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EFFICIENCY EVALUATION AND COMPARISON OF YANTAI PORT AND THE PORT OF GDAŃSK BASED ON THE POLICY OF BELT AND ROAD INITIATIVE

1. Introduction and methodology

In September 2013, China began to propose the "Belt and Road" cooperation initiative, and in March 2015 officially published "Vision and Action on Jointly Building the Silk Road Economic Zone and the 21st Century Maritime Silk Road". China actively expands the number of countries along the "Belt and Road" Initiative to build a multi-layered hinterland of port economy. With the formulation and implementation of the Belt and Road Policy, Yantai Port along with 14 other ports has become a strong support for this strategic layout. Poland is the largest, most populous country with the highest gross domestic product among the sixteen Central and Eastern European countries. As an important region along the Belt and Road Initiative, Central and Eastern Europe is a significant hub and channel connecting Europe and Asia, while the Gdańsk central port of the city of Gdańsk plans to build a new deep-water wharf, which will allow the largest ships entering the Baltic Sea to dock. For these reasons, the city of Gdańsk will also become a crucial port in Central and Eastern Europe. It has important practical meaning and can provide a typical reference for China to expand cooperation with other countries in Central and Eastern Europe.

Based on the basic principle of data envelopment analysis, this paper chooses relevant data of Yantai Port and the Port Gdańsk, and uses scale-invariant return model (CCR model), variable return model (VRS model), and efficiency model (SE-DEA model) to measure the overall efficiency, pure technical efficiency, scale efficiency of the two ports, and to compare the relatively effective decision making units.

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2. Development status of two ports

After more than 150 years of Yantai Port's development since its opening in August 1861, it has grown into a modern port group with four major port areas. Its functions not only involve basic port businesses such as passenger, cargo transport, warehousing and processing, but also include comprehensive port logistics services such as shipbuilding industry, shipping agent, petroleum strategic reserve and so forth. As the main hub port of the harbour group around the Bohai Sea, Yantai harbour is backed by Beijing, Tianjin, Shandong and Hainan and borders on the main international waterways. It has business contacts with many regions such as South Korea, Japan and Northeast Asia. At present, Yantai Port is the largest timber gathering and distributing base in the north of the river, and it is also the main non-export trade port along the coast of China. Recently, Yantai Port is working on building the FOB Yantai price index of world fertilizer logistics.

The Port of Gdańsk is situated in the central part of the southern Baltic coast – in the region that is among Europe's fastest growing ones.[1] This Polish port is a key link connecting the northern European countries with southern and eastern Europe, as a part of the No. 1 Trans-European Transport Corridor, playing significant role in the European Union Strategy. Gdańsk is centrally located in the southern Baltic, so its situation is crucial for its partners, as it is a major international transportation hub. The town is a capital of the Pomeranian Voivodship and the center of the country's fourth metropolitan area. Gdańsk seaport is one of the four most important seaports in Poland's national economy. In fact it is Poland's principal seaport. This is a commercial port, which regularly provides transportation services to 17 countries and regions. The main parts of its cargo turnover are liquid fuel, general cargo and timber, coal, corn and other goods. The Port of Gdańsk has ferry terminal, coal terminal, liquefied gas terminal and container terminal.

3. Operating performance of the two major ports

The production and operational performance of ports are generally measured by major economic indicators such as cargo handling capacity, container handling capacity and passenger throughput.[2] The following three indicators are examined and compared. The cargo handling capacity of both ports is presented in fig. 1.

1 https://www.portgdansk.pl/about-port/general-info (accessed: 26.10.2020).

2 China Yearbooks Full-text Database, "Chinese Academic Journal" (CD version) edited and published by e-magazine", 2008–2018.

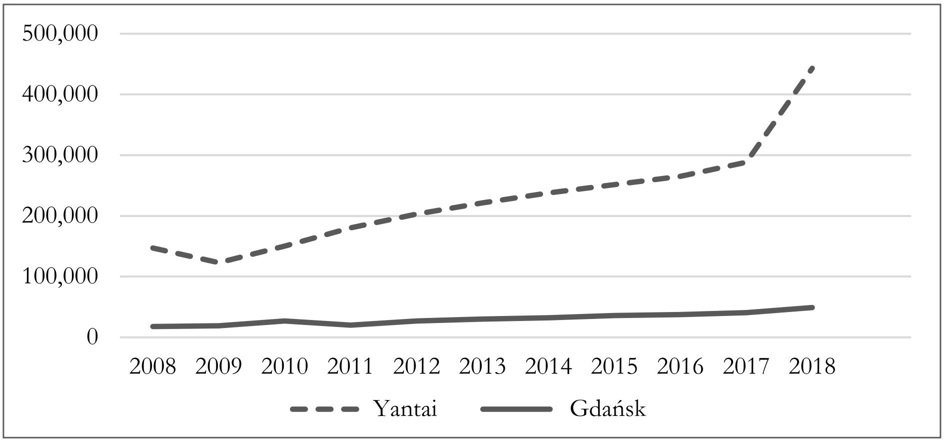

Fig. 1. Cargo handling capacity of the two ports in 2008–2018 (thousand tons)

Source: China Port Yearbook, "Chinese Academic Journal" (CD version) edited and published by e-magazine, 2008–2019.

The cargo handling capacity of Yantai Port was increasing significantly from 2008 to 2018. In 2009, the cargo handling capacity of Yantai Port decreased, but in 2010 it began to rise again. By comparison, Gdańsk's cargo handling capacity has been stable, and from 2008 to 2018 Gdańsk neither had a clear upward trend nor had a significant decline.

Container throughput of Yantai Port and the Port of Gdańsk is shown in fig. 2.

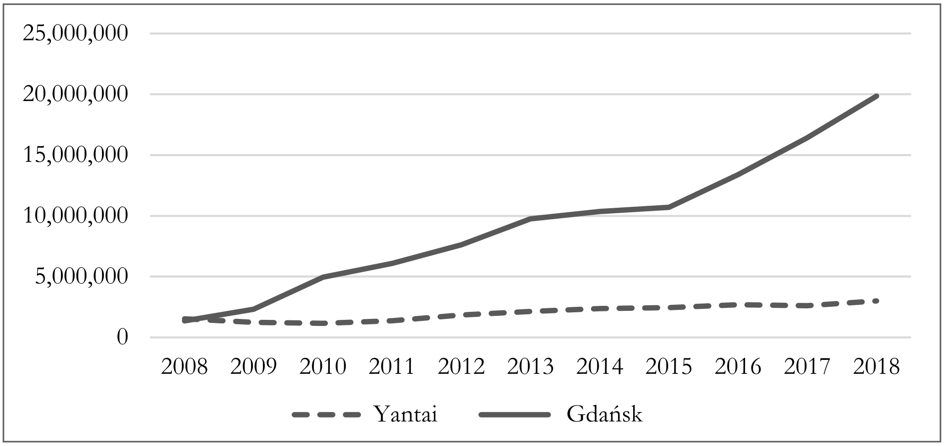

Fig. 2. Container throughput of the two ports in 2008–2018 (tons)

Source: China Port Yearbook, "Chinese Academic Journal" (CD version) edited and published by e-magazine, 2008–2019.

As shown in fig. 2, the freight throughput of Yantai Port was increasing significantly from 2008 to 2018. In 2009, the freight through put of Yantai Port decreased, but the it began to rise again in 2010. By comparison, Gdańsk's freight throughput has been stable, and from 2008 to 2018 neither Gdańsk had a clear upward trend nor had a significant decline.

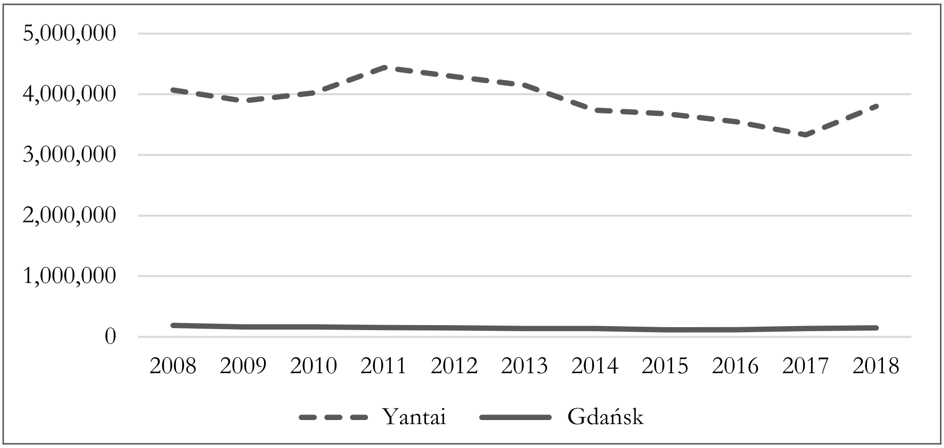

Fig. 3. Passenger throughput of the two ports in 2008–2018

Source: China Port Yearbook, "Chinese Academic Journal" (CD version) edited and published by e-magazine, 2008–2019.

As shown in fig. 3 from 2008 to 2011, the passenger throughput of Yantai Port increased, but from 2012 to 2017, the passenger throughput of Yantai Port began to show a downward trend, and in 2018 it began to show an upward trend gradually. However, the passenger throughput of the Port of Gdańsk has shown a steady trend from 2008 to 2018, with no significant increase or decrease.

4. Necessity of research efficiency evaluation

Port operation efficiency is an important indicator of port competitiveness. It is of practical significance to evaluate port operation efficiency. Firstly, the efficiency evaluation can provide valuable information, for instance the theoretical basis and policy suggestions for relevant departments to formulate rational planning, targeted development strategy and accurate monitoring measures. Secondly, it is a powerful tool to improve management performance, help ports to judge the differences between themselves and other ports, promote inefficient ports to reflect on and solve systemic problems, target performance improvement, adjust structure, reduce input redundancy, save costs etc., effectively improve operational efficiency and competition.

Finally, it is helpful to optimize the allocation of port resources among port enterprises that is important for the interactive and sustainable development of both port and hinterland economy. This paper evaluates the efficiency of Yantai Port and the Port of Gdańsk on the basis of referring to the existing research documents.

5. Research ideas and model establishment

Since port production and operation is a complex system, there are many efficiency indicators reflecting port competitiveness and production and operation status, which need to be evaluated comprehensively in combination with many indicators. The common evaluation methods include data envelope analysis (DEA), cluster analysis, comprehensive distance evaluation, principal component analysis, etc. DEA is widely used due to its simplicity and convenience. The DEA method was first proposed by Charnes.[3] It is based on the concept of relative efficiency and is used to evaluate the relative validity of several units of the same type. In comparison with the production function method, which is another method to evaluate the efficiency of harbour use, DEA method does not need a prior form of production function with parameters and is more objective. Therefore, it is more suitable for efficiency analysis with multiple inputs and outputs. In addition, we can use the DEA projection theorem to improve the evaluation objects on the basis of assessing the efficiency of each unit, so as to make scientific management decisions, which is also a shortage of other methods mentioned above.

In the DEA model, the evaluated units are called Decision Making Units (DMU). DMU can be divided into three categories according to the results of model solving: DEA is effective, DEA is relatively effective, and DEA is invalid. We can sort DMU and diagnose problems in production process of non-DEA effective decision units to get effective decision information.[4] Based on the basic principles of data envelopment analysis, this paper uses scale-based remuneration invariant model (CCR model), Variable Returns to Scale model (VRS model), Non-Increasing Returns to Scale model (NIRS model), and super-efficiency DEA model (SE-DEA model) measures the comprehensive efficiency, pure technical efficiency and scale efficiency of Yantai Port and the Port of Gdańsk, and compares the relatively effective decision-making

[3] A. Charnes, W.W. Cooper, E. Rhodes, *Measuring the efficiency of DMU [J]*, "European Journal of Operational Research" 1978, no. 2.

[4] P. Andersen, N.C. Petersen, *A Procedure for Ranking Efficient Units in Data Envelopment Analysis [J]*, "Management Science" 1993, no. 39.

units. Finally, based on the analysis results, relevant improvement regarding directions and policy recommendations are put forward.

5.1. DEM-CCR model

The general linear programming form of the CCR model is expressed as follows:

$$\min \theta$$

$$s.t. \sum_{j=1}^{n} \lambda_j x_j + s^- = \theta x_0$$

$$\sum_{j=1}^{n} \lambda_j y_j - s^+ = y_0$$

$$\lambda_j \geq 0, j = 1, 2, \ldots, n$$

$$s^+ \geq 0, s^- \geq 0$$

Set the input and output vectors corresponding to the j decision unit $DMU_j (1 \leq j \leq n)$ to be $x_j = \left(x_{1j} + x_{2j} + \ldots x_{nj}\right)^r \geq 0, j = 1, 2, \ldots, n, Y_j = \left(y_{1j}, y_{2j}, \ldots, y_{nj}\right)^r \geq 0$, that is, x_{ij} is the input of the j unit to the input of the i unit, y_{rj} is the output of the i unit to the output of the r unit, and each decision making unit has m types of input and s types of output, where s^- is the vector composed of relaxation variables corresponding to the input. While s^+ is a vector consisting of relaxed variables corresponding to the output.[5]

The non-Archimedes infinitesimal CCR model is mainly used to evaluate the overall efficiency of DMU, and its optimal solution is λ^*, S^{*-}, S^{*+}, θ^*. If $\theta^* = 1$ DMU_{ij} being a relatively effective DEA, indicating that some inputs of decision making unit are in the minimum state, all inputs cannot be reduced in the same proportion, but there is still the possibility of structural adjustment of inputs and outputs. If $\theta^* = 1$, $s^{*-} = 0$, $s^{*+} = 0$, DMU_0 is effective for DEA, which means that it is impossible to reduce various inputs equally or individually without reducing output. If $\theta^* \leq 1$, or $s^{*-} \neq 0$, DMU_0 is non-DEA effective, indicating that DMU_0 can achieve the same proportion of input reduction while maintaining the same output, there is less input to achieve the same output.

[5] Pang Ruizhi, *Dynamic efficiency evaluation of major coastal ports in China [J]*, "Economic Research" 2006.

5.2. DEM-VRS model

Assuming the same scale in CCR model, VRS model with variable scale reward is used to measure pure technical efficiency of DMU. The model is represented as follows:

$$\min\left\{\theta_v - \varepsilon\left(\hat{e}^T s^- + e^T s^+\right)\right\} = V_{D_t}$$

$$s.t.\sum_{j=1}^{n} \lambda_j x_j + s^- = \theta_i x_0$$

$$\sum_{j=1}^{n} \lambda_j y_j - s^+ = y_0$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0, j = 1, 2, ..., n$$

$$s^+ \geq 0, s^- \geq 0$$

Among them, θ_v represents the pure technical efficiency level of DMU. If $\theta_v^* = 1$, $s^{*-} \neq 0$, $s^{*+} \neq 0$, then DMU_0 is productive technology weak efficiency.

5.3. SE-DEA model

Since CCR models may have multiple relatively valid decision making units at the same time and cannot be further evaluated, Andersen and Petersen have improved the CCR model by proposing a super-efficiency model (SE-DEA) to solve effectively the direct comparison problem between relatively valid units. In comparison with the CCR model, the main improvements of the SE-DEA model are when evaluating the efficiency of a decision unit j_0, replace its inputs and outputs with a linear combination of inputs and outputs of all other decision making units. The decision-making units remain relatively effective when increasing input.[6] The proportion of input they increase is the super-efficiency value. We can sort the effective decision-making units according to the size of the super efficiency value. The super efficiency model formula is as follows:

[6] Zhang Xingxiang, Zheng Xiaojia, *Evaluation and Comparison of Port Efficiency – Taking Fujian Three Major Ports as Examples [J]*, "Journal of the Party School of CPC Xiamen Municipal Committee" 2014.

$$\min\left[\omega-\varepsilon\left(\hat{e}^{T}s^{-}+e^{T}s^{+}\right)\right]$$

$$s.t.\sum_{\substack{j=1\\ j\neq j_0}}^{n}\lambda_j x_j+s^{-}=\omega x_0$$

$$\sum_{\substack{j=1\\ j\neq j_0}}^{n}\lambda_j y_j-s^{+}=y_0$$

$$j\geq 0,\ j=1,2,\ldots,n$$

$$s^{+}\geq 0, s^{-}\geq 0$$

ω represents the efficiency index of a relatively effective DMU, and other mathematical symbols have the same meaning as the previous model.

5.4. Data sources and index selection

Table 1. Relevant data of two major port efficiency evaluation indexes

City	**Year**	**Cargo handling capacity (thousand tons)**	**TEU (tons)**	**Passenger throughput**	**Means of production terminal length (meter)**	**Number of means of production terminal**
		output			**input**	
Yantai	2008	146,990	1,532,000	4,070,000	12,897	71
Gdańsk	2008	17,781	1,361,693	188,392	1,300	38
Yantai	2009	123,000	1,229,282	3,890,000	13,866	72
Gdańsk	2009	18,863	2,321,910	164,630	1,300	38
Yantai	2010	150,326	1,160,914	4,020,000	14,166	75
Gdańsk	2010	27,182	4,947,223	164,331	1,300	38
Yantai	2011	180,289	1,379,020	4,440,000	16,140	82
Gdańsk	2011	20,305	6,100,512	154,651	1,300	38
Yantai	2012	202,976	1,850,500	4,290,000	17,020	85
Gdańsk	2012	26,898	7,629,909	150,099	1,300	38
Yantai	2013	221,572	2,150,000	4,150,000	17,911	88
Gdańsk	2013	30,259	9,745,259	136,378	1,300	38
Yantai	2014	237,667	2,361,200	3,740,000	17,911	88

Table 1. cont.

City	Year	Cargo handling capacity (thousand tons)	TEU (tons)	Passenger throughput	Means of production terminal length (meter)	Number of means of production terminal
		output			input	
Gdańsk	2014	32,278	10,366,114	137,784	1,300	38
Yantai	2015	251,630	24,500,00	3,680,000	17,911	88
Gdańsk	2015	35,914	10,706,301	118,354	1,300	38
Yantai	2016	265,370	2,700,000	3,550,000	19,494	94
Gdańsk	2016	37,289	13,398,464	117,238	1,300	38
Yantai	2017	288,160	2,600,000	3,330,000	32,550	195
Gdańsk	2017	40,614	16,412,287	137,346	1,300	38
Yantai	2018	443,080	3,002,000	3,802,000	33,474	197
Gdańsk	2018	49,032	19,850,762	148,294	1,300	38

Source: China Yearbooks Full-text Database, "Chinese Academic Journal" (CD version) edited and published by e-magazine, 2008–2018; Gdańsk data is on the basis of website of the Port of Gdańsk 2008–2018.

At present, the international commonly used port output indicators mainly include cargo handling capacity, container throughput, user satisfaction, etc. Port input indicators usually select labour, land, capital for consideration. Port berth length, berth number etc. are important measurement indicators of capital input. Based on the availability and accuracy of data, we select port cargo throughput, container throughput as output indicators, and select production berth length and production berth number as input indicators to analyze the effectiveness of Yantai Port and the Port of Gdańsk.

5.5. Empirical result analysis

5.5.1. Making analysis of two ports on relative efficiency

Table 2. Results of Port Efficiency Evaluation

City	Year	Comprehensive technical efficiency	Pure technical efficiency	Scale efficiency	Returns to Scale
Yantai	2008	1.000	1.000	1.000	–
Gdańsk	2008	0.620	1.000	0.620	irs

Table 2. cont.

City	Year	Comprehensive technical efficiency	Pure technical efficiency	Scale efficiency	Returns to Scale
Yantai	2009	0.942	0.948	0.994	drs
Gdańsk	2009	0.590	0.894	0.660	irs
Yantai	2010	0.949	0.956	0.992	drs
Gdańsk	2010	0.711	0.943	0.754	irs
Yantai	2011	0.993	1.000	0.993	drs
Gdańsk	2011	0.592	0.877	0.675	irs
Yantai	2012	0.994	1.000	0.994	drs
Gdańsk	2012	0.680	0.874	0.778	irs
Yantai	2013	0.986	1.000	0.986	drs
Gdańsk	2013	0.703	0.83	0.847	irs
Yantai	2014	0.976	0.981	0.995	drs
Gdańsk	2014	0.735	0.848	0.866	irs
Yantai	2015	1.000	1.000	1.000	–
Gdańsk	2015	0.751	0.779	0.965	irs
Yantai	2016	0.989	1.000	0.989	drs
Gdańsk	2016	0.769	0.782	0.984	irs
Yantai	2017	0.586	0.855	0.686	drs
Gdańsk	2017	0.863	0.904	0.954	irs
Yantai	2018	0.883	1.000	0.883	drs
Gdańsk	2018	1.000	1.000	1.000	–
Mean		0.832	0.930	0.892	–

Source: China Yearbooks Full-text Database, "Chinese Academic Journal" (CD version) edited and published by e-magazine, 2008–2018; Gdańsk data is on the basis of website of the Port of Gdańsk 2008–2018. All calculations made by the author herself.

In terms of efficiency of the two ports, this paper considers each year from 2008 to 2018 as a decision-making unit. Based on the CCR and VRS models established above, DEAP software is used to calculate the efficiency index values as shown in table 2.

Firstly, it is clear that each of the efficiency is worth quantifying: comprehensive technical efficiency = pure technical efficiency * scale efficiency. It is also necessary to note that if return to scale increases, the efficiency index is the same as the comprehensive efficiency; if the return to scale decreases, the efficiency index is the same as pure technical efficiency; if return to scale does not change, the efficiency index is equal to 1.[7]

It is shown in the table 2 that from the perspective of comprehensive technical efficiency, first of all, the overall average value of the two ports is 0.832. It indicates that under the existing input conditions, the overall industrial efficiency of the two ports still has a large room for growth and improvement. The scale efficiency and pure technology efficiency of the two ports are 0.93 and 0.892 respectively. Therefore, it indicates that the overall management level of the regional industry needs to be strengthened, and the scale of operation is not reasonable. Yantai Port was an effective DEA in 2008 and 2015. In 2011, 2012, 2013, 2016 and 2018, the pure technical efficiency was 1, which is larger than the scale efficiency in these years respectively. This shows that in order to improve the comprehensive technical efficiency of Yantai Port, the attention must be paid to making the scale of port industry's development reasonable. From the perspective of return to scale, except for 2008 and 2015, the return to scale of Yantai Port has been in a declining state. If the scale of the port is further enlarged, the problem of waste of resources and reduction of comprehensive technical efficiency may occur. Therefore, the problem can be solved only by rational allocation.

The Port of Gdańsk was only effective DEA in 2018, and the pure technical efficiency was only 1 in 2008. From the perspective of pure technical efficiency, the pure technical efficiency of the Port of Gdańsk was greater than the scale efficiency in each of the years in the period 2008–2012 respectively. It means that in order to improve the comprehensive technical efficiency of the Port of Gdańsk, we must focus on making the development scale of the port industry reasonable. Furthermore, the pure technical efficiency of the Port of Gdańsk was less than the efficiency of scale in each of the years 2013–2017 respectively. It indicates that the level of management and management of the Port of Gdańsk is low and the resource allocation capacity is insufficient. From the perspective of the return to scale, the return to scale of the Port of Gdańsk has been increasing. Increasing returns to scale further expand the scale of the port industry in Gdańsk, thus the overall technical efficiency of the Port of Gdańsk will increase.

[7] He Binghua, *Research on Ningbo Port Logistics Development Strategy under the Background of the Belt and Road Initiative*, "Journal of Zhejiang Business Technology Institute" 2019.

5.5.2. Analysis of the two ports on super efficiency

Table 3. Super efficiency of the two ports

Port	Year	Score	Rank
Gdańsk	2018	1.209506146	1
Yantai	2008	1.113141959	2
Yantai	2015	1.043642282	3
Yantai	2012	0.993760008	4
Yantai	2011	0.993312341	5
Yantai	2016	0.988619619	6
Yantai	2011	0.986016074	7
Yantai	2014	0.975664512	8
Yantai	2010	0.948781994	9
Yantai	2009	0.942499317	10
Yantai	2018	0.882734625	11
Gdańsk	2017	0.862531441	12
Gdańsk	2016	0.769019748	13
Gdańsk	2015	0.751048905	14
Gdańsk	2014	0.734994609	15
Gdańsk	2010	0.711185976	16
Gdańsk	2013	0.702792902	17
Gdańsk	2012	0.679857404	18
Gdańsk	2008	0.619693016	19
Gdańsk	2011	0.592162891	20
Gdańsk	2009	0.590136817	21
Yantai	2017	0.586369252	22

Source: China Yearbooks Full-text Database, "Chinese Academic Journal" (CD version) edited and published by e-magazine, 2008–2018; Gdańsk data are presented on the basis of website of Port of Gdańsk from 2008–2018. All calculations are made by the author herself.

On the basis of calculating the relative validity of each decision making unit, we use LINDO software to calculate the super-efficiency value of each effective unit according to the SE-DEA model and further rank the effective decision making units. The ranking of production and operation capacity of relative effective decision making units of ports is shown in table 3.

The production and operation status of the Port of Gdańsk in 2018 was the best in the past 10 years, and the production and operation status of Yantai Port in 2008 and 2015 ranked second and third. This calculation result is also consistent with the previous analysis. Relying on the hinterland of economic development, Yantai Port has sufficient sources of funds. It is a step forward in port construction and reform. After the Sino-foreign joint venture integration of Yantai Port in 2015, the port efficiency of Yantai Port has been improved. The integration of Yantai Port achieved good results in 2015, which can be effectively proved from the DEA in 2015. The production and operation of the Port of Gdańsk reached the DEA effectiveness in 2018. Although the score of the effective decision-making unit ranked first, in this decade, it achieved the first substantial and breakthrough progress. This is not the time to adjust the production scale. It has a certain relationship and has also promoted the development of the Port of Gdańsk to a certain extent.

6. Conclusions and policy recommendations

Based on the data envelopment analysis (DEA) model, this paper evaluates the efficiency of the two major ports, Yantai Port and the Port of Gdańsk. From 2008 to 2018, there was a big difference in the efficiency indicators of the two major ports. Two decision-making units in Yantai Port achieved DEA effectiveness, and one decision-making unit in the Port of Gdańsk achieved DEA effectiveness. In terms of the comprehensive technical efficiency rankings of Yantai and Gdańsk ports, most of the comprehensive technical efficiency is not 1, and both have good performance in terms of pure technical efficiency and scale efficiency, indicating that these two ports still have room for improvement.

In general, the integration of Yantai Port was relatively successful, and various efficiency indicators still showed a good trend after the port integration, which provided a reference for the port integration of the Port of Gdańsk. In order to improve the operation efficiency, the Port of Gdańsk must further improve the comprehensive technical efficiency, promote the informationization[8] and the automation of port logistics operations which means that automation and informationization rely on modern port equipment to maximize cargo throughput, and improve the port operation efficiency. At the same time, Yantai Port should appropriately improve its internal management level at the current stage. Moreover, it should introduce advanced management technology, adopt new management information systems, reduce the scale of port production, and make reasonable and effective adjustments to the port structure.

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[8] Informationization is the historical process of making full use of information technology, developing and utilizing information resources, promoting information exchange and knowledge sharing, improving the quality of economic growth and promoting the transformation of economic and social development.

6.1. Suggestions for port development based on the Belt Road Initiative

In the context of the in-depth implementation of the Belt and Road strategy, we should leverage our own advantages, accelerate port upgrades, and focus on the quality of modern port and its supply chain services. In the era of economic globalization, the competition between ports is not just a competition in cargo throughput. To be invincible in the new round of challenges, Yantai Port and the Port of Gdańsk should form their own logistics characteristics and pay attention to the construction of supply chain service quality.

Under the guidance of the comprehensive strategic partnership framework between China and Poland, we will work to strengthen strategic cooperation between Yantai and Gdańsk, set up offices with each other, establish a coordination mechanism, and coordinate all cooperation matters in an all-round way. Secondly, we should promulgate supporting policies on trade, logistics, cross-border e-commerce, customs clearance, etc. to form cohesion, which will drive other countries along the line (cities, regions) to join, and achieve greater policy collaboration. In addition, we should build a cross-regional cooperation mechanism, promote the information exchange between Yantai and Gdańsk, unify regulatory standards, optimize regulatory processes, and build an integrated cross-regional cooperation mechanism.

There are three main factors to be taken under consideration. The first one is to promote efficient and convenient customs clearance services and create a unified logistics service information platform. The second one is to strengthen policy coordination with major Polish ports and cities, and vigorously promote the application of unified information standards in transportation and port logistics. The main aim of the first factor is to effectively establish a cooperation platform and liaison mechanism between the Chinese customs and the customs of Poland and Central and Eastern European countries, improve and unify the regulatory rules and standards, clarify legal responsibilities, and simplify the customs clearance process. The aim of the second factor is to strengthen the good cooperation with major Polish ports and the "Belt and Road" inland ports, and gradually expand the scope of "direct import and direct export" commodities. The third one is to create a cross-regional logistics integrated service environment, accelerate the promotion of the whole logistics "one order system" to realize the "one-stop consignment, one year charge, one certification, one order to the end" of the goods, focusing on promoting the "one order system" in cross-region sea-rail combined transport, public-rail combined transport and expect the full implementation of multimodal transport[9].

Under the influence of the in-depth implementation of the "Belt and Road" strategy, Yantai puts forward a major strategic decision to build a port economic

[9] Zou Lu, *Analysis of Yantai Port Group's Development Strategy under the Background of "One Belt and One Road"*, „China Academic Journal Electronic Publishing House" 2016.

circle and vigorously expand the economic zone of sixteen countries in Central and Eastern Europe. The two sides can strengthen communication and cooperation in policy coordination, industrial cooperation, transportation interconnection, rapid customs clearance, cultural exchanges, etc. to build a connection between Yantai Port and the Port of Gdańsk. The efficient multimodal transport system finally achieved a mutually beneficial and win-win cooperation between the Port of Gdańsk and Yantai Port.

STRESZCZENIE

OCENA I PORÓWNANIE WYDAJNOŚCI PORTU YANTAI I PORTU GDAŃSK NA PODSTAWIE POLITYKI OBOWIĄZUJĄCEJ W RAMACH INICJATYWY PASA I SZLAKU

W artykule poddano analizie interesy handlowe Portu Gdańskiego oraz Portu Yantai z punktu widzenia ich wydajności, korzystając z jakościowych i ilościowych metod badawczych. W oparciu o teorię wydajności w ekonomii zachodniej wyjaśniono przede wszystkim znaczenie wydajności portów oraz dokonano analizy, wskazując na wydajność operacyjną portu, wydajność konfiguracji sieci portowej oraz wydajność promieniowania portu w głąb lądu. Wykazano wzrost wydajności badanych portów oraz systematyczne obniżanie uogólnionych kosztów transportu. Aby zwiększyć porównywalne korzyści z handlu, zastosowano efekt zachęty eksportowej, efekt redukcji barier importowych oraz efekt agregacji-dyfuzji. Na podstawie powyższych wskaźników szacuje się odpowiednio poziom wydajności portów w Yantai i w Gdańsku. Do pomiaru ogólnej wydajności, wydajności czysto technicznej, wydajności skali obu portów oraz do porównania stosunkowo efektywnych jednostek decyzyjnych stosuje się model oparty na skali zwrotu (model CCR), model zmiennego zwrotu (model VRS) i model wydajności (model SE-DEA).