of co-evolution uncovered. Second, few studies pay attention to the characteristics of the port evolution, such as policy or region, especially for Belt and Road Initiative. In fact, different region has its unique development features and policy will always play a very important role in the port evolution. Therefore, this paper conducts a study on the port co-evolution under the Belt and Road Initiative from a provincial perspective, hoping to fill these research gaps.

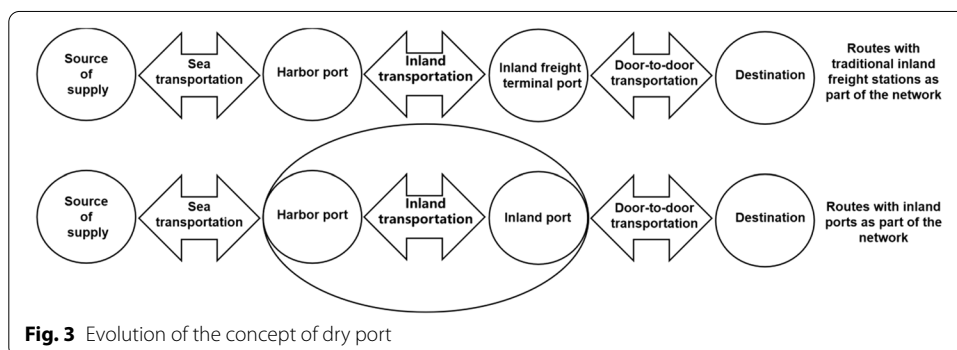


Fig. 3 Evolution of the concept of dry port

Port evolution mechanism

The evolution trend of seaports and dry ports

According to the literature review, we can see that logistics network may be a new trend for the port evolution. More and more researchers start to pay much attention to the networks construction problems. We will give explanations from the following three aspects.

Space dynamics

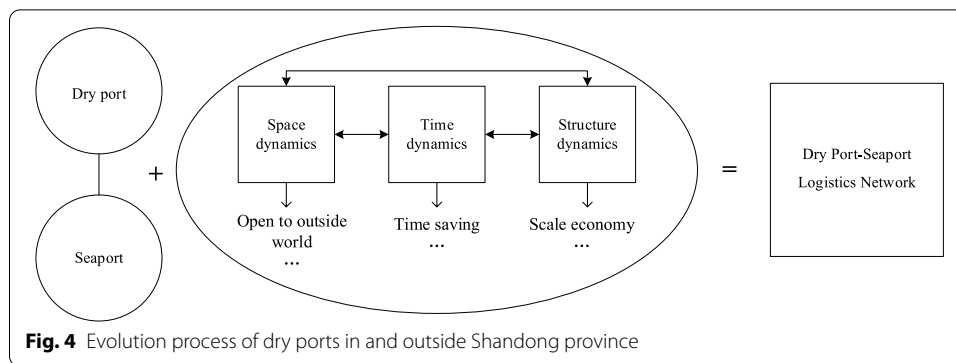
The emergence of the dry port-seaport logistics network is the result of the optimized configuration of the logistics infrastructure at the spatial level brought about by the economic and social development of the inland and seaport city. The spatial networking of infrastructure and the continuous improvement of its service infrastructure have led to a change in the relationship between space and time, which has greatly promoted the development of the network economy. The integrated development of the inland and seaport economy, the continuous improvement and development of the logistics infrastructure network, and the resulting changes in the economies of scale and scope, have shaped new hubs and nodes, and promoted the expansion of the coverage of the original logistics nodes. The hinterland has also been effectively improved, and the service coverage and capabilities have been expanded. Therefore, the pursuit of the optimal allocation of resources in the land and seaport space is the main driving force of the dry port-sea port logistics network.

Time dynamics

Inland logistics and seaport logistics need to provide time-value services for the time difference between supply and demand, and often create value by shortening the time and making up for the time difference. In the dry port-seaport logistics network, the logistics network system formed by elements and units, such as hubs, nodes and routes, to achieve the best match between time and space can maximize time value and minimize logistics costs. Therefore, the efficient use of time is also the main driving force for the formation of the dry port-seaport logistics network.

Structure dynamics

Structure dynamics mainly include low-cost operation achieved by the scale economy of the network, line density and the scope. Scale economy utilizes the dry port-seaport logistics network to centrally allocate resources of sea and land, make full use of the service infrastructure and personnel, obtain the benefits brought by the dry port-seaport logistics network, and reduce the time and cost of logistics operations. The line density can economically raise the service response rate by increasing the service demand and service density of hubs and nodes. Economies of scope are obtained by concentrating goods in different hinterland spaces in the same dry port-seaport logistics network. Generally speaking, the larger the network is, the more obvious the scope economy is.



The formation of dry port-seaport logistics network

Figure 4 shows the co-evolution model of the dry port-seaport logistics model we put forward, which is the mechanism of the port evolution. As for the seaport, connecting with dry port to form a logistics network is the development trend. And from the perspective of the dry port, seeking cooperation with seaports is necessary for future development. And most importantly, with the space, time and structure dynamics influencing and interacting with each other and eventually a dry port-seaport logistics network is formed. The development needs in space, time and structure of dry port and seaport have led to the emergence of the network, and the construction of the network can also bring good promotion to the dry port and seaport cities. For example, seaport starts to pay much attention to connecting with inland city to build dry port. Also, dry port can integrate the logistics process at home and abroad, improve transportation efficiency, and reduce time and transportation costs. Through the multimodal transport service between dry port and seaport, the export process of goods can be simplified, and the One-Click operation can be realized. The formation of the logistics network results from the two-way interaction among space, time and structure dynamics. Affected by the connection between dry ports and seaports, this co-evolution model will be affected by factors such as logistics transportation methods and routes.

Features of traditional network

First of all, each node in the traditional logistics network does not have a clear distinction between primary and secondary. The area where each node is located is keen to become a logistics hub, transaction center or distribution center, which is not only detrimental to the effective use of resources, but even causes waste. Secondly, in the traditional logistics network, each node is directly connected, and the circulation of goods on each connection line is usually relatively small, resulting in a relatively low full load rate of transportation vehicles on each transportation route, leading to the waste of transportation resources, and causing costs. Finally, most of the traditional logistics network nodes are very scattered, and the degree of informatization is very low. The transportation between nodes is chaotic and disorderly, which often causes repeated and incorrect transportation, causing problems such as low transportation efficiency.

Characteristics of dry port-seaport network

First of all, building a dry port-seaport logistics network is conducive to optimizing resource allocation. Establishing connections between seaports and dry ports can make the roles and meanings of seaports and dry ports clearer, which will help form a standardized and reasonable port system, reducing vehicles, and rationally allocating transportation resources. For cities with large freight demand between inland cities and seaports, railway container transportation can be arranged directly in order to fully reflect the advantages of economies of scale. However, cities with low freight demand can use road transportation, which can save most of the transportation capacity. In addition, the dry port-seaport logistics network can enable customs clearance, inspection and quarantine and other procedures to be handled in advance at the dry port, which not only improves the deployment capacity, but also reduces backup resources.

Secondly, the dry port-sea port logistics network can reduce the imbalance of cargo transportation, increase the utilization rate of transportation resources, and generate economies of scale, which is conducive to the effect of density economy. Density economy means that the cost decreases as the frequency of flights increases. In the logistics transportation system, there is an imbalance in the flow of goods between the nodes. The dry port-sea port logistics network can concentrate transportation needs to a few hub inland ports through the transit of inland ports, and then flexibly arrange logistics routes according to the needs of different transportation routes.

Finally, it is conducive to bringing into play the economic benefits of network scale. In the dry port-sea port logistics network, the needs of the same origin and different destinations can be concentrated to the same route through the inland port of the hub; and the needs of different origins and the same destination can also be passed through the hub. The dry port transfers to the same route. Compared with the point-to-point direct route, the dry port-seaport logistics network does not change the number of nodes in the network, nor does it change the traffic volume of passengers and goods in the network, but it can reduce the number of connections between nodes, so that the connected nodes increase in transportation volume and reduce unit transportation cost.

Case study: the evolution of seaports and dry ports in Shandong province

The evolution stage of seaports

Connection platform with primary logistic function

On the stage of its primary establishment, the port of Shandong Province was mostly used as a gateway which connected land and sea, and also as a docking place for ships. The time period usually stays around 1980s. Port production was mainly based on cargo transportation services and provided fundamental service businesses. These connection platforms were equipped with basic logistics functions as well. After Qingdao Port started its container business in 1976, it set up container yards, container loading and unloading bridges and other related logistics facilities. At the beginning of the Yantai Port, it was used as a terminal for urban passenger and freight transport. There were 4 large warehouses established in Weihai Port, as well as a freight yard with an area of nearly 50,000 square meters in 1988. In order to meet the demand for transportation, the annual designed throughput of Rizhao Port was set

at 15 million tons when it was established, exceeding most of the international ports established during the same period. Because of historical factors, most of the ports were also connected with the city's industry, commerce or service industry, and could provide services such as processing, packaging goods and so forth.

Comprehensive logistics center

With the maturity of multimodal transport and container freight business, Shandong Port has evolved into a comprehensive logistics center based on the first phase of its functions. While the means of transportation have been diversified, the services and goods have also been gradually enriched before the 21st century. Qingdao Port expanded and refined its container business by degrees. Yantai Port opened a bulk fertilizer filling business at the end of the twentieth century. Weihai Port also began opening container trade routes during this period. The container throughput of Rizhao Port gradually entered the top tenth in the country. From the perspective of the whole province, the varieties of cargo transportation in Shandong Province have been gradually improving.

Global resource allocation hub

Since the twenty-first century, the development of the Internet has made the application of information technology in Shandong ports more and more extensive, making Shandong ports closely connected with international trade. In 1996, Qingdao Port used the EDI system to transport container, and in 2006 it became the Top 500 Chinese Enterprises in Information Technology. As one of the earliest ports on the coast of China to apply computer technology, Yantai Port has been establishing an information port since the early 2000. The application of information technology has contributed to the continuous polish of port functions in Shandong Province.

Due to the development of networks and logistics, Shandong seaports have become an indispensable part of the global supply chain, gradually becoming a global resource allocation center. By the beginning of 2019, there has been nearly 170 routes in Qingdao ports, with routes to Japan, South Korea, Taiwan, Hong Kong, Southeast Asia, South America, the Persian Gulf, Australia, the Mediterranean, the Middle East, Europe, and the east and west of the United States included. There are 4 routes, and it has established connections with more than 450 ports in 130 countries and regions around the world. The routes of Yantai Port mainly include South Korea, Japan, Southeast Asia, Europe and the United States, and the country is connected to inland regions such as Shandong, Hebei and Shanxi. As of 2017, Yantai Port has adopted the route layout of "North to South" strategy and successfully opened 13 large-scale self-operated shipping routes. The routes that have been opened to Japan, South Korea, Southeast Asia, and Europe and the United States also show a good growth trend. A standardized route layout has been gradually formed. Rizhao Port has currently opened routes from Rizhao to Pyeongtaek, Busan and other places in South Korea, as well as routes to Portland Port in the United States and Australia. It can connect with ports in more than 100 countries and regions in the world, realizing the freedom of navigation. The general cargo liner route from Rizhao to the Middle East passes through Singapore, Pakistan, the UAE, Saudi Arabia and other countries to transport steel and other goods. The opening of

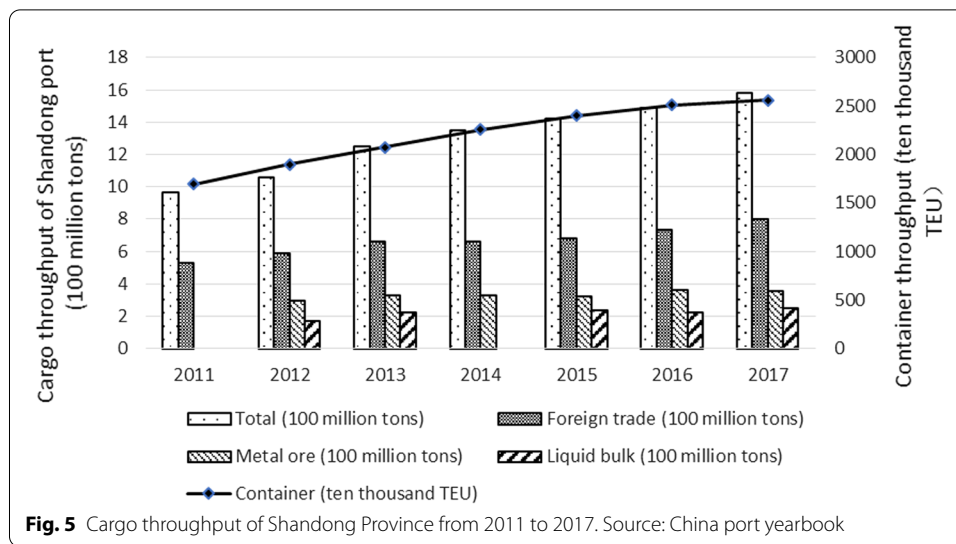


Table 2 Berths of Shandong port. Source: China port yearbook

Year	2011	2012	2013	2014	2015	2016	2017
Production berth (units)	485	501	519	540	561	566	581
Berth length (m)	82,660	86,787	92,465	97,190	104,048	106,152	10,719

the “Zhaorongou” container international line also connects Rizhao with inland countries and cities. Figure 5 shows the cargo throughput of Shandong ports since 2011. The total throughput of Shandong Seaport has exceeded 1 billion and maintained a steady increase. Among them, foreign trade accounts for the largest proportion, which is more than 50% of the total cargo throughput each year, and ranks the first in the country over the years. The second and third are metal ore and liquid bulk cargo, which account for about 20% and 15% of the total cargo throughput each year respectively. In addition, container throughput in Shandong ranks the third in the country, but its growth rate has declined slightly.

At this stage, the container, dry bulk and liquid bulk cargo ships of Shandong ports have moved into a large-scale development and at the same time, many large-scale deep-water, specialized berths have been built. Shandong Province would increase the investment on berth every year, and the investment completed in 2017 reached 11.8 billion yuan. As shown in Table 2, the production berths and berth length have witnessed a steady growth each year. The seaport adopts a fully commercialized operation method and gradually grows into a logistics center for global trade, and its business has also expanded to a full range of services from the port to inland.

Table 3 illustrates the current development of major large ports in Shandong Province. Most of Shandong’s seaports have now developed into the stage of global resource allocation hubs, and have gradually become an important point in the global supply chain, playing an increasingly significant pivotal role in global resource allocation. After 2013, the BRI was initiated, the container throughput of large ports in Shandong Province rank the top in the country and even the world, because the active trade happens among

Table 3 Construction of large ports in Shandong province (as of 2018)

Seaports	Throughput of container	Annual berth passing capacity (ten thousand TEU)	Types of goods	Evolution stage
Qingdao Port	Eighth in the world, fifth in the country	1650	Iron ore, crude oil, coal products, food, etc	Global resource allocation center
Yantai Port	Third in the province	211	Mainly of bulk cargo transportation	Global resource allocation center
Rizhao Port	Second in the province	323	Mainly of bulk cargo	Global resource allocation center

Table 4 Situation of each stage of port evolution in Shandong province

Seaports	Phase 1: Connection platform	Phase 2: Integrated logistics center	Phase 3: Global resource allocation hub
Qingdao Port	Container Yard	Containerization and multi-modal Intermodal business	170 routes have been opened
Yantai Port	Passenger and cargo terminal establishment	Open bulk fertilizer filling business	"North to South" route layout
Rizhao Port	Designed annual throughput of 15 million tons at the time of completion	Throughput rises to the 9th of whole country	Navigate with more than 100 countries and regions around the world
Weihai Port	Large warehouses and goods yards	Open container trade route	–

Shandong Province and other regions. The annual berth throughput capacity is strong, and the types of goods are various. These characteristics can be transformed into strong transportation capacity in the global resource allocation. The development of Shandong Port at this stage is relatively mature and has the material foundation for the next stage of evolution.

According to the definition of UNCTAD (United Nations Conference on Trade and Development) and in the theory of port evolution, we can conclude that there are five evolutionary stages of seaports in Shandong Province from the initial connection platform to the co-operated parent port. Compared with international ports, most of the ports in Shandong Province were officially established at the end of the twentieth century or at the beginning of the twenty-first century. At this time, the evolution of international ports is different. Based on the construction experience of foreign seaports, at the beginning of the establishment, the seaports of Shandong Province had the characteristics of close ties with industry and commerce, and can provide value-added services, which promotes the merger of the first two evolutionary stages in the traditional way.

The evolution process of Shandong Seaport is shown in Table 4. At first, the ports in Shandong province serve as the connection platform, which includes basic functions, such as barge dock, loading and unloading, warehouse and transport. Then, with the development of the Internet and technology, seaports gradually transfer into the integrated logistics center. Now the global trade is becoming more and more important, leading to enormous role change of seaports. Most of the ports go to the stage of global resource allocation hub, which offers not only information and technology but also the other logistics functions.

The evolution stage of dry ports

Basic situation of dry port

Dry port in Shandong province (1) Dezhou port

Dezhou Port was established in 2008, which is the earliest dry port in Shandong Province. It was invested and built by Tianjin Port and mainly served the import and export goods. At the beginning of its establishment, Dezhou Port was not closely connected with the ports in Shandong Province. It is mainly equipped with basic warehousing and transportation functions, integrating the goods exported to Tianjin Port. On this basis, the Dezhou Port was equipped with the functions of customs clearance and delivery at the beginning of its establishment, mostly to facilitate the customs clearance of Tianjin Port.

With the opening of the “Pingyuan” sea-rail intermodal container train, Dezhou Port and Qingdao Port are becoming more and more closely connected. After the container arrives at Qingdao Port, there is no need to go through lots of procedures, such as the arrival report. Qingdao Port is specially designed for “Pingyuan Hao”, adding a special container station to realize the real-time docking of cargo information. Through the connection with Qingdao Port, Dezhou Port is gradually becoming an inland multimodal transport terminal directly connected to Qingdao Port with functions such as warehousing and customs. “Pingyuan Hao” makes the Dezhou Port take an active part in the Belt and Road Initiative by shortening the distance between the inland areas and countries along the Belt and Road. In 2018, Dezhou Port actively coordinated Taiyuan, Hohhot, Urumqi and other cities to open Xinjiang Express and Ningxia Express, connecting China–Europe Express, and realizing the connection to the nodes of Belt and Road.

(2) Zaozhuang port

In 2019, the Zaozhuang Port was invested and built by Qingdao Port in Zaozhuang city. As a vital source of goods in southwestern Shandong, the establishment of Zaozhuang Port provided convenient and efficient comprehensive logistics services for a wide range of customers in the coverage area, and supported the steady growth of Qingdao Port’s throughput.

The major business of Zaozhuang Port is sea-rail combined transportation. The “Zaozhuang” train off Qingdao Port runs daily, opening up a new channel between the inland areas of Shandong Province and the seaport. Zaozhuang Port is currently equipped with nearly 60 container transport trucks and 3 container operation lines, which will accumulate power for further building the integrated development of dry ports and seaports. Zaozhuang Port will, in accordance with the development requirements of the Belt and Road Initiative, follow the principle of “Resource Sharing, Mutual Promotion, Long-term Cooperation, and Common Development”, and leverage on the advantages of location, supply of goods, policies and other aspects of Zaozhuang to give full play to the port resources and other advantages of Shandong Port, to jointly create Belt and Road logistics cooperation.

(3) Linyi port

As a vigorously developed dry port in Shandong Province in recent years, Linyi Port’s evolution process is like that of Dezhou Port. Linyi Port was put into trial operation in 2013. At the beginning of its establishment, it had the functions of booking, consolidation, customs declaration, and warehousing. With the establishment of the Qingdao Port

container station, Linyi Port has developed into a dry port multimodal transport Wharf, a coastal railway can enter the port directly. To follow the trend of coastal port construction, Linyi Port has strengthened strategic cooperation with Qingdao Port, Rizhao Port, Yantai Port and Lianyungang Port outside the province to build a green channel for multi-port linkage.

Linyi Port is committed to building an important transit logistics node and a multimodal transport service hub of the Belt and Road, expanding the operation scale of the “Qilu” Eurasian train, and becoming one of the three assembly centers of the Eurasian train in Shandong Province.

Dry port outside Shandong province Different from dry ports in Shandong province, their counterparts outside province are mostly invested by national or provincial governments for the local economic development (shown in Appendix 1). The investment is relatively large, and there are certain policy supports to make the infrastructure construction refined. At the beginning, it has the fundamental functions of a dry port, including warehousing, transportation, customs, etc. These dry ports are usually selected in logistics hub cities with efficient transportation, various transportation methods and obvious geographic location advantages.

Xi’an Port is an economic development pilot zone established by Xi’an City to build a new highland for reform and opening up. With convenient roads, railways, and comprehensive bonded areas as advantages, it has created a relocation of ports, local orders, multimodal transport, and the operation model of Seam and Docking. With Xi’an Port being the center of development, and the China–Europe Express “Chang’an” as the carrier, an opening-up pattern based on cross-border e-commerce pilots are forming and striving to build the largest new center and an inland international transit hub port under the Belt and Road Initiative.

Zhengzhou Port was established in 2013. Its business relies on railways and roads to involve Japan, South Korea, Central Asia and Europe, with direct sourcing and purchase, full traceability, and active cross-border trade. The original intention of Zhengzhou International Dry Port was to satisfy the inland transportation of containers and simplify the procedures for customs clearance. The development of Zhengzhou International Dry Port has always adhered to the development concept of “transportation, trade and integration”, expanding multimodal transport, and relying on its own excellent traffic conditions to continue to grow and become stronger. Zhengzhou Port has basically built a logistics channel hub connecting domestic and foreign countries, radiating east, middle and west of China. In the next step, it will continue to increase the number of opening schedules, enrich the opening routes of China Railway Express, deepen the integration of transportation and trade, and promote the construction of a comprehensive service information platform for China–Europe international multimodal transportation. Zhengzhou Port will establish a modern international multimodal logistics center in Henan, radiating across China, and facing countries along the Belt and Road.

Shizuishan Dry Port Economic Zone was established in 2010 by the autonomous region government. The role of this economic zone is to promote Ningxia’s strategy of going out and strengthen the ties between Ningxia and the world. At the beginning of its establishment, the construction of customs, inspection and quarantine, container yard

and other areas has been completed, providing basic conditions for international container transportation, warehousing and storage in the dry port economic zone. Shizuishan Port focuses on building a gateway hub for countries along the Silk Road Economic Belt and an important regional hub in the western region. Thus it has opened flights from Yinchuan to important international aviation hub cities along the Belt and Road route, such as Hong Kong, Dubai in the UAE, Bangkok in Thailand, and Nha Trang in Vietnam.

Similarly, Gansu (Lanzhou) International Port Area, Shijiazhuang Dry Port Area and Datong International Dry Port were all invested and built by provincial and municipal government to push the inland economic development and to promote the local opening-up level. The city these ports in are equipped with developed transportation conditions, which are convenient for multimodal transport and take good advantage of the potential of dry ports. The planning and construction of Lanzhou Global Port will form a northwest global port group effect with Kashgar’s South Xinjiang Global Port, which will radiate the entire ancient Silk Road cities and accelerate the Belt and Road coastal business exchanges and cooperation, consumer experience upgrades, cultural tourism industry Expansion and development provide great impetus.

Analysis of dry port evolution

Figure 6 shows the evolution process of dry ports in and outside Shandong Province. Since most of the dry ports in the province are established by seaports, they were cargo-base stations with warehousing and delivery functions at the beginning of their establishment. These base stations also have the special functions of dry ports, such as mode coordination and assembly transfer. With the increase of functions such as customs, the dry ports in Shandong are rapidly developing to the next stage.

Dry ports in the province have almost evolved into inland multimodal transport terminal. The opening of direct trains is the foundation of a better service for seaports from dry ports. As dry ports have already been equipped with unique functions such as customs, the role of dry ports in the province has gradually widened, not only increasing the channels for external contact but also improve its own strength.

As for the dry ports outside the province, apart from the basic functions, dry ports outside the province are mostly built in areas with logistics efficiency, which makes it possible for dry ports to communicate with other provinces and areas by various means of transportation, including roads, railways, rivers, etc. Therefore, some of the dry ports enjoy a high evolution starting point and a quick evolution speed. Some dry ports could merge the first stage and the second stage and directly develop into an inland multimodal

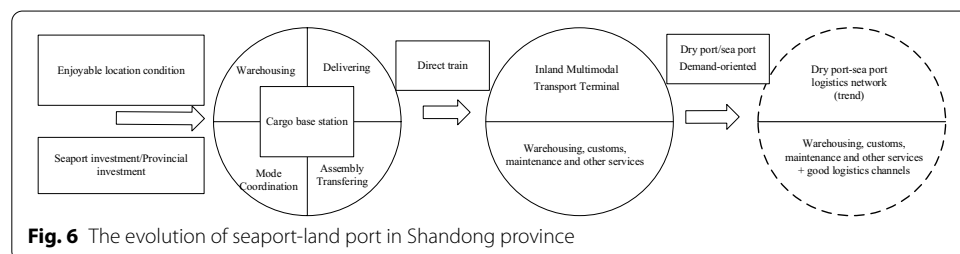


Fig. 6 The evolution of seaport-land port in Shandong province

terminal at the beginning of establishment, which is also the difference to the evolution of interior ports in Shandong Province.

In conclusion, the evolution of dry ports can be divided into three stages. The evolution of dry ports in and outside Shandong Province conforms to this theory, and is affected by investors, geographical location, port demand orientation and other factors, which is clearly shown in Fig. 6. We can see that the difference between the dry ports in and outside Shandong Province lies in the allocation lay out and evolution speed even though the whole trend is alike.

The evolution trend of ports in Shandong province

The evolution trend of seaport

According to the seaport evolution theory, since 2007, the fifth generation of ports has boomed. This generation uses a large seaport as its hub port, and regional ports as feed ports, forming a group of hub and spoke network jointly operated by the seaports. With the prosperity of shipping business in Shandong port, expanding the business in the inland economic hinterland as a network has become a new direction of development, changing the operation mode of large ports only focusing on coastal cities, and exploring how to build connections with inland hinterland cities.

Under the influence of this development trend, most ports in Shandong Province have explored business cooperation with dry port areas. In 2019, Qingdao Port deepened cooperation with Zhengzhou City and planned to build an important dry port in Zhengzhou International Dry port Zone under the theme of jointly building the twenty-first century Maritime Silk Road. At the same time, the construction of dry ports in the inland areas of Xi'an and Urumqi has also become a hard task for Qingdao Port in 2019. Yantai Port also signed a strategic cooperation agreement with Jinan to promote cooperation in establishing a dry port. Through the cooperation with dry ports, Shandong seaports are gradually forming the rudiment of the sub-home port group of joint management.

The major business in large ports of Shandong shows a clear homogenization competition in traditional business of iron ore, kerosene, loading, unloading and handling, which makes it difficult for their misplaced development and forming joint force. Rizhao Port, Yantai Port, Qingdao Port, Lianyungang Port and other ports belong to the same port group, and the economic hinterland is basically the same. However, because of the prominent position of Qingdao Port in both international and domestic ports, it usually attracts goods from surrounding ports, leading to the different development levels of Shandong Ports and a wide gap in profit levels.

Nowadays, the competition between large seaports in the region has been gradually weakened, and the development trend of port agglomeration is gradually booming. Like the New York-New Jersey Port, which occupies nearly 30% of the market share on the East Coast of the United States, or the internationally famous port industrial city clusters in the Tokyo Bay Area of Japan, even the Zhejiang Port Group in Zhejiang Province of China, integrating port resources has been prompted by the general trend, and the ports have gradually moved from competition to cooperation. Aiming at the world famous port and to create first-class port group, Shandong ports integration roughly divided into three steps in terms of the Shandong government's strategy. In April 2019,

Shandong Expressway Group served as the port integration platform, integrating resources in three ports of Binzhou, Weifang and Dongying and setting up the Bohai bay port. On this basis, Qingdao Port and Weihai Port would be integrated. Thus, forming the development form of Qingdao Port, Yantai Port, Rizhao Port and Bohai Bay Port. Finally, Shandong Port Group was formed to promote the common development of the whole province's ports. Under the impact of the trend of port integration, the evolution of ports should not be considered from the perspective of a single port, but from the perspective of all ports in Shandong Province.

Shandong ports continue to increase the density of routes with ports along the Belt and Road. The total number of routes has reached 317, ranking first in northern China in number and density. Among them, the total number of direct routes to countries and regions along the Belt and Road has reached 87. Accumulatively, it has established friendly port relations with 37 foreign ports, becoming an important hub for China's Belt and Road, building a huge maritime trade route network linking countries and regions along the Maritime Silk Road to provide convenience and support for trade exchanges.

At this time, when evolving into a group of hub and spoke network jointly operated, Shandong Ports need to take the connection between several ports in province and dry ports into consideration, forming enormous dry port-seaport logistics network. Therefore, homogeneous competition between ports can be converted into competing advantages, and it improves the comprehensive power in Shandong. When making the distribution of inland goods sources, it is expected that it can be designed from perspectives of several ports rather than single seaport. With the help of the integration of international logistics channels and customs clearance in inland provinces, they should build an efficient logistics network, to realize the mutual benefit and win-win situation of all ports in Shandong.

The evolution trend of dry ports in and outside Shandong province

There are two common characteristics of dry port evolution in Shandong Province can be seen from the analysis in 4.1.1. First, most of them are invested and built directly by seaports. The second is that they are closely connected with seaports. During this evolutionary process, the dry ports were built due to the demand of the seaports. With the establishment of dry ports and the opening of railways, it has grown into inland multimodal transport terminal. During this process, the seaports have always been the primary guide, and dry ports are closely connected with seaports. As a result, with the continuous improvement of logistics infrastructure and enhancement of its own strength, the dry port of Shandong Province is bound to strengthen its relationship with the seaport in the province. The connection of the company gradually develops towards the direction of the dry port-seaport logistics network.

Dry ports outside the province are always equipped with excellent logistics basic infrastructure and advanced technology, outperforming in customs clearance and transportation. They own institutional mechanisms that are in line with international standards, including free trade zone policies, tax exemption policies and so on, which can fully realize their interactive relationship with seaports.

In recent years, Xi'an port has built a China-Europe Railway Express assembly center, working with eastern coastal provinces in China, which makes Xi'an Port become a new

door connecting inland and the seaports. Also, it can promote the establishment of “21st Century Maritime Silk Road”. In 2017, Xi’an Port extended the route of the “Chang’an” eastward to Qingdao Port, and pushed its transportation destination eastward to deliver to Europe, America, Australia and New Zealand.

After the enhancement of its own infrastructure and conditions, Zhengzhou has become the development business opportunity in the eyes of neighboring provinces. More and more seaports have established cooperation with Zhengzhou Port, including Qingdao Port, Yantai Port, Lianyungang Port and other large ports. The pattern of provincial radiation has changed the sales path of the distribution of imported goods from the coast to the inland in the past.

In the evolution process of the dry ports outside Shandong Province, dry ports usually played a major guiding role and located in certain helpful position. They are not invested and built by a single seaport, but attracted cooperation from neighboring seaports, among which include some large-scale ports. Through the continuous deepening of cooperation with seaports, the formation of a dry port-seaport logistics network is the general trend.

The evolution result

We can conclude from the above analysis that a logistics network is necessary for future evolution of both dry port and seaport.

Seaports seek development and expand inland hinterland demand

To improve the comprehensive strength, it is essential for seaports in Shandong to be furnished with a fluent collection and distribution network, a vast economic hinterland, and a system and mechanism that are in line with international standards. Seaports in Shandong have a certain strength in international logistics transportation. The establishment of a dry port-seaport logistics network is suitable for land-to-sea transit transportation, improving port service functions and reducing the transportation time. And handling various businesses in dry ports can improve the efficiency of terminal operations and are conducive to the realization of the expansion of the port hinterland, which transform from inland trade to the international transit service.

The inevitable choice for dry ports to open to the outside world

In order to open up the international market, inland cities need to develop export trade and build inland passages to the sea. The most important connection node of the dry port is seaport. Majority of domestic exports are first shipped to the coast and then shipped to the world. The logistics cost of inland processing is often higher than that of the coast. Therefore, it is necessary to reduce labor costs while reducing logistics costs. Forming a logistics network with seaports to open up a large inland channel to the sea can save costs in all aspects of the condition of ensuring smooth transportation.

Therefore, the result of the co-evolution of seaport and dry port is to build a dry port-seaport logistics network, making the dry port and seaport more connected. Establishing a convenient, economical “end-to-end” one-stop logistics service avenue, which can intensify the connection between the upstream and downstream of the port logistics

chain, improve the quality of port service, reduce logistics costs, and strive to improve comprehensive service capabilities of the port.

Discussion

The impact of the Belt and Road Initiative on the evolution of Shandong ports

Fully integrate into the Belt and Road

In 2017, the National Development and Reform Commission and the State Oceanic Administration specially planned and released the Belt and Road Maritime Cooperation Plan, which emphasized the important role of the 21st Century Maritime Silk Road. According to the planning requirements of the Belt and Road, Shandong Province should fully integrate into the Belt and Road construction and successfully host the Belt and Road copyright trade fair. They support Qingdao, Yantai, Weihai and Rizhao to build strategic fulcrums for maritime cooperation and vigorously develop cross-border trade. With the implement of the Choose Shandong Global Roadshow, exploring new models of China–Europe freight trains is another important way. In order to actively integrate into the Belt and Road, Qingdao Port has been continuously promoting innovation and transformation, and establishing dry ports in Zibo, Linyi, Dongying in Shandong Province and expanding the market at the same time. It also gradually deploys dry port in Xi'an and Urumqi. Recently, Qingdao Port and Zhengzhou City are planning to further strengthen cooperation on the “Maritime Silk Road” and build an important dry port in Zhengzhou. Since the implementation of the Belt and Road Initiative, Yantai Port has been committed to the transformation and upgrading of the port and increasing the links between its various businesses and the Belt and Road. Rizhao Port embarks on the construction of a comprehensive hub port under the Belt and Road Initiative, and opens international trains to Chengdu, Europe and Central Asia in the inland areas. It makes the Maritime Silk Road open to Australia, the Middle East and Southeast Asia Land liner routes.

Fully utilize the energy of the inland regions

Policy background of the Belt and Road determines that ports in Shandong should establish ties with inland cities, not only to allow foreign resources to flow into inland areas in China, but also to use their own maritime advantages to transport inland resources overseas. Whether it is the overall trend of port development or the Belt and Road Initiative, it shows the necessity of establishing a dry port-seaport joint operation and cooperation logistics network. The basis of stimulating the vitality of inland areas is an important change brought about by the Belt and Road to the evolution of ports in Shandong Province. This requires that the node cities along the Belt and Road should be taken into consideration when constructing a dry port-seaport logistics network. Among these inland cities, suitable cities are selected as candidate cities for dry ports. These cities have the demand for opening up to the outside world and convenient transportation facilities, and the support of the Belt and Road policy as well.

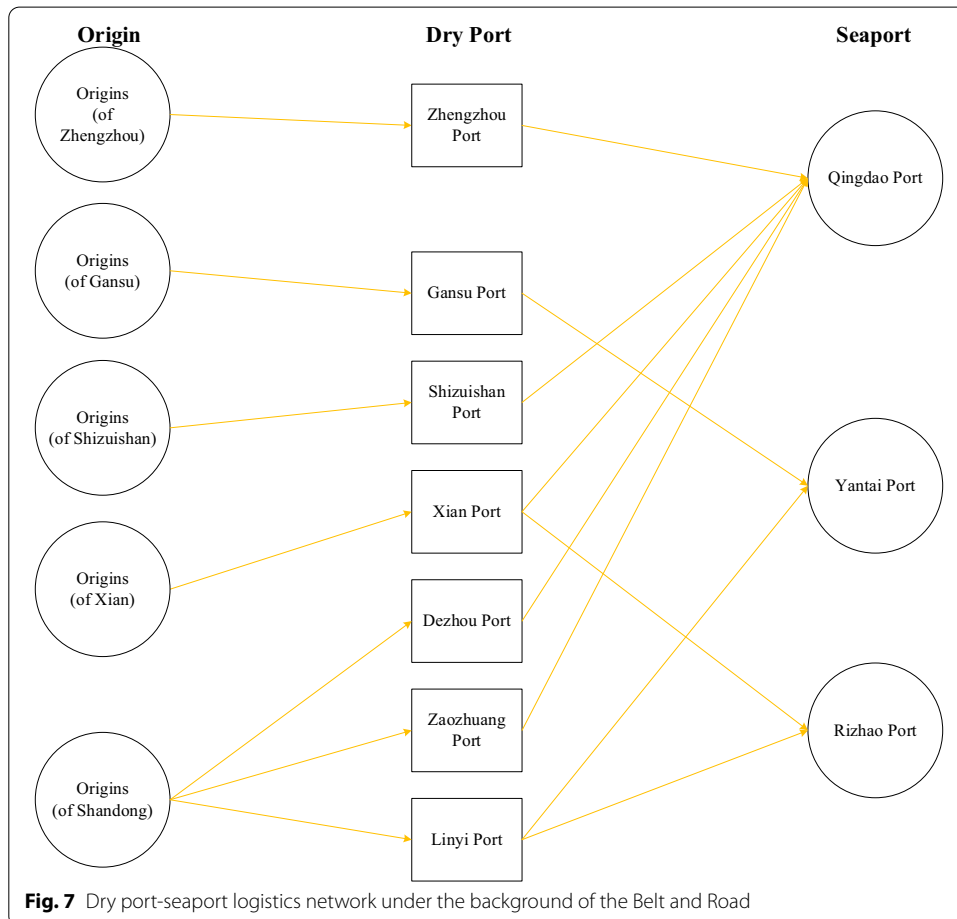
From the perspective of seaports, it is not only following the trend of a joint evolution of seaports and dry ports, but also a significant measure for ports in Shandong to integrate in the Belt and Road Initiative, to set up dry ports in an inland city.

The dry port-seaport network under the BRI

Combining the analysis in 4.4, it can be concluded that it is very necessary to construct the dry port-seaport logistics network under the background of the Belt and Road. Combining with the detailed information of dry ports in Appendix 1, Fig. 7 is a network of the several dry ports and seaports mentioned in the paper, and there are many other dry ports and origins except what are listed in this figure. The operation of the dry port-seaport network can be described as follows. Cargos can be transported to neighboring dry ports after being assembled at the source of goods. After the corresponding consolidation, customs declaration, inspection and other activities are carried out at the dry port, goods can be transported by rail or road to the target seaport. We give the detailed description of the Fig. 7 in the following two aspects.

Dry-port based network

Shandong port can take the inland cities along the Belt and Road as the main line, and the surrounding cities as branch lines. Then using the surrounding cities as the source of goods, building dry ports in the main line cities, and transporting the goods to the corresponding seaport after integration. Most of the main-line cities of the Belt and Road are transportation hub cities, with excellent transportation infrastructure and convenient location conditions. At the same time, the Belt and Road Initiative will also give certain



support to major cities, such as subsidies for the construction cost of dry ports. Under the condition that the seaport and the source of goods are determined, the selection of candidate cities for dry ports is very important. Reasonable selection of candidate cities for dry ports requires comprehensive consideration of the characteristics of the cities, such as import and export trade, logistics, as well as the impact of the Belt and Road Initiative. Through the construction of the above dry port-seaport logistics network, the inland resources of Shandong Port can be rationally distributed, the goods along the Belt and Road and surrounding cities can be shipped overseas, and Shandong will become a link between the Land Silk Road and the 21st Century Maritime Silk Road. Therefore, Shandong Province's participation in the construction of the Belt and Road Initiative logistics network should be based on dry ports and rationally select candidate cities for dry ports is also important.

Importance of all aspects of the cost

When constructing a logistics network, it is necessary to start from the perspective of the seaport and comprehensively consider the factors that affect the decision-making of the seaport. These factors include transportation costs, construction costs, congestion costs, etc. At the same time, the capacity of dry ports should also be considered when building dry ports in inland areas to meet the demand for freight volume. In addition, factors such as the environmental protection policy formulated by the state or the preferential policies of the Belt and Road should also be taken into consideration. As more and more cities open the China–Europe train, local governments are vying to better participate in the construction of the Belt and Road through subsidies and preferential policies. Therefore, after screening the dry port cities, researchers can set targets according to the needs of various aspects of the seaport, design a dry port-seaport logistics network, and figure out freight routes and freight volume distribution that meet the needs of the seaport.

Conclusion

This paper deeply analyses the reasons for the formation of the dry port-seaport logistics network and points out the new features brought about by the Belt and Road Initiative. At the same time, this paper takes Shandong Province as an example and introduces the evolution process and trend of Shandong Port, providing a certain theoretical basis for the selection of dry port candidate cities and the construction of logistics network. The research first analyses the evolution process of the seaport inside and outside the Shandong province, then introduces the evolution stage of the dry port inside and outside the province. After that, mechanism analysis of evolution is used to study the relationship between the Belt and Road Initiative and evolution process of the seaport and dry port.

The conclusions of this study are as follows. First, the dry port-seaport logistics network is the result of the joint evolution of dry ports and seaports in Shandong Province under the background of the Belt and Road Initiative. In order to seek its own development and improve comprehensive competitiveness, the seaport seeks cooperation with dry ports. In order to complete the goal of opening up to the outside world, dry ports usually need large inland passages to the sea. Thus, the dry port-seaport logistics network is the result of the interaction and mutual influence of the two part. Second, in the

context of the BRI, the construction of a dry port-seaport logistics network is required to be based on dry ports and comprehensive consideration of costs in all aspects. This is not only in compliance with the trend of co-evolution of seaports and dry ports, but also an important measure for Shandong ports to integrate into the Belt and Road Initiative.

The co-evolution of the seaport and dry port of Shandong Province under the BRI has been thoroughly evaluated in this paper. Despite evolution result are shown, there are still some limitations that underlines the needs for future research. Market competition model or other mathematical models can be devised to explain the interaction between dry ports and seaport based on the theoretical foundations and the current seaport practices introduced in this paper. In addition, the impact of the dry port seaport network on the global trade can be further discussed.

Appendix 1

Province	Name of dry port	Time of establishment	Annually designed total volume	Investor	Hinterland	Connection to the seaport	Development stage	Development characteristics
Shandong	Dezhou port	2008	500,000 TEU	Tianjin Port	Shanxi, Hebei, Tianjin, Qing- Inner Mongo- lia and other places	Qingdao	Cargo base station → inland multimodal transport terminal	"Plain" train
Shandong	Linyi port	2013	300,000 TEU	Linyi	Linyi and surrounding areas	Qingdao, Rizhao	Cargo base station → inland multimodal transport terminal	The only integrated warehouse in the province
Shandong	Zaozhuang port	2019	50,000 TEU	Qingdao Port	Zaozhuang and South- western Shandong area	Qingdao	Cargo base station → inland multimodal transport terminal	"Zaozhuang" special train
Shanxi	Xi'an inter- national land port district	2008	3,050,000 TEU	Xi'an	Xi'an and surrounding cities	Tianjin, Qing- dao, Rizhao	Inland multi- modal transport terminal → dry port-sea port network	Relocation of the port, local order process- ing, multimodal transportation, seamless docking
He'nan	Zhengzhou international land port area	2013	1200,000 TEU	Henan province	Henan Province and surrounding cities	Lianyungang, Qingdao	Inland multi- modal transport terminal → dry port-sea port network	Trade with transportation, integrated transportation and trade
Gansu	Lanzhou international dry port area	2016	–	Gansu province	Gansu Province and surrounding cities	few	Inland Multi- modal Transport pier	International cargo train center
Xinjiang	Xinjiang international dry port area	2017	–	China Railway Urumqi Branch and Qingdao Port	Xinjiang, Qinghai and other regions	Tianjin, Qing- dao, etc	Cargo base station → inland Multimodal terminal	The core area of the Silk Road Economic Belt
Hebei	Shijiazhuang dry port area	2007	400,000 TEU	Hebei province govern- ment	Hebei Prov- ince	Tianjin	Cargo base station → inland multimodal transport terminal	Realize the real function of coastal ports and border ports to inland areas extend

Province	Name of dry port	Time of establishment	Annually designed total volume	Investor	Hinterland	Connection to the seaport	Development stage	Development characteristics
Ningxia	Shizuishan Lugang economic zone	2010	–	Ningxia Autonomous Region Government	Ningxia, Gansu, Qinghai, Inner Mongolia and other places	Tianjin, Qingdao	Inland Multi-modal Transport pier	Focus on the requirements of large-scale customs clearance and the needs of foreign trade enterprises
Shanxi	Datong international dry port	2018	–	Shanxi Province	Shanxi, Hebei and Inner Mongolia	Tianjin harbor	Inland Multi-modal Transport pier	Convenient and efficient access to the sea in northern Shanxi

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Authors' contributions

Conceptualization, JX, YS and YW; Formal analysis, JX, YS and YW; Writing—original draft, YS, YW and JX; Writing—review and editing, JX and YS. All authors have read and agreed to the published version of the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets used and analyzed during the current study are available in the China Port Year Book, <https://navi.cnki.net/knavi/yearbooks/YZGAW/detail>.

Declarations

Competing interests

The authors declare that they have no competing interests.

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