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MULTICRITERIA ASSESSMENT OF THE EFFICIENCY OF TRANSPORT AND CUSTOMS INFRASTRUCTURE FACILITIES

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Abstract

The article proposes the approach regarding the multicriteria assessment of the efficiency of transport and customs infrastructure facilities by comparing the objects under examination with the benchmark. The object of the research is the process of multicriteria efficiency assessment of freight customs complexes operation. The purpose of the work is the development of theoretical foundations and a comprehensive efficiency assessment of transport and customs infrastructure facilities. The research method is the multicriteria assessment of transport and customs infrastructure facilities. A significant number of transport and customs infrastructure facilities and criteria for their functioning, the need to assess the effectiveness of the fiscal service in general as well as of individual facilities naturally require the use of mathematical apparatus for assessing the effectiveness of management and state regulation of the processes of cargo transportation across the customs border. The peculiarities of operation of transport and customs infrastructure facilities require unification of project decisions regarding the operation of transport and customs infrastructure facilities, their capacity, size, technical, technological and organizational support. The peculiarities of determining the efficiency of transport and customs infrastructure facilities, depending on the specifics of their operation, include: the dependence of the value of their performance indicators on the form of ownership of the subject to assessment; inconsistencies in the local criteria characterizing customs infrastructure facilities; heterogeneity and incompatibility of local criteria not only in relation to each other, but also with respect to the integral efficiency indicator peculiar to customs infrastructure facilities; the need for cost accounting of the forced unification of design decisions on customs infrastructure facilities. The results of the article can be implemented in logistics intermediaries' activities when performing foreign trade operations. Possible assumptions on the further development of the research object are elaborating a methodology for evaluating the activity of transport and customs infrastructure facilities.

Keywords: transport and customs infrastructure; freight customs complex; criteria; multicriteria assessment; rang; expert

1. Problem statement

In the modern conditions, at the new stage of market reforms the State Fiscal Service should become an effective tool for stimulating exports, ensuring favorable conditions for access of Ukrainian goods to international markets, an improvement in the regulation system and principles of foreign economic relations, the protection of the domestic market and competitive domestic producers, setting the country's international regional priorities of foreign economic policy in the conditions when new participants of foreign economic activities enter the market. In this regard, the improvement of the existing transport and customs infrastructure facilities, ensuring their compliance with the requirements of the world standards of logistics and customs activities is a critical task.

2. Recent research and publications analysis

The determination of any process or object efficiency is always associated with the study of the specificity of its functioning and development prospects. The works by such scientists as A.M. Pasichnyk, N.N. Kotsan, K.M. Horb, N.M. Duk [1-4] are dedicated to the formulation of scientific principles and methodology for determining the effectiveness of transport and customs infrastructure facilities on a regional basis.

3. Articulation of the research objectives

At present, Ukraine's strategic task is the creation of a powerful transport and customs infrastructure which would foster the development of foreign trade with partner countries ensuring an adequate quality level in the provision of customs and logistics services. The overall multicriteria rating assessment of transport and customs infrastructure facilities depends on the demand for services, their technical,

technological and organizational support. In order to carry out such an assessment, it must be formulated the criteria for assessing the efficiency of transport and customs infrastructure facilities and their conformity with the benchmark characteristics.

4. Statement of basic materials

An important prerequisite for customs development in Ukraine is the improvement of customs infrastructure facilities efficiency as the main functional and technological components of customs control. It is obvious that for the effective customs control in the conditions of continuous traffic flow it is necessary to create the whole system of customs infrastructure objects, including freight customs complexes, customs warehouses, temporary storage warehouses together with the establishment of a mechanism for their effective functioning and development.

The peculiarities underlying the efficiency determination of any customs infrastructure facilities connected with the specifics of their operation include: the dependence of the value of their performance indicators on the form of ownership of the subject to assessment; inconsistencies in the local criteria characterizing customs infrastructure facilities; heterogeneity and incompatibility of local criteria not only in relation to each other, but also with respect to the integral efficiency indicator peculiar to customs infrastructure facilities; the need for cost accounting of the forced unification of design decisions on customs infrastructure facilities.

At present, there are no scientific research results that would take into account field-specific peculiarities of assessing the operating efficiency of customs infrastructure facilities. At the same time, in the modern domestic and foreign practice it is used a number of multicriteria models for the assessment of economic entities' activity [5-7]. These can include: models of dynamic priorities, utility scales, methods of multi-criteria decision making, the multivariable regression model and the model of cluster analysis. All the existing methods have one common weak point – they are narrow-focused, subjective and do not contain any recommendations for the multicriteria assessment of the utilization efficiency of customs infrastructure facilities.

In the practice of comparative multicriteria efficiency assessment of Ukraine's customs infrastructure facilities there is no single obligatory set of indicators based on which such an assessment is carried out. This is due to the fact that the process

of organizing and conducting comparative multicriteria assessments, as a rule, is individual and the structure, number and methods of determining its technical and economic indicators depend on many factors, the main among which are the following:

1. The type of a subject to multi-criteria assessment and the complexity of its research.
2. The state of micro- and macro environment where the assessed transport and customs infrastructure facilities function.
3. Capacity, organizational and technical capabilities of transport and customs infrastructure facilities.
4. Availability of the necessary transport and customs infrastructure facilities in the region, the lease or purchase of which is considered as expedient.
5. Conditions and the operating mode of a subject to assessment.
6. Social and environmental aspects of a subject to assessment.
7. Geographic, political, economic, and demographic features of the region in which a subject to assessment is located.

As we see, the task of determining the set of certain technical and economic indicators on the one hand, is aimed at ensuring the fact that the content and features of a subject to assessment are taken into account to the greatest possible extent, and on the other hand to enable the conditions and requirements laid down by the consumer of customs and logistics services to be unequivocally assessed. It is obvious that a universal set of technical and economic indicators for the efficiency assessment of customs infrastructure facilities [8,9] cannot be compiled due to a significant number of existing items to assessment, the priorities of which, in any case, are determined by the user of customs and logistics services in accordance with the specific purpose. However, there are technical and economic indicators that are standardized enough to be considered as quite a typical set of separate criteria. Most of such technical and economic indicators are used both in domestic and international practices.

Freight customs complexes as a structure reflecting industry-specific features can be characterized by a set of standard indicators, the main of which are:

1. Investments in the construction and operation of freight customs complexes.
2. Capacity of such a complex.
3. Loading levels of freight customs complexes

while handling export-import cargo flows and providing the related services.

The list of criteria adopted for facility assessment is subject to consideration by an expert commission or a taskforce specially created to determine the significance of each of them. Ranged criteria as well as their ratios serve as source information for determining the generalized indicators of the benchmark and the subject to evaluation. In this case, the obtained small values of certain criteria cannot be compensated by the value given to their components, because otherwise the more effective customs infrastructure facilities can be considered those that have a relatively larger value according to less significant criteria.

To determine the generalized assessment index of the benchmark and the subject to assessment it is necessary to use the sum of products that are homogeneous criteria multiplied by the corresponding values of weighing coefficients.

$$F = \sum_{i=1}^n K_i \times X_i \quad (1)$$

where F is the generalized assessment index of the benchmark and the subject to assessment;

X_i is the ratio value according to i -criterion ;

K_i – the value of the weighing coefficient according to i -criterion determined from the formula:

$$K_i = (\ln M_i + 1)^{n-1}, \quad i = 1, 2, \dots, n \quad (2)$$

where M_i – the ratio of the largest amount of the indicator relative value to the smallest one

n – the number of indicators in the ordered series;

\ln – the natural logarithmic function.

At first glance, the generalized index allows for compensation for a slight increase in more significant indicators at the account of less important ones, since it represents the sum of products for which it is not important due to what indicators we obtain its largest amount. In this case, such a transformation does not take place, since the growing coefficient values together with a decrease in the sequence numbers of individual indicators in the ordered series is so fast that even minimal changes in a more significant individual indicator raise the composite index more than the increase obtained due to the maximum changes in all less important indicators.

In general, the composite efficiency index of transport and customs infrastructure facilities can be presented in the following way:

$$F_N = \sum_{i=1}^n (\ln M_i + 1)^{n-1} \times X_i \quad (3)$$

Since for the benchmark each ratio is basic, its generalized efficiency index is calculated using the following formula:

$$F_Z = \sum_{i=1}^n (\ln M_i + 1)^{n-1} \quad (4)$$

It enables not only to take into account the influence of the significance and changes in individual indicators, their focus on the composite index, but also to level the differences in units of measurement, which in turn allows us to conclude that the method of determining the generalized efficiency index is characterized by reliability highlighting the need to switch to the determination of the integrated index of multicriteria efficiency assessment of customs infrastructure facilities.

The integrated index of comparative multicriteria assessment of transport and customs infrastructure facilities is determined by collating the generalized indicator of the benchmark F_Z with the generalized indicator of the subject to assessment F_N , that is:

$$J_{ZN} = F_Z - F_N \quad (5)$$

Where J_{ZN} is the integrated index of the comparative efficiency assessment of transport and customs infrastructure facilities;

F_Z – the generalized indicator of the benchmark;

F_N – the generalized indicator of the N - th transport and customs infrastructure facility, or:

$$J_{ZN} = \sum_{i=1}^n (\ln M_i + 1)^{n-1} - \sum_{i=1}^n (\ln M_i + 1)^{n-1} \times X_i \quad (6)$$

Taking into account that the equation $(\ln M_i + n - i)$ is common for generalized indicators as well as the ratio of a basic level ($X_{Zi} = 1$) for the benchmark, the integrated index of the comparative efficiency assessment of transport and customs infrastructure facilities has the following form:

$$J_{ZN} = \sum_{i=1}^n (\ln M_i + 1)^{n-1} \times (1 - X_{Ni}) \quad (7)$$

The analysis of the integrated index with the aim of studying its limits shows that the weighing coefficient is a function of natural logarithm raised to the power. If the indicators of the assessed facility coincide with the indicators of the benchmark, then $M_i = 1$. Consequently, the value of the logarithmic function equals zero, and the basis of the power function will amount to figure one, but solely provided that the corresponding indicators of the benchmark and the subject to assessment are the same, that is $(1 - X_{ni}) = 0$. It means that when the generalized indicators of the benchmark and the subject to assessment coincide, the integrated index equals zero. From the formula it is clear that the integrated index cannot be greater than zero if the sum of the ratios of the benchmark is greater than the sum of the ratios of the subject to assessment and vice versa.

The value of the integrated index will always be greater than zero, since the generalized indicator of the benchmark is determined on the basis of the best individual technical and economic indicators. The latter is maximum in absolute magnitude and in determining the sum of their ratios become smaller that is equal to figure one multiplied by the number of individual technical- economic indicators applied to efficiency assessment. The smaller the absolute magnitude of integrated indices, the higher the efficiency of transport and customs infrastructure facilities or in other words, the efficiency of the subject to assessment is closer to the efficiency indicator of the benchmark.

The value M_i solves the problem of compensation for the influence of the ratios of low significance indicators, which brings separate criteria to a certain scale of change in indicators. Variable values of power coefficients of the logarithmic function, where n is the total number of individual criteria, and i stands for their sequence numbers in the ordered series, enables to reflect the effect of more important criteria on the value of the integrated index. So, if the values of criteria are the same, then the logarithmic function is equal to one. Hence, the integrated index will be equal to the difference between the sum of the ratios of the benchmark and the sum of the ratios of the subject to assessment. The optimal range of extreme values of the integrated index depends on the magnitude and number of criteria, and their weighting coefficients.

The proposed empirical formula of the integrated index of comparative multicriteria efficiency

assessment of transport and customs infrastructure facilities allows: to conduct a reliable multi-criteria efficiency assessment of transport and customs infrastructure facilities; to determine the degree of conformity between the facility efficiency assessment and the benchmark assessment characterized by the best technical and economic indicators in the form of the integrated index; to carry out a multi-criteria assessment and selection of customs infrastructure facilities based on a confidence interval of the integrated indicator for their most efficient operation reducing the risk of making false decisions; to calculate the integrated index value for any number of indicators and their different values; to take into account the factors peculiar to multicriteria assessments; to carry out a comprehensive analysis of variants of transport and customs infrastructure facilities as objects of economic evaluation; to significantly reduce the influence of subjective factors thus making evaluation more reliable; in case there is no such a transport and customs infrastructure facility suitable to be a benchmark the empirical formula of the integrated index and the method of its construction make it possible to model a benchmark facility on the basis of the best values of the technical and economic indicators of the set of options for subjects to assessment.

The proposed list of indicators for assessing the efficiency of freight customs complexes is not compulsory or mandatory. Depending on the characteristics of the subject to efficiency assessment the set of indicators can vary both in terms of quantity and qualitative differences according to the pursued goals and objectives. Putting into practice the calculations of the efficiency indicator values of transport and customs infrastructure facilities in comparison with the benchmark involves a step-by-step assessment procedure. The most important variables in the calculations are:

P_i – facility performance indicator;

S_i – the expert significance value of each individual indicator;

n – the number of indicators based on which generalized indicators and integrated indices are determined; x_i – the ratio value of an individual indicator;

M_i – the ratio of the largest value of an indicator to the smallest one ;

i – the sequence number of an individual indicator in the ordered series;

K_i – the significance value of an indicator determined from the formula;

F_z – the generalized indicator of the benchmark;

F_N – the generalized indicator of the assessed facility;

J – the integrated index for the efficiency assessment of transport and customs infrastructure facilities as compared to the benchmark;

In general, the procedure for determining the integrated index for efficiency assessment of transport and customs infrastructure facilities is as follows:

1. It is determined the quantitative and qualitative composition of the criteria for assessing facilities. The set of criteria should provide a comprehensive description of the state of the object under examination.

2. Since individual criteria may have a different focus on final outcomes, they should be grouped on this basis.

3. A quantitative assessment of a facility is carried out.

4. Once the numerical values of the criteria have been determined, an expert or a specially created commission arranges the criteria in order of their significance, thus assessing the importance of each of them.

5. The definition of the criteria of the benchmark is carried out by a simple selection of the best relevant criteria from the set of such indicators of evaluated objects.

6. The calculation of relative indicators is carried out by dividing the benchmark criteria by the corresponding criteria of the evaluated facility.

7. For all the criteria, the ratio of the maximum value to the minimum value is determined.

8. Using the tables of natural logarithms, the value of the logarithmic function $(\ln M_i + 1)$ is determined according to each criterion for all objects.

9. Determination of the instantaneous value of the power coefficient of the logarithmic function for a criterion is performed according to the formula $(n - i)$ using the variable number of criteria in the ordered series.

10. Determination of the significance indicator of a criterion.

11. Since, following the appropriate way of determining criteria, for the benchmark they are always equal to one, then its generalized indicator is determined using the same formula as for the weighing coefficient, namely F_z .

12. Determination of the generalized indicator of a facility F_N .

13. Determination of the integrated index for the efficiency assessment of transport and customs infrastructure facilities J .

14. After determining the value of the integrated index, its analysis is carried out to identify its compliance with the given interval of extreme values. In case of non-compliance with such an interval an expert either decides on further evaluation or stops searching for the integrated index.

5. Conclusions

The constantly increasing level of competition in the field of transport and customs infrastructure requires timely response to the needs of foreign economic activity entities by means of quality service provision and optimization of internal technological processes related to the handling of cargo flows, the development of the standard requirements at the state level for transport and customs infrastructure facilities and the criteria for their efficiency assessment in comparison with competing organizations. The paper defines the main criteria for the efficiency assessment of transport and customs infrastructure facilities. In order to assess the efficiency of such facilities it is proposed the procedure for defining the integrated index.

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Багатокритеріальна оцінка ефективності об'єктів транспортно-митної інфраструктури

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В статті запропоновано підхід, щодо багатокритеріальної оцінки ефективності об'єктів транспортно-митної інфраструктури шляхом порівняння об'єктів, що аналізуються з об'єктом-еталоном. Об'єкт дослідження – процес багатокритеріальної оцінки ефективності функціонування вантажних митних комплексів. Мета роботи – розробка теоретичних основ і проведення комплексної оцінки ефективності об'єктів транспортно-митної інфраструктури. Метод дослідження – багатокритеріальна оцінка діяльності об'єктів транспортно-митної інфраструктури. Значна кількість об'єктів транспортно-митної інфраструктури і критеріїв їх функціонування, необхідність оцінки результативності фіскальної служби в цілому і окремих об'єктів закономірно потребують використання математичного апарату оцінки ефективності управління та державного регулювання процесів переміщення вантажів через митний кордон. Особливість експлуатації об'єктів транспортно-митної інфраструктури потребує уніфікації проектних рішень щодо діяльності об'єктів транспортно-митної інфраструктури їх пропускної здатності, місткості, технічного, технологічного та організаційного забезпечення. До особливостей визначення ефективності об'єктів транспортно-митної інфраструктури, що залежать від специфіки їх експлуатації, належать: залежність величини показників ефективності від форми власності, в якій знаходиться об'єкт оцінки; суперечливість множини локальних критеріїв, що характеризують об'єкт інфраструктури; неоднорідність і несумісність локальних критеріїв, не тільки по відношенню один до одного, але і по відношенню до інтегрального показника ефективності об'єктів митної інфраструктури; необхідність урахування витрат на вимушену уніфікацію проектних рішень за об'єктами інфраструктури. Результати статті можуть бути впроваджені в діяльності логістичних посередників при виконанні зовнішньоторговельних операцій. Прогнозні припущення щодо розвитку об'єкта дослідження – розробка методики оцінки діяльності об'єктів транспортно-митної інфраструктури.

Ключові слова: транспортно-митна інфраструктура; вантажний митний комплекс; критерій; багатокритеріальна оцінка; ранг; експерт

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В статье предложен подход, к многокритериальной оценке эффективности объектов транспортно-таможенной инфраструктуры путем сравнения объектов, которые анализируются с объектом-эталоном. Объект исследования - процесс многокритериальной оценки эффективности функционирования грузовых таможенных комплексов. Цель работы - разработка теоретических основ и проведения комплексной оценки эффективности объектов транспортно-таможенной инфраструктуры. Метод исследования - многокритериальная оценка деятельности объектов транспортно-таможенной инфраструктуры. Значительное количество объектов транспортно-таможенной инфраструктуры и критериев их функционирования, необходимость оценки результативности фискальной службы в целом и отдельных объектов, закономерно требуют использования математического аппарата оценки эффективности управления и государственного регулирования процессов перемещения грузов через таможенную границу. Особенность эксплуатации объектов транспортно-таможенной инфраструктуры требует унификации проектных решений по деятельности объектов транспортно-таможенной инфраструктуры их пропускной способности, вместимости, технического, технологического и организационного обеспечения. К особенностям определения эффективности объектов транспортно-таможенной инфраструктуры, в зависимости от специфики их эксплуатации, относятся: зависимость величины показателей эффективности от формы собственности, в которой находится объект оценки; противоречивость множества локальных критериев, характеризующих объект инфраструктуры; неоднородность и несовместимость локальных критериев, не только по отношению друг к другу, но и по отношению к интегральному показателю эффективности объектов таможенной инфраструктуры; необходимость учета расходов на вынужденную унификацию проектных решений по объектам инфраструктуры. Результаты статьи могут быть внедрены в деятельности логистических посредников при выполнении внешнеторговых операций. Прогнозные предположения по развитию объекта исследования - разработка методики оценки деятельности объектов транспортно-таможенной инфраструктуры.

Ключевые слова: транспортно-таможенная инфраструктура; грузовой таможенный комплекс; критерий; многокритериальная оценка; ранг; эксперт

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