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## METHODOLOGY FOR THE MULTI-CRITERIA EFFICIENCY ASSESSMENT OF CARGO CUSTOMS COMPLEXES

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### ABSTRACT

Operation efficiency assessment of cargo customs complexes located throughout Ukraine and having different technical, technological and organizational support levels can be made based on various technical and economic performance indicators

The paper develops the methodology for a comprehensive efficiency assessment of customs infrastructure facilities as an integral system of local measures and system performance indicators as a whole. Forming the integral criterion and the generalized integral criterion, we take into account the parameters of the benchmark cargo customs complex.

The developed methodology for multi-criteria efficiency assessment of customs infrastructure facilities makes it possible to identify the groups of technical and economic performance indicators, to rank the technical and economic performance indicators according to the significance of their influence on the final generalized efficiency indicator; to form a vector with the parameters of the benchmark cargo customs complex; to determine the generalized efficiency assessment indicator of a cargo customs complex according to each group of factors; to determine the integral and generalized integral indicator of the operation of a cargo customs complex.

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**Introduction.** Cargo customs complexes located throughout Ukraine are of a different technical, technological and organizational support level. Their operation efficiency assessment can be made based on various technical and economic performance indicators [1-3].

The task of determining technical and economic performance indicators, on the one hand, rests upon the fact that they should take into account the content and characteristics of the assessment object to the fullest extent, and, on the other hand, they should unambiguously define the objectives of modeling (generalized integral criterion). A universal set of technical and economic performance indicators for assessing the efficiency of cargo customs complexes cannot exist due to a significant number of assessment objects, and the fact that their priorities in each case are determined by the modeling objective.

The purpose of the paper is to develop a methodology for a comprehensive efficiency assessment of customs infrastructure facilities as an integral system of local measures and system performance indicators as a whole as well as their comparison with the benchmark version.

#### Statement of basic materials.

For the efficiency determination of customs infrastructure facilities and their benchmark assessment, the technical and economic indicator set or the group of factors (local measures) are distinguished characterizing a different technical, technological and organizational support level of cargo customs complexes.

The specifics of efficiency determination of customs infrastructure facilities include:

- the division of technical and economic performance indicators into the groups of factors (local measures) characterizing a technical, technological and organizational support level of cargo customs complexes;
- the definition of an integral criterion for each group of factors underlying generalized integral criterion formation;
- inconsistency, heterogeneity and incomparability of the set of local measures with one another, within each group and in relation to a generalized integral efficiency indicator of cargo customs complexes;
- the expert assessment subjectivity of a technical and economic performance indicator weight reflecting each factor contribution to both an integral criterion by each group and generalized integral criterion formation;
- the definition of the integral criterion and generalized integral criterion assessment scale;
- taking into account the parameters of the benchmark cargo customs complex in integral criterion and generalized integral criterion formation.

The set of efficiency assessment factors for cargo customs complexes has different units of measurement and is composed of both absolute and relative indicators differing from each other in qualitative content; it is of various influence (weight) degrees and has different influence directions in relation to the final efficiency indicator.

Due to the fact that technical and economic performance indicators have different final efficiency indicator influence directions, they can be divided into two groups:

- first group indicators that are of an inverse direction in relation to the generalized integral criterion,
- second group indicators that are of a direct direction in relation to the generalized integral criterion.

To normalize the second group indicators with the first group indicators, it is necessary to find the values reciprocal to the given ones (raise their values to the «minus one» power).

Since technical and economic performance indicators have an unequal degree of influence (weight) on the final efficiency indicator, it is necessary to rank them according to the significance of their effect on the final generalized efficiency indicator.

Thus, all technical and economic indicators will be ranked according to the significance of their effect and will have a single inverse direction in relation to the generalized integral criterion.

For each group of factors, a matrix of technical and economic performance indicators is formed ranked according to their signification and with a single inverse direction in relation to the generalized integral criterion of the assessed cargo customs complexes (Table 1).

Table 1. Matrix of technical and economic performance indicators of cargo customs complexes

Technical and economic performance indicators	Technical and economic performance indicator values						
	O <sub>1</sub>	O <sub>2</sub>	...	O <sub>j</sub>	...	O <sub>m</sub>	Benchmark O
F <sub>1</sub>	X <sub>11</sub>	X <sub>12</sub>	...	X <sub>1j</sub>	...	X <sub>1m</sub>	RX <sub>1</sub>
F <sub>2</sub>	X <sub>21</sub>	X <sub>22</sub>	...	X <sub>2j</sub>	...	X <sub>2m</sub>	RX <sub>2</sub>
...	...	...	...	...	...	...	...
F <sub>i</sub>	X <sub>i1</sub>	X <sub>i2</sub>	...	X <sub>ij</sub>	...	X <sub>im</sub>	RX <sub>i</sub>
...	...	...	...	...	...	...	...
F <sub>n</sub>	X <sub>n1</sub>	X <sub>n2</sub>	...	X <sub>nj</sub>	...	X <sub>nm</sub>	RX <sub>n</sub>

*Authors' development*

where  $X_{ij}$  is the value of the  $i$  technical and economic performance indicator for the  $j$  cargo customs complex.

To determine the parameters of the benchmark cargo customs complex for each group of factors, the minimum value of technical and economic performance indicators is selected:

$$RX_i = \min_j \{X_{ij}\}. \quad (1)$$

As a result, for each group of factors, a vector with the parameters of the benchmark cargo customs complex will be formed

$$R = \{RX_1, RX_1, \dots, RX_j, \dots, RX_n\}.$$

Although the analyzed technical and economic performance indicator data are consistent at the methodological level, they cannot be used without preliminary preparation.

Therefore, the given data must be normalized to a certain range ([0, ..., 1]) by normalizing the data [4] by means of dividing the indicators characterizing the benchmark cargo customs complex by the indicators characterizing cargo customs complexes (Table 2).

Table 2. Relational matrix of the technical and economic performance indicators of cargo customs complexes

Ratio of technical and economic performance indicators	Technical and economic performance indicator ratio values					
	O <sub>1</sub>	...	O <sub>j</sub>	...	O <sub>m</sub>	Benchmark O
F <sub>1</sub>	$RX_1 / X_{11}$	...	$RX_1 / X_{1j}$	...	$RX_1 / X_{1m}$	$RX_1 / RX_1 = 1$
F <sub>2</sub>	$RX_2 / X_{21}$	...	$RX_2 / X_{2j}$	...	$RX_2 / X_{2m}$	$RX_2 / RX_2 = 1$
...	...	...	...	...	...	...
F <sub>i</sub>	$RX_i / X_{i1}$	...	$RX_i / X_{ij}$	...	$RX_i / X_{im}$	$RX_i / RX_i = 1$
...	...	...	...	...	...	...
F <sub>n</sub>	$RX_n / X_{n1}$	...	$RX_n / X_{nj}$	...	$RX_n / X_{nm}$	$RX_n / RX_n = 1$

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The significance of each factor is determined by the  $W_i$  weighting coefficient reflecting the contribution of each factor to the integral criterion by each group; it is calculated by the formula:

$$W_i = (\ln M_i + 1)^{n-i}, \quad i = (\overline{1, n}). \quad (2)$$

where  $M_i$  is the ratio of the maximum relative value to the minimum value,  
 $n$  is the number of technical and economic performance indicators.

The generalized efficiency assessment indicator for the customs cargo complex according to each group of factors is determined by the formula:

$$FG_j = \sum_{i=1}^n W_i \cdot \frac{RX_i}{X_{ij}} = \sum_{i=1}^n (\ln M_i + 1)^{n-i} \cdot \frac{RX_i}{X_{ij}}, \quad j = (\overline{1, m}). \quad (3)$$

The generalized efficiency indicator for the benchmark cargo customs complex is:

$$FRG_j = \sum_{i=1}^n W_i \cdot \frac{RX_i}{RX_i} = \sum_{i=1}^n (\ln M_i + 1)^{n-i}, \quad j = (\overline{1, m}). \quad (4)$$

The integral multi-criteria assessment indicator for the cargo customs complex by the groups of factors is determined by comparing the generalized efficiency indicator for the benchmark with the generalized indicator of the assessed cargo customs complex:

$$IG_j = FRG_j - FG_j = \sum_{i=1}^n W_i \cdot \left(1 - \frac{RX_i}{X_{ij}}\right) = \sum_{i=1}^n (\ln M_i + 1)^{n-i} \cdot \left(1 - \frac{RX_i}{X_{ij}}\right), \quad j = (\overline{1, m}). \quad (5)$$

The generalized integral criterion according to the technical and economic performance indicators of cargo customs complexes is equal to the sum of the integral multi-criteria assessment indicators by groups

$$I_j = \sum IG_j. \quad (6)$$

The lower the generalized integral multi-criteria assessment efficiency indicator in absolute value, the higher the efficiency of the assessed cargo customs complex, i.e. the closer the efficiency of the assessed complex to the benchmark one.

**Conclusions.** The developed methodology for multi-criteria efficiency assessment of customs infrastructure facilities makes it possible to:

- identify the groups of technical and economic performance indicators characterizing the different technical, technological and organizational support levels of cargo customs complexes;
- rank the technical and economic performance indicators according to the significance of their influence on the final generalized efficiency indicator;
- determine the parameters of the benchmark cargo customs complex by each group of factors;
- form a vector with the parameters of the benchmark cargo customs complex by each group of factors;
- to determine the generalized efficiency assessment indicator of a cargo customs complex by each group of factors;
- to determine the integral and generalized integral indicator of the operation of a cargo customs complex.

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