

Analysis of Digital Transformation Strategies Based on an Integrated Approach of Analytical Tools

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Abstract: In the context of rapid development of digital technologies, organizations increasingly turn to the concept of digital transformation to improve their competitiveness and efficient operations. In this regard, the development and application of suitable tools for choosing a digital transformation strategy is one of the important applied tasks of each organization. This fact indicates the need to select advanced analytical tools. In the article, the author conducts a comprehensive study aimed at creating an innovative model for assessing digital transformation strategies. The model combines innovative methods of multi-criteria analysis, in particular multi-criteria decision making, fuzzy logic and other mathematical approaches that allow for a comprehensive analysis and development of the most optimal strategies for the development of an organization. Based on the results of the study, the optimal strategy for the object under study was determined for the purpose of successful digital transformation. Further, the main conclusions and promising areas for further research are formulated.

Key words: digital transformation, strategy selection, decision making, cybernetic systematicity, multicriterial decision making, fuzzy logic, analytical process from the standpoint of hierarchy, axiomatic design.

I. Introduction

The Industry 4.0 concept, which emerged at the turn of the decade, has become a driver of innovation in various industries today. Digital transformation, as an integral part of this concept, allows organizations to implement new technologies, create intelligent products and services, and optimize business processes. The interaction of people, machines, and data in real time opens up new horizons for innovation and allows companies to take leading positions in the market.

Digital transformation affects all aspects of a company's activities: from business models to corporate culture. In these conditions, developing an effective strategy becomes a complex multifactorial task. Analyzing digital transformation strategies requires the use of special analytical and applied methods that allow evaluating various options and choosing the most optimal one. Despite the growing interest in digital transformation, there is a lack of research in the scientific literature devoted to the development of such methods and models. Based on this, the cornerstone focus is the development of analytical tools that will allow organizations to objectively evaluate strategic alternatives and make informed decisions in the context of digital transformation.

It should be noted that when choosing the right development strategy, each organization must take into account a huge number of factors. This process is also complicated by the presence of enormous uncertainty, which is characteristic of modern global economic development [4]. At the same time, the modern economic system is characterized by its complexity and emergence. Based on this, we propose a comprehensive approach based on the methods of fuzzy logic and multi-criteria decision-making, which would allow taking into account these two phenomena. In this case, the fuzzy logic method is reduced to reflecting the uncertainty and vagueness in the assessment of criteria and alternatives, while the multi-criteria decision-making method takes into account the totality of the criteria and factors themselves.

This approach was implemented using certain stages. First, a decision-making model is built taking into account the multifactorial nature and uncertainty of development. Second, a research methodology is implemented based on the tools of the fuzzy analytical process from the standpoint of hierarchy and fuzzy axiomatic design. Factor weights are determined by the method of fuzzy analytical process from the standpoint of hierarchy, and the most appropriate strategy is selected using fuzzy analytical design. The advantages of using this method are its convenience and consistency, in particular its ability to group criteria from the standpoint of hierarchy. In turn, the fuzzy analytical design method is attractive due to its ability to measure the compliance of system characteristics with its functional requirements. In addition, it excludes alternative strategies that do not meet the functional requirements of the system.

Digital transformation is radically changing the business landscape, requiring companies to constantly adapt and rethink their strategies. Successful digital transformation involves not only the implementation of new technologies, but also a comprehensive transformation of business processes, structures, and cultural norms [1-3]. According to research, effective digital transformation requires aligning four key aspects: technological, economic, organizational, and cultural.

Digital transformation creates both new opportunities and significant challenges for organizations (Figure 1).

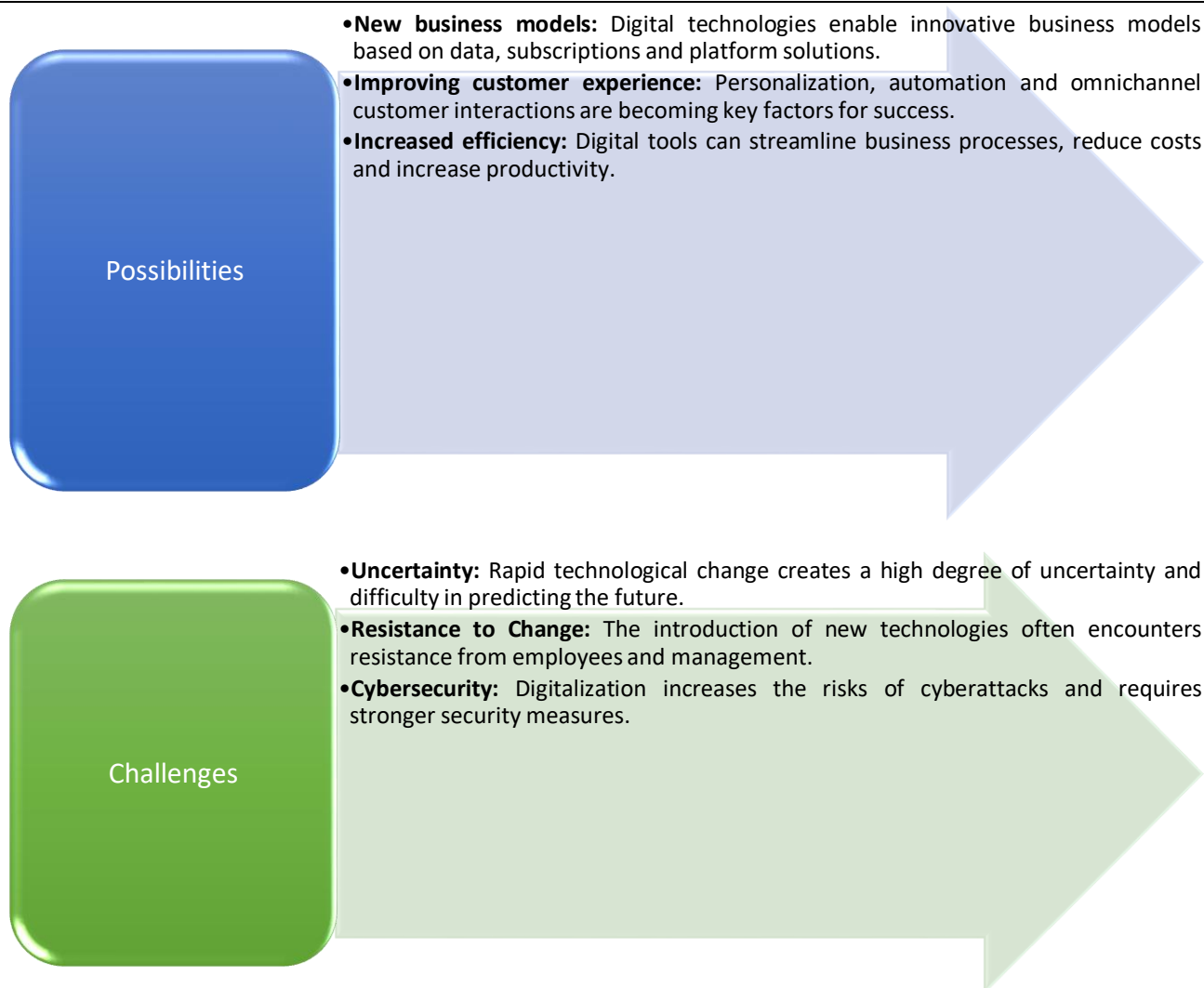


Fig. 1. The role of digital transformation

Source: developed by the author based on research

There are a number of publications in the scientific literature devoted to the impact of digital transformation at the micro and macro levels. Thus, Porter's classic work is devoted to analysis of the competitive advantages of companies through the use of technology. McCaffrey and Brynjolfsson examine the impact of digital technologies on the economy and society, emphasizing the importance of innovation and adaptation to new conditions. For practical recommendations, the work of Westerman is interesting, where he offers practical recommendations for managers seeking to successfully implement digital transformation in their companies.

Research in the field of digital strategy development is actively developing in the academic world. Early works laid the foundations for a systemic approach to digital strategies. Later, studies by Bharadwaj and Bleischer deepened the understanding of key aspects of companies' digital transformation strategy. Lerner investigated the integration of digital strategy into the overall business strategy, while Limani in his works substantiated the need for flexible and adaptable approaches to the study of company strategies. Hyvonen contributed to the study of the specific features of digital transformation in Scandinavian countries.

Existing studies, such as Yeh's work, demonstrate the potential of multi-criteria decision-making methods in choosing digital transformation strategies. However, it should be noted that the approach presented by Yeh does not provide an opportunity to take into account the uncertainty factor, which is the driver of modern development. In order to fill this gap in scientific circles, we propose an integrated approach based on the above-mentioned tools. This integrated approach will allow companies to more effectively choose optimal digital transformation strategies for organizations in the face of uncertainty and complexity of development.

Model specification.

The developed model is based on the synthesis of fundamental scientific research [5,6,9], industry reports [7,8,12] and expert opinions. The conceptual decision-making scheme is presented in Fig.2.

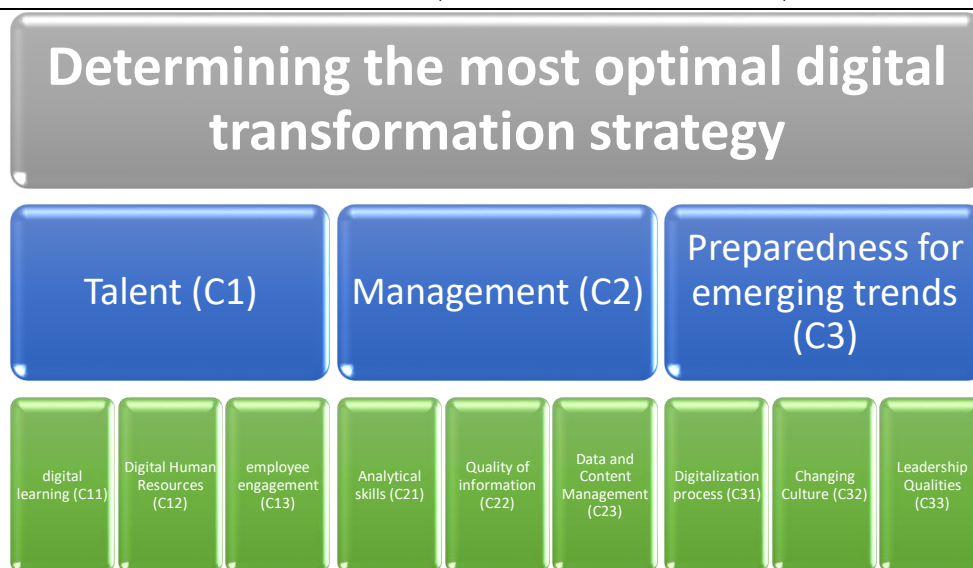


Fig. 2. Conceptual diagram of decision making

Source: developed by the author based on research

The analysis also examines four alternative digital transformation strategies: a customer- and people-focused strategy; a profit-focused strategy; a strategy focused on the integration and alignment of business processes; and a strategy focused on collaboration and innovation.

A1. Customer and People-Oriented Strategy

This strategy is subjective and is aimed at taking into account the interests of customers and staff. In other words, the focus is on the economic entity. To obtain more detailed information about consumer behavior and their interests, information about the client, his tastes and preferences is used. Information about the purchasing power of VIP clients and their age characteristics is also used for segmentation. In order to create an expanded client base, organizations need to think through the path and maintain communication with clients throughout their lives.

To ensure a successful digital transformation, it is essential not only to implement new technologies, but also to transform the corporate culture. This requires creating an open and trusting atmosphere, delegating authority to employees, developing their digital competencies and using digital technologies to determine their behavior.

A2. Profit-oriented strategy.

The value-based approach requires companies to rethink their business models and create new value propositions that meet changing customer needs. Digital technologies, as well-known companies like *Walmart* and *Zara* have shown, namely the integration of digital supply chains into their operations, can significantly improve efficiency and create new business opportunities. The emergence of innovative business solutions, such as consulting services and free apps, highlights the need to constantly search for new sources of income and adapt to changing market conditions. To develop successfully, organizations must be flexible and able to change quickly.

A3. Strategy focused on integration and alignment of business processes

An effective integration and alignment strategy involves creating a unified ecosystem where all elements of the company work in concert to achieve common goals. In other words, all strategies, capabilities, resources, and management systems of the company must be aligned and coordinated with each other to support the organization's goals. Communication plays a key role in this process. The lack of clear communication and coordination between different departments can lead to decreased efficiency and the inability of the organization to adapt to a rapidly changing environment. In this case, organizations become part of a larger ecosystem with integrated value chains. Digital technologies here enable organizations to collaborate more closely with external entities (partners).

A4. Strategy focused on collaboration and innovation

A strategy focused on collaboration and innovation requires the creation of integrated platforms and the development of a corporate culture. In the era of digital transformation, where the integrated form of business prevails, only corporate efforts can achieve success. Digital transformation requires more than technology; it must be balanced with a culture of knowledge sharing. Technology teams and subject matter experts must come together early on. Personnel must work in cross-functional teams, and open learning mechanisms must be adopted throughout the company. Only companies that work quickly and in real time have a better chance of innovating faster and being successful.

II. Research methodology

The research methodology consists of three consecutive stages, schematically presented in Figure 3. **The first stage** is aimed at formulating the research problem and identifying the key factors influencing the choice of digital transformation strategy. **At the second stage**, using the fuzzy analytical hierarchy process method, the weights of the factors are determined, allowing us to determine their relative importance. **The final stage** of the research is devoted to choosing the optimal strategy using the fuzzy analytical network method. This method allows us to take into account the relationships between various criteria and alternatives, which increases the accuracy of decisions made.

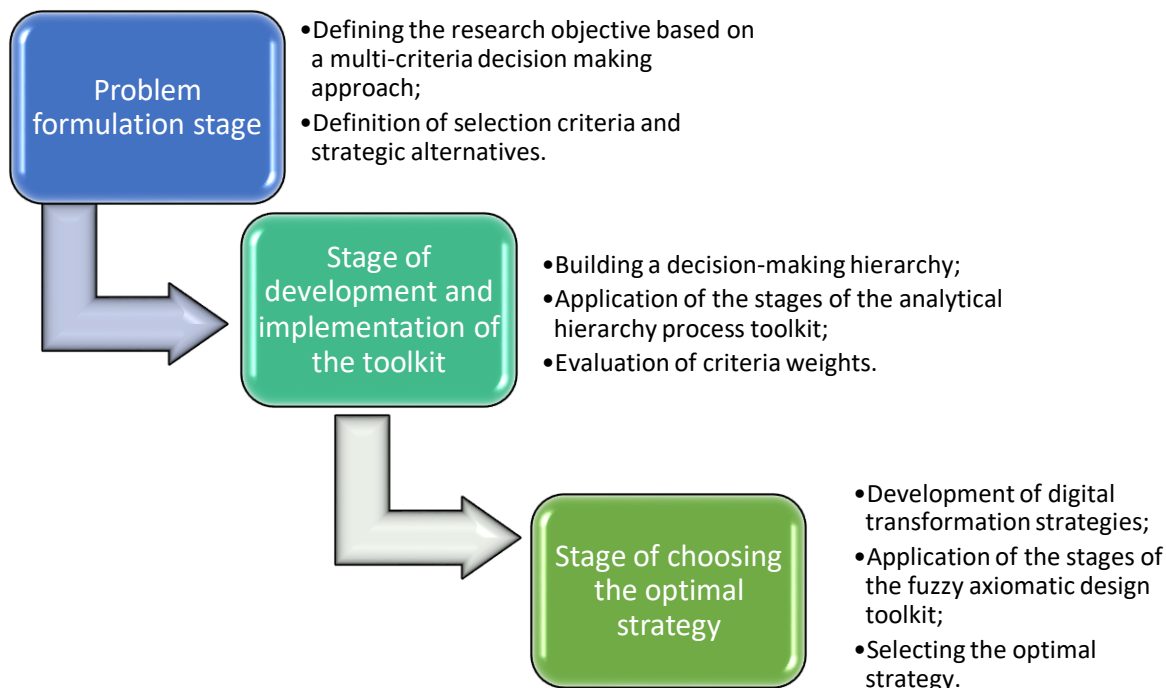


Fig.3. Methodological approach.

Source: developed by the author based on research

Saaty 's Analytical Hierarchy Process is a powerful tool for multi-criteria decision making, allowing alternatives to be ranked according to their degree of preference [10]. The flexibility of this method lies in the fuzzy (chaotic) environment, which describes well the chaotic behavior of the subjects of the study. This, in turn, allows the toolkit to be successfully applied in various fields of science, including economics, engineering, and social sciences.

The process of applying the fuzzy hierarchy process analysis toolkit includes the following steps:

Building a Hierarchical Structure: Breaking down the problem into hierarchical levels, including the goal, criteria, and alternatives.

Pairwise comparison of elements: Comparison of elements of each level in pairs using linguistic variables (see Table 1).

Table 1. Linguistic scale of analysis of fuzzy analytical hierarchy process.

Linguistic expression	Abbreviation	Three-dimensional fuzzy numbers
Equal	E	(1,1,1)
Equally significant	E.I.	(0,5,1,1,5)
Low degree of significance	WMI	(1,1,5,2)
Medium level of significance	SMI	(1,5,2,2,5)
High degree of significance	VSMI	(2,2,5,3)
Extremely high degree of significance	AMI	(2,5,3,3,5)

Construction of fuzzy matrices of pairwise comparisons: Transformation of linguistic evaluations into fuzzy numbers for each comparison. For this purpose, the membership function $\tilde{A}=(l,m,u)$ is used, which can be expressed as follows:

$$\mu_{\tilde{A}}(x) = \begin{cases} \frac{(x-l)}{(m-l)} & \text{if } l \leq x \leq m, \\ \frac{(u-x)}{(u-m)} & \text{if } m \leq x \leq u, \\ 0 & \text{otherwise.} \end{cases} \quad (1)$$

Calculation of weights of criteria and alternatives: For calculating the weights of elements at each level of the hierarchy Fuzzy mathematics methods are used.

Synthesis of results: At this stage, the weights of the criteria and alternatives are combined to determine the overall ranking of the alternatives.

It should be noted that the toolkit of the fuzzy hierarchy process allows one to take into account the uncertainty and subjectivity of assessments, which makes it especially useful for solving complex problems related to decision-making under emergent conditions.

axiomatic design (AD) method used in this paper and proposed by Suh in 1990 has become a widely used method in engineering disciplines [11]. It is based on two key axioms - independence of functional requirements and minimization of the information content of the system. The fuzzy modification of the axiomatic design allows taking into account the uncertainty of estimates by representing them as triangular fuzzy numbers. The design process is carried out as follows: first, an evaluation matrix is constructed by collecting the selected policy decisions. Next, a paired comparison of elements is made using linguistic expressions (see Table 2). In the third stage, the linguistic expressions are transformed into three-dimensional fuzzy numbers.

Table 2. Linguistic scale of fuzzy axiomatic design analysis.

Linguistic expression	Abbreviation - atura	Three-dimensional fuzzy numbers
Very bad	VB	5,1,1,5)
Bad	B	,1,5,2)
Average	M	,5,2,2,5)
Good	G	,2,5,3)
Very good	VG	5,3,3,5)

Next, the aggregation of the assessments of the decisions made and three-dimensional fuzzy numbers is carried out using the following equation:

$$\tilde{S}_{ij} = \frac{1}{K} (\tilde{S}_{ij}^1 + \tilde{S}_{ij}^2 + \dots + \tilde{S}_{ij}^{1t} + \dots + \tilde{S}_{ij}^K), \tilde{S}_{ij}^{1t} = (a_{ij}, b_{ij}, c_{ij}) \quad (2),$$

where K is the number of decisions taken, \tilde{S}_{ij} are the ranks of alternatives of political decisions with the i^{th} alternative and j^{th} criterion.

Next, the functional scope for each criterion is determined, followed by the calculation of the information content (I) for each alternative. The basic concept of axiomatic design is to find the intersection region between the design range and the system range, as shown in Fig. 4. In the fuzzy case, the system range and the design range are determined using three-dimensional fuzzy numbers, as shown in Fig. 5.

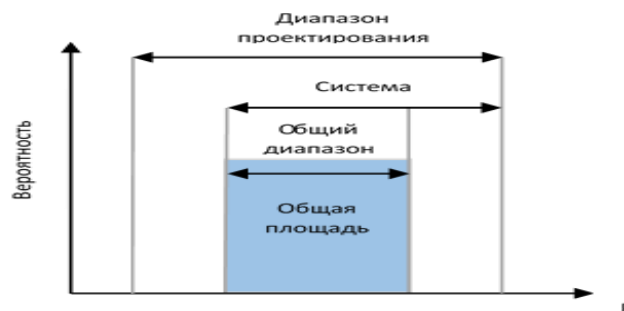


Fig.4. Research ranges based on criteria

Source: developed by the author based on research

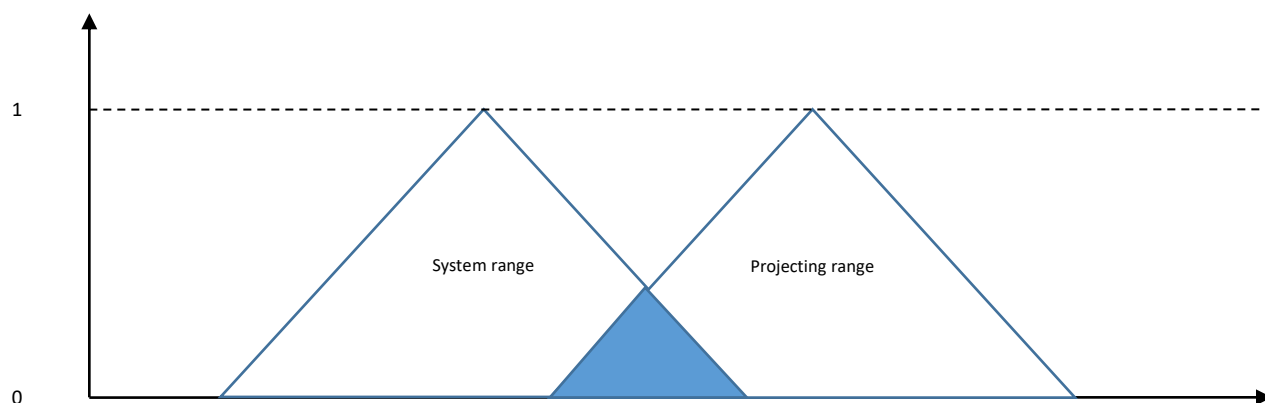


Fig.5. General area of research

Source: developed by the author based on research

Based on the results obtained, the most optimal strategies are determined based on the following equations:

$$I_i^t = \sum_{j=1}^n I_{ij}^t. \quad (2)$$

$$I^* = \min \left\{ \begin{matrix} I_1^t \\ I_2^t \\ \vdots \\ I_m^t \end{matrix} \right\}. \quad (3)$$

Practical application of the model.

The implementation of the model is demonstrated using the example of a commercial bank in Tajikistan. ¹The banking sector was chosen due to its high dynamism and the need for constant adaptation to new technologies. The model was built to determine the optimal digital transformation strategy for the selected commercial bank in order to maximize profits. To determine the weights of the criteria using the above stages. The results are presented in Table 3.

Table 3. Criteria weights

Type of criterion	Weight	Secondary criterion	Internal weight	Weight	Rank
From 1	0.316	From 11	0.358	0.113	5
		From 12	0.387	0.122	3
		From 13	0.255	0,080	9
From 2	0.374	From 21	0.406	0.152	1
		From 22	0.326	0.122	4
		From 23	0.267	0,100	6
From 3		From 31	0.315	0.098	7

¹For confidentiality reasons, the name of the commercial bank is not provided.

	0.310	From ₃₂	0.408	0.126	2
		From ₃₃	0.277	0.086	8

Source: calculated by the author based on research

The results of the table show that the most significant criteria selected after the entire evaluation procedure are C_{21} - analytical skills, C_{32} - cultural modification, C_{12} - digital human resources. Then, based on the obtained results, expert and functional assessments were carried out, the results of which are presented in Table 4. The calculations were carried out as follows: for each alternative and each criterion, the average value of expert assessments was calculated. Then the correspondence between the obtained value and the functional requirement was determined. Based on these data, the information content of each alternative was calculated, presented in Table 5.

Table 4. Evaluation of strategy alternatives

A_i	From ₁₁	From ₁₂	From ₁₃	From ₂₁	From ₂₂	From ₂₃	From ₃₁	C_{32}	C_{33}
A_1	VB	B	M	B	M	G	M	B	VB
A_2	G	M	B	M	B	M	G	M	B
A_3	M	G	M	G	M	G	M	G	M
A_4	G	VG	G	G	VG	G	M	VG	VG
FRs	M	M	VB	B	B	M	VB	VB	B

Source: calculated by the author based on research

Table 5. Ranking of strategy alternatives

C_j		A_1			A_2		
		Area of the system	Total area	I	Area of the system	Total area	I
C_1	From ₁₁	0.500	0.055	3.173	0.500	0.222	1.168
	From ₁₂	0.500	0.500	0.000	0.500	0.500	0.000
	From ₁₃	0.500	0.222	1.168	0.500	0.222	1.168
C_2	From ₂₁	0.500	0.014	5.164	0.500	0.222	1.168
	From ₂₂	0.500	0.347	0.527	0.500	0.222	1.168
	From ₂₃	0.500	0.125	2.000	0.500	0.222	1.168
C_3	From ₃₁	0.500	0.500	0.000	0.500	0.347	0.527
	C_{32}	0.500	0.125	2.000	0.500	0.125	2.000
	C_{33}	0.500	0.000	inf	0.500	0.222	1.168
C_j		A_1			A_2		
		Total area	I	Area of the system	Total area	I	
C_1	From ₁₁	0.500	0.125	2.000	0.500	0.055	3.173
	From ₁₂	0.500	0.222	1.168	0.500	0.014	5.164
	From ₁₃	0.500	0.347	0.527	0.500	0.500	0.000
C_2	From ₂₁	0.500	0.500	0.000	0.500	0.347	0.527
	From ₂₂	0.500	0.222	1.168	0.500	0.125	2.000
	From ₂₃	0.500	0.125	2.000	0.500	0.222	1.168

C ₃	From ₃₁	0.500	0.347	0.527	0.500	0.347	0.527
	C ₃₂	0.500	0.125	2.000	0.500	0.222	1.168
	C ₃₃	0.500	0.347	0.527	0.500	0.222	1.168

Source: calculated by the author based on research

Based on the analysis, in order to achieve maximum efficiency, the commercial bank under study must move to a customer- and staff-oriented strategy. This will require significant changes in the bank's business model, including a review of the product portfolio, optimization of customer service processes, and the development of new digital channels. In addition, it will be necessary to adapt the organizational structure so that it supports new business processes and promotes flexibility and innovation in processes.

In summary, it should be noted that the developed model for assessing digital transformation strategies, based on fuzzy multi-criteria assessment methods, allows for the effective consideration of uncertainty and subjectivity in decision-making. Testing the model using a service enterprise (commercial bank) as an example confirmed its operability. Future research will be aimed at improving the model and expanding its functionality.

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