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Multi-criteria Analysis of the Competitiveness of Major Baltic Sea Container Terminals

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Abstract

The rapid growth in the volume of international container transport requires that the entire transport chain become more competitive, including maritime container terminals. The aim of the article is to identify the number and location of major Baltic container terminals and to perform a multi-criteria analysis of the competitiveness of maritime container terminals in the Baltic Sea Region (BSR). In our study, we perform the AHP multi-criteria analysis with subjective criteria weights, as well as the entropy method with objective criteria weights. Thus, we can evaluate the competitive advantages of each of the specified terminals in the region. We are among the first to study the competitiveness of individual maritime container terminals in the BSR. Thus, our research adds to the literature that has yielded results on the competitive advantage of the Baltic seaports.

Keywords: maritime container terminals, Baltic Sea, competitiveness, multi-criteria analysis, AHP, entropy

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Introduction

In 2020, 815.6 million twenty-foot containers (twenty-foot equivalent units – TEUs) were handled in ports worldwide, with the top 15 handling 76.8 million TEUs (2.8% less than in 2019). Although world container port throughput declined by 1.2% after the COVID–19 pandemic, this reduction is moderate compared to other shipping market segments and total seaborne trade (Notteboom 2021; UNCTAD 2021). Maritime container transportation will continue to grow because of economic growth and globalization, increased demand for this kind of transport, and the growing emphasis on efficient and environmentally friendly transport.

The intensive development of container transport increased the competitiveness of the entire transport chain, including maritime container terminals. Since the Baltic Sea is one of the most exploited water areas in terms of transport in the world (Klimek and Dąbrowski 2018, p. 1), it is worth comparing and evaluating the competitiveness of selected Baltic container terminals.

Competitiveness is a measure of past efficiency (Bernacki 2003, p. 56). Both Polish and foreign researchers are interested in the competitiveness of seaports, and some have contributed to the academic literature by conducting a thorough literature review on the subject. For example, Luo, Chen, and Zhang (2022) reviewed the relationships between port competition, cooperation, and competitiveness, while Baştuğ et al. (2022) undertook a 20-year-long literature search in peer-reviewed journals to identify the competitiveness criteria of both carriers and terminal operators. Ignasiak-Szulc, Juščius, and Bogatova (2018) developed an evaluation model of seaport performance to make it possible to assess the financial situation of the organization and determine its position in the market in relation to its competitors. On the other hand, Kaliszewski et al. (2021) aimed to understand forwarders' perceptions of competitiveness factors by surveying the global forwarder community using a unique snowball-like method.

Other authors have concentrated on a more empirical approach. Most recently, Li et al. (2021) empirically examined the relationship between dry port logistics supply chain integration, its operational performance, and dry port competitiveness in China. Zhao and Yu (2021) used principal component analysis to analyze 14 main coastal ports in China to clarify the position of Qingdao port in the whole country and to analyze its development potential. Meanwhile, Castelein, Geerlings, and Van Duin (2019) analyzed the Rotterdam container handling sector and described how pressures for competition and cooperation conflict, what problems this causes, and how they can be resolved. Using both linear regression and factor analysis, Haezendonck and Langenus (2019) analyzed the competitive advantages of the Antwerp port cluster for its integrated hinterland network area on data of fifty-nine port experts. Kusuma and Tseng (2019) investigated the impact of the "sea toll" program on seaport resilience and competitiveness through an online survey of key stakeholders of Indonesian seaports, while Mustafa, Khan, and Farea (2019) employed Herfindahl-Hirschman Index (HHI) and Boston consulting group matrix (BCG) approach to analyze and compare different ports. Dang and Yeo (2017) also used the BCG matrix, but to investigate the competitive position of the largest ports in Southeast Asia. Issues such as the impact of using low-sulfur fuel in maritime transport (Vaferi, Ghaderi, and Jeevan 2017), the effectiveness of pro-ecological solutions used in the latest generation of seaports (di Vaio and Varriale 2018), and the impact of dry ports on the effectiveness of marine nodes (Jeevan, Chen, and Cahoon 2019) have also been included in the research on the competitiveness of seaports.

Some authors have used Data Envelopment Analysis (DEA) (Cruz and Ferreira 2016; Kuo, Lu, and Le 2020; Nguyen et al. 2021; Wang et al. 2021) and multi-criteria methods to study the competitiveness of marine reloading and storage bases (Bartosiewicz 2020a; 2020b; Elgazzar and Ismail 2021; Park 2021). At the same time, only a few authors have dealt with the issue of the competitiveness of seaports in the Baltic Sea Region (BSR) (Matczak 2016; Kotowska 2017; Bartosiewicz and Szterlik 2021).

Industry reports and research on the BSR usually consider the annual results achieved by individual ports, ignoring the effectiveness of the terminals that comprise them. Consequently, we decided to identify the Baltic maritime container terminals to determine their competitive position in relation to their biggest competitors in this region. To this end, we used the Analytic Hierarchy Process (AHP) multi-criteria analysis with subjective criteria weights and the entropy method with objective criteria weights. Thus, our research adds to the literature that has yielded results on the competitive advantage of the Baltic seaports.

Maritime container terminals in the Baltic Sea Region

Russia and eight European Union (EU) member states are part of the BSR. The region consists of Scandinavian countries (Denmark, Finland, and Sweden), Germany, Poland, the Baltic countries (Lithuania, Latvia, Estonia) and Russia. Due to shipping connections with the largest ocean ports and developed land transport corridors, the BSR maritime transport system, including the ports that operate in the region, is an important part of the European transport system. At the same time, Baltic ports are intermediaries in trade, not only between the BSR countries but also with the EU single market and the Far and Middle East (Grzybowski 2012).

At the end of 2021, there were more than fifty maritime container terminals in the BSR. Our study considers only those Baltic container terminals whose maximum annual transshipment capacity was over 150,000 TEUs (the *major terminals*).[1] The bounda-

1 The list of Baltic container terminals in 2021 was prepared based on the information provided by European Transport Maps (n.d.).

ry of this division is conventional. For comparison, Karwacka (2011, p. 697) distinguishes three types of terminals: peripheral with a transshipment of several hundred thousand TEUs, regional with a transshipment of over one million TEUs, and large (the continental hubs). Table 1 below lists eighteen major maritime container terminals ordered by country. Among the biggest container terminals, there are no German ones. There are four Russian, three Finnish, three Polish, and three Swedish terminals. At the same time, there are two Lithuanian, one Danish, one Estonian, and one Latvian maritime container terminals with a maximum annual transshipment capacity of over 150,000 TEUs.

Table 1. Eighteen major Baltic container terminals in 2021

Country	Place	Name of the terminal (code)
Denmark (D)	Aarhus	APM Terminals – Cargo Service (APM–T–CS)
Estonia (EE)	Tallin (Maardu)	Muuga Container Terminal (MCT)
Finland (FIN)	Kotka	Kotka (Mussalo CT)
	Helsinki	Vuosaari (Vuosaari) Vuosaari (Steveco)
	Rauma	Euroports Finland (Euroports Finland)
Latvia (LV)	Riga	Baltic Container Terminal Riga (BCT Riga)
Lithuania (LT)	Klaipeda	Klaipeda Container Terminal (KCT Klaipeda)
		Klaipedos Smelte (Smelte)
Poland (PL)	Gdańsk	Deepwater Container Terminal Gdańsk (DCT Gdańsk)
	Gdynia	Baltic Container Terminal Gdynia (BCT Gdynia)
		Gdynia Container Terminal (GCT Gdynia)
Russia (RUS)	St Petersburg	Bronka Container Terminal (Bronka CT)
		Container Terminal Saint–Petersburg (CTSP)
		First Container Terminal (FCT)
		Petrolesport (Petrolesport)
Sweden (S)	Gävle	Gävle Container Terminal (GCT Gävle)
	Gothenburg	APM Terminals Gothenburg (APMT)
	Helsingborg	Västhamnen Container Terminal (Västhamnen)

Source: authors based on European Transport Maps (n.d.).

The competitiveness of a maritime container terminal is influenced by factors such as its technical infrastructure, the work organization of the terminal, the use of advanced information technologies, and the provision of comprehensive logistic services (Urbanyi 2010, p. 1). In our study, we assumed that technical infrastructure is among the most important factors that determine a terminal's efficiency. Thus, in the multi-criteria analysis described below, we include factors such as the length of the quay (c_1), the maximum depth at the quay (c_5), the distance from the nearest motorways, expressways/national roads (c_6), and national railway stations (c_7). We also analyzed superstructural factors (i.e., the number of STS, Ship to Shore (c_3) and RTG, Rubber Tyred Gantry (c_2), cranes) as well as service factors (i.e., the number of short-sea shipping connections (c_4)).

For the first five factors, we obtained data from either the websites of individual terminals or various types of collective studies. We determined the distance from motorways and expressways/national roads, as well as national railway stations, based on our own calculations. To this end, we used navigation programs and digital maps. Table 2 summarizes the data used in the study.

Table 2. Data for eighteen major Baltic container terminals (2021)

Terminal	c_1	c_2	c_3	c_4	c_5	c_6	c_7
APM–T–CS (DK)	1,300	0	8	9	15	4,500	6,700
MCT (EE)	1,096	6	3	6	14.5	1,000	16,100
Mussalo CT (FIN)	1,850	0	9	4	15.3	4,800	6,700
Vuosaari (FIN)	2,500	0	8	14	13	600	16,500
Euroports Finland (FIN)	160	0	2	5	12	900	2,100
BCT Riga (LV)	450	4	5	4	12.5	8,500	5,600
KCT Klaipeda (LT)	820	13	4	5	13.4	4,800	9,800
Smelte (LT)	1,088	12	5	4	13.4	1,100	6,800
DCT Gdańsk (PL)	1,300	40	14	9	17	2,600	10,400
BCT Gdynia (PL)	800	18	6	6	12.7	4,100	3,100
GCT Gdynia (PL)	620	14	6	17	13.5	3,300	2,700
Bronka CT (RUS)	1,220	10	4	4	14.4	1,500	5,500
CTSP (RUS)	972	24	4	2	11.4	4,000	4,600
FCT (RUS)	780	12	7	15	11	2,600	3,000
Petrolesport (RUS)	2,071	26	7	12	11	3,700	4,000
GCT Gävle (S)	680	6	3	4	12.2	8,400	7,900
APMT (S)	1,800	0	10	9	16	1,900	10,300
Västhamnen (S)	770	0	3	11	13	1,600	3,900

Source: authors' elaboration based on European Transport Maps (n.d.) and the websites of individual terminals.

AHP multi-criteria analysis

Methods based on the utility function and on the outranking are among the most important multi-criteria analysis methods of decision-making (Kobryń 2014). The first group of methods applies a "top-down" approach where individual decision variants (alternatives) from each criterion point of view are considered separately and then aggregated into one synthetic indicator (or function). The second group of methods implements a "bottom-up" approach, where first, partial outranking between alternatives are constructed for each criterion separately, and then, overall outrankings are created. AHP belongs to the first group described above, while the family of Preference Ranking Organization Methods for Enrichment Evaluations (PROMETHEE) is an example of the method based on the outranking. The AHP method is presented in more detail later in this section.

Given a set of alternatives (variants, objects) and a set of assessment criteria (and their weights), the AHP method can be performed in five steps: (1) model the problem as a hierarchy, (2) pairwise compare alternatives and criteria, (3) determine local and global preference indexes, (4) test the compatibility of the pairwise comparison matrix, and (5) build the final multi-criteria ranking.

First, we must create the structure of the decision problem. We put the main decision-making goal at the top of the hierarchy. At the second level, there is a set of decision criteria by which the alternatives are compared. All alternatives of the problem are placed at the bottom of the structure.

Next, we must create a pairwise comparison matrix **P** between all alternatives for each criterion separately. We also construct such a matrix separately for all criteria. In the first case, we make comparisons based on the criteria values for each variant, while we compare pairs of criteria by their weights. Elements of matrix **P** are coherent $[p_{i,i}]$ – each element is equivalent to itself ($p_{i,i} = 1$) while the evaluation value of element j respect to element i is the reciprocal of the evaluation value of element i respect to element j ($p_{j,i} = 1/p_{i,j}$). The general form of matrix **P** is shown below:

$$\boldsymbol{P} = \begin{bmatrix} 1 & p_{1,2} & \cdots & p_{1,n} \\ \frac{1}{p_{1,2}} & 1 & \cdots & p_{2,n} \\ \cdots & \cdots & \cdots & \cdots \\ \frac{1}{p_{1,n}} & \frac{1}{p_{2,n}} & \cdots & 1 \end{bmatrix}. \tag{1}$$

When creating matrix **P**, we use a relative grading scale defined by Saaty (2004). We may compare the variants descriptively by assigning an integer value from 1 to 9. The value of *pij* expresses the rank of the relationship between the compared variants, where *pij* = 1 means that variant *i* is equivalent to variant *j*, *pij* = 5 means that variant *j* is strongly preferred to variant *i*, and *pij* = 9 means that variant *j* is absolutely preferred to variant *i*. If quantitative data are available for a given criterion (where the decision vector $\mathbf{q}^{(c)}$ for the criterion *c* is given), the elements of matrix **P** for stimulants are determined according to the formula:

$$p_{ij} = \frac{q_i^{(c)} - q_j^{(c)}}{q_{max}^{(c)} - q_{min}^{(c)}} \cdot 8 + 1 \text{ for } q_i^{(c)} \geq q_j^{(c)} \tag{2}$$

and for destimulants according to the formula:

$$p_{ij} = \frac{q_j^{(c)} - q_i^{(c)}}{q_{max}^{(c)} - q_{min}^{(c)}} \cdot 8 + 1 \text{ for } q_i^{(c)} \leq q_j^{(c)}, \tag{3}$$

where $qi^{(c)}$ and $qj^{(c)}$ are the variants' evaluations for criterion *c*. It means that the elements *pij* take any value from the interval ⟨0, 1⟩.

In the third step of the AHP algorithm, we determine the indexes of local $\omega V^{(c)}$ and global preference ωC. The former correspond to individual rankings of variants for each criterion separately. The global preference index, in turn, sets the final weights for all criteria. We determine the global and local indexes through the normalized matrix $\hat{\mathbf{P}}$, with elements $\hat{p}\, ij$:

$$\hat{p}_{ij} = \frac{p_{ij}}{\sum_{i=1}^{n} p_{ij}}. \tag{4}$$

The local indexes ($\omega V^{(c)}$) for each criterion *c* are calculated according to the formula:

$$\omega_v = \frac{\hat{p}_{ij}}{\sum_{i=1}^{n}\sum_{j=1}^{n} \hat{p}_{ij}}. \tag{5}$$

The indexes of global preference ωC (final weights) are determined respectively according to formulas (4) and (5).

Next, we verify the compliance of the ratings that result from the pairwise comparisons. The consistency of the ratings should be maintained, which means that the relation of transitivity (i.e., if a > b and b > c then a > c) must be fulfilled. To this end, we calculate index *CR* (6). The condition is satisfied when the *CR* value does not exceed 0.1. When we use quantitative data, the condition of consistency is always satisfied.

$$CR = \frac{CI}{RI} = \frac{\lambda_{\max} - n}{RI(n-1)}, \tag{6}$$

where $\lambda_{\max}$ is the maximal eigenvalue of matrix P, and *RI* is the average of *CI* values calculated for a big number of randomly generated matrixes P. The *RI* value can be taken from the Saaty table.

Finally, we must determine a final ranking of variants by calculating the value of the utility function for each variant separately, which is the sum of products of the local index for criterion *c* and its final weight (7):

$$U_v = \sum_j \omega_v^{(c)} \omega_c. \tag{7}$$

Multi-criteria analysis of maritime container terminals

We used the data from Table 2 in the AHP multi-criteria analysis of Baltic container terminals' competitiveness. The goal of the proposed multi-criteria scheme was to indicate the best terminal among $N = 18$ alternatives (CT*i*, where $i = 1, 2, ..., 18$) based on $C = 7$ criteria (*cj*, where $j = 1, 2, ..., 7$). Five of the seven criteria were maximized (stimulants), while two were minimized (destimulants). First, we determined our own weights for each criterion. Table 3 below presents all criteria along with their weights and desired direction.

The biggest weight (8) was assigned to criteria c_1 and c_4 since these parameters significantly affect the efficiency and accessibility of maritime container bases. A slightly lower weight (7) was assigned to the maximum water depth at the quay (c_5), as it is a parameter that determines the size of ships that can call at a given port, consequently affecting the ability to maintain oceanic connections. The c_3 (weight 5) and c_2 (weight 4) criteria were considered the least important as some container terminals use other types of equipment for handling multimodal units at the quay and in the storage yard. The technical equipment of container terminals may include gantry cranes, side lift trucks, front lift trucks, or reach stackers. However, both criteria were included in the analysis because the use of specialized equipment significantly improves the efficiency of container bases. In the last two criteria (the distance from motorways and expressways/national roads, as well as national railway stations), the parameters go to the minimum, and their weight is 6.

Table 3. Criteria selected for the competitiveness analysis along with their weights and desired direction

Criterion	c_1	c_2	c_3	c_4	c_5	c_6	c_7
Direction	max	max	max	max	max	min	min
Weight (w_j[s])	8	4	5	8	7	6	6

Source: authors.

Table 4 presents the AHP ranking for subjective criteria weights. The objects (container terminals) are listed, starting with those with the biggest annual transshipment capacity in TEUs. The table also shows the utility function values for each container terminal.

Table 4. The AHP multi-criteria rankings with utility function values (N = 18 CT) for subjective criteria weights

Terminal	CT_n	*Rank*	U_{CT}
DCT Gdańsk (PL)	CT_1	4	0.0867
Mussalo CT (FIN)	CT_2	7	0.0653
FCT (RUS)	CT_3	6	0.0709
Vuosaari (FIN)	CT_4	1	0.1231
BCT Gdynia (PL)	CT_5	13	0.0343
Bronka CT (RUS)	CT_6	10	0.0444
Petrolesport (RUS)	CT_7	3	0.0880
APMT (S)	CT_8	5	0.0837
CTSP (RUS)	CT_9	15	0.0270
APM–T–CS (DK)	CT_{10}	8	0.0571
MCT (EE)	CT_{11}	11	0.0435
GCT Gdynia (PL)	CT_{12}	2	0.0891
Smelte (LT)	CT_{13}	12	0.0377
KCT Klaipeda (LT)	CT_{14}	16	0.0268
BCT Riga (LV)	CT_{15}	17	0.0201
Euroports Finland (FIN)	CT_{16}	14	0.0327
GCT Gävle (S)	CT_{17}	18	0.0191
Västhamnen (S)	CT_{18}	9	0.0503

Source: authors.

The highest position in the ranking goes to the Vuosaari terminal in Helsinki, with a $U_{CT[4]}$ = 0.1231. The next four places are taken by two Polish terminals, one Swedish and one Russian, with U_{CT} values ranging from 0.0837 to 0.0891. If we consider the values of the utility function, the Finnish terminal has a clear advantage over the next four terminals. Two terminals – BCT in Riga in Latvia and GCT Gävle in Sweden – achieved the worst results.

As mentioned earlier, first, we assigned the criteria weights subjectively, given that the decision-maker can provide scaled preferences of pairs of the decision criteria and alternatives with acceptable inconsistency. Thus, later in our study, we assessed criteria weights another way using the entropy method (Shannon 1948). In this approach, the evaluations of the decision alternatives at a certain criterion determine its relative importance without the direct involvement of the decision-maker. The main idea of this method is that the estimation of a criterion's weight is based on dispersion in the evaluations of the variants at the criterion (Al-Aomar 2010).

Given decision matrix $\mathbf{Q}_{[N\times K]}$, whose elements correspond to the values presented in Table 2, we must create matrix $\mathbf{M}_{[N\times K]}$, where $mij = qij$ for stimulants and $mij = 1/qij$ for destimulants. Next, matrix **M** must be normalized according to formula (4) to obtain matrix $\hat{\mathbf{M}}$. Based on matrix $\hat{\mathbf{M}}$, the degree of the internal divergence of evaluations dj is calculated for each criterion separately (8):

$$d_j = 1 + \frac{1}{\ln N} \sum_{i=1}^{N} \hat{m}_{ij} \ln \hat{m}_{ij}. \tag{8}$$

Finally, we use values dj to determine weights wj for the individual criteria (9):

$$w_j = \frac{d_j}{\sum_{j=1}^{K} d_j}. \tag{9}$$

Importantly, we can correct subjective weights $wj^{[s]}$ by using the weights obtained in the entropy method (10):

$$\overline{w}_j = \frac{w_j w_j^{[s]}}{\sum_{j=1}^{K} w_j w_j^{[s]}}. \tag{10}$$

Considering the formulas presented above, we determined two other sets of criterion weights. Table 5 shows all three sets of weights, where the subjective weights shown in Table 3 were normalized.

Table 5. Three sets of criteria weights

Criterion	c_1	c_2	c_3	c_4	c_5	c_6	c_7
Direction	max	max	max	max	max	min	min
subjective	0.182	0.091	0.114	0.182	0.159	0.136	0.136
entropy	0.094	0.417	0.080	0.104	0.005	0.192	0.107
corrected	0.138	0.304	0.073	0.152	0.007	0.210	0.117

Source: authors.

The values of two weights increased: the number of RTGs and the distance from the main roads. Note the significant increase in the second criterion, where the weight value increased four times and three times to the entropy method and the correction of the initial weights by the entropy method, respectively. On the other hand, the values of the remaining five weights decreased. Among them, there is a significant decrease in the significance of the c_5 criterion (maximum depth at the quay) from 0.159 to 0.005 and 0.007, respectively. Table 6 presents AHP rankings for all sets of weights.

Table 6. The AHP multi-criteria rankings (N = 18 CT) for subjective criteria weights, entropy, and corrected subjective weights

Terminal	CT_n	*Subjective weights*	*Entropy weights*	*Corrected entropy weights*
DCT Gdańsk (PL)	CT_1	4	1	1
Mussalo CT (FIN)	CT_2	7	15	15
FCT (RUS)	CT_3	6	7	6
Vuosaari (FIN)	CT_4	1	5	3
BCT Gdynia (PL)	CT_5	13	6	7
Bronka CT (RUS)	CT_6	10	9	9
Petrolesport (RUS)	CT_7	3	2	2
APMT (S)	CT_8	5	10	10
CTSP (RUS)	CT_9	15	3	5
APM–T–CS (DK)	CT_{10}	8	16	16
MCT (EE)	CT_{11}	11	11	11
GCT Gdynia (PL)	CT_{12}	2	4	4
Smelte (LT)	CT_{13}	12	8	8
KCT Klaipeda (LT)	CT_{14}	16	13	14
BCT Riga (LV)	CT_{15}	17	18	18
Euroports Finland (FIN)	CT_{16}	14	12	12

Terminal	CT_n	*Subjective weights*	*Entropy weights*	*Corrected entropy weights*
GCT Gävle (S)	CT_{17}	18	17	17
Västhamnen (S)	CT_{18}	9	14	13

Source: authors.

There are changes in the rankings if we use a different set of weights. As changes in relation to the first ranking (subjective weights) are clearly visible, the differences between two successive rankings are insignificant. If the entropy method is used, first place goes to Polish terminal DCT Gdańsk, which has a significant advantage over second place Petrolesport (Russia). In both rankings, the next five positions are occupied by two Polish (GCT Gdynia and BCT Gdynia), two Russian (FCT St Petersburg and CTSP St Petersburg) and one Finnish terminal (Vuosaari Helsinki – winner of the first ranking with subjective weights), where U_{CT} values range from 0.0621 to 0.0741.

Finally, we decided to measure the similarity of the three rankings. We used Spearman's rank correlation coefficient r_s (Zeliaś 2000, p. 91):

$$r_s = \frac{6\sum_{i=1}^{N} d_i}{N^3 - N}, \tag{11}$$

where *di* is the difference between the positions in the ranking of a given object and r_s take values from the interval $\langle -1, 1 \rangle$. Values close to 1 indicate a high similarity of rankings. Once again, there is a high similarity when we compare both rankings that used weights obtained through the entropy method. The similarity between the ranking based on subjective weights and the other two rankings can be considered moderate.

Table 7. Values of r_s coefficients

	Entropy weights	*Corrected entropy weights*
Subjective weights	0.552	0.639
Entropy's weights	×	0.987

Source: authors.

Conclusion

This article identified eighteen major maritime container terminals located in the BSR, gathered the information for $C = 7$ criteria related to the technical infrastructure and location of the terminals, and presented the AHP multi-criteria analysis of the terminals' competitiveness. Thus, our research adds to the literature that has yielded results on the competitive advantage of Baltic seaports. More specifically, the goal of the multi-criteria scheme was to indicate the best terminal among $N = 18$ alternatives based on five stimulants and two destimulants. Since the adopted values of the weights of individual criteria are a critical factor in all multi-criteria analyses, the rankings were built based on both the subjective weights of the decision-maker and the objectified weights obtained using the entropy method.

The results allow us to conclude that out of all eighteen terminals, four should be rated the highest: two Polish terminals (DCT Gdańsk and BCT Gdynia), one Russian (Petrolesport), and one Finnish (Vuosaari). On the other hand, three terminals belong to the group of the lowest rated objects: GCT Gävle (Sweden), BCT Riga (Latvia), and KCT Klaipeda (Lithuania). Moreover, if we change the weights from subjective to objective (entropy method), the significant change in the position of four terminals deserves particular attention. Two terminals, CTSP (Russia) and BCT Gdynia (Poland), obtained better positions in the objective ranking, while the position of two other terminals, APM-T-CS (Denmark) and Mussalo CT (Finland), worsened.

Even though the rankings differ, we can identify groups of similarly assessed terminals. Moreover, the Spearman's rank coefficients allow us to conclude that these rankings are at least moderately similar. At the same time, we are aware that our analysis of the competitiveness of maritime container terminals in the BSR may be further developed. Hence, in further stages of the research, we plan, inter alia, to complete the analysis based on other discrete multi-criteria methods. We also plan to analyze the effectiveness of terminals and the use of their potential, and then incorporate the results into an extended multi-criteria analysis.

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Wielokryteriowa analiza konkurencyjności dużych terminali kontenerowych Morza Bałtyckiego

Szybki wzrost wolumenu międzynarodowych przewozów kontenerowych wymusza poprawę konkurencyjności całego łańcucha transportowego, w tym morskich terminali kontenerowych. Celem artykułu jest identyfikacja liczby i lokalizacji głównych bałtyckich terminali kontenerowych oraz przeprowadzenie wielokryteriowej analizy konkurencyjności morskich terminali kontenerowych w regionie Morza Bałtyckiego (RMB). W naszym badaniu zastosowaliśmy metodę AHP, aby uzyskać subiektywną ocenę wag kryteriów, a także metodę entropii, aby uzyskać obiektywne wagi kryteriów. Dzięki temu możemy ocenić przewagi konkurencyjne każdego z wyszczególnionych terminali w danym regionie. Jako jedni z pierwszych badamy konkurencyjność poszczególnych morskich terminali kontenerowych w RMB. Z tego powodu nasze badanie stanowi cenne uzupełnienie innych prac poświęconych identyfikacji przewag konkurencyjnych portów bałtyckich.

Słowa kluczowe: morskie terminale kontenerowe, Morze Bałtyckie, konkurencyjność, analiza wielokryteriowa, AHP, entropia