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MULTICRITERIA EVALUATION OF COMPETITIVENESS OF CONTAINER TERMINALS IN THE BALTIC SEA REGION

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Purpose: After the outbreak of the covid-19 pandemic and Russo-Ukrainian war, the situation in the Baltic Sea Region (BSR) changed, especially regarding maritime container terminals. The aim of the article is to identify major Baltic container terminals and to perform a multicriteria analysis of their competitiveness. The analysis will be carried out before (2019) and after (2022) the turmoil on the market in question.
Design/methodology/approach: The study uses the Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE II) with subjective criteria weights, as well as the entropy method with objective criteria weights.
Findings: The obtained results show that two Polish maritime container terminals, DCT Gdańsk and GCT Gdynia, as well as Finnish Vuossari can be assessed as the most competitive both in 2019 and 2022. At the same time, in the analyzed years, the lowest positions in the rankings were maintained by Swedish GCT Gävle and Västhamnen, Finnish Euroports Finland as well as Latvian BCT Riga.
Research limitations/implications: Limited data availability influenced the choice of criteria used in the study. Moreover, website data sources used in the study may result in the inaccuracy of our calculations. Finally, the subjectivity involved in the selection of chosen criteria and some of their weights could lead to different competitiveness assessment results of maritime container terminals in the BSR.
Practical implications: Our findings should be of interest to terminal operators and managers planning their strategy for next years, especially if they want to maintain their competitive advantage in the region after the lifting of sanctions imposed on Russian ports.
Originality/value: This is the first paper to compare the multicriteria rankings of competitiveness before and after the turmoil on the BSR container market, especially as industry reports and research on the BSR usually consider the annual results achieved by individual ports, ignoring the efficiency of the terminals that comprise them.

Keywords: maritime container terminals, multicriteria analysis, Baltic Sea Region, competitiveness.

Category of the paper: research paper.

1. Introduction

The covid-19 pandemic has clearly affected the maritime transport of containers. In 2020, world seaports handled 2.8% twenty-foot equivalent units (TEU) less than in 2019 (UNCTAD, 2021). Yet, this reduction proved moderate compared to other shipping market segments and total seaborne trade (Notteboom, 2021). Despite the obstruction of the Suez Canal, the shortage of containers on the global market and the high freight rates, already in 2021, the global maritime container market quickly made up for the losses incurred a year earlier.

The recent market situation is much more complicated in the Baltic Sea Region (BSR). Following the global trend, in 2021, the Top 10 Baltic container ports increased the volume of container turnover by 4.56% y/y and handled 9.2 million TEU (Synak, Ołdakowski, 2020; Ziajka, Rozmarynowska-Mrozek, 2021). Yet, after the Russian aggression on the Ukraine in the beginning of 2022, the geopolitical local tension, and a considerable decrease of calls by container carriers to the ports of Russia triggered significant declines in container throughput of Russian ports. The most extensive drops were recorded in the second quarter of the year, when all Russian Baltic ports handled 61.2% TEU less than in the corresponding period of 2021 (Ziajka, Rozmarynowska-Mrozek, 2022).

Considering all the above, the competitiveness between Baltic seaports has recently increased. Thus, for the purposes of this article we decided to identify the leading Baltic maritime container terminals and to determine their competitive position in relation to their biggest competitors in the BSR. To this end, we used the Preference Ranking Organization Method for Enrichment Evaluations (PROMETHEE II) multicriteria analysis with subjective criteria weights and the entropy method with objective criteria weights which will be described in more details in Section 3. Then, we compared the obtained results with the multicriteria rankings of competitiveness for 2019, that is before the turmoil on the BSR container market. It will certainly fill the existing research gap and add to the literature, especially as industry reports and research on the BSR usually consider the annual results achieved by individual ports, ignoring the efficiency of the terminals that comprise them.

The rest of the paper is organized as follows. Section 2 summarizes a literature review of the multicriteria analysis of seaports' competitiveness. Section 3 explains the methods applied in this study. The results are presented in Section 4 while Section 5 presents conclusions and research opportunities.

2. Literature review

Many articles discuss different aspects of seaport competitiveness. Most relevant for this paper are recent studies using different multicriteria methods. For example, Teng, Huang and Huang (2004) tried to clarify the characteristics of a port's competitiveness using Grey Relational Analysis (GRA) model by taking eight East Asian container ports for identification. Guy and Urli (2006), in turn, assessed how port preference is affected by changes in criteria weight and evaluation. Madeira et al. (2012) used factor analysis to reduce the number of criteria necessary in the ordering of container terminals of major Brazilian ports. Then, Lee et al. (2014) attempted to find the factors that reflect strategic investments in terms of port policy and used the Analytic Hierarchy Process (AHP) method to compare eight major container ports throughout five continents. Dyck and Ismael (2015) also used the AHP method, but to evaluate the competitiveness of major ports in the West African region. Acer and Yanginlar (2017), on the other hand, analyzed the performance of 20 container ports operating in Turkey with the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method, using non-financial data from 2015.

More recently, authors started to implement fuzzy Multicriteria Decision Making (MCDM) methods for the evaluation of ports' and shipping industry's competitiveness. Wang et al. (2018) evaluated and ranked the key developmental factors of Shanghai's cruise tourism industry by using an interval-valued fuzzy number method. Then, Liu et al. (2020) used the fuzzy AHP to calculate the weight of the evaluation criteria layer and the concept of fuzzy TOPSIS to create an evaluation method suitable for container carriers to choose the most attractive port. Pamucar and Faruk Görçün (2022), in turn, proposed a fuzzy integrated MCDM approach consisting of the Fuzzy Level Based Weight Assessment (LBWA) and fuzzy Combined Compromise Solution with Bonferroni (CoCoSo'B) techniques. Thus, they evaluated the European container ports and proved that these methods can be implemented to solve the highly complex decision-making problems faced in the maritime industry. Finally, some researchers have recently started to propose their own novel multiple criteria sorting methods. For example, Qin et al. (2022) introduced the ORESTE-SORT method for sorting port group competitiveness and performed sensitivity analysis and comparative analysis with the ELECTRE-SORT method to determine their method effectiveness.

At the same time, only a few authors have yet discussed the competitiveness of maritime container terminals in the BSR. Bartosiewicz (2020) examined the competitiveness of the most important maritime container terminals in Poland and Russia using a strategic group mapping, as well as the AHP and PROMETHEE II methods. Bartosiewicz and Szterlik (2021) performed the multicriteria PROMETHEE II analysis to identify small Baltic container terminals which are in the area of strategic benefits for the analyzed market. Bartosiewicz and Jadczak (2023), in turn, performed the AHP multicriteria analysis with subjective criteria weights and objective criteria weights to evaluate the competitive advantages of major maritime container terminals in the BSR in 2021. In this context, this study adds to the literature as it identifies major Baltic container terminals in 2019 and 2022, as well as determines their competitive position in the BSR before and after the covid-19 pandemic and Russian aggression on Ukraine.

3. Methods

Similarly to Zhang and Wu (2023), this study follows a four-step process for evaluating competitiveness of the maritime container terminals in the BSR, as depicted in Fig. 1. The first step is to collect information for the assessment from multisource website data. The next phase defines the seven assessment criteria: length of the quay, number of RTGs, number of STS cranes, number of shortsea shipping connections, maximum depth at the quay and the distance from the nearest motorways, expressways/national roads, as well as national railway stations. The third stage aims to assign weights to the proposed assessment criteria. The fourth phase uses PROMETHEE II and entropy methods to analytically assess competitiveness of maritime container terminals in the BSR.

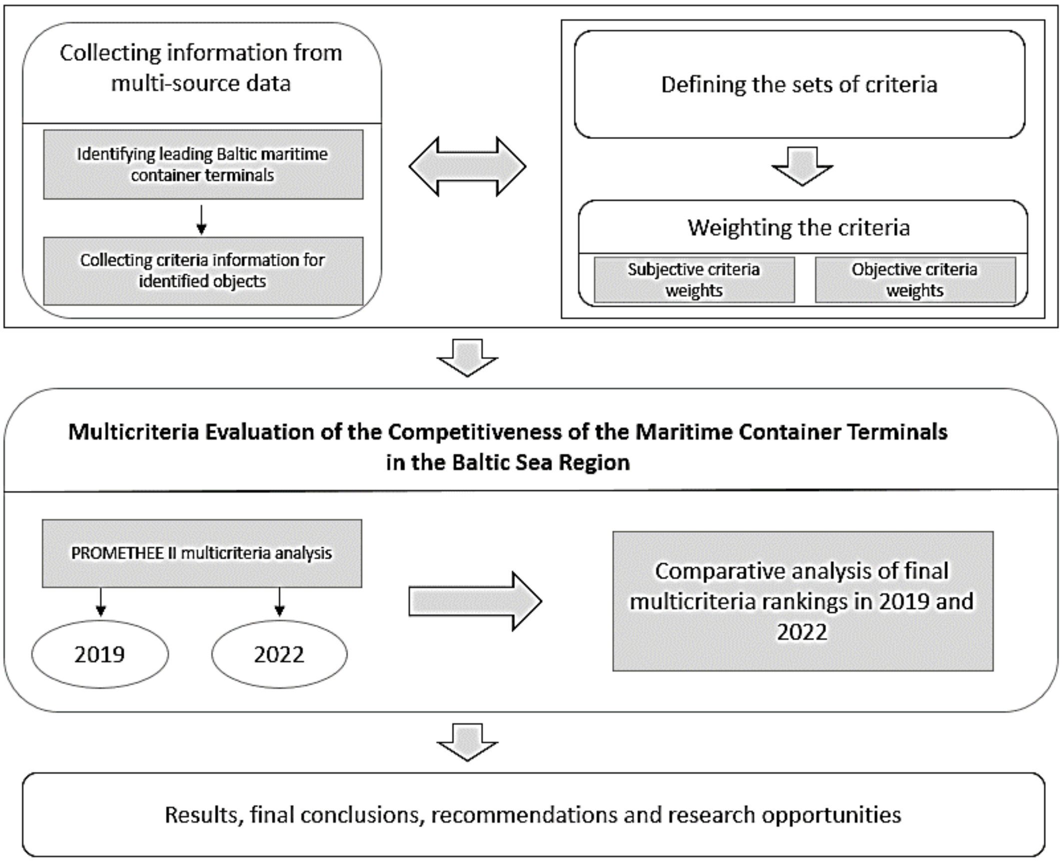

Figure 1. Proposed framework for multicriteria analysis of maritime container terminals in the BSR. Source: own study.

3.1. Data and general problem description

The BSR consists of eight European Union countries (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, and Sweden) and Russia. At the beginning of 2022, there were above fifty maritime container terminals in the described region. Our study considers only those Baltic container terminals whose maximum annual transshipment capacity was over 150,000 TEUs (the major terminals). This means that the number of studied terminals was different in 2019 and 2022 (Table 1). In our multicriteria analysis for 2022 we excluded Russian terminals and included newly built terminal in Stockholm. We had to exclude Russian terminals because, although they are still operating in 2022, their annual TEU turnover is greatly disturbed by the introduced sanctions. For example, container throughput of two biggest St Petersburg's container terminals (FCT, PLP) decreased by about 58% in the second quarter of 2022 comparing to the same period of 2021 (Bruno, 2022). In other words, in 2022, Russian terminals could be no longer included to the group of major terminals with annual turnover over 150,000 TEU. Table 1 below lists terminals chosen for our study. They are ordered alphabetically as registered in 2019 and 2022. Figure 2, in turn, presents the location of all analyzed objects.

Table 1.
Major Baltic container terminals chosen for the study (2019 and 2022)

2019		2022	
symbol	**terminal (country)**	**symbol**	**terminal (country)**
CT_1	APMT Aarhus (DK)	**CT_1**	APMT Aarhus (DK)
CT_2	APMT Gothenburg (S)	**CT_2**	APMT Gothenburg (S)
CT_3	BCT Riga (LV)	**CT_3**	BCT Riga (LV)
CT_4	BCT Gdynia (PL)	**CT_4**	BCT Gdynia (PL)
CT_5	Bronka (RUS)	**CT_5**	DCT Gdańsk (PL)
CT_6	DCT Gdańsk (PL)	**CT_6**	Euroports Finland (FIN, Rauma)
CT_7	Euroports Finland (FIN, Rauma)	**CT_7**	GCT Gävle (S)
CT_8	FCT (RUS, St Petersburg)	**CT_8**	GCT Gdynia (PL)
CT_9	GCT Gävle (S)	**CT_9**	HPS Stockholm (S)
CT_{10}	GCT Gdynia (PL)	**CT_{10}**	KCT Klaipeda (LT)
CT_{11}	KCT Klaipeda (LT)	**CT_{11}**	Klaipedos Smelte (LT)
CT_{12}	Klaipedos Smelte (LT)	**CT_{12}**	Mussalo CT (FIN, HaminaKotka)
CT_{13}	Mussalo CT (FIN, HaminaKotka)	**CT_{13}**	MCT (E, Tallin)
CT_{14}	MCT (E, Tallin)	**CT_{14}**	Västhamnen (S, Helsingborg)
CT_{15}	PLP (RUS, St Petersburg)	**CT_{15}**	Vuosaari (FIN, Helsinki)
CT_{16}	CTSP (RUS, St Petersburg)		
CT_{17}	Västhamnen (S, Helsingborg)		
CT_{18}	Vuosaari (FIN, Helsinki)		

Note. Denmark (DK), Estonia (EE), Finland (FIN), Latvia (LV), Lithuania (LT), Poland (PL), Russia (RUS), Sweden (S).

Source: own study.

Figure 2. Location of major maritime container terminals in the BSR.

Source: own study.

Such factors as technical infrastructure, the work organization of the terminal, the use of advanced information technologies or the provision of comprehensive logistic services influence the competitiveness of a maritime container terminal. This study includes five infrastructural, two superstructural and one service factors. More specifically, the multicriteria PROMETHEE II analysis uses the length of the quay (c_1), the number of RTG, Rubber Tyred Gantry (c_2) and STS, Ship to Shore (c_3) cranes, the number of shortsea shipping connections (c_4), the maximum depth at the quay (c_5) and the distance from the nearest motorways, expressways/national roads (c_6), as well as national railway stations (c_7). For five factors data was obtained from the websites of individual terminals or various types of collective studies. The distance from motorways and expressways/national roads, as well as national railway stations, in turn, was calculated using navigation programs and digital maps. Table 2 lists the proposed criteria with explanation for multicriteria analysis of competitiveness of major maritime container terminals in the BSR. Table 3, in turn, presents the data used in the study. Data for 2022 is given in bracket if any change occurred comparing to 2019.

Table 2.
The proposed criteria with explanation for multicriteria analysis of competitiveness of major maritime container terminals in the BSR

Criterion	Criterion name	Explanation	Units
c_1	length of the quay	the length of berths at which container ships anchor	m
c_2	number of RTGs	the total number of Rubber-Tyred Gantry cranes (RTG)	item
c_3	number of STS	the total number of Ship to Shore cranes (STS)	item
c_4	number of shortsea shipping connections	the number of shortsea shipping regular (linear) connections	item
c_5	maximum depth at the quay	the maximum depth at berths at which container ships anchor	m
c_6	distance from the nearest motorways, expressways/ national roads	distance from the nearest motorways, expressways/ national roads measured in the straight line	m
c_7	distance from the nearest railway stations	distance from the nearest railway stations measured in the straight line	m

Source: own study.

Table 3.
Data for major Baltic container terminals and seven criteria for 2019 (2022)

Terminal	c_1	c_2	c_3	c_4	c_5	c_6	c_7
APMT Aarhus (DK)	1,300	0	8	15 (9)	14 (15)	4,500	6,700
APMT Gothenburg (S)	1,800	0	10	10 (9)	16	1,900	10,300
BCT Riga (LV)	450	6 (4)	4 (5)	9 (4)	12.5	8,500	5,600
BCT Gdynia (PL)	800	20 (18)	8 (6)	9 (6)	12.7	4,100	3,100
Bronka (RUS)	1,220	8 (10)	4	8 (4)	14.4	1,500	5,500
DCT Gdańsk (PL)	1,300	35 (40)	11 (14)	8 (9)	16.5 (17)	2,600	10,400
Euroports Finland (FIN)	160	0	3 (2)	8 (5)	12	900	2,100
FCT (RUS)	780	12	7	12	11	2,600	3,000
GCT Gävle (S)	328 (680)	0 (6)	2 (3)	2 (4)	10.1 (12.5)	8,400	7,900
GCT Gdynia (PL)	620	14	6	15 (17)	13.5	3,300	2,700
HPS Stockholm (S)	(450)	(0)	(2)	(3)	(16.5)	(2,400)	(4,800)
KCT Klaipeda (LT)	820	7 (13)	2 (4)	14 (5)	10 (13.4)	4,800	9,800
Klaipedos Smelte (LT)	1,088	7 (12)	3 (5)	5 (4)	14 (13.4)	1,100	6,800
Mussalo CT (FIN)	1,850	0	7 (9)	8 (4)	15.3	4,800	6,700
MCT (E)	1,094 (1,096)	6	3	10 (6)	14.5	1,000	16,100
PLP (RUS)	2,201 (2,071)	20 (26)	10 (7)	13 (12)	11	3,700	4,000
CTSP (RUS)	787.2	19	4	3	11.4	4,000	4,600
Västhamnen (S)	700 (770)	0	4 (3)	8 (11)	13.5 (13)	1,600	3,900
Vuosaari (FIN)	2,500	0	10 (8)	11 (14)	13	600	16,500

Source: own study.

As we may notice, except for two Russian terminals (FCT, CTSP), at least one criterion has changed for all analyzed terminals in 2022 comparing to 2019. At the same time, criteria c_6 and c_7 have not changed at all. It stems from the fact that the geographical location of analyzed terminals has not changed throughout the analyzed period and at the same time no new road or rail infrastructure was built. Moreover, the number of shortsea shipping connections (c_4) have changed the most frequently while the length of the quay (c_1) and the maximum depth at the quay (c_5) – the least. Surprisingly, in three cases these indicators decreased in 2022 when comparing to 2019 (c_1 for PLP, and c_5 for Klaipedos Smelte and Västhamnen). The difference seems insignificant, though, and may simply be the difference in the way data is presented on the website.

3.2. PROMETHEE II algorithm

In operations research literature, quantitative decision support methods are divided into single-criteria and multicriteria. This is very often a result of the decision problem's nature. In many situations decision-making requires the consideration of at least several decision options, each of which is influenced by several factors that determine its acceptability. Further, multicriteria analysis methods can be divided into methods based on utility function or methods based on superiority relationships. The latter implement a 'bottom-up' approach. We construct an overall superiority relationship between objects based on partial relationships (constructed for each criterion separately). The representative of this group of methods is the POMETHEE II algorithm. The method is presented below in few steps.

Step 1: The objects must be compared in pairs for each criterion separately, which amounts to counting the following differences:

$$d^k(O_{[i]}, O_{[j]}) = O^k_{[i]} - O^k_{[j]} \tag{1}$$

where $O^k_{[i]}, O^k_{[j]}$ denote the ratings of objects i and j for criterion k ($i,j = 1, \dots, M$; $k = 1, \dots, K$).

Step 2: Based on the calculated differences in step 1, so-called pairwise object comparison preferences are created according to a given criterion. This boils down to applying one of the preference functions, the values of which are in the interval [0,1]. The preferences for stimulants and destimulants may be calculated as follows, respectively:

$$P^k(O_{[i]}, O_{[j]}) = F^k\{d^k(O_{[i]}, O_{[j]})\} \tag{2}$$

$$P^k(O_{[i]}, O_{[j]}) = F^k\{-d^k(O_{[i]}, O_{[j]})\} \tag{3}$$

Each preference function has the important property that if $P^k(O_{[i]},O_{[j]}) > 0$ then $P^k(O_{[j]},O_{[i]}) = 0$.

Step 3: When all criteria are considered, calculate aggregated preference indices for each pair of objects $O_{[i]}$ and $O_{[j]}$. This procedure is performed using the formulas:

$$\Pi(O_{[i]}, O_{[j]}) = \sum_{k=1}^{K} w_k \, P^k(O_{[i]}, O_{[j]}) \tag{4}$$

$$\Pi(O_{[j]}, O_{[i]}) = \sum_{k=1}^{K} w_k \, P^k(O_{[j]}, O_{[i]}) \tag{5}$$

This index indicates the extent to which, overall, in terms of all criteria, object $O_{[i]}$ is preferred over object $O_{[j]}$ or object $O_{[j]}$ over object $O_{[i]}$.

Step 4: Calculation of preference flows for each object. First, calculations of positive flows $\Phi^{+}(O_{[i]})$ and negative flows $\Phi^{-}(O_{[i]})$ are performed:

$$\Phi^{+}(O_{[i]}) = \frac{1}{m-1}\sum_{O_{[i]}\in O}\Pi(O_{[i]}, O_{[j]}) \quad (6)$$

$$\Phi^{-}(O_{[i]}) = \frac{1}{m-1}\sum_{O_{[i]}\in O}\Pi(O_{[j]}, O_{[i]}) \quad (7)$$

Positive preference flow should be interpreted as the degree to which object $O[i]$ is superior to all other objects, while negative flow tells which object $O[i]$ is superior to all other objects.

Step 5: In the last step, calculation of net preference flows $\Phi(O_{[i]})$ is performed according to the formula:

$$\Phi(O_{[i]}) = \Phi^{+}(O_{[i]}) - \Phi^{-}(O_{[i]}) \quad (8)$$

The values of the net preference flows of the offers are in the range $[-1,1]$, and their sum is 0. Based on the net preference values, the final ranking of the sites can be constructed by arranging them in descending order of the indicator's value.

In the PROMETHEE II algorithm presented here, step 2 is particularly noteworthy, in which a preference calculation must be performed using appropriate top-down functions. Of the proposed functions, the Gaussian function was used, which is expressed by the formula:

$$P^{k}(O_{[i]}, O_{[j]}) = 1 - exp\left(-\frac{d^{k}(O_{[i]},O_{[j]})^{2}}{2\sigma^{2}}\right) \quad (9)$$

where σ^2 denotes the variance of the scores for the k-th criterion.

The Gaussian function has quite a few advantages over the other functions in the PROMETHEE II method. The preference index reacts approximately linearly for medium values of the preference function, rendering almost proportional relationships for different pairs of objects. In contrast, the preference indices are close to each other within very large values of the preference function. The same is true for minimal differences – here, the preference indices are close to each other.

3.3. Criteria weights

In multicriteria analyses, criteria are given weights to express their importance. These can be adopted arbitrarily using, for example, expert judgements or determined in a more objective way using specific numerical procedures.

Determining the weights of criteria by experts can be done using an ordinal scale, e.g., from 1 to 10, where the least important weight takes the value of 1, and the most important – value of 10. Since the weights are very often the numbers from the range (0,1), their ranking values should be then normalized.

Another way of determining the weights is to use the Saaty scale known in the multicriteria AHP method (Trzaskalik, 2009; Kobryń, 2014). A pairwise comparison matrix **P** between all weights must be created. The property of matrix **P** is cohesion of its elements *[$p_{i,i}$]* which means that each element is equivalent to itself *($p_{i,i}$ = 1)* and the evaluation value of element *i* respect to element *j* is the reciprocal of the evaluation value of element *i* respect to element *j* *($p_{i,i}$ = 1/$p_{i,i}$)*. The general form of the matrix **P** is shown below:

$$\boldsymbol{P} = \begin{bmatrix} 1 & p_{1,2} & \cdots & p_{1,n} \\ \frac{1}{p_{1,2}} & 1 & \cdots & p_{2,n} \\ \cdots & \cdots & \cdots & \cdots \\ \frac{1}{p_{1,n}} & \frac{1}{p_{2,n}} & \cdots & 1 \end{bmatrix} \tag{10}$$

The elements p_{ij} of matrix **P** are set based on a relative grading scale defined by Saaty (2004). The comparison between variants can be made descriptively, to which is assigned an integer value from the set {1,9}. The value of p_{ij} expresses a rank of the relationship between the compared variants, where $p_{ij} = 1$ means the same significance (equivalence) between variant *i* and *j*, $p_{ij} = 5$ means that variant *i* is strongly preferred to variant *j*, and finally $p_{ij} = 9$ means that variant *i* is absolutely preferred to variant *j*. In the next step, normalized matrix $\widehat{\mathbf{P}}$ should be calculated, where its elements $\hat{p}_{ij}$ equal:

$$\hat{p}_{ij} = \frac{p_{ij}}{\sum_{i=1}^{n} p_{ij}} \tag{11}$$

Final weights are determined respectively according to formula:

$$\omega_v = \frac{\hat{p}_{ij}}{\sum_{i=1}^{n}\sum_{j=1}^{n} \hat{p}_{ij}} \tag{12}$$

It is worth noting here that verification of compliance of the ratings resulting from pairwise comparisons should be performed. This compliance is a consistency of ratings in which the transitivity relation is preserved: if a > b and b > c then a > c.

Another method of determining objective weights is based on entropy, the so-called Shannon entropy method, which is taken from information theory (Shannon, 1948). Entropy determines the degree of disorder in a set. It allows the significance of individual criteria to be determined from the divergence of the values of each criterion. The Shannon method consists of several steps (Al-Aomar, 2010). Given a matrix $\mathbf{Q}_{[N\times K]}$, which elements correspond to values of Table 3, first matrix $\mathbf{M}_{[N\times K]}$ must be created with elements $m_{ij} = q_{ij}$ for stimulants and $m_{ij} = 1/q_{ij}$ for destimulants. Next, matrix **M** must be normalized according to the formula (11) to obtain matrix $\widehat{\mathbf{M}}$. Based on elements $\widehat{m}_{ij}$ of the matrix $\widehat{\mathbf{M}}$, in the next step the degree of the internal divergence of evaluations d_j is calculated for each criterion separately:

$$d_j = 1 + \frac{1}{\ln N}\sum_{i=1}^{N} \widehat{m}_{ij} \ln \widehat{m}_{ij} \tag{13}$$

In the last step, values d_j are used to determine final weights w_j for the individual criteria, what is shown below:

$$d_j = 1 + \frac{1}{\ln N}\sum_{i=1}^{N} \widehat{m}_{ij} \ln \widehat{m}_{ij} \tag{14}$$

$$w_j = \frac{d_j}{\sum_{j=1}^{K} d_j} \tag{15}$$

It is also worth noting, that it is possible to correct the subjective weights with the weights obtained by the entropy method:

$$\overline{w}_j = \frac{w_j w_j^{[s]}}{\sum_{j=1}^{K} w_j w_j^{[s]}} \tag{16}$$

where $w_j^{[s]}$ denotes a subjective weight of criterion j obtained, i.e., according to the Saaty's scale.

4. Results

The assumed weight values are of key importance for the final rankings. Therefore, our intention was to build three rankings of the competitiveness of seaports separately for 2019 and 2022. In the first stage, three sets of scales were generated. The first set consists of subjective weights obtained in accordance with the procedure of the AHP method based on the constructed matrix of pairwise comparisons shown below (Table 4). The elements p_{ij} of the matrix represent the decision maker's preferences regarding the significance of criterion i in relation to criterion j.

Table 4.
A pairwise comparison matrix between all weights

Criterion	c_1	c_2	c_3	c_4	c_5	c_6	c_7
c_1	1	5	4	1	2	3	3
c_2	1/5	1	1/2	1/5	1/4	1/3	1/3
c_3	1/4	2	1	1/4	1/3	1/2	1/2
c_4	1	5	4	1	2	3	3
c_5	1/2	4	3	1/2	1	2	2
c_6	1/3	3	2	1/3	1/2	1	1
c_7	1/3	3	2	1/3	1/2	1	1

Source: own study.

The second set of weights is independent of the decision maker. In this case, the Shannon entropy method was used, which is based only on a set of input data. Finally, the third set of weights is a combination of the first two. The weights obtained by the AHP method were corrected by the weights generated by the entropy method. The table below (Table 5) presents a summary of all sets of scales used in further calculations.

Table 5.
Sets of scales used in further calculations

Criterion	c_1	c_2	c_3	c_4	c_5	c_6	c_7
Saaty's scale weights	0.267	0.041	0.061	0.267	0.165	0.100	0.100
Entropy weights	0.100	0.470	0.085	0.066	0.005	0.173	0.101
Corrected weights	0.276	0.197	0.054	0.182	0.009	0.178	0.104

Source: own study.

When changing the set of weights from subjective to entropy and corrected weights, the weight of the number of RTGs (c_2) increased significantly from 0.041 to 0.470 (ten times) and 0.197 (five times), respectively. On the other hand, there is also a significant decrease in the weight of the maximum water depth at the quay (c_5) from 0.165 to 0.005 and 0.009, respectively. The other five weights also changed their values. Three of them (c_1, c_4 and c_6) changed their values in the range of 15-20 pp, while changes in the values of two weights (c_3 and c_7) can be considered small or insignificant.

In the second stage of calculations, rankings of maritime container terminals' competitiveness were generated for 2019 and 2022 separately. Tables 6 and 7 present PROMETHEE II results.

Table 6.
Final rankings of maritime container terminals' competitiveness in the BSR (2019)

Terminal	Saaty's scale weights		Entropy weights		Corrected weights	
	No.	***Φ***	***No.***	***Φ***	***No.***	***Φ***
APMT Aarhus (DK)	4	0.2288	12	-0.1149	7	0.0665
APMT Gothenburg (S)	2	0.2673	10	-0.0486	5	0.1267
BCT Riga (LV)	16	-0.2422	17	-0.3039	17	-0.3192
BCT Gdynia (PL)	11	-0.0210	3	0.2307	9	0.0536
Bronka (RUS)	8	0.0599	7	0.0774	8	0.0654
DCT Gdańsk (PL)	5	0.1690	1	0.4947	2	0.2223
Euroports Finland (FIN)	15	-0.1920	16	-0.1527	16	-0.1620
FCT (RUS)	9	0.0140	5	0.1532	6	0.0985
GCT Gävle (S)	18	-0.5879	18	-0.4700	18	-0.5426
GCT Gdynia (PL)	7	0.1584	4	0.1813	4	0.1289
KCT Klaipeda (LT)	14	-0.1067	14	-0.1452	13	-0.0830
Klaipedos Smelte (LT)	13	-0.0932	9	-0.0362	12	-0.0626
Mussalo CT (FIN)	6	0.1590	15	-0.1470	10	0.0206
MCT (E)	10	-0.0109	11	-0.1055	11	-0.0551
PLP (RUS)	1	0.3103	2	0.4167	1	0.4294
CTSP (RUS)	17	-0.3020	6	0.1389	15	-0.1097
Västhamnen (S)	12	-0.0642	13	-0.1429	14	-0.0977
Vuosaari (FIN)	3	0.2533	8	-0.0261	3	0.2198

Source: own study.

As shown in the obtained rankings for 2019, the Russian terminal Pertolesport (PLP) received the highest positions (1, 2 and 1). The Polish terminal DCT Gdańsk may also be ranked high (positions 5, 1 and 2). The Finnish Vuosaari also scored highly, while Swedish terminal GCT Gävle, the Latvian BCT Riga and the Finnish Euroports recorded the lowest positions (between 15 and 18) regardless of the value of the criteria weights.

Due to different sets of the adopted criteria weights, the positions of individual terminals in the rankings are subject to change. Still, these changes are minor or even imperceptible for some terminals. A certain stability of the position in the obtained rankings is characterized by the following terminals: BCT Riga (LV), Bronka (RUS), Euroports Finland (FIN), GCT Gävle (S), KCT Kleipeda (LT), MCT (E), PLP (RUS) and Västhamnen (S).

The net preference flows Φ enable distinguishing two groups of terminals in each of the rankings: dominant (positive Φ values) and dominated (negative Φ values). In 2019, considering all three rankings, the group of dominant terminals includes always five of them: Bronka (RUS), DCT Gdańsk (PL), FCT (RUS), GCT Gdynia (PL), PLP (RUS). The group of dominated terminals includes always seven of them: BCT Riga (LV), Euroports Finland (FIN), GCT Gävle (S), KCT Kleipeda (LT), Kleipedos Smelte (LT), MCT (E) and Västhamnen (S).

Table 7.
Final rankings of maritime container terminals' competitiveness in the BSR (2022)

Terminal	Saaty's scale weights		Entropy weights		Corrected weights	
	No.	***Φ***	***No.***	***Φ***	***No.***	***Φ***
APMT Aarhus (DK)	4	0.2086	9	-0.0695	7	0.0894
APMT Gothenburg (S)	2	0.2711	7	-0.0073	5	0.1414
BCT Riga (LV)	14	-0.3715	15	-0.2800	15	-0.3723
BCT Gdynia (PL)	12	-0.1485	3	0.1863	10	-0.0185
DCT Gdańsk (PL)	3	0.2650	1	0.5544	2	0.2880
Euroports Finland (FIN)	13	-0.2806	12	-0.1316	12	-0.1903
GCT Gävle (S)	15	-0.3730	14	-0.2743	14	-0.3598
GCT Gdynia (PL)	5	0.1738	2	0.2059	3	0.1718
HPS Stockholm (S)	10	-0.1327	13	-0.1828	13	-0.2316
KCT Klaipeda (LT)	11	-0.1484	6	0.0097	11	-0.0753
Klaipedos Smelte (LT)	8	0.0273	4	0.1705	4	0.1527
Mussalo CT (FIN)	7	0.0875	11	-0.1014	8	-0.0068
MCT (E)	6	0.1112	8	-0.0149	6	0.1285
Västhamnen (S)	9	-0.0017	10	-0.0787	9	-0.0080
Vuosaari (FIN)	1	0.3120	5	0.0135	1	0.2908

Source: own study.

In 2022, we omitted all Russian terminals and included one newly opened Swedish terminal, HPS Stockholm. The obtained results show the strengthening of the high positions in the rankings of the Polish terminal DCT Gdańsk (positions 3, 1 and 2) and the Finnish Vuosaari (positions 1, 5 and 1). The second Polish terminal, GCT Gdynia (positions 5, 2 and 3) joined the top-rated terminals. Like in 2019, three terminals: BCT Riga (LV), Euroports Finland (FIN), GCT Gävle (S) and additionally the Swedish HPS Stockholm took the lowest positions in this ranking (between 12 and 15).

As for the stability of positions in individual rankings in 2022, BCT Riga (LV), DCT Gdańsk (PL), Euroports Finland (FIN), GCT Gävle (S), MCT (E), and Västhamnen (S) occupied relatively similar places in rankings, irrespective of the sets of evaluating criteria weights. For 2022, two Polish terminals, DCT Gdańsk and GCT Gdynia, as well as the Lithuanian Kleipedos Smelte and the Finnish Vuosaari are the dominant ones. Five terminals: BCT Riga (LV), Euroports Finland (FIN), GCT Gävle (S), HPS Stockholm (S), and Västhamnen (S) belong to the dominated group.

Due to the different sets of terminals analyzed in 2019 and 2022, it is difficult to clearly compare specific positions in the rankings obtained by individual terminals. However, based on the analysis of the sign of the net preference flows Φ, we may indicate terminals that were dominant or dominated both in 2019 and 2022. Two Polish terminals, DCT Gdańsk and GCT Gdynia, should be mentioned in this regard as these are the only terminals in all six rankings for which the net preference flows were positive. On the other hand, four terminals: BCT Riga (LV), Euroports Finland (FIN), GCT Gävle (S) and Västhamnen (S) have always been dominated (in all six rankings the net preference flow was negative).

5. Discussion

This study presents a multicriteria analysis of the competitiveness of maritime container terminals in the BSR. To this end, 18 major container terminals in 2019 and 15 in 2022 were analyzed after the prior exclusion of four Russian terminals and the inclusion of one Swedish terminal in 2022. The multicriteria analyses were carried out based on the PROMETHEE II method using a set of seven criteria considered to be the most important and relating to the technical infra- and superstructure. Since multicriteria methods show significant sensitivity to the values of weights assigned to individual criteria, three rankings were built for each year based on subjective and objectified weights (resulting from the collected input data).

Even though the obtained rankings used different sets of weights and thus show some differences, it was possible to identify groups of similarly rated terminals. The obtained results show that two Polish maritime container terminals can be assessed as the most competitive both in 2019 and 2022. These are DCT Gdańsk and GCT Gdynia. The high competitiveness of these terminals is visible in all rankings, regardless of the weights' values. In addition, after excluding Russian terminals from the analyses, terminals whose competitiveness seems to be greater compared to others are: Lithuanian Kleipedos Smelte and Finnish Vuosaari. On the other hand, regardless of the changes in terminals' set and values of the weights, the lowest positions in the rankings were maintained both in 2019 and 2022 by two Swedish ports: GCT Gävle and Västhamnen, one Finnish (Euroports Finland) and one Latvian (BCT Riga).

The results of our study allow us to draw some general conclusions as regards the competitiveness of maritime container terminals in the BSR before and after covid-19 pandemic and Russo-Ukrainian war. First, after the Russian invasion on Ukraine in February 2022 and sanctions imposed afterwards on Russia, there were significant drops in TEU handled in Russian Baltic container ports. In consequence, Russian terminals in the BSR have lost their highly competitive position and we may have recently observed higher turnover of containerized cargo in Polish, Finnish and Baltic states' seaports (Global Ports Investments PLC, 2023). Our results confirm this as generally Polish, Finnish, and Baltic states' terminals improved their positions in our multicriteria rankings for 2022. At the same time, according to our findings, the terminals in Gdańsk, Gdynia, and Klaipeda are most competitive in the BSR in 2022. As our criteria sets comprise infra-, superstructural as well as service factors, it may suggest that these terminals invest more than their competitors in their port site infrastructure and company's reputation. Indeed, in Table 3 we may notice that DCT Gdańsk, GCT Gdynia, KCT Klaipeda and Klaipedos Smelte terminals improved at least one of their criteria in 2022 compared to 2019.

As in general huge investments are made when the terminal's TEU turnover increases, this prompted us to compare whether terminals in question intercepted part of the container traffic from sanctioned Russian ports. Latest results show, however, that in 2022 the Port of Gdańsk handled 2.2% TEU less than in 2021 while the Port of Gdynia handled 7.3% less y/y. Both in the BCT and in the GCT a decrease in container turnover was noticeable. These decreases were caused by changes related to handling transshipments from/to Russia, which accounted for a significant part of the ports' handling. Yet, there were huge increases in the container turnover in both ports in 2021, and last year's decreases still bring the number of TEU handled there at the higher level than before the covid-19 pandemic and the Russo-Ukrainian war. On the other hand, impressive growth was recorded by the Port of Klaipeda (+57% y/y). This is the result of the introduction of new container routes in 2022, including the MSC connection connecting Klaipeda, Gdynia, and Gothenburg with New York. Thus, it is of no surprise that the growth in container handling was also noticed in the Port of Gothenburg (+6.9% y/y). In 2022 container throughput in the Port of Riga also increased (+10.8% y/y), while the biggest container terminal operating in the port, the BCT Riga, reached a record result of 326,000 TEU. Finally, moderate growth in the number of TEUs handled was also noticed in the ports of HaminaKotka, Aarhus, Helsinki, and Rauma (+6.0%, +5.7%, +5.4%, +1.0% y/y, respectively) (Ziajka, Rozmarynowska-Mrozek, 2023).

6. Conclusion

This broader perspective allows us to draw more conclusions as regards this study. First, considering seven criteria chosen for our research, the biggest competitive potential in the BSR have such maritime container terminals as DCT Gdańsk, GCT Gdynia, Klaipedos Smelte and Vuosaari. Second, the maritime container traffic on the Baltic Sea is of regional character. It means that there is a high level of competitiveness between seaports in the BSR. Thus, high positions in our multicriteria rankings of the abovementioned terminals should be a warning signal for other maritime terminals located in their vicinity, especially for BCT Gdynia, KCT Klaipeda and Mussalo CT in HaminaKotka. Finally, our results suggest that the terminal geographical location and the geopolitical situation in the BSR are of uttermost importance regardless of infra- and superstructural investments and/or hinterland connections with other modes of transport. Thus, our findings should be of interest to terminal operators and managers planning their strategy for next years, especially if they want to maintain their competitive advantage in the region after the lifting of sanctions imposed on Russian ports.

Like any study, this study has some limitations. The first and the most important one is about the data availability which influenced the choice of criteria used in the study. As it is usually difficult or impossible to obtain operational and/or financial data for all analyzed terminals, we had to exclude some criteria suitable for this research. Then, because of the website data sources used in the study, there may be some errors and discrepancies which could affect the accuracy of our calculations. Finally, the subjectivity involved in the selection of chosen criteria and some of their weights could also lead to different competitiveness assessment results of maritime container terminals in the BSR. Yet, these limitations constitute the research opportunities for the future as, for example, inclusion of other criteria sets could lead to interesting conclusions concerning the problem in question.

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