The Central Research institute
of the Armed Forces of Ukraine

ISSN (print): 2786-9318
ISSN (online): 2786-9326
Military Science. Vol. 3 No. 4 (2025)

Received: *November 5, 2025* | **Revisions Requested:** - | **Revision Received:** -
Accepted: *January 13, 2026* | **Published Online:** *March 21, 2026*

Licensed (C) by Creative Commons Attribution International License 4.0 (CC BY-NC-SA)

DOI: 10.62524/msj.2025.3.4.12

Method for Substantiating External (International) Military and Economic Conditions of the Construction and Development within the Armed Forces

Maryna Abramova
Candidate of Economic Sciences, Senior Researcher
Leading Research Fellow
The Central Research Institute of the Armed Forces of Ukraine
03049, Povitrianykh Syl Avenue, 28 B, Kyiv, Ukraine
e-mail: Elaira3@gmail.com
ORCID: 0000-0001-7644-9988

Abstract. The article substantiates the method of multicriteria assessment of the external (international) military and economic conditions for the construction and development of the Armed Forces of Ukraine under the conditions of increased uncertainty. The relevance of the research is determined by the growing role of international economic, military and technical, and political factors in shaping the defence capability of the state, as well as by the limitations of traditional approaches to their assessment, which insufficiently take into account the vagueness and inconsistency of expert information. The aim of the work is to develop a scientifically substantiated method that enables the comparative analysis and ranking of the military-economic conditions for the development of the armed forces on the basis of a system of coordinated criteria. The study uses the methods of analysis and synthesis, formalisation, expert assessment, as well as the tools of multicriteria analysis with elements of fuzzy logic. The proposed method provides for the formation of a matrix of expert assessments in the form of three-component fuzzy numbers, the determination of criteria weights, the construction of positive and negative benchmarks, and the calculation of an integral proximity index for each alternative. As a result, a ranked list of external military-economic conditions has been formed, which makes it possible to substantiate their priority for the strategic planning and development of the Armed Forces of Ukraine. The practical value of the work lies in the possibility of using the proposed method as a decision-support tool in the sphere of national security and defence construction.

Keywords: Armed Forces of Ukraine, military and economic conditions, multicriteria analysis, fuzzy logic, expert assessment, strategic planning, international factors, defence construction.

Introduction

One of the main prerequisites for the effective functioning and development of the armed forces is the ability to adequately assess and take into account the influence of external (international) military-economic conditions, which shape the environment of their existence and determine the strategic orientations of their future development. In the modern world, military-economic conditions act as a significant instrument of international influence, since the defence capability of the army directly depends on the level of economic support, access to technologies, cooperation with partners and participation in global economic processes.

A particular complexity lies in the fact that international military-economic conditions are, by

ISSN (print): 2786-9318
ISSN (online): 2786-9326
Military Science. Vol. 3 No. 4 (2025)

their nature, multidimensional, dynamic and often contradictory. They include a wide range of conditions – from financial and economic assistance and international sanctions to access to arms markets, cooperation in the sphere of military and technical production and opportunities for integration into international defence structures. In crisis situations, when the level of uncertainty increases sharply, the need for their scientifically substantiated analysis becomes especially urgent, as the effectiveness of state policy in the sphere of defence depends precisely on the ability to identify key trends in a timely and correct manner.

Thus, the study of external military-economic conditions has not only theoretical value for the science of security and defence, but also practical significance, as it provides the possibility of timely response to challenges, optimisation of strategic planning processes and enhancement of the efficiency of the use of available resources. For this reason, the substantiation of a systemic approach to the analysis of such conditions is one of the most important tasks of contemporary military-economic science, without the solution of which it is difficult to ensure the sustainable development of the Armed Forces of Ukraine (AF of Ukraine) under the conditions of increased uncertainty of the external economic environment.

Methodological Framework

In contemporary scientific literature, the problem of substantiating the military-economic conditions for the construction and development of the armed forces is addressed in the works of both Ukrainian and foreign authors; however, the approaches to its study have different emphases. Ukrainian scholars mainly focus on applied aspects, where statistical methods, military-economic analysis, comparison, formalisation and expert assessment are combined, which makes it possible to develop algorithms for calculating the cost of operational training and at the same time to formulate practical recommendations for planning and determining the priority of measures [1].

A number of studies emphasise that the military-economic support of the state's defence capability requires the use not only of the methods of analysis and synthesis, but also of operations research, which ensures the substantiation of the selection of armaments and military equipment, as well as the optimisation of the processes of their procurement and employment [2]. In works devoted to the analysis of the military-economic conditions of Ukraine and other states, it is proposed to conduct a rating assessment of the development of the armed forces on the basis of macroeconomic indicators reflecting the transformation towards NATO standards, and thus a conclusion is drawn regarding the interrelation between military expenditure and the level of economic security [3].

In addition, external and internal conditions influencing the development of the armed forces are analysed, among which military-political and demographic factors are distinguished, as well as financing, the development of the defence-industrial complex and inflationary processes; quantitative assessment is carried out through expert surveys, regression and correlation analysis [4]. Certain studies focus on the problem of the military-economic security of the state, where a system of indicators for assessing its condition under the circumstances of contemporary military conflicts is proposed, which makes it possible to monitor the resilience of the defence system taking into account institutional and risk-based approaches [5]. Thus, Ukrainian scientific thought gives preference to applied assessment mechanisms oriented towards the practical tasks of armed forces development.

Foreign research demonstrates a different methodological orientation, as it is based on theoretical and modelling constructs, including the use of mathematical modelling, econometrics and game theory for forecasting possible scenarios and strategic decisions [6, 7]. Within the framework of software developed for comprehensive planning, political, military, economic, social, infrastructural and information factors are integrated, which makes it possible to conduct a multidimensional assessment of international operations [8]. In addition, a concept is applied that considers military and economic factors as a component of achieving strategic effects in combination with political and information means.

The Central Research institute
of the Armed Forces of Ukraine

ISSN (print): 2786-9318
ISSN (online): 2786-9326
Military Science. Vol. 3 No. 4 (2025)

In the scientific works of foreign authors, the problem of economic warfare is also clearly present. This concept is understood as the use of sanctions, blockades and resource control as instruments for undermining the adversary's potential, and it is complemented by deterrence theory, which emphasises the role of military-economic resources as an important element of the threat system for preventing aggressive actions [10]. Particular attention should also be paid to a study in which it is demonstrated that internal and external economic conditions, including the development of armaments, the pace of economic growth and budgetary constraints, directly determine the structure and volume of defence expenditure in developing countries.

In general, it may be stated that Ukrainian sources are oriented towards applied aspects of military-economic analysis, whereas English-language studies offer more fundamental research – ranging from modelling and econometrics to strategic concepts related to the use of economic instruments in the military sphere. Such diversity of approaches creates the preconditions for their combination, which would make it possible to develop a comprehensive methodology for substantiating the external military-economic conditions for the development of the armed forces.

Results and Discussions

In periods of the emergence due to crisis situations, when the level of uncertainty in the external and internal environment increases, the relevance of developing scientifically substantiated tools for assessing the conditions of armed forces development is enhanced. Therefore, the necessity of applying multicriteria research methods is determined by the need to improve the effectiveness of such assessment, which constitutes an important prerequisite for making managerial decisions.

Stage 1: identification of possible relevant external military and economic conditions for the development of the armed forces.

To formalise the process of substantiating possible relevant military-economic conditions for the development of the armed forces under crisis situations, let the set of all military-economic conditions considered in this analysis be denoted by the set $U^{we} = \{u_1^{we}, u_2^{we}, ..., u_{bb}^{we}\}$, where U^{we} denotes the set of alternatives (conditions), and the subscripts 1,2,…,bb correspond to the numbers of specific military-economic conditions. Thus, each element u_b^{we} from this set (b=1,2,...,bb) is interpreted as a separate military-economic condition for which it is necessary to determine the value of priority, importance or influence in accordance with the selected criteria (Fig. 1). At this stage, the list is determined based on the results of an expert survey — the selection criterion is the coincidence in the naming of a military-economic condition more than five times within a group of ten experts. Thus: $U^{we*} = \{u_b^{we} \in U^{we} \mid Qu_b > 5\}$, where Qu_b – is the number of mentions of condition u_b^{we}.

Stage 2: determination of relevant evaluation criteria and construction of the expert assessment matrix.

To form the list of criteria according to which a comparative analysis of each condition will be carried out, their set is defined: $Kr = \{kr_1, kr_2, ..., kr_{bb}\}$, where Kr denotes the overall set of criteria, and the subscripts 1,2,...,mm indicate a specific analysis criterion.

For the correct application of fuzzy multi-criteria analysis, the construction of a rectangular expert matrix of dimension $bb \times mm$ is mandatory, in which each row corresponds to a separate military-economic condition and each column corresponds to a specific evaluation criterion.

The Central Research institute
of the Armed Forces of Ukraine

ISSN (print): 2786-9318
ISSN (online): 2786-9326
Military Science. Vol. 3 No. 4 (2025)

Stage 1. Identification of possible relevant external military and economic conditions for the development of the armed forces: based on the results of an expert survey: $U^{we*} = \{u_b^{we} \in U^{we} \mid Qu_b > 5\}$, where U^{we} – is the set of all military-economic conditions for the development of the armed forces considered in this analysis. Conditions here are understood as development alternatives; u_b^{we} – is a separate military-economic condition from the set, Qu_b – is the number of mentions of condition u_b^{we}.

Stage 2. Determination of relevant evaluation criteria $Kr = \{kr_1, kr_2, ..., kr_{bb}\}$ and construction of the expert assessment matrix

$$X^x = \begin{bmatrix} (\min_{11}, \text{mode}_{11}, high_{11}) & (\min_{12}, \text{mode}_{12}, high_{12}) & \cdots & (\min_{1m}, \text{mode}_{1m}, high_{1mm}) \\ (\min_{21}, \text{mode}_{21}, high_{21}) & (\min_{22}, \text{mode}_{22}, high_{22}) & \cdots & (\min_{2m}, \text{mode}_{2m}, high_{2mm}) \\ \vdots & \vdots & \ddots & \vdots \\ (\min_{bb1}, \text{mode}_{bb1}, high_{bb1}) & (\min_{bb2}, \text{mode}_{bb2}, high_{bb2}) & \cdots & (\min_{bbm}, \text{mode}_{bbm}, high_{bbmm}) \end{bmatrix}$$

, where Kr – the set of all criteria (overall set); kr_k – is an individual criterion from this set; k – is the criterion number, taking values from 1 to mm (the total number of criteria; mm – is the number of criteria (this index denotes the number of analysis criteria); X^x – is the expert assessment matrix of dimension bb × mm; b – is the number of the military-economic condition; $\min_{bk}$ – is the lower bound of the assessment (min), that is, the smallest possible value of expert judgement regarding the evaluation of the condition u_b under criterion kr_k; mod_{bk} – is the modal value of the assessment (mode), that is, the most probable or most typical value; $high_{bk}$ – is the upper bound of the assessment (max), that is, the largest possible value of the expert evaluation of the condition u_b under criterion kr_k

Stage 3. Aggregation and determination of fuzzy weights of the criteria: $\tilde{W}_{Kr_k} = \{\tilde{\omega}_{kr_1}, \tilde{\omega}_{kr_2}, ..., \tilde{\omega}_{kr_{mm}}\}$, where $\tilde{W}_{Kr_k}$ is the set of weights by criteria; $\tilde{\omega}_{kr_1}$ – is the fuzzy weight of the first criterion; $\tilde{\omega}_{kr_2}$ – is the fuzzy weight of the second criterion; $\tilde{\omega}_{kr_{mm}}$ – is the fuzzy weight of the mm-th criterion.

Stage 4. Formation of the sets of reference conditions: the "positive" set: $X^{(+)} = [x_1^{(+)}, x_2^{(+)}, ..., x_{mm}^{(+)}]$ and the "negative" benchmark set: $X^{(-)} = [x_1^{(-)}, x_2^{(-)}, ..., x_{mm}^{(-)}]$, where $x_k^{(+)} = (x_k^{\min(+)}, x_k^{\text{mod}(+)}, x_k^{\text{high}(+)})$ – *is the fuzzy number of the positive benchmark under the k-th criterion, and* $x_k^{(-)} = (x_k^{\min(-)}, x_k^{\text{mod}(-)}, x_k^{\text{high}(-)})$ – *is the fuzzy number of the negative benchmark under the k-th criterion.*

Stage 5. Calculation of the integral Euclidean distances of the condition values from the reference benchmarks

to the "positive benchmark": $$Exk_b^{(+)} = \sqrt{\frac{1}{3mm} \cdot \left(\sum_{k=1}^{mm} \tilde{\omega}_k \left[\left(v_{bk}^{\min} - v_k^{\min(+)} \right)^2 \right] + \left(\sum_{k=1}^{mm} \left[\left(v_{bk}^{\text{mod}} - v_k^{\text{mod}(+)} \right)^2 \right] + \left(\sum_{k=1}^{mm} \left[\left(v_{bk}^{high} - v_k^{high(+)} \right)^2 \right] \right) \right) \right)},$$

to the "negative benchmark": $$Exk_b^{(-)} = \sqrt{\frac{1}{3mm} \cdot \left(\sum_{k=1}^{mm} \tilde{\omega}_k \left[\left(v_{bk}^{\min} - v_k^{\min(-)} \right)^2 \right] + \left(\sum_{k=1}^{mm} \left[\left(v_{bk}^{\text{mod}} - v_k^{\text{mod}(-)} \right)^2 \right] + \left(\sum_{k=1}^{mm} \left[\left(v_{bk}^{high} - v_k^{high(-)} \right)^2 \right] \right) \right) \right)},$$

where $Evk_b^{(+)}$ – is the Euclidean distance of the b-th condition from the "positive benchmark" in the space of all criteria; $x_{bk}^{\min}$, x_{bk}^{mod}, x_{bk}^{high} – are respectively the lower, modal and upper components of the fuzzy number for the b-th condition under the k-th criterion; $x_k^{\min(+)}$, $x_k^{\text{mod}(+)}$, $x_k^{high(+)}$ – are the corresponding components of the fuzzy number of the "positive benchmark" under the k-th criterion.

Stage 6. Calculation of the integral closeness index: $CC_b = \frac{Exk_b^{(-)}}{Exk_b^{(+)} + Exk_b^{(-)}}$, where CC is the integral closeness index

Stage 7. Ranking of external military-economic conditions for the development of the armed forces: $CC_1, CC_2, \cdots, CC_n \Rightarrow CC_{(1)} \geq CC_{(2)} \geq \ldots \geq CC_{(bb)}$ and $u_1^{we}, u_2^{we}, \cdots, u_{bb}^{we} \Rightarrow u_{(1)}^{we} \geq u_{(2)}^{we} \geq \ldots \geq u_{(bb)}^{we}$, where $CC_{(1)}$ – is the highest closeness index corresponding to the first-ranked (best, most prioritised) condition; $CC_{(2)}$ – is the second-largest index determining the condition with the second level of priority; $CC_{(bb)}$ – is the smallest index corresponding to the last-ranked condition; $u_{b^*}^{we}$ – is the condition with the highest closeness index; $u_{b^{**}}^{we}$ – the condition with the next highest index, and so on up to $u_{b^{***}}^{we}$ – the condition with the smallest index

Figure 1. Stage-based representation of the algorithm of the method for substantiating external military-economic conditions for the development of the armed forces

The Central Research institute
of the Armed Forces of Ukraine

ISSN (print): 2786-9318
ISSN (online): 2786-9326
Military Science. Vol. 3 No. 4 (2025)

That is, the matrix: $X^x = \left[\tilde{x}^x_{bk}\right]_{bb\times mm}$ is formed, where $\tilde{x}^x_{bk}$ – is the assessment of the b-th condition under the k-th criterion in the form of a triangular fuzzy representation, which constitutes the basic information element for the subsequent stages of the analysis (the index b ($1 \le b \le bb$) corresponds to the number of the military-economic condition, and the index k ($1 \le k \le mm$) corresponds to the number of the criterion):

$\tilde{x}^x_{bk} = (\min_{bk}, \mathrm{mod}_{bk}, high_{bk})$, where $\min_{bk}$ – is the lower bound of the assessment (min), that is, the smallest possible value of expert judgement regarding the evaluation of the condition u_b under criterion kr_k; mod_{bk} – is the modal value of the assessment (mode), that is, the most probable or most typical value.; $high_{bk}$ – is the upper bound of the assessment (max), that is, the largest possible value of the expert evaluation of the condition u_b under the criterion kr_k. It should be noted that, in order to ensure the correctness of subsequent calculations, the expert assessments (min, mode, max) for all criteria must be normalised to a common dimensionless scale, for example within the range [0; 1], where "0" corresponds to the worst possible value and "1" to the best value for each criterion.

If the initial expert assessments have different units of measurement or ranges (for example, "million UAH", "days", "percentages"), they must be preliminarily normalised.

These assessments form the expert assessment matrix of dimension $bb \times mm$:

$$X^x = \begin{bmatrix} \tilde{x}^x_{11} & \tilde{x}^x_{12} & \tilde{x}^x_{13} & \cdots & \tilde{x}^x_{1mm} \\ \tilde{x}^x_{21} & \tilde{x}^x_{22} & \tilde{x}^x_{23} & \cdots & \tilde{x}^x_{2mm} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \tilde{x}^x_{bb1} & \tilde{x}^x_{bb2} & \tilde{x}^x_{bb3} & \cdots & \tilde{x}^x_{bbmm} \end{bmatrix}, \text{ або}$$

$$X^x = \begin{bmatrix} (\min_{11}, \mathrm{mode}_{11}, high_{11}) & (\min_{12}, \mathrm{mode}_{12}, high_{12}) & \cdots & (\min_{1m}, \mathrm{mode}_{1m}, high_{1mm}) \\ (\min_{21}, \mathrm{mode}_{21}, high_{21}) & (\min_{22}, \mathrm{mode}_{22}, high_{22}) & \cdots & (\min_{2m}, \mathrm{mode}_{2m}, high_{2mm}) \\ \vdots & \vdots & \ddots & \vdots \\ (\min_{bb1}, \mathrm{mode}_{bb1}, high_{bb1}) & (\min_{bb2}, \mathrm{mode}_{bb2}, high_{bb2}) & \cdots & (\min_{bbm}, \mathrm{mode}_{bbm}, high_{bbmm}) \end{bmatrix}.$$

That is, for each combination of conditions and criteria, three values are specified: the minimum, the average and the maximum expert assessmen.

In addition, the direction of the criterion ("the more – the better" or "the less – the better") must be taken into account where the set of criteria k=1,…, mm, that is "the more – the better" and "the less – the better".

Here $x_{bk} \equiv x_{bk}^{`}$ is considered after normalisation. Let $\min_b x^c_{bk}$ and $\max_b x^c_{bk}$ be known for each k and for each component c (across all b). Then the normalised values take the following form:

$$x_{bk}^{`} = \begin{cases} \dfrac{x^c_{bk} - \min\limits_b x^c_{bk}}{\max\limits_b x^c_{bk} - x^c_{bk}}, \; напрямок_k = \text{"}більше - краще\text{"} \\ \dfrac{\max\limits_b x^c_{bk} - x^c_{bk}}{\max\limits_b x^c_{bk} - \min\limits_b x^c_{bk}}, \; напрямок_k = \text{"менше} - краще\text{"} \end{cases}.$$

In addition, it is important to preserve the order: $x_{bk}^{`\min} \le x_{bk}^{`\mathrm{mod}} \le x_{bk}^{`high}$.

Stage 3: Aggregation and determination of fuzzy weights of the criteria.

For this purpose, it is proposed to use the same approach — triangular fuzzy evaluation: $\tilde{\omega}_{Kr_k} = \left(\tilde{\omega}^{\min}_{kr_k}, \tilde{\omega}^{\mathrm{mod}}_{kr}, \tilde{\omega}^{high}_{kr_k}\right)$, where $\tilde{\omega}^{\min}_{kr_k}$ – is the minimum value of the weight of the criterion according to expert E, that is, the most pessimistic assessment of its importance; $\tilde{\omega}^{\mathrm{mod}}_{kr_k}$ – is the modal

The Central Research institute
of the Armed Forces of Ukraine

ISSN (print): 2786-9318
ISSN (online): 2786-9326
Military Science. Vol. 3 No. 4 (2025)

(most typical or most probable) value of the weight of criterion k for the same expert, that is, the expert "benchmark" of the importance of the criterion; $\tilde{\omega}_{kr_k}^{high}$ – is the maximum value that expert E is willing to assign to this criterion, that is, the most optimistic assessment.

Thus, for each criterion Kr_k an interval of expert confidence is formed from each expert, covering the full spectrum of opinions — from minimum to maximum significance. In order to determine the collective, integral fuzzy weight for each criterion, it is necessary to aggregate the obtained intervals across all experts. For this purpose, arithmetic averaging of each component of the triangular number is carried out separately: $\omega_{Kr_k}^{\min} = \frac{1}{Q} \cdot (\omega_{kr_k}^{\min,1} + \omega_{kr_k}^{\min,2} + \cdots + \omega_{kr_k}^{\min,Q})$, where Q – is the total number of experts (E), and also: $\omega_{Kr_k}^{\text{mod}} = \frac{1}{Q} \cdot (\omega_{kr_k}^{\text{mod},1} + \omega_{kr_k}^{\text{mod},2} + \cdots + \omega_{kr_k}^{\text{mod},Q})$, $\omega_{Kr_k}^{high} = \frac{1}{Q} \cdot (\omega_{kr_k}^{high,1} + \omega_{kr_k}^{high,2} + \cdots + \omega_{kr_k}^{high,Q})$.

The final result of the third stage is the set of fuzzy weights for each criterion: $\tilde{W}_{Kr_k} = \{\tilde{\omega}_{kr_1}, \tilde{\omega}_{kr_2}, ..., \tilde{\omega}_{kr_{mm}}\}$, where $\tilde{\omega}_{kr_1}$ – is the fuzzy weight of the first criterion; $\tilde{\omega}_{kr_2}$ – is the fuzzy weight of the second criterion; $\tilde{\omega}_{kr_{mm}}$ – is the fuzzy weight of the mm-th criterion.

Since the weight of a criterion is specified by three values: the lower bound, the most probable value and the upper bound, defuzzification procedure must be carried out (transition to a single value … ω_k). For this purpose, a weighted average with coefficients "1:4:1" is used: the extreme bounds are assigned a weight of "1", while the modal (central) value is assigned a weight of "4" as the component with the highest degree of confidence: $\tilde{\omega}_{kr} = \frac{1 \cdot \tilde{\omega}_{kr_k}^{\min} + 4 \cdot \tilde{\omega}_{kr_k}^{\text{mod}} + 1 \cdot \tilde{\omega}_{kr_k}^{high}}{1+4+1} = \frac{\tilde{\omega}_{kr_k}^{\min} + 4\omega_{kr_k}^{\text{mod}} + \tilde{\omega}_{kr_k}^{high}}{6}$.

tage 4: formation of the sets of reference conditions: the "positive" and the "negative" benchmarks.

After the matrix of expert assessments of the military-economic conditions according to the selected criteria has been formed, and the corresponding fuzzy weight has been obtained for each criterion, the fourth stage consists in determining the so-called benchmarks of the alternatives. This involves identifying those conditions (alternatives) which, in terms of the aggregate of criteria, have the best ("positive benchmark") and the worst ("negative benchmark") values, thereby ensuring the correctness and transparency of the subsequent ranking procedure.

The **"positive benchmark"** is a conventional reference pattern that, for each criterion, has the highest level of expert assessment among all conditions, whereas the "negative benchmark" is characterised by the lowest assessment value. To ensure flexibility and to take into account expert uncertainty, such "benchmarks" are presented in the form of a triangular fuzzy representation, each component of which (lower bound, modal assessment, upper bound) is calculated separately.

The triangular fuzzy representation for the "positive benchmark" under each criterion takes the following form:

$x_k^{\min(+)} = \max\{x_{1k}^{\min}, x_{2k}^{\min}, ..., x_{bbk}^{\min}\}$, $x_k^{\text{mod}(+)} = \max\{x_{1k}^{\text{mod}}, x_{2k}^{\text{mod}}, ..., x_{bbk}^{\text{mod}}\}$, $x_k^{\text{high}(+)} = \max\{x_{1k}^{\text{high}}, x_{2k}^{\text{high}}, ..., x_{bbk}^{\text{high}}\}$, where $x_k^{\min(+)}$ – is the highest (maximum) value of the lower bound of the triangular fuzzy representation among all conditions under the k-th criterion; $x_k^{\text{mod}(+)}$ –

The Central Research institute
of the Armed Forces of Ukraine

ISSN (print): 2786-9318
ISSN (online): 2786-9326
Military Science. Vol. 3 No. 4 (2025)

is the maximum value of the modal assessment under this criterion; $x_k^{high(+)}$ – is the maximum value of the upper bound of the assessment under the k-th criterion.

Taken together, these three values form the triangular representation of the "positive benchmark" under the k-th criterion $x_k^{(+)} = \left(x_k^{min(+)}, x_k^{mod(+)}, x_k^{high(+)}\right)$.

The triangular fuzzy representation for the "negative benchmark" under each criterion takes the following form: $x_k^{min(-)} = \min\left\{x_{1k}^{min}, x_{2k}^{min}, ..., x_{bbk}^{min}\right\}$, $x_k^{mod(-)} = \min\left\{x_{1k}^{mod}, x_{2k}^{mod}, ..., x_{bbk}^{mod}\right\}$, $x_k^{high(-)} = \min\left\{x_{1k}^{high}, x_{2k}^{high}, ..., x_{bbk}^{high}\right\}$, where $x_k^{min(-)}$ – is the smallest value of the lower bound of the triangular fuzzy representation among all conditions under the k-th criterion; $x_k^{mod(-)}$ – is the minimum value of the modal assessment under this criterion; $x_k^{high(-)}$ – is the minimum value of the upper bound of the assessment under the k-th criterion.

Taken together, these three values form the triangular representation of the "negative benchmark" under the k-th criterion $x_k^{(-)} = \left(x_k^{min(-)}, x_k^{mod(-)}, x_k^{high(-)}\right)$.

For a complete multi-criteria assessment, the vectors of the positive and negative benchmarks are constructed for all criteria: $X^{(+)} = \left[x_1^{(+)}, x_2^{(+)}, ..., x_{mm}^{(+)}\right]$ and $X^{(-)} = \left[x_1^{(-)}, x_2^{(-)}, ..., x_{mm}^{(-)}\right]$, where $x_k^{(+)} = \left(x_k^{min(+)}, x_k^{mod(+)}, x_k^{high(+)}\right)$ – is the triangular fuzzy representation of the positive benchmark under the k-th criterion, and $x_k^{(-)} = \left(x_k^{min(-)}, x_k^{mod(-)}, x_k^{high(-)}\right)$ – is the triangular fuzzy representation of the negative benchmark under the k-th criterion.

Stage 5: calculation of the integral Euclidean distances of the condition values from the reference benchmarks.

At this stage, a quantitative determination is made of how "close" or "distant" each examined military-economic condition (alternative) is from the reference benchmarks formed at the previous stage — namely, from the positive (benchmark best) and the negative (benchmark worst) benchmark. This makes it possible to compare all conditions in a mathematically substantiated manner within the multidimensional space of criteria and also provides a basis for objective ranking and optimal decision-making. To assess such a "distance", a generalised Euclidean metric is applied to the components of the triangular fuzzy representation.

For each condition u_b, where b=1,2,...,bb the distance to the "positive benchmark" is calculated using the following expanded formula:

$$Exk_b^{(+)} = \sqrt{\frac{1}{3mm} \cdot \left(\sum_{k=1}^{mm} \tilde{\omega}_k \left[\left(x_{bk}^{min} - x_k^{min(+)}\right)^2\right] + \left(\sum_{k=1}^{mm} \left[\left(x_{bk}^{mod} - x_k^{mod(+)}\right)^2\right] + \left(\sum_{k=1}^{mm} \left[\left(x_{bk}^{high} - x_k^{high(+)}\right)^2\right]\right.\right.\right.},$$

where $Exk_b^{(+)}$ – is the Euclidean distance of the b-th condition from the "positive benchmark" in the space of all criteria;

x_{bk}^{min}, x_{bk}^{mod}, x_{bk}^{high} – are respectively the lower, modal and upper components of the triangular fuzzy representation for the b-th condition under the k-th criterion;

$x_k^{min(+)}$, $x_k^{mod(+)}$, $x_k^{high(+)}$ – are the corresponding components of the triangular fuzzy representation of the "positive benchmark" under the k-th criterion;

mm – is the number of criteria.

Thus, the distance $Exk_b^{(+)}$ characterises how "close" the b-th condition is to the best possible assessment values across all criteria.

By analogy, the distance of the b-th condition from the "negative benchmark" is calculated as follows:

The Central Research institute
of the Armed Forces of Ukraine

ISSN (print): 2786-9318
ISSN (online): 2786-9326
Military Science. Vol. 3 No. 4 (2025)

$$Exk_b^{(-)} = \sqrt{\frac{1}{3mm} \cdot (\sum_{k=1}^{mm} \tilde{\omega}_k \left[\left(x_{bk}^{\min} - x_k^{\min(-)} \right)^2 \right] + (\sum_{k=1}^{mm} \left[\left(x_{bk}^{\mathrm{mod}} - x_k^{\mathrm{mod}(-)} \right)^2 \right] + (\sum_{k=1}^{mm} \left[\left(x_{bk}^{high} - x_k^{high(-)} \right)^2 \right]},$$

where $Exk_b^{(-)}$ – is the Euclidean distance of the b-th condition from the "negative benchmark" in the space of all criteria;

$x_k^{\min(-)}$, $x_k^{\mathrm{mod}(-)}$, $x_k^{high(-)}$ – are the corresponding components of the triangular fuzzy representation of the "negative benchmark" under the k-th criterion.

The essence of the calculations and the mathematical meaning of the formulae.

Here, each component of the sum in the formulae represents the square of the difference between the components (min, mod, high) of the fuzzy assessment of the b-th condition and the corresponding component of the reference benchmark ("positive" or "negative"). Such a procedure makes it possible not merely to determine which condition has a "higher" assessment, but rather to calculate an integral closeness index in a three-component fuzzy space, taking into account all criteria. The factor $\frac{1}{6mm}$ under the radical sign ensures averaging of the distance across all criteria and all components of the fuzzy number, thereby allowing a single numerical metric of remoteness to be obtained.

Thus, each military-economic condition receives quantitative indicators of its closeness (or remoteness) both to the best and to the worst possible alternative within the space of all criteria. This creates the basis for determining the integral ranking of the conditions and for selecting the most prioritised directions of development or implementation, taking into account the full scope of expert information and the fuzzy nature of judgements.

Stage 6: calculation of the integral closeness index.

At the sixth stage of the Method, after determining for each military-economic condition (alternative) its distance from the "positive benchmark" $Exk_b^{(+)}$ and from the "negative benchmark" $Exk_b^{(-)}$ the integral indicator — the closeness index (CC, from the English "Closeness coefficient") — is calculated, which makes it possible to quantitatively reflect the extent to which each alternative is simultaneously "close" to the "positive" (benchmark) and "distant" from the "negative" (worst) benchmark within the multidimensional space of criteria:

$$CC_b = \frac{Exk_b^{(-)}}{Exk_b^{(+)} + Exk_b^{(-)}}.$$

The mathematical meaning of this index lies in the fact that its value varies within the range from "0" to "1", and the index CC_b is defined under the following condition: $Exk_b^{(+)} + Exk_b^{(-)} > 0$:

if the value CC_b approaches "1", the b-th condition is located very close to the "positive" benchmark (and far from the "negative"), that is, it is the best among the conditions considered;

if the value CC_b approaches "0", then, conversely, the condition is maximally distant from the benchmark alternative and closest to the worst scenario, and therefore its priority is low.

Thus, the results of calculating the closeness index are used for the final ranking of all conditions, which makes it possible not only to compare the conditions with one another, but also to substantiate the identification of those that are the most prioritised for decision-making or implementation under conditions of uncertainty.

Stage 7: ranking of external military-economic conditions for the development of the armed forces.

At the seventh stage of the Method, the conditions (alternatives) are ranked according to the integral closeness index. This procedure consists in ordering all conditions in descending order of their closeness indices:

ISSN (print): 2786-9318
ISSN (online): 2786-9326
Military Science. Vol. 3 No. 4 (2025)

$CC_{(1)} \geq CC_{(2)} \geq \ldots \geq CC_{(bb)}$,

where $CC_{(1)}$ – is the highest closeness index corresponding to the first-ranked (best, most prioritised) condition;

$CC_{(2)}$ – is the second-largest index determining the condition with the second level of priority;

$CC_{(bb)}$ – is the smallest index corresponding to the last-ranked condition.

Accordingly, such ordering determines the list of alternatives (conditions) from the most to the least prioritised:

$$U^{we(ранж)} = \left\{ u^{we}_{b^*} : CC_{b^*} \geq CC_{b^{**}} \geq \cdots \geq CC_{b^{***}} \right\}, \text{ or}$$

$$CC_1, CC_2, \cdots, CC_n \Rightarrow CC_{(1)} \geq CC_{(2)} \geq \ldots \geq CC_{(bb)},$$

$$u^{we}_1, u^{we}_2, \cdots, u^{we}_n \Rightarrow u^{we}_{(1)} \geq u^{we}_{(2)} \geq \ldots \geq u^{we}_{(bb)},$$

where $we(ранж)$ – is the ordered (ranked) list of conditions according to the integral closeness index;

$u^{we}_{b^*}$ – is the condition with the highest closeness index;

$u^{we}_{b^{**}}$ – is the condition with the next highest index, and so on up to $u^{we}_{b^{***}}$ – the condition with the smallest index.

Thus, the proposed multi-criteria approach using fuzzy expert assessments can ensure a systematic and formalised substantiation of external military-economic conditions for the development of the armed forces under conditions of increased uncertainty. The step-by-step implementation of the method makes it possible to consistently take into account heterogeneous criteria, expert uncertainty and their relative importance, while the application of the integral closeness index can enhance the substantiation of managerial decisions in the field of defence planning and the development of the Armed Forces of Ukraine.

Conclusion

A distinctive feature of the above-described Method is that its application makes it possible to substantiate the relevance of external military-economic conditions for the development of the armed forces in situations characterised by a high level of uncertainty. Unlike traditional approaches, this method is based on the use of multi-criteria analysis involving fuzzy expert assessments presented in the form of triangular intervals (minimum, modal and maximum values). This makes it possible not only to take into account the full scope and fuzziness of expert judgements, but also to increase objectivity.

The key distinguishing features are as follows:

the construction of a specialised expert assessment matrix (in which, for each condition and each criterion, not one but three assessment values are recorded, making it possible to reflect the full spectrum of possible expert perceptions, normalised to a single dimensionless scale, while the criteria are assigned fuzzy weights aggregated across all expert assessments);

the formation of reference (“positive” and “negative”) conditions for each criterion;

the use of a generalised Euclidean metric to calculate the integral “distance” of each condition from these benchmarks in the multidimensional space of criteria, with each of the three components (min, mode, max) of the fuzzy number being taken into account. Owing to such an approach, it becomes possible to calculate an integral closeness index that quantitatively reflects the extent to which each condition is superior relative to the benchmark pattern, and on this basis the ranking of possible directions of development is carried out.

Thus, the essence of the method lies in combining fuzzy logic, multi-criteria analysis and the

ISSN (print): 2786-9318
ISSN (online): 2786-9326
Military Science. Vol. 3 No. 4 (2025)

Euclidean metric into a single system, which makes it possible to operate even in situations where expert information is contradictory, incomplete or fuzzy — which is most often the case under crisis conditions. Accordingly, the practical application of the Method increases the substantiation of determining relevant external (international) military-economic conditions for the development of the armed forces under conditions of uncertainty in the external environment.

A further direction of research is the expansion of the proposed method by taking into account the dynamics of external military-economic conditions and by testing it on empirical data in the course of strategic planning for the development of the armed forces.

Recommendations

The results presented above may be of interest to researchers applying methods of fuzzy logic and multi-criteria analysis to substantiate managerial decision-making in the field of defence.

Conflict of Interest

The authors declare that they have no competing interests related to the subject matter of the article.

References

1. Semenenko, O., Kharchenko, V., Fedorenko, A., Tkachuk, V., & Halimov, S. (2023). Recommendations for the military-economic substantiation of operational training activities in the Armed Forces of Ukraine. *Social Development and Security, 13* (3). https://doi.org/10.33445/sds.2023.13.3.2
2. Levchenko, O., & Cherniak, V. (2022). Metodolohichni aspekty voienno-ekonomichnoho zabezpechennia oboronozdatnosti derzhavy. *Social Development and Security, 12* (6), 80–93. https://paperssds.eu/index.php/JSPSDS/article/download/538/660
3. Horbachov, O., Kovaliuk, V., & Koliadenko, V. (2021). Analysis and assessment of the military-economic conditions of the development of the Armed Forces of the world and Ukraine as the main factor of ensuring the necessary level of military-economic security (2012–2021). *Social Development and Security, 11* (6), 25–36. https://doi.org/10.33445/sds.2021.11.6.3
4. Datskiv, R., & Semenenko, O. (2021). Analysis and assessment of the influence of external and internal military-economic factors on the development of the Armed Forces of Ukraine. *Military Science and Security Studies.* https://media.neliti.com/media/publications/545837-analysis-and-assessment-the-influence-of-f345b373.pdf
5. Havryliuk, R. (2025). Military and economic security of Ukraine: Theoretical principles and practical assessment. *Social Development and Security. (in press).* https://www.paperssds.eu/index.php/JSPSDS/article/download/816/940
6. Ho, H., Nguyen, D., & Dinh, H. (2021). *A survey of game theory applications in defense. arXiv preprint.* https://arxiv.org/abs/2111.01876
7. Kott, A., Alberts, D., & Quillen, C. (2015). *COMPOEX: Planning and assessment in complex environments. arXiv preprint.* https://arxiv.org/abs/1512.07941
8. Economic warfare in modern conflicts. (2020). *Journal of Strategic Studies, 43* (5), 700–715. https://doi.org/10.1080/01402390.2020.1716875
9. Deterrence theory and military-economic potential. (2018). *Journal of Peace Research, 55* (3), 331–345. https://doi.org/10.1177/0022343318760400
10. Looney, R. (1989). The determinants of Third World military expenditures: Internal and external factors. *Journal of Peace Research, 26* (1), 33–49. https://doi.org/10.1177/0022343389026001004

The Central Research institute
of the Armed Forces of Ukraine

ISSN (print): 2786-9318
ISSN (online): 2786-9326
Military Science. Vol. 3 No. 4 (2025)

Метод обґрунтування зовнішніх (міжнародних) воєнно-економічних умов будівництва та розвитку збройних сил

Марина Абрамова
кандидат економічних наук, старший дослідник
провідний науковий співробітник
Центральний науково-дослідний інститут Збройних Сил України
03049, проспект Повітряних Сил, 28 Б, Київ, Україна
e-mail: Elaira3@gmail.com
ORCID: 0000-0001-7644-9988

Анотація. У статті обґрунтовано метод багатокритеріального оцінювання зовнішніх (міжнародних) воєнно-економічних умов будівництва та розвитку Збройних Сил України в умовах підвищеної невизначеності. Актуальність дослідження зумовлена зростанням ролі міжнародних економічних, військово-технічних та політичних чинників у формуванні обороноздатності держави, а також обмеженістю традиційних підходів до їх оцінювання, які недостатньо враховують нечіткість і суперечливість експертної інформації. Метою роботи є розроблення науково обґрунтованого методу, що дозволяє здійснювати порівняльний аналіз та ранжування воєнно-економічних умов розвитку збройних сил на основі системи узгоджених критеріїв. У дослідженні використано методи аналізу й синтезу, формалізації, експертного оцінювання, а також інструментарій багатокритеріального аналізу з елементами нечіткої логіки. Запропонований метод передбачає формування матриці експертних оцінок у вигляді трикомпонентних нечітких чисел, визначення ваг критеріїв, побудову позитивного та негативного еталонів і розрахунок інтегрального індексу близькості для кожної альтернативи. У результаті сформовано ранжований перелік зовнішніх воєнно-економічних умов, що дозволяє обґрунтовано визначати їхню пріоритетність для стратегічного планування та розвитку Збройних Сил України. Практична цінність роботи полягає у можливості використання запропонованого методу як інструменту підтримки управлінських рішень у сфері національної безпеки та оборонного будівництва.

Ключові слова: Збройні Сили України, воєнно-економічні умови, багатокритеріальний аналіз, нечітка логіка, експертне оцінювання, стратегічне планування, міжнародні чинники, оборонне будівництво.