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USING THE SIMPLE ADDITIVE WEIGHTING (SAW) MULTI-CRITERIA ANALYSIS METHODOLOGY FOR SELECTING THE OPTIMAL STRATEGY FOR CREATING A PRODUCTION ALLIANCE

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Firsova S. H., Perevozchykova A. A. Using the Simple Additive Weighting (SAW) Multi-Criteria Analysis Methodology for Selecting the Optimal Strategy for Creating a Production Alliance

The aim of the study is to adapt the method of multi-criteria analysis of alternatives SAW (simple additive weighing), as considered in both domestic and foreign publications, for the possibility of creating a production alliance of «Chumak» PJSC; to carry out an assessment of the prospects for the use of such a methodology in domestic practice; further, an identification of its strengths and weaknesses; outlining the main aspects of using strengths and minimizing weaknesses in Ukrainian business practice. The article is devoted to the issue of creation of production alliances among Ukrainian enterprises in order to overcome the consequences of russian aggression, stimulate innovative processes in the management of operational activities of enterprises and further creation of strategic alliances for mutual promotion and sale of goods and services, i. e. affiliate marketing. The methodology of multi-criteria analysis of alternatives SAW (simple additive weighing) was used stage by stage to select the optimal strategy for creating a production alliance. For this purpose, the problematic issue of advanced analysis has been identified, a system of alternatives, criteria for evaluating alternatives and a system for determining assessments of criteria based on qualitative and quantitative indicators has been formed. An integrated grading scale has been developed. A quantitative assessment of alternatives according to the proposed criteria has been carried out. The Altman model and the financial stability coefficient are applied as criteria for alternatives. A matrix of decisions has been built, its normalization has been implemented by certain weighting coefficients of criteria. Based on the calculations, a possible order of alternative options for creating a production alliance between «Chumak» PJSC and enterprises operating in the food market of Ukraine has been derived. The relevance of the problem of forming a strategic alliance is attested, given the presence of different approaches to choosing partners and the impossibility of allocating a single correct approach to determining groups of criteria without adapting to each individual industry.

Keywords: *multi-criteria analysis, enterprise, alliance, grade.*
Tabl.: *8.* ***Formulae:*** *7.* ***Bibl.:*** *14.*

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Фірсова С. Г., Перевозчикова А. А. Використання методики багатокритеріального аналізу на основі простого адитивного зважування (SAW) для вибору оптимальної стратегії створення виробничого альянсу

Метою дослідження є адаптація методу багатокритеріального аналізу альтернатив SAW (просте адитивне зважування), розглянутого як у вітчизняних, так і закордонних публікаціях, для можливості створення виробничого альянсу ПрАТ «Чумак»; оцінка перспектив використання такої методики у вітчизняній практиці; визначення його сильних і слабких сторін; окреслення основних аспектів використання сильних і мінімізації слабких сторін в українській бізнес-практиці. Статтю присвячено питанню створення виробничих альянсів серед українських підприємств з метою подолання наслідків російської агресії, стимулювання інноваційних процесів в управлінні операційною діяльність підприємств і подальшого створення стратегічних альянсів для взаємного просування та продажу товарів і послуг – партнерського маркетингу. Поетапно використано методику багатокритеріального аналізу альтернатив SAW (просте адитивне зважування) для вибору оптимальної стратегії створення виробничого альянсу. Для цього було визначено проблемне питання подальшого аналізу, сформовано систему альтернатив, критеріїв оцінки альтернативи та систему визначення оцінок критеріїв на основі якісних і кількісних показників. Розроблено інтегровану шкалу оцінювання. Виконано кількісну оцінку альтернатив за запропонованими критеріями. Застосовано модель Альтмана та коефіцієнт фінансової стійкості як критерії альтернатив. Побудовано матрицю рішень, здійснено її нормалізацію визначеними ваговими коефіцієнтами критеріїв. За проведеними розрахунками виведено можливий порядок альтернативних варіантів для створення виробничого альянсу між ПрАТ «Чумак» і підприємствами, що діють на продовольчому ринку України. Засвідчено актуальність проблеми формування стратегічного альянсу, з огляду на наявність різних підходів вибору партнерів і неможливість виділення єдиного правильного підходу визначення груп критеріїв без адаптації до кожної окремої галузі.

Ключові слова: *багатокритеріальний аналіз, підприємство, альянс, оцінка.*
Табл.: *8.* ***Формул:*** *7.* ***Бібл.:*** *14.*

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The full-scale invasion of Russia into Ukrainian territory has once again raised questions about finding strategic solutions to restore the operations of enterprises affected by military actions. Based on the experience of JSC "Chumak", it is considered expedient to create a system of production alliances, which will include companies willing to provide their production capacities to restore production in similar cases. To optimize the process of selecting partner enterprises, it is proposed to apply the Simple Additive Weighting (SAW) method.

In domestic practice, the issue of creating strategic alliances has been studied by N. Tsybko, I. Maksymenko, and M. Yefimova. The SAW multi-criteria analysis methodology has been researched by V. Priymak and T. Androsenko. In foreign practice, the SAW multi-criteria analysis methodology has been studied by V. Podvezko and H. Taherdoost.

Researchers conducting studies on the formation of production and strategic alliances have identified that an alliance involves conducting joint research, technology exchange, shared use of production facilities, mutual product promotion (partner marketing), or pooling efforts in component production or final product manufacturing [3; 6]. However, insufficient attention has been paid to studying the peculiarities of the practical implementation of forming production alliances as a tool for overcoming the consequences of the war, going on in Ukraine, on the part of enterprises, and further on, optimizing the formation of such alliances using the multi-criteria analysis methods.

The *aim* of the study is to adapt the SAW multi-criteria analysis method for the possibility of creating a production alliance for JSC "Chumak" and to assess the prospects of using this methodology in domestic practice.

The *methodological basis* of this research is formed by the works of domestic and foreign researchers regarding the description and substantiation of the stages of conducting multi-criteria analysis using the Simple Additive Weighting (SAW) method and the possibilities of its practical implementation based on the activities of a Ukrainian food market enterprise JSC "Chumak".

JSC "Chumak" is the largest fresh tomato processing enterprise in Ukraine. The company is known for its tomato paste, ketchup and mayonnaise, and other products under the same brand. Before the full-scaled war, JSC "Chumak" held about 20% of the Ukrainian market, with a turnover of UAH 1.3 billion (excluding VAT) in 2021. As result of the armed aggression of the Russian Federation against Ukraine and following the occupation of parts of the Kherson and Mykolaiv regions of Ukraine, JSC "Chumak" has lost a significant share of exports (from 25% to zero) and reduced the company's turnover in the domestic market by almost 70% [14]. Considering the loss of control over a significant part of assets and production activities, the company's strategy was aimed at restoring production of its own products at third-party production facilities. By the end of 2023, the company was already producing its products at the plants of its former competitors in Lutsk, Kyiv, and even abroad [14].

Thus, to optimize and accelerate the process of restoring production for enterprises affected by hostilities, it is advisable to create a system of production alliances. Such associations will include companies willing to provide their production capacities to restore production in similar cases. This will save time for businesses in finding partners, accelerate negotiations on cooperation terms, and restore production volumes in the shortest possible terms [4]. The experience of JSC "Chumak" proves the relevance of the alike solution in the current realities. The association of Ukrainian producers with the involvement of foreign partners will also stimulate innovative processes in operational management of enterprises. Simultaneously, a new network of business relationships between companies will be formed, based on which the creation of strategic alliances for promotion and sale of goods and services, or partnership marketing, will be possible [6]. Such a B2B strategy ensures growth and profit for both organizations involved, through joint cooperation in marketing and selling their products, attracting each other's consumer audience, and pooling their resources to improve results.

It is proposed to consider the possibility of applying the Simple Additive Weighting (SAW) method, which will allow substantiating the choice of the most optimal strategy for forming a strategic alliance of enterprises through mathematical calculations. There is a sufficient amount of research on the application of this method. Let's proceed with the following step-by-step analysis [5; 7].

Stage 1: defining the list of alternatives (*A*) and the criteria (*C*) by which these alternatives will be assessed. In the studied situation with JSC "Chumak", we take a list of possible partner companies among the competitors of this enterprise in the food products market as alternatives (*Tbl. 1*).

Table 1

Description of alternative options for creating a production alliance

Alternatives	Description
*A*1	PJSC "Lutsk Foods"
*A*2	LLC "Shchedro"
*A*3	TM "Korolivs`kyi Smak" (PE "Victor and K")
*A*4	Company Group "Veres" (LLC "Vidzhy Production")
*A*5	TM "Torchyn" (PJSC "Volynholding" Nestlé Ukraine)

Source: developed by the authors.

Based on the alternatives, we determine the criteria that will most effectively prioritize the selection by JSC "Chumak". It is proposed to form 3 groups of criteria:

1) *"Advantages of partnership marketing"* – the criteria that assess the growth and profit provision for both organizations through joint cooperation in marketing and selling their products, attracting each other's audience, and pooling their resources to improve results;
2) *"Financial condition"* – the criteria that assess the ability of the enterprise to provide production and organizational support to the partner;
3) *"Strategic alignment"* – the criteria that assess the degree of alignment of goals and vision of the alliance, which must be clearly defined and aligned with the overall strategies of the companies.

It is important to note the significance of an individual approach to selecting criteria for specific industries. Each industry has its peculiarities that influence partner selection. For example, in B2B industries, criteria such as experience, reputation, and financial status of the partner may be more important. Additionally, more attention may be given to the target audience, content, and distribution channels of the partner. Moreover, the level of industry competition can influence the choice of criteria. For instance, if a company operates in a highly competitive industry, it may require a partner with a strong brand and a loyal audience.

Stage 2: Performing a quantitative assessment of alternatives based on the proposed criteria. *Tbl. 2* contains both qualitative and quantitative assessment criteria. Using the proposed scale, necessary calculations will be performed. The assessment of bankruptcy probability is proposed to be conducted using the Altman's five-factor model (*Tbl. 3*), where

$$Z = 1.2A + 1.4B + 3.3C + 0{,}6D + 1{,}0E. \text{ [1]} \quad \textbf{(1)}$$

The calculation formula:

$$F.\,s.\,c. = (Eq + L) / TL, \text{ [2]} \quad \textbf{(2)}$$

where *Eq* – Equity; *L* – Liabilities; *TL* – Total Liabilities.

Based on the calculation results, we input the corresponding data and expert assessments into *Tbl. 5*.

Stage 3: Construction of a decision matrix by the form:

$$R = \left\| x_{ij} \right\|_{n\times m} = \begin{matrix} A1 \\ A2 \\ A3 \\ \dots \\ A_n \end{matrix} \begin{bmatrix} x_{11}\ x_{12}\ x_{13} \dots x_{1m} \\ x_{21}\ x_{22}\ x_{23} \dots x_{2m} \\ x_{31}\ x_{32}\ x_{33} \dots x_{3,} \\ \dots\ \dots\ \dots\ \dots\ \dots\ \dots \\ x_{n1}\ x_{n2}\ x_{n3} \dots x_{nm} \end{bmatrix}, \text{ [7]} \quad \textbf{(3)}$$

where x_{ij} – assessment of the *i*-th alternative according to the C_j criterion;

n – number of alternatives:;

m – number of assessment criteria;

$i = 1, \dots, n$;

$j = 1, \dots, m$.

Then we have a matrix of the following form:

$$R = \left\| x_{ij} \right\|_{5\times 9} = \begin{matrix} A1 \\ A2 \\ A3 \\ \dots \\ A_n \end{matrix} \begin{bmatrix} 714141 & 96051 & 9 & 10 & 0 & 0 & 8 & 1 & 1 \\ 4876696 & 777445 & 9 & 10 & 0 & 1 & 8 & 1 & 1 \\ 4649731 & 583645 & 9 & 10 & 0 & 0 & 8 & 1 & 1 \\ 763202 & 35639 & 8 & 10 & 0 & 1 & 9 & 1 & 1 \\ 1963184 & 5613 & 7 & 10 & 0 & 0 & 9 & 1 & 1 \end{bmatrix}.$$

Stage 4: Ranking the criteria by importance and assigning a score of 100 points to the most important criterion. We assign a W_i score (measured in points) to each criterion and determine their weight using the formula:

$$w_i = \frac{w_i}{\sum W_i}, \text{ [5; 7]} \quad \textbf{(4)}$$

where w_i – criterion weight;

W_i – assessment on a 100-point scale.

Stage 5: Normalization of the solution matrix. It is necessary to transform the elements of the solution matrix $R = \left\| x_{ij} \right\|_{5\times 9}$ according to the following formulas:

Table 2

Description of criteria for assessing the alternatives

Group	Criterion	Description	Assessment scale	Monotonicity of the function
Advantages of partnership marketing	*C*1	Sales volume	thousand UAH	↑ (max)
	*C*2	Selling expenses	thousand UAH	↑ (max)
	*C*3	Reputation	from 1 to 10	↑ (max)
	*C*4	Target audience	from 1 to 10	↑ (max)
Financial condition	*C*5	Probability of bankruptcy (according to Altman)	1) if $Z < 1.8$, then 3; 2) if $1.8 \le Z \le 2.70$, then 2; 3) if $2.71 \le Z \le 2.99$, then 1; 4) if $Z \ge 3$, then 0	↓ (min)
	*C*6	Coefficient of financial sustainability	1) if $0.5 < K < 0.9$, then 0; 2) if $0.5 \ge K \ge 0.9$, then 1	↓ (min)
Strategic alignment	*C*7	Access to new markets and technologies, resources, or competencies that are lacking	from 1 to 10	↑ (max)
	*C*8	Values and culture	1) if "yes", then 1; 2) if "no", then 0	↑ (max)
	*C*9	Location	1) "in the hostilities zone" – 0; 2) "remote from the hostilities zone" – 1	↑ (max)

Source: developed by the authors.

Table 3

The assessment of bankruptcy probability for the proposed enterprises (alternatives) using the Altman model for 2022

Indicators	*A*1	*A*2	*A*3	*A*4	*A*5
A – financial assets / total asset value	0.802	0.968	0.835	0.762	0.562
B – net profit / total asset value	0.152	0.094	0.195	–0.077	0.006
C – gross profit / total asset value	2.565	1.673	1.574	1.174	1.778
D – equity / liabilities	0.998	0.169	3.550	–0.121	4.085
E – sales / total assets	2.565	1.673	1.574	1.174	1.778
Z –	12.804	8.587	10.171	5.783	10.779
Probability of bankruptcy =	very low	very low	very low	very low	very low
Integrated assessment	0	0	0	0	0

Source: developed by the authors based on [1; 9–13].

Table 4

Calculation of the financial sustainability coefficient (F. s. c.) for the proposed enterprises (alternatives) for 2022

Alternative	F. s. c.	Integrated assessment
*A*1	0.539	0
*A*2	0.250	1
*A*3	0.782	0
*A*4	–0.096	1
*A*5	0.732	0

Source: developed by the authors based on [2; 9; 10; 11; 12; 13].

1) $r_{ij} = \dfrac{x_{ij}}{\max\limits_{k} x_{kj}}$ [5; 7] **(5)** – for criteria with a monotonically increasing objective function (which need to be maximized – ↑ (max));

2) $r_{ij} = \dfrac{\min\limits_{k} x_{kj}}{x_{ij}}$ [5; 7] **(6)** – for criteria with a monotonically decreasing objective function (which need to be minimized – ↑ (max));

where x_{ij} – assessment of the i-th alternative according to the C_j criterion;

Table 5

Quantitative assessment of alternatives

Alternative	Criteria								
	Advantages of partnership marketing			Financial condition			Strategic alignment		
	C1	C2	C3	C4	C5	C6	C7	C8	C9
A1	714141	96051	9	10	0	0	8	1	1
A2	4876696	777445	9	10	0	1	8	1	1
A3	4649731	583645	9	10	0	0	8	1	1
A4	763202	35639	8	10	0	1	9	1	1
A5	1963184	5613	7	10	0	0	9	1	1
Monot.	↑ (max)	↑ (max)	↑ (max)	↑ (max)	↓ (min)	↓ (min)	↑ (max)	↑ (max)	↑ (max)

Source: developed by the authors.

Table 6

Expert assessment of criteria

Criteria	Assessment on a 100-point scale (W_i)	Weighting coefficient (w_i)
C1	70	0.130
C2	60	0.111
C3	40	0.074
C4	50	0.093
C5	80	0.148
C6	90	0.167
C7	100	0.185
C8	20	0.037
C9	30	0.056
Total		540

Source: developed by the authors based on [8].

$\max_k x_{kj}$ – the highest score of the *i*-th alternative according to the C_j criterion;

$\min_k x_{kj}$ – the lowest score of the *i*-th alternative according to the C_j criterion;

r_{ij} – normalized value.

Stage 6: Calculating the weighted sum of scores for each alternative across all criteria necessary for alternative ranking (the higher the value of S, the more preferable the alternative). We will use the following formula:

$$S_i = \sum_{k=1}^{m} (w_k \cdot r_{ik}), \ [5; 7] \qquad (7)$$

where S_i – final value of the alternative;

r_{ij} – normalized value;

w_k – criterion weight.

Therefore, according to the SAW method, we have the following sequence of alternative options for creating a production alliance:

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

or:

LLC "Shchedro" > TM "Korolivs`kyi Smak" (PE "Victor and K") > TM "Torchyn" (PJSC "Volynholding" Nestlé Ukraine) > Company Group "Veres" (LLC "Vidzhy Production") > PJSC "Lutsk Foods".

CONCLUSIONS

The preservation of enterprise functioning in the conditions of the ongoing Russian military aggression in Ukraine is determined primarily by strategic flexibility and innovative solutions in crisis conditions, which are one of the most important tools for implementing a system approach in management. The use of strategic management tools, including methods of multi-criteria analysis, allows for a comprehensive assessment of strategic alternatives, based on which the determination of strategic development vectors of the organization is further based. The issue of forming a strategic alliance remains relevant, taking into account the presence of different approaches to the selection of partners. Special attention should be paid to the development and improvement of a set of universal criteria that would comprehensively disclose the aspects of forming production and strategic alliances, as well as take into account the specificity of the industry in which partner enterprises operate. ■

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Table 7

Normalization of the solution matrix

Criteria	C1	C2	C3	C4	C7	C8	C9	C5	C6
Monot.	↑ (max)	↑ (max)	↑ (max)	↑ (max)	↑ (max)	↑ (max)	↑ (max)	↓ (min)	↓ (min)
*A*1	714141	96051	9	10	8	1	1	0	0
*A*2	4876696	777445	9	10	8	1	1	0	1
*A*3	4649731	583645	9	10	8	1	1	0	0
*A*4	763202	35639	8	10	9	1	1	0	1
*A*5	1963184	5613	7	10	9	1	1	0	0
		*Select the **maximum** values for each criterion (in each column)*						*Select the **minimum** values for each criterion (in each column)*	
		4876696	777445	9	10	9	1	1	0
	*We divide each value in the column of the solution matrix by the **maximum** value in that column*							*We divide the **minimum** value in each column by each value in the same column of the solution matrix*	
	Normalized matrix								
	C1*	**C2***	**C3***	**C4***	**C7***	**C8***	**C9***	**C5***	**C6***
Weight	0.130	0.111	0.074	0.093	0.185	0.037	0.056	0.148	0.167
*A*1	0.146	0.124	1.000	1.000	0.889	1.000	1.000	0.000	0.000
*A*2	1.000	1.000	1.000	1.000	0.889	1.000	1.000	0.000	0.000
*A*3	0.953	0.751	1.000	1.000	0.889	1.000	1.000	0.000	0.000
*A*4	0.156	0.046	0.889	1.000	1.000	1.000	1.000	0.000	0.000
*A*5	0.403	0.007	0.778	1.000	1.000	1.000	1.000	0.000	0.000

Source: developed by the author based on [5; 7; 8].

Table 8

Final value of the alternative and ranking

Alternative	S_i	Rank
*A*1	0.457	5
*A*2	0.665	1
*A*3	0.632	2
*A*4	0.462	4
*A*5	0.482	3

Source: developed by the author based on [5; 7].

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