








“Methodological support for intellectual capital strategic management of the research organization”

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METHODOLOGICAL SUPPORT FOR INTELLECTUAL CAPITAL STRATEGIC MANAGEMENT OF THE RESEARCH ORGANIZATION

Abstract

Making intellectual capital the strategic resource of an innovation-oriented organization under post-industrial economy formation requires improving the decision-making quality while choosing its development strategies. To a large extent, the effectiveness of strategic intellectual capital management depends on its methodological principles development, which determines the relevance of the subject chosen.

The purpose of the article is to form a methodical tool for substantiating the strategies of intellectual capital development in a research organization based on multi-criteria analysis.

As a methodological platform, the following methods for conducting research were chosen: an aggregated structural approach, in particular, the method of audit-evaluation by Brooking, to evaluate intellectual capital; SWOT analysis – to determine the strategic position of the company regarding its intellectual capital. To confirm the expert opinions consistency within the empirical studies framework, the concordance coefficient, estimated on the Pearson criterion, was calculated. The key to research is the multi-criteria analysis (SAW, TOPSIS, COPRAS) methods for evaluating, ranking and selecting strategic alternatives for the intellectual capital development of the research company.

Thus, the article takes a new view of using the scenario approach to the formation of an intellectual capital strategy. The strategy development stages are outlined, and the peculiarities of their methodological support are determined. In particular, the necessity to include into the test program for intellectual capital the estimation of its management efficiency is proved. The authors present an example of adapting SAW, TOPSIS, COPRAS methods for the evaluation and ranking of strategic alternatives to human, structural and market capital development.

Consequently, the results allowed to mathematically formalize the rating task and to form the optimal strategies portfolio of human, structural, market capital of organization, as well as to combine factors of the internal and external environment. Thus, the suggested methodological approach can be used by the heads of research organizations to develop and substantiate strategic management decisions to optimize their intellectual capital development.

Keywords

strategic management, intellectual capital, research organization, multi-criteria analysis, SAW, TOPSIS, COPRAS

JEL Classification

C44, D81, I23, O34

INTRODUCTION

Trends and regularities of innovative development under knowledge economy formation determine the vectors of the domestic organizations' competitiveness in the world economic space. The emphasis on the effective use of existing and hidden opportunities in the national intellectual capital may indicate its transformation into an important strategic resource for achieving the innovative, socio-economic goals of

the country's development. The development and implementation of a strategy for the intellectual capital development becomes a priority task for the activation of intellectual growth factors in domestic realities.

The perspective research vector is to clarify the conceptual foundations of the strategic intellectual capital management of the organization, its functional load, mechanisms and algorithms for implementation, depending on the initial goals, dynamic characteristics of the environment and intellectual capital elements.

Essential component of task solving is shaping the appropriate methodical toolkit able to combine general and special, basic theoretical and methodological provisions of strategic management and specific features of intellectual capital management. Thus, strengthening the managerial decisions validity makes actual the use of methodical tools for choosing the best strategies for the intellectual capital development of a research organization.

The purpose of the article is to study the possibilities for adapting the methodical tools of multi-criteria analysis in substantiating the strategy for intellectual capital development of a research company to provide a comprehensive understanding of its further development prospects.

1. METHODS

The specificity of the study object determines the interdisciplinary nature of its methodical platform, which is based on intellectual capital and strategic management theories.

First of all, when developing methodological support, one should take into account that in the strategic structure of an organization, depending on the defined hierarchy of development goals, internal and external factors, different types of strategies of intellectual capital may exist with a different combination of subordination. At the same time, in reference to the object of strategic decision-making and the unification of all typologies while implementing any strategic development scenario, the basic classification of types of intellectual capital strategies by its structure (human, structural, market capital) is of the dominant, system-forming significance. It forms the core of a strategy portfolio with an emphasis on ensuring the interaction between different structural elements of intellectual capital. This approach is based on justifying the choice of strategic alternatives for the development of intellectual capital in this study.

In order to assess the intellectual capital development in the organization and to determine the strategic directions of its development, methods of the aggregated structural approach are proposed to be applied. In contrast to the aggregated cost ap-

proach (cost, revenue, market approaches, Sveiby methods: direct measurement, market capitalization, return on assets, Tobin's q-index, etc. (Sveiby, 2005; Stuart, 1997; Liashenko, 2012; Kravchenko & Kornieva, 2011; Chupryna & Chupryn, 2013)), the structural approach is based on the use of different units of measurement for intellectual capital elements (cost and natural, relative and qualitative indicators), and it also considers and evaluates each intellectual capital component.

Among the methods of structural approach, the most used are: Sveiby's intangible assets monitor, the Skandia Navigator by Edvinsson, and the Balanced Scorecard by Kaplan and Norton (Sveiby, 2005; Edvinsson, 2000; Kaplan & Norton, 1996). When using Sveiby's intangible assets monitor, diagnosis of intellectual capital is carried out, first of all, through the study of employee competencies. Each of these three components is studied in terms of growth, innovation, efficiency and stability, for which the corresponding matrix of evaluation is constructed. According to Edvinsson's Skandia Navigator, 164 metrics of intellectual capital are analyzed, covering five components: finances, clients, processes, updating and development, and people. The matrix construction makes it possible to trace how human capital while interacting with consumer capital, internal processes and the ability to innovate, creates the financial value of the organization. The Kaplan-Norton Balanced Scorecard (BSC) method is a combination of stra-

tegic and operational aspects of the organization's functioning. At the same time, intellectual capital as a strategic resource is analyzed through the prism of the following elements: relations with clients, internal business processes, finance, development of the perspective for training.

Audit-assessment methodology of intellectual capital, proposed by Brooking (1996), is relatively universal in applying to organization of various activities. The methodology provides for allocating the objectives for the audit-assessment of intellectual capital; determining optimal set of parameters of intellectual capital assets; setting the optimal desired parameter values for a particular organization; choice of audit methods that may be different for certain components of intellectual capital; actually conducting an audit and interpreting its results. The ultimate goal is to express the value of intellectual capital assets based on indexing their parameters (from 1 to 5). A visual synthesis of the results of the audit-evaluation is carried out through the construction of the "target" (five circles: from 1 to 5 in the center). The target is divided into sectors according the intellectual capital structure. On the target, in each sector, the average values of the indices for each asset of the corresponding component of the intellectual capital are displayed. At the same time, the degree of the asset importance to achieve intellectual capital development corresponds to the diameter of its reflection on the "target". The assessment results and their visual representation allow us to diagnose the state of the structural elements of intellectual capital and outline the strategic alternatives to their development.

One of the areas of interdisciplinary research in this subject is considering the possibilities of using the methodical tools for strategic management in substantiating the strategy of intellectual capital development of the organization. The theory and practice demonstrate a great many of strategic management methods (Balan, 2012), in particular the BCG model, GE/McKinsey, Shell/DPM, SWOT, SPACE analysis, etc. With the appropriate adaptation, taking into account the specifics of the management object, these methods can be used in determining the strategic position of the organization in relation to its intellectual capital in general or individual components.

Empirical studies are based on the use of observation and generalization – to select the criteria for choosing strategic vectors for the development of intellectual capital components; analytical and calculation method – to estimate alternative strategic directions according to predefined criteria; dynamic approach – to systematize the study results; expert assessments and interviews – to determine the pre-selected criteria importance.

The difficulties in implementing the initial study concept are due to limited access to information, due to its confidential nature. The negative aspect of scientific and methodological experience was manifested in the difficulty of finding qualified experts and their thoughts subjectivity. Considering the problem of selection and evaluation of the criterion constraints on the choice of strategic alternatives to the development of intellectual capital structural components in the research organization was based on the generalized survey results for the group of experts in the chosen field of research (25 employees of the management apparatus of research institutions). To confirm the consistency of expert opinions, the coefficient of concordance (w) was calculated, which was further evaluated by the Pearson criterion (Kendall, 1995; Podvezko, 2005; Zavadskas & Viliutene, 2006):

$$w = \frac{\sum_{i=1}^n (S_i - \bar{S})^2}{\frac{1}{12} \cdot m^2 \cdot (n^3 - n) - m \cdot \sum_{j=1}^u T_j}, \quad (1)$$

where S_i – sum of rank expert evaluations according to each criterion, \bar{S} – average rank for all criteria, m , n – number of experts and criteria, respectively, T_j – a value that takes into account the same evaluation of different criteria by some experts.

For this purpose, \bar{S} and T_j are calculated according to the formulae:

$$\bar{S} = 0.5 \cdot m \cdot (n + 1), \quad (2)$$

$$T_j = \frac{1}{12} \cdot \sum_{j=1}^u (t_j^3 - t_j), \quad (3)$$

where u is a number of ranks with the same evaluations of the j -th expert, t_j – number of evaluations with similar ranks of the j -th expert.

While assessing these ratios significance, we consider that the closer the unit approaches the concordance coefficient, the more concurred are the expert opinions. One of the methods to confirm the significance of the concordance coefficient is its estimation by the Pearson criterion χ^2 . If $\chi > \chi_c$, then the concordance coefficient is significant for degrees of freedom $f = n - 1$ and the given level of significance $\alpha = 0.01$.

The estimated value of χ^2 was determined by the formula:

$$\chi_{calc.}^2 = w \cdot m \cdot (n - 1). \quad (4)$$

After the significance of the concordance coefficient is confirmed, the importance of each criterion for selecting the source of the candidate search was determined. The weighting factor was determined by the formula:

$$\alpha_i = \frac{m \cdot n - S_i}{0.5 \cdot m \cdot n \cdot (n - 1)}. \quad (5)$$

Choosing strategic alternatives at a practical level can be reduced to their ranking using multicriteria analysis methods, which are widely represented in the theory and practice of management. Currently, to solve the research tasks, the article, to evaluate the alternatives, uses SAW, TOPSIS, COPRAS methods, which differ in their algorithm for determining the optimal alternatives.

Determining the effectiveness of choosing alternatives is possible with the Simple Additive Weighting Method (SAW) (MacCrimmon, 1968) – the method of simple additive weighing – one of the oldest and most widely used methods. The main principles of the method were described by MacCrimmon (1968), Klee (1971), Hwang and Yoon (1981), Chu et al. (2007), Ginevicius and Podvezko (2008), Zavadskas et al. (2007), Qin et al. (2008), Podvezko (2011), Tzeng and Huang (2011), Wang (2015), Velasquez and Hester (2013).

Another very popular method for choosing alternative solutions is TOSIS (Hwang & Yoon, 1981). This method has become particularly popular in solving socio-economic problems (Triantaphyllou & Lin, 1996; Chen, 2000; Qin et al., 2008; Tzeng & Huang, 2011; Yang et al., 2011; Behzadian et al., 2012; Rahman et al., 2012; Velasquez & Hester,

2013; Mardani et al., 2015; Zavadskas et al., 2016; Zyoud, Fuchs-Hanusch, 2017).

The method that allows a multicriteria assessment of alternatives, both maximizing and minimizing the criteria values, is COPRAS (COMplex PROportional ASsessment) (Zavadskas & Kaklauskas, 1996). It is widely used by its authors, their students and experts involved in the evaluation of complex processes using multicriteria analysis methods (Kaklauskas et al., 2005; Ustinovichius et al., 2007; Datta et al., 2009; Hofer, 2009; Uzsilaityte & Martinaitis, 2010; Mazumbar et al., 2010; Bindu Madhuri et al., 2010a,b; Chatterjee et al., 2011; Podvezko, 2011; Razavi et al., 2013; Ghorabae et al., 2014).

Consequently, systematic strategic development of intellectual capital is based on a broad methodological basis, envisages its methodological support, in particular, consideration of possibilities for adapting the methodical tools for strategic management in choosing strategies to develop intellectual capital components of the organization.

2. RESULTS

The search for ways to ensure the modern organizations competitiveness in innovative-oriented economies shifts the emphasis in strategic management. Innovative strategies and intellectual capital development strategies acquire the dominant nature in the strategic portfolio.

The strategy for the intellectual capital development can be considered as one of the means for achieving the goals of the organization associated with the formation and efficient use of intellectual resources. This is a detailed comprehensive plan to ensure the competitive advantages of the organization based on interaction and balanced growth of all intellectual capital elements (Baranov & Zaytsev, 2009).

The uniqueness of structural elements of the intellectual capital in each individual organization makes it impossible to create a universal strategy for its development. Also, due to the multipurpose nature of intellectual capital, one should speak about the formation of a strategies portfolio with

a different combination of their subordination, which complicates the process of their choice.

The theory of strategic management offers different approaches to the development of intellectual capital strategy, in particular scenario, decomposition, and integrated approach (Kornilova et al., 2016). Their use depends on the stage of the company's life cycle, management efficiency, the chosen competitive strategy, and most importantly, on the level of development (complexity, branching out) of intellectual capital itself. For example, using the scenario approach allows choosing the optimal strategy of intellectual capital through synthesis of possible combinations of strategies for its individual components development (strategies presented on the map). The decomposition approach makes it possible to build a unified strategy of intellectual capital on the development strategies for the "Target Capital" group, formed of its more meaningful and active constituents. Within the framework of the integrated approach in shaping the strategy, the emphasis is on developing a system of balanced indicators for selected perspectives (financial, client, training and growth, development of internal business processes, etc.), as well as on non-linear redistribution, transformation, transfer of knowledge between all elements of intellectual capital.

Shaping an optimal portfolio of intellectual capital development strategies involves the following stages:

- 1) diagnostics of the intellectual capital of the research organization through the analysis of its structural elements and managerial components;
- 2) allocating the alternatives to the strategic development of intellectual capital by its types;
- 3) ranking of strategic alternatives to the development of human, structural and market capital of a research organization.

Choosing the promising directions for the intellectual capital development in a research organization begins with its intellectual capital evaluation. Important is the information on both qualitative and quantitative state of the intellectual

capital structural elements, their pros and cons, the existing potential and prospects for building and use. This will determine the ability of the intellectual capital to fulfill its purpose in ensuring the strategic goals implementation. The intellectual capital assessment is proposed to be conducted through the universal method of audit-evaluation by Brooking (1996) by calculating indices for individual elements of intellectual capital and their visual reflection on the "target".

In the context of strategic management, it is appropriate to supplement the intellectual capital assessment by Brooking with the evaluation of the efficiency of the intellectual capital management in the organization. It can be implemented through management subsystems, taking into account their functional load, the specifics and content of management of the intellectual capital structural elements. The expert assessments of each subsystem of intellectual capital management ($\omega_j x_j$, where ω_j – is the weight factor, and x_j – expert estimation of the parameter) and the overall integrated estimation of efficiency ($\sum \omega_j x_j$) as basic indicators take the best practices in the selected market as benchmarks. The set of indicators and their weight under subsystems can be mobile, taking into account the environment development dynamics.

The assessment results of intellectual capital and its management are taken into account when conducting the SWOT-analysis adapted to the research object – intellectual capital. In particular, the parameters of a score of 4-5 points with a large diameter point of reflection on the "target" are considered as the strengths of intellectual capital, all others as weaknesses. Estimation of the possibilities ($1, n$) and threats ($1, m$) created by the external environment are carried out using the Wilson matrix. The matrix allows for distinguishing the most influential ones on the intellectual capital assets.

Construction of SWOT-analysis matrix allows to allocate strategic alternatives to the intellectual capital development. The formation of an optimal set of them, which is as closely as possible to the possibilities of their implementation within the framework of a specific organization, is proposed to be carried out using the multi-criteria analysis.

They allow to evaluate alternative strategies for a number of criteria in the context of their convergence with the goal.

As starting conditions of multi-criteria analysis the following are determined:

- only the WO, SO, and ST strategies remain as objects of selection. They are focused on introducing new characteristics of intellectual capital, on improving its weak points, as well as on avoiding the negative external effects;
- the basic scenario approach to choosing strategies is adopted. For further evaluation, the selected alternatives are divided into three groups according to the structural feature of development: human, structural and market capital.

This study presents an example of the adaptation of SAW, TOPSIS, COPRAS methods to justify the choice of strategies for the development of human, structural, and market capital of the research organization based on the evaluation results of its intellectual capital, opportunities and threats of the external environment and the allocation of a set of strategic development alternatives for each structural component of the intellectual capital.

In order to make a decision in the process of multi-criteria analysis of strategic alternatives justified, it is necessary to determine the criteria for their choice. While choosing strategy options, each expert or manager independently chooses one or another combination of selection criteria. The complexity of the solution is which of the criteria to prefer. Today, there is no single set of criteria that can be used to select a strategy. To substantiate the choice of strategic vectors for the intellectual capital development of a research organization, the following criteria were chosen:

K1 – estimated costs for developing and implementing a strategy (score on a 10-point scale: the higher the cost, the higher the score);

K2 – expected duration of strategy development and implementation (score on a 10-point scale: the longer the term, the higher the score);

K3 – the level of complexity of implementing a strategy (score on a 10-point scale: the higher the difficulty level, the higher the score);

K4 – the probability of a successful strategy implementation (score on a 10-point scale: the greater the probability, the higher the score);

K5 – the expected support from the organization's staff (score on a 10-point scale: the higher the degree of support, the higher the score);

K6 – possibility of forecasting the results of strategy implementation (score on a 10-point scale: the greater the possibility of forecasting, the higher the score);

K7 – strategy flexibility (10-point score: the greater the flexibility, the higher the score).

Determining the importance and structure of the above criteria is based on the results of the survey conducted by a group of experts. The expert survey was carried out by determining the rank. In this case, the minimum rank was assigned to the most influential criterion defined by each expert. To confirm the expert opinions' consistency, the concordance coefficient was calculated. The starting condition for assessing the significance of these coefficients is the statement: the closer the unit approaches the concordance coefficient, the more concurred the expert opinions are. To confirm the concordance coefficient significance, its estimation according to the Pearson criterion (χ^2) is used. If $\chi^2_{calc.} > \chi^2_{tabl.}$, then the concordance coefficient is significant for degrees of freedom $f = n - 1$ and the given level of significance $\alpha = 0.01$ (Kendal, 1995; Podvezko, 2005; Zavadskas & Vilutiene, 2006).

After confirming the concordance coefficient significance, the weight of the selected criteria is determined. The results of the expert evaluation of the criteria, concordance coefficients, Pearson and the importance of each of the criteria are given in Table 1.

As can be seen from the calculations, the obtained values of the Pearson criterion testify to the significance of the concordance coefficient, since the calculated value of χ^2 is more than tabular

Table 1. Results of the criteria ranking for choosing strategic direction for the research organization development

Source: Compiled by authors.

Estimation parameter	Notations	Results of the criteria estimation						
		K1	K2	K3	K4	K5	K6	K7
Rank sum of indices	S_i	55	104	88	75	117	123	138
Average rank sum	\bar{S}	100						
Deviation square	$(\bar{S}_i - \bar{S})^2$	2025	16	144	625	289	529	1444
Concordance coefficient	W	$w = \frac{5072}{\frac{1}{12} \cdot 25^2 \cdot (7^3 - 7) - 25 \cdot 0} = 0.2898$						
Pearson criterion	$\chi^2_{calc.}$	$\chi^2_{calc.} = 0.2898 \cdot 25 \cdot (7 - 1) = 43.47$ $43.47 > 16.8$						
Competence weight coefficient	α	0.2286	0.1352	0.1657	0.1905	0.1105	0.099	0.0705

($\chi^2_{calc.} = 43.47$, which is more than the tabular value of $\chi^2_{tabl.} = 16.8$) for six degrees of freedom and significance level $\alpha = 0.01$.

Thus, based on an expert survey conducted by a group of experts whose thoughts on the study subject were consistent, the structure of the criteria and importance of each of them was determined, which is the basis for further evaluation and ranking of the strategic directions of intellectual capital development in the research organization.

To evaluate and rank human capital development strategies, the method of multi-criteria analysis is used in the study, namely, the Simple Additive Weighting (SAW) method.

The use of the method involves the following steps.

1. Evaluating selected human capital development strategies according to predefined criteria. The value of the evaluation criteria for each strategy (determined by expert evaluation), as well as the relevant constraints, are presented in Table 2 (the values of all the criteria given in the table belong to the Edgeworth – Pareto set).

Normalizing the decision matrix for convenient use of the obtained results of evaluating alternatives to strategic directions according to the criteria (Table 3).

Table 2. Output data (decision matrix) on ranking strategies for human capital development using the SAW method

Source: Compiled by authors.

Alternatives	Criteria	K1	K2	K3	K4	K5	K6	K7
		min	min	min	max	max	max	max
A1. Strategy for maintaining staff size and structure		4	3	7	4	5	3	5
A2. Strategy for increasing staff satisfaction		4	3	7	3	5	7	5
A3. Strategy for increasing the staff's innovative activity		6	5	2	4	7	8	9
A4. Strategy for development of personnel competitive advantages		6	5	2	6	8	8	7
A5. Strategy for activation of international scientific cooperation		5	7	5	7	7	5	7
A6. Strategy for creating an effective HR management		7	7	2	8	7	4	5
A7. Strategy for increasing the personnel competence		9	9	2	8	7	5	9

Table 3. Normalized decision matrix

Source: Compiled by authors.

Criteria \ Alternatives	K1	K2	K3	K4	K5	K6	K7
Function	min	min	min	max	max	max	max
A1	4	3	7	4	5	3	5
A2	4	3	7	3	5	7	5
A3	6	5	2	4	7	8	9
A4	6	5	2	6	8	8	7
A5	5	7	5	7	7	5	7
A6	7	7	2	8	7	4	5
A7	9	9	2	8	7	5	9
	Selecting a minimum value according to each criterion			Selecting a maximum value according to each criterion			
	4	3	2	8	8	8	9
	The ratio of minimum value in each column to each value in the same column of the decision matrix			The ratio of each value of the decision matrix column to the maximum value in this column			
	Normalized decision matrix						
Criteria \ Alternatives	K1	K2	K3	K4	K5	K6	K7
Function	min	min	min	max	max	max	max
A1	1	1	0.2857	0.5	0.625	0.375	0.5556
A2	1	1	0.2857	0.375	0.525	0.875	0.5556
A3	0.6667	0.6	1	0.5	0.875	1	1
A4	0.6667	0.6	1	0.75	1	1	0.7778
A5	0.8	0.4286	0.4	0.875	0.875	0.625	0.7778
A6	0.5714	0.4286	1	1	0.875	0.5	0.5556
A7	0.4446	0.3336	1	1	0.875	0.625	1

Obtaining a weighted normalized decision matrix (Table 4).

$$P(A2) = 0.2286 + 0.1352 + 0.0474 + 0.0715 + 0.0581 + 0.0867 + 0.0392 = 0.6667;$$

Identification of alternatives rating by calculating the weighted sum of estimates for each of the alternatives by all criteria. In this case, the alternative with the highest value of the weighted sum of estimates is considered as the best one.

$$P(A3) = 0.1524 + 0.0812 + 0.1657 + 0.0953 + 0.0967 + 0.0990 + 0.0705 = 0.7608;$$

$$P(A4) = 0.1524 + 0.0812 + 0.1657 + 0.1429 + 0.1105 + 0.0990 + 0.0549 = 0.8066;$$

$$P(A1) = 0.2286 + 0.1352 + 0.0474 + 0.0953 + 0.0691 + 0.0372 + 0.0392 = 0.6520;$$

$$P(A5) = 0.1829 + 0.0580 + 0.0663 + 0.1667 + 0.0967 + 0.0619 + 0.0549 = 0.6874;$$

Table 4. Weighted normalized decision matrix

Source: Compiled by authors.

Criteria \ Alternatives	K1	K2	K3	K4	K5	K6	K7
Weight	0.2286	0.1352	0.1657	0.1905	0.1105	0.099	0.0705
Function	min	min	min	max	max	max	max
A1	0.2286	0.1352	0.0474	0.0953	0.0691	0.0372	0.0392
A2	0.2286	0.1352	0.0474	0.0715	0.0581	0.0867	0.0392
A3	0.1524	0.0812	0.1657	0.0953	0.0967	0.099	0.0705
A4	0.1524	0.0812	0.1657	0.1429	0.1105	0.099	0.0549
A5	0.1829	0.0580	0.0663	0.1667	0.0967	0.0619	0.0549
A6	0.1307	0.0580	0.1657	0.1905	0.0967	0.0495	0.0392
A7	0.1017	0.0451	0.1657	0.1905	0.0967	0.0619	0.0705

$$P(A6) = 0.1307 + 0.0580 + 0.1657 + 0.1905 + 0.0967 + 0.0495 + 0.0392 = 0.7303;$$

$$P(A7) = 0.1017 + 0.0451 + 0.1657 + 0.1905 + 0.0967 + 0.0619 + 0.0705 = 0.7321.$$

Consequently, given the calculated weighted sum of estimates for each alternative according to all criteria, the following ranking of alternatives is formed (Table 5).

Table 5. Ranking alternative strategies for human capital development

Source: Compiled by authors.

Alternative	Weighted sum	Rank
A1	0.6520	7
A2	0.6667	6
A3	0.7608	2
A4	0.8086	1
A5	0.6874	5
A6	0.7303	4
A7	0.7321	3

The results of the ranking of available alternatives to the human capital development strategies of the research institution indicate their next priority: $A4 \rightarrow A3 \rightarrow A7 \rightarrow A6 \rightarrow A5 \rightarrow A2 \rightarrow A1$.

The next stage is the assessment and ranking of strategies for the structural capital development of the research organization. For this end, it is suggested to use the TOPSIS method (Technique for Order Preference to Similarity to the Ideal Solution).

Table 6. Output data (decision matrix) on ranking the strategies for structural capital development by the TOPSIS method

Source: Compiled by authors.

Alternatives \ Criteria	K1	K2	K3	K4	K5	K6	K7
Function	min	min	min	max	max	max	max
B1. Strategy for information and communication technologies and network development	5	4	5	6	5	7	5
B2. Strategy for building the portfolio of rights to intellectual property objects	4	6	5	5	7	8	5
B3. Patenting strategy	3	6	7	4	4	3	6
B4. Strategy for optimizing funding sources	5	7	7	6	8	8	5
B5. Licensing strategy	4	5	7	7	6	5	8
B6. Strategy for organizational culture improvement	6	5	5	8	6	4	7
B7. Cooperation strategy	7	5	9	8	6	6	7

Justifying the choice of strategies is carried out in several stages.

1. Assessing the selected strategies for structural capital development according to predefined criteria (determined by expert evaluation). It is assumed that each criterion of the decision matrix has either a monotonically increasing, or a monotonously decreasing target function. The matrix of solutions $\tilde{O} = \|X_{ij}\|$ (the values of all criteria belong to the Edgeworth – Pareto set) is presented in Table 6.
2. Normalizing the decision matrix. At this stage, the criteria that have different units of measurement are transformed into dimensionless criteria that allows them to make a further comparison. One approach is to divide the value according to each criterion into the norm of sum of values for the criterion vector.

The first step is to calculate the values of X_{kj}^2 , $\sum_{k=1}^n x_{kj}^2$ and $\sqrt{\sum_{k=1}^n x_{kj}^2}$. The next is to build a normal-

ized decision matrix (Table 7), in which the element r_{ij} is calculated as:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{k=1}^n x_{kj}^2}}. \quad (6)$$

3. Constructing a weighted normalized decision matrix (Table 8). The criteria determined at the previous stage of the criteria study are also used.

Table 7. Normalized decision matrix

x_{kj}^2	K1	K2	K3	K4	K5	K6	K7
B1	25	16	25	36	25	49	25
B2	16	36	25	25	49	64	25
B3	9	36	49	16	16	9	36
B4	25	49	49	36	64	64	25
B5	16	25	49	49	36	25	64
B6	36	25	25	64	36	16	49
B7	49	25	81	64	36	36	49
$\sum_{k=1}^n x_{kj}^2$	176	212	303	290	262	280	273
$\sqrt{\sum_{k=1}^n x_{kj}^2}$	13.27	14.56	17.41	17.03	16.19	16.73	16.52
$r_{ij} = x_{ij} / \sqrt{\sum_{k=1}^n x_{kj}^2}$	K1	K2	K3	K4	K5	K6	K7
B1	0.3768	0.2748	0.2872	0.3524	0.3089	0.4185	0.3027
B2	0.3015	0.4121	0.2872	0.2936	0.4324	0.4782	0.3027
B3	0.2261	0.4121	0.4021	0.2349	0.2471	0.1794	0.3632
B4	0.3768	0.4808	0.4021	0.3524	0.4942	0.4782	0.3027
B5	0.3015	0.3434	0.4021	0.4111	0.3706	0.2989	0.4843
B6	0.4522	0.3434	0.2872	0.4698	0.3706	0.2391	0.4238
B7	0.5275	0.3434	0.5170	0.4698	0.3706	0.3587	0.4238

4. Determining an ideal positive and ideal negative decision by searching for two artificial alternatives B^+ and B^- (Table 9).

$$S_i^+ = \sqrt{\sum_{j=1}^m (u_{ij} - u_j^+)^2}, \quad (7)$$

5. Ranking alternative options for organizational capital development by calculating the closeness. The distance from one alternative to another can be calculated using the formulas determining the n -dimensional Euclidean distance:

$$S_i^- = \sqrt{\sum_{j=1}^m (u_{ij} - u_j^-)^2}. \quad (8)$$

6. Calculating relative proximity to an “ideal solution”. The closer the C_i to 1, then the closer is the alternative B to B^* (Table 10).

Table 8. Weighted normalized decision matrix

Source: Compiled by authors.

Criteria	K1	K2	K3	K4	K5	K6	K7
Alternatives							
Weight	0.2286	0.1352	0.1657	0.1905	0.1105	0.099	0.0705
Function	min	min	min	max	max	max	max
B1	0.0862	0.0372	0.0476	0.0672	0.0342	0.0415	0.0214
B2	0.0690	0.0558	0.0476	0.0560	0.0478	0.0474	0.0214
B3	0.0517	0.0558	0.0667	0.0448	0.0273	0.0178	0.0256
B4	0.0862	0.0650	0.0667	0.0672	0.0546	0.0474	0.0214
B5	0.0690	0.0465	0.0667	0.0784	0.0410	0.0296	0.0342
B6	0.1034	0.0465	0.0476	0.0895	0.0410	0.0237	0.0299
B7	0.1206	0.0465	0.0857	0.0895	0.0410	0.0356	0.0299

Table 9. Ideal positive and ideal negative matrix solution (artificial alternatives)

Source: Compiled by authors.

Artificial alternatives	Min u_1	Min u_2	Min u_3	Max u_4	Max u_5	Max u_6	Max u_7
B+ (ideal positive)	0.0517	0.0372	0.0476	0.0895	0.0546	0.0474	0.0342
B– (ideal negative)	0.1206	0.0650	0.0857	0.0448	0.0273	0.0178	0.0214

$$C_i^* = \frac{S_i^-}{S_i^- + S_i^+}, \quad 0 < C_i^* < 1. \quad (9)$$

Consequently, the ranking of strategic alternatives to the structural capital development in order to reduce their attractiveness is as follows:

$$B5 \rightarrow B2 \rightarrow B1 \rightarrow B6 \rightarrow B4 \rightarrow B3 \rightarrow B7.$$

The final stage of the study is the assessment and ranking of strategies for the market capital development. For this end, the COPRAS (Complex PROportional ASsessment) method is proposed using the following scheme.

1. Assessing selected strategies for the market capital development according to predefined criteria (the criteria values are obtained by expertise) (Table 11) whose values belong to the Edgeworth – Pareto set.
2. Normalizing the decision matrix (Table 12). It implies:
 - determining the sum of estimation values according to each criterion

$$\sum_{k=1}^n x_{kj}, \quad (10)$$

Table 10. Ranking of alternative strategies for the structural capital development of the organization

Source: Compiled by authors.

Alternatives	S_i^+	S_i^-	$C_i^* = S_i^- / (S_i^- + S_i^+)$	Rank
B1	0.0480	0.0672	0.5833	3
B2	0.0445	0.0760	0.6307	2
B3	0.0664	0.0722	0.5209	6
B4	0.0547	0.0606	0.5256	5
B5	0.0371	0.0706	0.6555	1
B6	0.0594	0.0662	0.5271	4
B7	0.0814	0.0540	0.3988	7

Table 11. Output data (decision matrix) on ranking the strategies for market capital development by the COPRAS method

Source: Compiled by authors.

Alternatives	Criteria	K1	K2	K3	K4	K5	K6	K7
Function		min	min	min	max	max	max	max
C1. Strategy for increasing customer and stakeholder loyalty		8	8	10	6	6	8	9
C2. Strategy for segmentation of the market of science-intensive products		5	5	8	5	5	5	7
C3. Strategy of marketing competitive advantages development on both domestic and foreign markets		6	7	10	8	5	9	7
C4. Strategy for the employer brand formation and development		5	5	8	6	5	5	7
C5. Strategy for the development of a research organization image in the market		5	5	9	5	7	6	8
C6. Strategy of partner network formation		7	8	5	8	6	7	8
C7. Strategy of innovation transfer through marketing channels		6	6	7	7	8	7	8

Table 12. Normalized decision matrix

Source: Compiled by authors.

Criteria \ Alternatives	K1	K2	K3	K4	K5	K6	K7
$\sum_{k=1}^n x_{kj}$	42	44	57	45	42	47	54
$r_{ij} = x_{ij} / \sum_{k=1}^n x_{kj}$	K1	K2	K3	K4	K5	K6	K7
C1	0.1905	0.1818	0.1754	0.1333	0.1429	0.1702	0.1667
C2	0.1190	0.1136	0.1404	0.1111	0.1190	0.1064	0.1296
C3	0.1429	0.1591	0.1754	0.1778	0.1190	0.1915	0.1296
C4	0.1190	0.1136	0.1404	0.1333	0.1190	0.1064	0.1296
C5	0.1190	0.1136	0.1579	0.1111	0.1667	0.1277	0.1481
C6	0.1667	0.1818	0.0877	0.1778	0.1429	0.1489	0.1481
C7	0.1429	0.1364	0.1228	0.1556	0.1905	0.1489	0.1481

- calculating the values of normalized decision matrix, where

$$r_{ij} = \frac{x_{ij}}{\sum_{k=1}^n x_{kj}} \quad (11)$$

$$S_{+i} = \sum_{j=1}^m w_{+j} \cdot r_{+ij}, \quad (12)$$

$$S_{-i} = \sum_{j=1}^m w_{-j} \cdot r_{-ij}. \quad (13)$$

- Constructing a weighted normalized decision matrix (Table 13) using the criteria values weighted above.

4.2. Calculating Z_{+i} , Z_{-i} and Z_i for each alternative by formulas:

- Ranking of alternative options for the market capital development of the organization.

$$Z_i = S_{+i} + \frac{\sum_{k=1}^n S_{-k}}{S_{-i} \cdot \sum_{k=1}^n \frac{1}{S_{-k}}} = Z_{+i} + Z_{-i}, \quad (14)$$

- 4.1. Calculating the weighted sum of evaluations of the i -th alternative on the criteria having monotonically increasing target function S_{+i} and the weighted sum of evaluations of the i -th alternative on the criteria having the monotonously decreasing target function S_{-i} by the formulas:

$$Z_{+i} = S_{+i}, \quad (15)$$

$$Z_{-i} = \frac{\sum_{k=1}^n S_{-k}}{S_{-i} \cdot \sum_{k=1}^n \frac{1}{S_{-k}}}. \quad (16)$$

Table 13. Weighted normalized decision matrix

Source: Compiled by authors.

Criteria \ Alternatives	K1	K2	K3	K4	K5	K6	K7
Weight	0.2286	0.1352	0.1657	0.1905	0.1105	0.099	0.0705
Function	min	min	min	max	max	max	max
C1	0.0435	0.0246	0.0291	0.0254	0.0158	0.0168	0.0117
C2	0.0272	0.0154	0.0233	0.0212	0.0131	0.0105	0.0091
C3	0.0327	0.0215	0.0291	0.0339	0.0131	0.0190	0.0091
C4	0.0272	0.0154	0.0233	0.0254	0.0131	0.0105	0.0091
C5	0.0272	0.0154	0.0262	0.0212	0.0184	0.0126	0.0104
C6	0.0381	0.0246	0.0145	0.0339	0.0158	0.0147	0.0104
C7	0.0327	0.0184	0.0203	0.0296	0.0211	0.0147	0.0104

Table 14. Ranking of alternative strategies for market capital development

Source: Compiled by authors.

Alternatives	S_{+i}	S_{-i}	$1/S_{-i}$	Z_{+i}	Z_{-i}	$Z_i = Z_{+i} + Z_{-i}$	Rank
C1	0.1689	0.0972	10.2881	0.1689	0.0579	0.2268	1
C2	0.0539	0.0659	15.1745	0.0539	0.0854	0.1393	7
C3	0.0751	0.0833	12.0048	0.0751	0.0676	0.1427	6
C4	0.0581	0.0659	15.1745	0.0581	0.0854	0.1435	5
C5	0.0626	0.0688	14.5349	0.0626	0.0818	0.1444	4
C6	0.0748	0.0772	12.9534	0.0748	0.0729	0.1477	3
C7	0.0758	0.0714	14.0056	0.0758	0.0788	0.1546	2
Σ	–	0,5297	94,1358	–	–	–	–

4.3. Defining the ranking of alternative strategies (Table 14) based on the Z_i inclusion (the greater the value of Z_i , the more attractive is the alternative).

Based on the calculations, the priority of the strategies for market capital development of a research organization in line with their attractiveness reducing is as follows:

$$C1 \rightarrow C7 \rightarrow C6 \rightarrow C5 \rightarrow C4 \rightarrow C3 \rightarrow C2.$$

Since allocating three types of intellectual capital (human, structural and market) is a source methodological provision in the article, the general strategy for the intellectual capital development of a research organization is considered as a strategy portfolio for each type of intellectual capital. The only general strategy is precisely the dialectic combination of several strategies for the development of each type of intellectual capital with the appropriate combination of the internal and external environment factors over a certain period of time. For the selected research institution, the strategic set includes the following strategies: strategy for the personnel competitive advantages development, licensing strategy and strategy for increasing customer and stakeholder loyalty. Their complex implementation will increase the organization competitiveness in the innovation market.

3. DISCUSSION

Thus, the application of SAW, TOPSIS and COPRAS methods allows for determining the optimum portfolio of intellectual capital strategies of the research organization. The focus on all its

components balanced development and the availability for practical implementation under limited time, financial and other resources determines the choice of rating of the first three strategies in each block of strategic alternatives. Thus, the optimal set of strategies for the intellectual capital development is as follows.

1. Among the vectors of human capital expanded reproduction, the research organization needs to focus first and foremost on ensuring the development of personnel competitive advantages. Realization of this strategy will allow the organization to take a steady competitive position in the market, because it is the personnel that is the main strategic resource in the competition especially among research institutions. Given the organization profile under investigation, the strategy for increasing the personnel innovative activity should also hold an important place in the portfolio. It will enable them to realize the main tasks facing these organizations. Taking measures to increase personnel competence must never be neglected. Innovative activity intensification and rapid pace of moral aging of information necessitate constant attention of managers to their employees' professional development. The current stage of the country's economic development is characterized not only by the quantitative requirements of the personnel (in particular, its size and structure), but rather by the qualitative characteristics that are reflected in the employee competence development.
2. Among the strategic alternatives to the structural capital development, priority is given to the licensing strategy. It will enable the realization of

the economic purpose of intellectual property assets that have significant unrealized commercial potential in this organization. The second ranking is the strategy of building a portfolio of rights to intellectual property objects. It is important in the context of strengthening the interconnections between the intellectual capital components, namely through the intensive use of the powerful human capital of a research organization with the subsequent wide market diffusion of created objects of intellectual property rights. It is also desirable to pay attention to the strategy for information-communication technologies and network development. In the context of shaping the information society, it plays a cross-cutting role in ensuring the effective management of intellectual capital in general, as well as operational and flexible interaction with a changing environment.

3. The results of the ranking of strategies for the market capital development indicate that the

priority for implementation in the research institution is a strategy for increasing customer and stakeholder loyalty. It forms the main component of market capital, namely, client capital, which is the sense of its marketing activities and the main source of existing and future profits from the generated knowledge commercialization. For organization, the strategy of innovation transfer through marketing channels has also been updated, which confirmed their commercial value and allow to optimize science-intensive products traffic. However, the dynamic spread of non-commercial exchange of useful knowledge by means of communication should also be taken into account. According to calculations, the strategy for shaping a partnership network ranks third. This strategy objectifies the need for shaping and developing network capital of the organization, which generates and disseminates useful knowledge and science-intensive products.

CONCLUSION

Consequently, it is indisputable that the strategic management of intellectual capital is an important element of the research organization management under increased competition in the innovative market. The transformation of intellectual capital into a dominant strategic resource of economic growth ensuring competitiveness and profitability requires the sensitivity of making managerial decisions regarding the choice of further extended reproduction vectors and effective commercial use of the intellectual component of the innovative organization. Methodological support for developing a strategy, the application of multi-criteria analysis methods adapted to the specifics of the intellectual capital of a research institution as an object of strategic management will contribute to the strengthening the development prospects validity.

The tasks of multi-purpose selection of strategic alternatives to the development of intellectual capital components are solved using SAW, TOPSIS and COPRAS methods under certain criteria constraints. Each of these methods differs by the mechanism of calculation and approaches to the primary decision matrix formulation. The obtained results allow mathematically formalizing the rating and forming the optimal strategy portfolio of human, structural, market capital of an organization under specific combination of internal and external factors. The proposed methodological approach can be used by research companies' leaders to develop and substantiate strategic management decisions to optimize their intellectual capital development.

Increasing the sensitivity of determining the strategic development prospects within this study is carried out through several methods of multi-criteria analysis, not covering the whole possible range of appropriate methodological tools. The directions for further research are outlined by testing the use of other multi-criteria analysis methods in relation to this object of strategic management; definition of criterion restrictions; integration of different approaches to the evaluation of strategic alternatives. Also, the application of intellectual capital matrix methods is relevant. In addition, the organic combination

of this study subject with the issues of strategic human resources management, intellectual property, information and communication technologies, marketing in the context of defining functional strategies for the development of certain components of intellectual capital, their content and organizational and methodological support should be taken into account. Focusing on these issues can open up new scientific research vectors. The above tasks solution is aimed at increasing the efficiency of strategic management of the intellectual capital in innovative organizations when entering the highly competitive innovative markets.

REFERENCES

1. Balan, V., & Sitnitskiy, M. (2012). The role of portfolio analysis in forming the competitive strategies of enterprise. *Aktualni problemy ekonomiky*, 5(131), 141-148.
2. Baranov, V. V., & Zaytsev, A. V. (2009). Стратегическое управление интеллектуальным капиталом высокотехнологичного предприятия [Strategicheskoye upravleniye intellektualnym kapitalom vysokotekhnologichnogo predpriyatiya]. *Kreativnaya ekonomika*, 12(36), 72-86. Retrieved from <https://cyberleninka.ru/article/v/strategicheskoe-upravlenie-intellektualnym-kapitalom-vysokotekhnologichnogo-predpriyatiya>
3. Behzadian, M., Otagsara, S. K., Yazdani, M., & Ignatius, J. (2012). A state-of-the-art survey of TOPSIS applications. *Expert Systems with Applications*, 39(17), 13051-13069. <https://doi.org/10.1016/j.eswa.2012.05.056>
4. Bindu Madhuri, Ch., & Anand Chandulal, J. (2010b). Evaluating web sites using COPRAS-GRA combined with grey clustering. *International Journal of Engineering Science and Technology*, 2(10), 5280-5294.
5. Bindu Madhuri, Ch., Anand Chandulal, J., & Padmaja, M. (2010a). Selection of best web site by applying COPRAS-G method. *International Journal of Computer Science and Information Technologies*, 1(2), 138-146.
6. Brooking, A. (1996). *Intellectual Capital: Core Asset for the Third Millennium Enterprise*. London: International Thomson Business Press.
7. Chatterjee, P., Athawale, V. M., & Chakraborty, S. (2011). Materials selection using complex proportional assessment and evaluation of mixed data methods. *Materials & Design*, 32(2), 851-860. <https://doi.org/10.1016/j.matdes.2010.07.010>
8. Chen, C. T. (2000). Extension of the TOPSIS for group decision-making under fuzzy environment. *Fuzzy Sets and Systems*, 114, 1-9. [https://doi.org/10.1016/S0165-0114\(97\)00377-1](https://doi.org/10.1016/S0165-0114(97)00377-1)
9. Chu, M. T., Shyu, J., Tzeng, G. H., & Khosla, R. (2007). Comparison among three analytical methods for knowledge communities group-decision analysis. *Expert systems with applications*, 33(4), 1011-1024. <https://doi.org/10.1016/j.eswa.2006.08.026>
10. Chupryna, O. O., & Chupryn, K. S. (2013). Методологічні підходи до оцінювання інтелектуального капіталу [Metodolohichni pidkhody do otsiniuvannya intellektualnoho kapitalu]. *Visnyk Natsionalnoho universytetu "Yurydychna akademiia Ukrainy imeni Yaroslava Mudroho"*, 3, 22-33. Retrieved from <http://econtlaw.nlu.edu.ua/wp-content/uploads/2016/01/3-22-34.pdf>
11. Datta, S., Beriha, G. S., Patnaik, B., & Mahapatra, S. S. (2009). Use of compromise ranking method for supervisor selection: A multi-criteria decision making (MCDM) approach. *International Journal of Vocational and Technical Education*, 1(1), 7-13. Retrieved from <http://www.academicjournals.org/journal/IJYTE/article-full-text-pdf/C2E3E5B592>
12. Edvinsson, L. (2000). Some perspectives on intangibles and intellectual capital. *Journal of Intellectual Capital*, 1(1), 12-16. <https://doi.org/10.1108/14691930010371618>
13. Ghorabae Mehdi Keshavarz, Amiri Maghsoud, Sadaghiani Jamshid Salehi, & Goodarzi Golnoosh Hassani (2014). Multiple criteria group decision-making for supplier selection based on COPRAS method with interval type-2 fuzzy sets. *The International Journal of Advanced Manufacturing Technology*, 75, 1115-1130. <https://doi.org/10.1007/s00170-014-6142-7>
14. Ginevicius, R., & Podvezko, V. (2008). Housing in the context of economic and social development of Lithuanian regions. *International Journal of Environment and Pollution*, 35(2/3/4), 309-330. <https://doi.org/10.1504/IJEP.2008.021363>
15. Hofer, N. L. (2009). *An evaluation of neighborhood sustainability assessment frameworks using ecosystems resilience as the evaluation criteria*. Master Science in Planning (217 p.). The University of British Columbia (Vancouver). Retrieved from <https://open.library.ubc.ca/cIRcle/collections/ubctheses/24/items/1.006785>
16. Hwang, C. L., & Yoon, K. P. (1981). *Multiple Attribute Decision Making: Methods and Applications* (259 p.). New York: Springer-Verlag.
17. Kaklauskas, A., Zavadskas, E. K., & Raslanas, S. (2005). Multivariate design and multiple criteria analysis of building refurbishments. *Energy and Buildings*, 37(4),

- 361-372. <https://doi.org/10.1016/j.enbuild.2004.07.005>
18. Kaplan, R. S., & Norton, D. P. (1996). *The Balanced Scorecard: Translating Strategy Into Action*. Harward Business School Press. Retrieved from http://www.netlibrary.com/ebook_info.asp?product_id=7252
 19. Kendall, M. G. (1995). *Rank Correlation Methods* (196 p.). N.Y.: Hafner Publishing Company.
 20. Klee, A. J. (1971). The Role of Decision Models in the Evaluation of Competing Environmental Health Alternatives. *Management Science*, 18(2), 52-67. <https://doi.org/10.1287/mnsc.18.2.B52>
 21. Kornilova, I., Bilorus, T., & Firsova, S. (2016). Види стратегій розвитку інтелектуального капіталу підприємства: підходи до систематизації [Vdy strategii rozvytku intelektualnoho kapitalu pidpriemstva: pidkhody do systematyzatsii]. *Skhid*, 6(146), 34-42.
 22. Kravchenko, S. I., & Kornieva, O. V. (2011). Оцінювання інтелектуального капіталу вищих навчальних закладів [Otsiniuvannia intelektualnoho kapitalu vyshchych navchalnykh zakladiv]. *Marketynh i menedzhment innovatsii*, 3, 55-61.
 23. Liashenko, N. Ye. (2012). Методичні підходи удосконалення аналізу моделей вимірювання інтелектуального капіталу підприємства [Metodychni pidkhody udoskonallennia analizu modelei vymiriuвання intelektualnoho kapitalu pidpriemstva]. *Nauk. pratsi Poltav. derzh. ahrar. akad.*, 151-160. Retrieved from <https://www.pdaa.edu.ua/sites/default/files/nppdaa/spec/151.pdf>
 24. MacCrimmon, K. R. (1968). Decision making among multiple – attribute alternatives: A Survey and Consolidated Approach. RAND Memorandum, RM-4823-ARPA. Retrieved from <http://www.dtic.mil/dtic/tr/fulltext/u2/681005.pdf>
 25. Mardani, A., Jusoh, A., & Zavadskas, E. K. (2015). Fuzzy multiple criteria decision-making techniques and applications – Two decades review from 1994 to 2014. *Expert Systems with Applications*, 42(8), 4126-4148. <https://doi.org/10.1016/j.eswa.2015.01.003>
 26. Mazumdar, A., Datta, S., & Mahapatra, S. S. (2010). Multi-criteria decision-making models for the evaluation and appraisal of teacher's performance. *International Journal of Productivity and Quality Management*, 6(2), 213-230. <https://doi.org/10.1504/IJPMQ.2010.034406>
 27. Podvezko, V. (2005). Development of expert estimates. *Technological and Economic Development of Economy*, 11(2), 101-107.
 28. Podvezko, V. (2011). The comparative analysis of MCDA methods SAW and COPRAS. *Inzinerine Ekonomika-Engineering Economics*, 22(2), 134-146.
 29. Qin, X., Huang, G., Chakma, A., Nie, X., & Lin, Q. (2008). A MCDM-based expert system for climate-change impact assessment and adaptation planning – A case study for the Georgia Basin, Canada. *Expert Systems with Applications*, 34(3), 2164-2179. <https://doi.org/10.1016/j.eswa.2007.02.024>
 30. Rahman, S., Odeyinka, H., Perera, S., & Bi, Y. (2012). Product-cost modelling approach for the development of a decision support system for optimal roofing material selection. *Expert Systems with Applications*, 39, 6857-6871. <https://doi.org/10.1016/j.eswa.2012.01.010>
 31. Razavi Hajiagha, S. H., Hashemi, S. S., & Zavadskas, E. K. (2013). A complex proportional assessment method for group decision making in an interval-valued intuitionistic fuzzy environment. *Technol. Econ. Dev. Econ.*, 19(1), 22-37. <https://doi.org/10.3846/20294913.2012.762953>
 32. Stuart, T. A. (1997). *Intellectual Capital: The New Wealth of Organizations* (115 p.). London.
 33. Sveiby, K. E. (2005). *Methods for Measuring Intangible Assets*. Retrieved from <http://www.sveiby.com/articles/IntangibleMethods.htm>
 34. Triantaphyllou, E., & Lin, C. T. (1996). Development and evaluation of five fuzzy multi-attribute decision-making methods. *International Journal of Approximate Reasoning*, 14, 281-310. [https://doi.org/10.1016/0888-613X\(95\)00119-2](https://doi.org/10.1016/0888-613X(95)00119-2)
 35. Tzeng, G. H., & Huang, J. J. (2011). *Multiple Attribute Decision Making methods and Applications* (337 p.). United States of America: CRC Press, Taylor & Francis Group. Retrieved from [https://books.google.com.ua/books?hl=uk&lr=&id=_C7n1ar4f8IC&oi=fnd&pg=PP1&dq=Tzeng,+G.+H.+Huang,+J.+J.,+\(2011\).+Multiple+Attribute&ots=5ghsD007sO&sig=ZsJif_vtvN8-eyS2Hgqjygl67vI&redir_esc=y#v=onepage&q&f=false](https://books.google.com.ua/books?hl=uk&lr=&id=_C7n1ar4f8IC&oi=fnd&pg=PP1&dq=Tzeng,+G.+H.+Huang,+J.+J.,+(2011).+Multiple+Attribute&ots=5ghsD007sO&sig=ZsJif_vtvN8-eyS2Hgqjygl67vI&redir_esc=y#v=onepage&q&f=false)
 36. Ustinovichius, L., Zavadskas, E. K., & Podvezko, V. (2007). Application of a quantitative multiple criteria decision making (MCDM-1) approach to the analysis of investments in construction. *Control and Cybernetics*, 36(1), 251-268.
 37. Uzsilaityte, L., & Martinaitis, V. (2010). Search for optimal solution of public building renovation in terms of life cycle. *Journal of Environment Engineering and Landscape Management*, 18(2), 102-110. <http://dx.doi.org/10.3846/jeelm.2010.12>
 38. Velasquez, M., & Hester, P. T. (2013). An analysis of multi-criteria decision making methods. *International Journal of Operations Research*, 10(2), 56-66. Retrieved from https://www.researchgate.net/profile/Patrick_Hester/publication/275960103_An_analysis_of_multi-criteria_decision_making_methods/links/55eefed208ae199d47bff202.pdf
 39. Wang, Y. J. (2015). A fuzzy multi-criteria decision-making model based on simple additive weighting method and relative preference relation. *Applied Soft Computing*, 30, 412-420. <https://doi.org/10.1016/j.asoc.2015.02.002>
 40. Yang, Z. L., Bonsall, S., & Wang, J. (2011). Approximate TOPSIS for vessel selection under uncertain environment. *Expert Systems with Applications*, 38(12), 14523-14534. <https://doi.org/10.1016/j.eswa.2011.05.032>
 41. Zavadskas, E. K., Mardani, A., Turskis, Z., Jusoh, A., & Nor, Kh.

- (2016). Development of TOPSIS Method to Solve Complicated Decision-Making Problems – An Overview on Developments from 2000 to 2015. *International Journal of Technology & Decision Making*, 645-682. <https://doi.org/10.1142/S0219622016300019>
42. Zavadskas, E. K., & Kaklauskas, A. (1996). *Multicriteria Evaluation of Building (Pastatų sistemos techninis įvertinimas)* (280 p.). Vilnius: Technika [in Lithuanian].
43. Zavadskas, E. K., Turskis, Z., Dejus, T., & Viteikiene, M. (2007). Sensitivity analysis of a simple additive weight method. *International Journal of Management and Decision Making*, 8(5/6), 555-574. <https://doi.org/10.1504/IJMDM.2007.013418>
44. Zavadskas, E. K., & Vilutiene, T. (2006) A multiple criteria evaluation of multi-family apartment block's maintenance contractors: I-model for maintenance contractor evaluation and the determination of its selection criteria. *Building and Environment*, 41(5), 621-632. <https://doi.org/10.1016/j.buildenv.2005.02.019>
45. Zyoud, S. H., & Fuchs-Hanusch, D. (2017). A bibliometric-based survey on AHP and TOPSIS techniques. *Expert Systems with Applications*, 78(15), 158-181. <https://doi.org/10.1016/j.eswa.2017.02.016>