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CRITERIA IMPACTING SYNCHRONIZATION OF TRANSPORT FLOWS ALONG INTERNATIONAL TRANSPORT CORRIDOR

ABSTRACT

The main goal of this paper is to determine the main technical and technological criteria impacting the effectiveness of the synchronization of transport flows in the East-West Transport Corridor (EWTC) in the southern part of the Baltic Sea Region (BSR) corridor using a specific questionnaire. The results were processed using the Kendall rating correlation method, and the compatibility of the expert selection was analysed using a match factor. Following Kendall's concordance coefficient and consistency ratio values, the expert opinions were reconciled. In the course of the research using the Average Rank Transformation into Weights (ARTIW) method, the normalized subjective weights of the main technical and technological impacting synchronization of transport flows were determined. The outcomes of the research presented in the paper have shown that the main technical criteria impacting synchronization are: railway infrastructure and road transport infrastructure at the terminals. The most important technological interaction criteria are accessibility of seaports and accessibility of railway distribution stations. In the following stages of research, the main criteria of the above two factors should be used to create models and facilitate synchronization with the purpose of building an interconnected transport system spanning all modes of transport.

KEY WORDS

synchronization; technical interoperability; technological interaction; intermodal terminal; transport corridor;

1. INTRODUCTION

Good transport connections and effective logistic services are a pre-requisite for the competitive Baltic Sea Region. Maritime and hinterland terminals enable the transhipment of load units between various modes of transport and play a significant role in intermodal transport. The interaction between road transport sector as well as the sea and other modes of transport is a very important factor in developing the transport corridors.

The poorly developed network and low levels of interconnectivity between the sea and land terminals along the East-West transport corridors in the BSR have negative effects and are a major obstacle in increasing the international competitiveness of this transport corridor. Thus, the greatest priority is to be given to synchronising activities of intermodal transport terminals. To ensure the efficiency of the carriage process within TEN-T corridors and its connections with the third countries, greater interoperability of the existing infrastructure is necessary. Additionally, it is imperative to coordinate the managers' and operators' actions, as well as to maintain the technological integration of the sea and land Terminal Operating System (TOS).

A comprehensive literature review was performed to obtain knowledge on how the subject of synchromodality has been developed in the academic literature. The synchromodality is flexible [1, 2] and a novel transport concept called "synchromodality" has been proposed recently to green freight transport by fostering a modal shift towards environmentally friendly modes [3, 4] of transport such as water (barge or short sea), rail and/or road can be used [5] for container transportation [4, 6].

The new knowledge gained from this review served as the basis for further research. Defares [7], Behdani and others [1] presented synchromodality definitions, and the concepts are closest to the opinion of the authors of the paper. It could be stated that, according to these authors, the synchromodal transport system includes both transport operations and transport infrastructure (e.g. inland terminals) resources. The synchronization is the most difficult task for transit planners and schedulers [8]. This task is sometimes accomplished intuitively in practice by simplifying the problem in favour of coordination in a few key points in the network. However, a networkwide synchronization is a complex task by nature [9, 10].

The purpose and objective of the research are to determine the main technical and technological criteria impacting synchronization of transport flows along international transport corridor aiming at more effective usage capacities of transport hubs.

2. BASIC HYPOTHESIS

Rodrigue identified the necessity to synchronise the activities among intermodal transport terminals by linking transport activities with the globalisation challenges. Globalisation underlines higher levels of integration between production and distribution systems [11, 12].

The development of transport infrastructure, as well as different modes of transport, should be synchronised. It is worth noting that Rodrigue [11, 12] suggests cooperating to meet the challenges of globalisation, while Wilmsmeier [13] highlights the importance of interaction between seaport terminals located in international transport corridors and land-based intermodal terminals. They mainly link the integration of land-based intermodal transport with the seaports located in the very same corridor. Limbourg and Jourquin [14] draw particular attention to the importance of container terminal locations in the European transport network. By employing modern modelling instruments, the authors have justified the statement that in order for intermodal transport to be competitive, the distance should be longer than 343 km. The authors have also presented the principles of the Hub-and-Spoke network design.

Networkwide synchronization is a complex task by nature. Several authors [1, 15, 16] argue that cost, quality and sustainability targets are the key to achieving synchromodality; others [17-20] say that service quality is the most important criterion. Also, the sufficiency of infrastructure, such as congestions, bottlenecks, obstructions, have a major impact on the synchromodal transport [18, 21].

Paper [9] was published to address the problems of synchronization transport by addressing a number of key factors, but very briefly in terms of technical and technological factors. Therefore, the authors of this paper have put forward the following basic hypothesis: the synchronization of intermodal transport activities in international transport corridors depends on the technical characteristics of the terminals and technological interoperability. These factors have a significant impact on the transport flows synchronization.

Comprehensive literature [19, 20, 22-24] analysis made it possible to identify the main technical and technological criteria impacting synchromodality. These criteria are presented in *Table 1*.

A and B groups of criteria characterise the technical and technological terminal capacities, as well as the possibilities for the use of interoperability of the transport modes. The larger the terminals, the more developed is their infrastructure, technical equipment and specialisation, the more attractive they are for the use of multimodal transport in the international transport corridors.

Table 1 – Criteria influencing synchromodality of transport activity

Titles of performance factor groups	Key factors criteria	References
A. Technical qualities of terminals	Railway infrastructure Road transport infrastructure Area of cargo storage Technical equipment Loading equipment	[22, 23]
B. Technological interaction	Seaports accessibility Railway distribution stations accessibility Airports accessibility Logistics centres accessibility Operational interaction of intermodal transport Roads accessibility Railway accessibility Inland waterways accessibility	[19, 20, 24]

3. RESEARCH RESULTS

3.1 Methodology significance of criteria

To rank the main criteria (presented in Table 1) their importance in the development of transport synchronization is necessary. The experts from Germany, Denmark, Sweden, Belarus, Ukraine and Lithuania conducted a survey by using a questionnaire (from January to April 2017). The responses were received from 14 experts and this was done in the framework of TENTacle (2019) project of the BSR INTERREG (2019) programme [25]. One of the aims of this project was to investigate the prospects of further development of transport networks, as well as the possibilities for a better convergence of transport planning, management and implementation of the integrity of transport patterns linking the EU BSR and the EU Eastern Partnership Countries [9].

The main purpose of the questionnaire was to assess (rank) the most important criteria of technical and technological criteria groups impacting synchronization of transport performance following the significance criteria.

All criteria of group A given in the questionnaire, which indicate the main technical characteristics of the terminals, were divided into five groups:

A1 – *Railway infrastructure*. This factor is expressed in terms of the number (units) and the length [m] of railway trains at intermodal terminals.

A2 – *Road transport infrastructure*. This factor is expressed in terms of production area [m^2] of road transport infrastructure in a terminal (the area designed for vehicle parking near terminal entrance and/or area for road transport servicing at the terminal).

A3 – *Area of cargo storage.* Expressed in terms of the total storage volume [m^2] of intermodal units (TEU and ro-ro cargo).

A4 – *Technical equipment* expressed by the number of equipment to service intermodal cargo as refrigerated cargo containers, equipment to eliminate accidents of hazardous cargo, and area for container servicing (repairing).

A5 – *Loading equipment.* This factor is expressed in terms of the number of ITU maintenance equipment (units) for servicing intermodal transport units (refrigeration container handling equipment, equipment for the collection of hazardous cargo emergency consequences) and the production area (space of containers for partial repairs) [m^2].

Criteria of technological interaction (group B), which characterise the interoperability of transport modes are as follows:

B1 – *Seaports accessibility*, expressed in km.

B2 – *Railway distribution stations accessibility*, expressed in km.

B3 – *Airports accessibility*, expressed in km.

B4 – *Logistics centres accessibility*, expressed in km.

B5 – *Operational interaction of intermodal transport* loading carried out in order according to prior enquiries, expressed as percentage per month.

B6 – *Roads accessibility*, expressed in km.

B7 – *Railway accessibility*, expressed in km.

B8 – *Inland waterways accessibility*, expressed in km.

Each group in the questionnaire was distributed based on the significances of smaller criteria. All expert assessments were ranked.

According to the answers provided, the distribution and agreement of opinions can be estimated. The Kendall's concordance coefficient was estimated to serve this purpose [26]. The values in the concordance coefficient (W) are in the range from 0 to 1. The higher the value obtained (W), the less do the opinions differ regarding the question under analysis. The higher the W, the stronger the correlation of the variables. When all of the ranks coincide, then W=1.

Kendall's concordance coefficient is based on the sum of the ranks assigned by n experts to each j-th criterion R_j:

$$R_j = \sum_{i=1}^{n} R_{ij} \, (j = 1,2,\ldots,m) \tag{1}$$

More exactly, it is based on sum S of the squared deviations R_j (the variance analogue) from the mean rank $\overline{R}$:

$$S = \sum_{j=1}^{m} (R_j - \overline{R})^2 \tag{2}$$

The average criterion rank $\overline{R}$ is obtained by dividing the sum of ranks, assigned to the criterion by the experts, by the number of the criteria, m:

$$\overline{R} = \frac{\sum_{j=1}^{m} R_{ij}}{m} = \frac{\sum_{i=1}^{n}\sum_{j=1}^{m} R_{ij}}{m} \tag{3}$$

where:

R_{ij} –rank assigned by i-th expert to j-th criterion;

n –number of experts (i=1, 2, …, n);

m –number of the criteria (j=1, 2, …, m).

If S is a real sum of the square value calculated by *Equation 2*, the concordance coefficient W is described (when there are no related ranks) by the ratio of the calculated S value:

$$W = \frac{12 \cdot S}{n^s \cdot (m^3 - m)} \tag{4}$$

When the estimates of the experts are in agreement, the value of the concordance coefficient W is about one, but if these estimates differ to a great extent, the value of W is about zero.

The sum of the squared deviations of ranks R_{ij} of each criterion from the mean rank can be calculated as follows:

$$S = \sum_{j=1}^{m} \left[\sum_{i=1}^{n} R_{ij} - \frac{1}{2} n \cdot (m+1) \right]^2 \tag{5}$$

where:

m –number of the criteria (j = 1, 2,..., m);

n –number of experts (i = 1, 2,..., n).

The value of the random number S is calculated by adding the squared values given to all the criteria, which are enclosed in square brackets (*Equation 5*).

The concordance coefficient W can be used in practice if its limiting value, showing the condition when expert estimates may be considered consistent, is determined.

Kendall and Gibbons [27] proved that when the number of the criteria is $m>7$ the significance of the concordance coefficient W can be determined by using the Pearson's criteria (chi-squared test).

The random value is distributed according to χ^2:

$$\chi^2 = n \cdot (m-1) \cdot W = \frac{12 \cdot S}{n \cdot m \cdot (m+1)} \tag{6}$$

with the degree of freedom $v=m-1$. Based on the selected confidence level α (which is assumed to be 0.05 or 0.01), the critical value $\chi^2_{v,\alpha}$ is found from the table of χ^2 distribution with the degree of freedom $v=m-1$. If the value of χ^2 calculated by *Equation 6* is larger than $\chi^2_{v,\alpha}$, it shows that the experts' estimates are consistent.

The smallest value of the concordance coefficient W_{min} can be estimated by applying *Equation 7*:

$$W_{min} = \frac{\chi^2_{v,\alpha}}{n \cdot (m-1)} \tag{7}$$

where:

n –expert opinions;

m –number of comparative criteria that indicates the quality of an object under analysis with the selected levels of significance α and degree of freedom $v=m-1$. Having calculated this value, it is thus not possible to assert that the expert opinions are in agreement;

$\chi^2_{v,\alpha}$ –critical Pearson‘s statistics when the degree of freedom and significant level are taken [28].

To assess the application possibilities of transport interoperability and associated efficiency in terminals, the experts were asked to evaluate the criteria impacting the application possibilities and attractiveness of intermodal terminals based on their technical and technological capabilities in international transport corridors.

When the quality of an object is assessed and allows it to be described by a single value and compared with the quality of other similar objects, the normalized criterion weight ω_j should be used. The significances (weight) of the criteria can be defined by ARTIW method [29] by which the relative importance of A and B criteria (*Tables 3* and *5*) is defined. For that, *Equation 8* is applied:

$$\omega_j = \frac{(m+1) - \overline{R}_j}{\sum_{j=1}^{m} \overline{R}_j} \tag{8}$$

where:

m –the number of criteria showing importance of synchronization;

$\overline{R}_j$ –average rank of j-th criterion calculated according to *Equation 9*:

$$\overline{R}_j = \frac{\sum_{i=1}^{n} R_{ij}}{n} (j = 1, 2, \ldots, m) \tag{9}$$

where

R_{ij}–the rank of the criteria granted by the experts;

n –number of experts.

ARTIW method was first presented in 2011 by the author Sivilevičius [29]. The significances (weights) of the criteria describing the quality of an object are determined by experts, who normalize them (i.e. equate their sum to one) and use the method of average rank transformation into weight.

3.2 Results and discussion

Research data were processed by Kendall's concordance coefficient method and ARTIW method.

The ranks of the importance of each criteria of group A – Technical qualities of terminals, which were assigned by the experts, were used calculating the average ranks $\overline{R}_j$, concordance coefficient W, Pearson's criteria (chi-squared test) χ^2 and the normalized criterion weight ω_j. All calculations were made according to the Equations given above.

The average of each criterion ranks was calculated as follows:

A1 average rank $\overline{R} = \frac{\sum_{i=1}^{n} R_{ij}}{n} = \frac{31}{14} = 2.21$; etc. (10)

A2 average rank $\overline{R} = \frac{\sum_{i=1}^{n} R_{ij}}{n} = \frac{34}{14} = 2.243$; etc. (11)

It indicated the importance of indicators expressed in priorities. The sum of A group criteria ranks is 15.

In the next step, the difference between the sum of the grades and the constant is calculated for each criterion, and the results are listed in the penultimate row of *Table 2*.

$$\sum_{i=1}^{n} R_{ij} - \frac{1}{2} n \cdot (m+1) = 31 - \frac{14 \cdot (5+1)}{2} = \\ = 31 - 42 = -11; \text{etc} \tag{12}$$

The sum of the differences between all five factors is 0. According to *Equation 13* the sum of squared deviations is calculated:

$$\left[\sum_{i=1}^{n} R_{ij} - \frac{1}{2} n \cdot (m+1)\right]^2 = [31-42]^2 = [-11]^2 = 121; \text{etc.} \tag{13}$$

The total sum of the square deviations S is 396. The data of the calculated index difference squares of each criterion of group A is indicated in *Table 2*.

In order to be sure that the expert views are not contradictive, coefficient of concordance W was calculated:

$$W = \frac{12 \cdot S}{n^2 \cdot (m^3 - m)} = \frac{12 \cdot S}{14^2 \cdot (5^3 - 5)} = \frac{12 \cdot 396}{196 \cdot 120} = \\ = \frac{4752}{23520} = 0.2020 \tag{14}$$

Since the number of criteria is greater (m>7), thus the significance of the concordance coefficient is determined by using the χ^2 criterion, to which the random variable is estimated by *Equation 15*:

$$\chi^2 = n \cdot (m-1) \cdot W = \frac{12 \cdot S}{n \cdot m \cdot (m+1)} = \\ = 14 \cdot (5-1) \cdot 0.2020 = \frac{12 \cdot 396}{14 \cdot 5 \cdot (5+1)} = 11.3143 \tag{15}$$

Table 2 – Criteria evaluated according to the importance of group A (Technical properties of terminals)

Codes of experts		Criteria for performance criteria are assessed by A group significances (j = 1,2, …, 5)					
		A1	A2	A3	A4	A5	Overall sum
i = 1,2,..,14	E1	1	4	3	5	2	15
	E2	3	1	2	4	5	15
	E3	3	2	4	5	1	15
	E4	1	3	4	5	2	15
	E5	4	5	1	3	2	15
	E6	2	1	4	3	5	15
	E7	4	1	3	5	2	15
	E8	2	1	4	3	5	15
	E9	2	1	4	3	5	15
	E10	2	3	1	5	4	15
	E11	1	5	3	4	2	15
	E12	4	3	5	1	2	15
	E13	1	2	4	5	3	15
	E14	1	2	4	5	3	15
Sum of the ranks $R_j = \sum_{i=1}^{n} R_{ij} (j = 1,2,\ldots,m)$		31	34	46	56	43	210
Average rank $\overline{R} = \frac{\sum_{j=1}^{m} R_{ij}}{m} = \frac{\sum_{i=1}^{n}\sum_{j=1}^{m} R_{ij}}{m}$		2.21	2.43	3.29	4.0	3.07	15
$\sum_{i=1}^{n} R_{ij} - \frac{1}{2} n(m+1)$		-11	-8	4.0	14	1	0
$\left[\sum_{i=1}^{n} R_{ij} - \frac{1}{2} n(m+1)\right]^2$		121	64	16	196	1	396
Hierarchy		1	2	4	5	3	

The lowest value of the concordance coefficient W_{min} is obtained:

$$W_{min} = \frac{\chi^2_{v,\alpha}}{n \cdot (m-1)} = \frac{9.48773}{14 \cdot (5-1)} = 0.1694 < 0.2020 \qquad (16)$$

The value is substantially lower than 0.202. Thus, it is possible to claim that the judgements of all 14 experts are in agreement.

In the group of A criteria the experts defined the following sequence of the main factors characterising the technical qualities of terminals:

A1 (A1=2.21) – *Railway infrastructure*. This factor is expressed in terms of the number (units) and the length (m) of railway trains at intermodal terminals.

A2 (A2=2.43) – *Road transport infrastructure*. This factor is expressed in terms of production area (m^2) of road transport infrastructure in a terminal (the area designed for vehicle parking near terminal entrance and/or area for road transport servicing at the terminal).

A5 (A1=3.07) – *Loading equipment*. This factor is expressed in terms of the number of ITU maintenance equipment (units) for servicing intermodal transport units (refrigeration container handling equipment, equipment for the collection of hazardous cargo emergency consequences) and the production area (space of containers for partial repairs) [m^2].

A3 (A3=3.29) – *Area of cargo storage.* Expressed in terms of the total storage volume [m^2] of intermodal units (TEU and ro-ro cargo).

A4 (A4=4.0) – *Technical equipment* expressed by the number of equipment to service intermodal cargo as refrigerated cargo containers, equipment to eliminate accidents of hazardous cargo, and the area for containers servicing (repairing).

The weights of importance of the action group A (A1, A2, A3, A4, A5) criteria estimated according to *Equation 17* are presented in *Table 3*, and the ranking by the importance of coefficients of criteria weights – in *Figure 1*.

$$\omega_1 = \frac{(m+1) - \overline{R}_1}{\sum_{j=1}^{5} \overline{R}_j} = \frac{(5+1) - 2.21}{15} = 0.253 \qquad (17)$$

The sum of normalised A1, A2, A3, A4, A5 group factors equals 1.

A vertical column diagram of the weight of importance of calculated values for all five Technical criteria is drawn in *Figure 1*.

As can be seen from *Figure 1*, the main factors of intermodal terminal technical parameters which have the greatest influence on the possibilities of transport synchromodality applications, are as follows: railway infrastructure (A1), road transport infrastructure (A2), and loading equipment (A5).

Factors of lesser importance: area of cargo storage (A3), and technical equipment (A4).

The following hierarchy is received of group factors affecting the transport synchronisation with weight coefficients:

$$A1 > A2 > A5 > A3 > A4$$

Table 3 – Weight of importance of group A (Technical qualities of terminals)

Size	Sign of action criteria					Sum
	A1	A2	A3	A4	A5	
ω_j	0.253	0.238	0.181	0.133	0.195	1
Hierarchy	1	2	4	5	3	

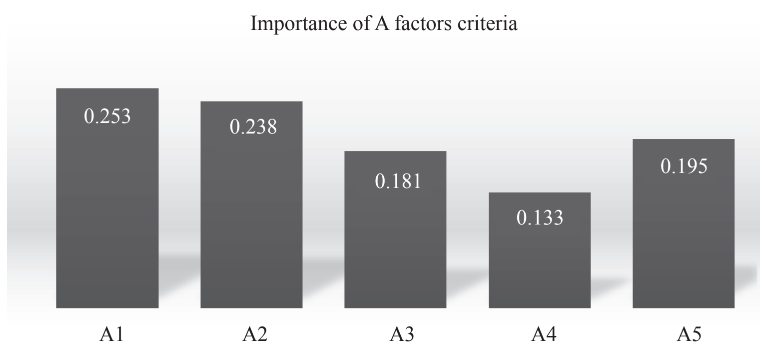

Figure 1 – Breakdown of criteria weights by importance of Intermodal terminal technical criteria

Technological interaction (criteria of group B) studies have been conducted similarly.

Table 4 indicates the calculations for rank averages of each criterion of group B. All calculations were made according to the formulas given above.

The concordance coefficient is calculated:

$$W=\frac{12\cdot S}{n^2\cdot(m^3\cdot m)}=\frac{12\cdot S}{14^2\cdot(8^3\cdot 8)}=\frac{12\cdot 2227}{196\cdot 504}= =\frac{26724}{98784}=0.2705 \tag{18}$$

Since the number of criteria is greater (m>7), thus the significance of the concordance coefficient is determined by using the χ^2 criterion, to which the random variable is estimated by *Equation 19*:

$$\chi^2=n\cdot(m-1)\cdot W=\frac{12\cdot S}{n\cdot m\cdot(m+1)}= =14\cdot(8-1)\cdot 0.2705=\frac{26724}{14\cdot 8\cdot(8+1)}=26.51 \tag{19}$$

The lowest value of the concordance coefficient W_{min} is obtained.

$$W_{min}=\frac{\chi^2_{v,\alpha}}{n\cdot(m-1)}=\frac{14.0671}{14\cdot(8-1)}=0.1435<0.2705 \tag{20}$$

The value is substantially lower; thus, it is possible to claim that the judgements of all experts are in agreement.

In the group of B factors, the experts defined that the sequence of criteria by importance characterising interoperability of transport modes is as follows:

B1 (B1=2.5) – *Seaports accessibility*, expressed in km.

B2 (B2=3.14) – *Railway distribution stations accessibility*, expressed in km.

B4 (B4=3.57) – *Logistics centres accessibility*, expressed in km.

B6 (B6=4.07) – *Roads accessibility*, expressed in km.

B7 (B7=4.29) – *Railways accessibility*, expressed in km.

B8 (B8=5.5) – *Inland waterways accessibility*, expressed in km.

B3 (B3=6.0) – *Airports accessibility*, expressed in km.

Table 4 – Criteria evaluated according to the importance of group B

Codes of experts		Criteria for performance criteria are assessed by B group significances (j = 1,2, ..., 8)								
		B1	B2	B3	B4	B5	B6	B7	B8	Overall sum
i = 1,2,..,14	E1	3	2	7	1	8	6	4	5	36
	E2	3	2	6	1	7	4	5	8	36
	E3	3	4	5	7	8	1	2	6	36
	E4	5	3	7	4	8	2	1	6	36
	E5	2	4	7	3	8	6	5	1	36
	E6	4	3	8	5	2	6	7	1	36
	E7	4	3	5	8	6	1	2	7	36
	E8	1	5	6	2	8	3	4	7	36
	E9	3	1	6	5	7	2	4	8	36
	E10	2	8	3	4	7	5	6	1	36
	E11	1	2	6	3	5	8	4	7	36
	E12	2	3	4	1	7	5	6	8	36
	E13	1	2	7	3	8	4	5	6	36
	E14	1	2	7	3	8	4	5	6	36
Sum of the ranks $R_j=\sum_{i=1}^{n}R_{ij}(j=1,2,\ldots,m)$		35	44	84	50	97	57	60	77	504
Average rank $\overline{R}=\frac{\sum_{j=1}^{n}R_{ij}}{n}(j=1,2,\ldots,m)$		2.5	3.14	6	3.57	6.93	4.07	4.29	5.5	36
$\sum_{i=1}^{n}R_{ij}-\frac{1}{2}n(m+1)$		-28	-14	16	-10	27	-5	-4	11	0
$\left[\sum_{i=1}^{n}R_{ij}-\frac{1}{2}n(m+1)\right]^2$		784	196	256	100	729	25	16	121	2,227
Hierarchy		1	2	7	3	8	4	5	6	

Table 5 – Weight of importance of group B (Technological interaction)

Size	Sign of action criteria								Sum
	B1	B2	B3	B4	B5	B6	B7	B8	
ω_j	0.181	0.163	0.083	0.151	0.057	0.137	0.131	0.097	1
Hierarchy	1	2	7	3	8	4	5	6	

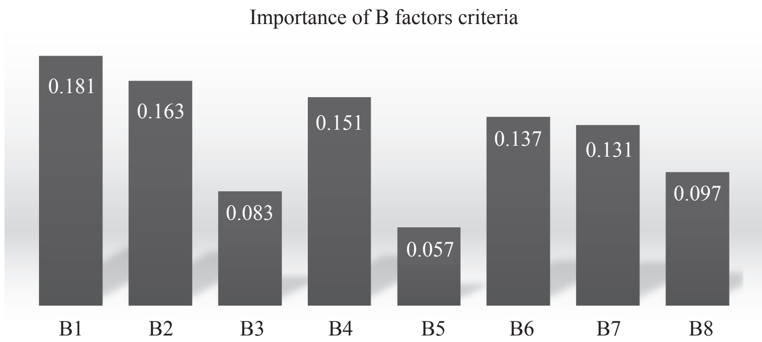

Figure 2 – Breakdown of criteria weights by importance of Intermodal terminals technological criteria

B5 (B5=6.93) – *Operational interaction of intermodal transport*, loading carried out in order according to prior enquiries expressed as a percentage per month.

The weights of importance of action group B (B1, B2, B3, B4, B5, B6, B7, B8) of criteria estimated according to *Equation 8* are presented in *Table 5*, and ranking by the importance of coefficients of criteria weights – in *Figure 2*.

The sum of normalised B1, B2, B3, B4, B5, B6, B7, B8 group criteria equals 1.

A vertical column diagram of the average ranks of calculated values for all eight technological criteria is presented in *Figure 2*.

The following hierarchy is received of group factors affecting transport synchronisation with weight coefficients:

B1 ≻ B2 ≻ B4 ≻ B6 ≻ B7 ≻ B8 ≻ B3 ≻ B5

It is observed that the most influencing factors of technological interaction are: accessibility of seaports (B1), accessibility of railway distribution stations (B2), accessibility of logistics centres (B4), accessibility of roads (B6), and accessibility of railways (B7),

Factors of lesser importance: accessibility of inland waterways (B8), accessibility of airports (B3), and operational interaction of intermodal transport (B5).

The hypothesis that the synchronization of intermodal transport activities in international transport corridors depends on the technical characteristics of the terminals and technological interoperability was formulated. The formulated basic hypothesis can be confirmed. The research found that one of the most important technical factors of terminals is the railway and road transport infrastructure at the terminals and the loading equipment that have the greatest influence on the synchronization of transport activities. The technological interaction is mainly influenced by the connection with the seaports and railway distribution stations.

Synchronization of transport flows in the transport corridor is related to the improvement of the transport service level, capacities utilisation of transport hubs, and modal shift along the transport corridor.

In the following stages of the research, technical properties of terminals and technology interaction factors should be used to create an optimal model describing and facilitating synchronization with the aim of building an interconnected transport system spanning all modes of transport, where vehicle transport infrastructure continuously interacts, and the businesses are provided with easy and safe door-to-door mobility services.

4. CONCLUSION

The major technical and technological factors impacting synchronization of transport activities between intermodal nodes along the transport corridor have been researched and identified.

According to experts the main factors of intermodal terminal technical parameters which have the greatest influence on the possibilities of transport synchronization applications, are as follows: railway infrastructure (A1), road transport infrastructure (A2), loading equipment (A5). Factors of lesser importance are: area of cargo storage (A3), technical equipment (A4).

It is observed that the most influencing factors of technological interaction are as follows: seaports accessibility (B1), railway distribution stations accessibility (B2), logistics centres accessibility (B4), roads accessibility (B6) as well as railway accessibility (B7). Factors of lesser importance are: inland waterways accessibility (B8), airports accessibility (B3) and operational interaction of intermodal transport (B5).

The main technical and technological factors (criteria) identified during the research as impacting synchronization of operational activity among transport hubs will help in further research to create models of synchronised activity in EWTC in the southern part of BSR and other international transport corridors. On the basis of synchronization it is possible to establish innovative transportation and logistics services through developing cooperation between intermodal terminals along a specific transport corridor.

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VEIKSNIAI, TURINTYS DIDŽIAUSIOS ĮTAKOS TRANSPORTO SRAUTŲ SINCHRONIZAVIMUI TARPTAUTINIAME TRANSPORTO KORIDORIUJE

SANTRAUKA

Transporto srautų sinchronizavimas rytų-vakarų transporto koridoriuje (EWTC) pietinėje Baltijos jūros regiono (BJR) dalyje yra susijęs su įvairiarūšio transporto terminalų techninių ir technologinių veiksnių suderinamumu ir su transporto paslaugų lygio gerinimu transporto koridoriuje. Pagrindinis šio straipsnio tikslas yra ištirti pagrindinius techninius ir technologinius veiksnius, kurie įtakoja transporto srautų veiklos sinchronizavimą EWTC koridoriuje, naudojant specialų klausimyną. Rezultatai buvo gauti naudojant Kendalo rangų koreliacijos metodą, o ekspertų atrankos suderinamumas buvo apskaičiuotas naudojant konkordancijos koeficientą. Pagal gautus skaičiavimus nustatyta, kad ekspertų nuomonės yra suderintos. Tyrimo metu, naudojant vidutinio rango transformacijos į svorius (ARTIW) metodą, buvo nustatyti normalizuotų subjektyviųjų svorių pagrindiniai techniniai ir technologiniai veiksniai, darantys didžiausią įtaką transporto srautų sinchronizavimui. Terminalų techniniai ir technologiniai veiksniai apibūdina įvairiarūšio transporto terminalų pajėgumus ir transporto rūšių sąveikos efektyvumo panaudojimo galimybes. Straipsnyje pateikto tyrimo rezultatai parodė, kad pagrindiniai įvairiarūšio transporto terminalų techniniai veiksniai, darantys įtaką transporto srautų sinchronizavimui, yra šie: terminalų geležinkelių infrastruktūra, kelių transporto infrastruktūra ir terminalų krovos įrangos kiekis. Mažesnės svarbos veiksniai: krovinių sandėliavimo plotas ir techninės aptarnavimo įrangos kiekis terminale. Taip pat buvo nustatyta, kad svarbiausi technologiniai veiksniai yra: susisiekimas su jūrų uostais, susisiekimas su geležinkelio paskirstymo stotimis, su logistikos centrais bei su keliais, taip pat susisiekimas geležinkeliais. Mažiau svarbūs veiksniai: susisiekimas vidaus vandens transportu, susisiekimas su oro uostais ir įvairiarūšio transporto organizacinė (operacinė) sąveika. Tolesniuose tyrimo etapuose šios dvi veiksnių grupės turėtų būti naudojamos kuriant sinchroninės veiklos modelius EWTC pietinėje BJR dalyje ir kituose tarptautiniuose transporto koridoriuose. Remiantis sinchronizavimu, galima sukurti novatoriškas transporto ir logistikos paslaugas plėtojant intermodalinių terminalų veiklos bendradarbiavimą konkrečiame transporto koridoriuje.

RAKTINIAI ŽODŽIAI

sinchronizavimas; techninis suderinamumas; technologinė sąveika; intermodalinis terminalas; transporto koridorius;

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