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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

**MULTI-ATTRIBUTE ECONOMIC GROUP DECISION
MAKING UNDER Z-INFORMATION**

Speciality: 5304.01 – “Types of economic activity”

Field of science: Economic sciences

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The dissertation work was performed at Azerbaijan State Oil and Industry University“ Intelligent Control and Decision-Making Systems in Industry and Economy” scientific research laboratory.


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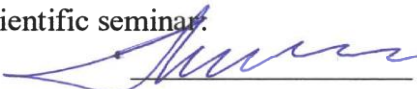
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GENERAL CHARACTERISTICS OF THE RESEARCH

Relevance of the topic and degree of elaboration. The rapid growth of the digital economic environment has led to an increase of information flow accompanied by uncertainty. In this context, exploring multi-criteria group decision-making models in situations where fuzzy information conditions exist has become a necessity. It is crucial to analyze the decision-making process, which is strategic importance and requires consideration of several criteria, such as the selection of Information Technology (hereinafter referred to as IT) specialists, which is a key requirement of the digital economic environment.¹ The scientific basis of such approaches and the practical modeling and solution of the conceptual solution of the problem with Z-information based on fuzzy logic enables decision-making in accordance with the requirements of the digital economic environment and determine the relevance of the dissertation topic. Regardless of the size and field of activity of the enterprise, its effective operation in the digital environment depends primarily on the correct selection of qualified IT specialists who meet the requirements of digital transformation. Therefore, applying multi-criteria decision-making methods with high scientific and practical effectiveness in accordance with the requirements of the information age is of great importance in terms of optimizing and systematically managing the process of selecting IT specialists.

Digital infrastructure, as the foundation of the digital economic environment, transforms traditional production-distribution models, automates the flow of products and services, and enables businesses created in new formats to reach to a wide range of consumers quickly through various platforms in a short period of time.

¹ G.A.Huseynzada, The significance of choosing the best IT engineer in digital enterprises/ Scientific conference of young researchers and doctoral students dedicated to the 99th anniversary of the birth of national leader Heydar Aliyev, Baku, 2022,

At the same time, the digital economic system faces new risks related to cyberattacks, storing and transmitting confidential data. The rise of artificial intelligence and automation in the daily business activities of enterprises is causing significant changes in the global work structure. While eliminating many traditional professions, it is also creating new digital specialties. Ensuring continuous and competitive activity in this complex transformation environment makes the growing demand for highly skilled personnel in the field of information technologies a strategic priority for enterprises.²

Dynamic trends in the labor market require both potential employees and employers acquire new technical-professional and soft skills. Although there are various approaches to recruitment and decision-making methods practices worldwide, a complete solution to the issue has not yet been found due to information uncertainty and incompleteness. The dissertation proposes a new approach to the process of selecting IT specialists by applying the decision-making methodology based on Z information - that is, Z-numbers, which is a novel area of Professor Lotfi Zadeh's fuzzy logic theory. This study highlights the growing demand for information technology personnel in all areas of the digital economy and the importance of applying modern selection methods.

The object and subject of the research. The object of the dissertation is the group decision-making process in a digital economy, and the subject is the study of multi-criteria group decision-making in the selection of information technology specialists by applying the Z-lab tool based on Z information.

The aim and objectives of the dissertation. The dissertation aims to optimize the economic decision-making process in digital enterprises on a scientific basis, striving for an optimal solution by applying the multi-criteria decision-making and rank reversal method with the application of fuzzy Z-numbers and information. The tasks of the dissertation include analyzing the main characteristics of a digital

² C.Blanka, B.Krumay, D.Rueckel, The interplay of digital transformation and employee competency: A design science approach, Technological Forecasting and Social Change, Vol.178,2022, p.1-15

enterprise and its impact on decision-making processes in economic activity.

The selection of an IT specialist is studied using the basic elements of fuzzy logic and Z-lab tools using a group decision-making method.

The main provisions for defense. The dissertation considers the following issues:

Establishment of a digital economic environment in enterprises, selection of criteria required for the selection of specialists with the necessary knowledge in information security, artificial intelligence, decision-making and relevant fields;

- Formation of decision preferences in the form of group consensus in the selection of specialists who can manage digital economic processes in enterprises;

- Formation of adaptive group consensus and preferences in a Z-information environment under conditions of deep uncertainty;

- Development of a rank reversal procedure in group decision-making, unlike classical decision-making methods;

- Verification of the model's sensitivity and robustness in making appropriate decisions within a digital economic environment.

Research methods. The dissertation mentions fuzzy logic, Z-number theory, eigenvector definition, and the Z-lab software package as research methods.

Scientific novelty of the research. The main scientific innovations presented in the dissertation are as follows:

- The formulation of the problem of multi-attribute group decision-making in the digital economic environment in enterprises in the conditions of bimodal information (Z-information);

- The aggregation issue of Z-matrices containing decision preferences in the problem of multi-attribute group decision-making in the Z-information environment has been solved, and the challenge of constructing adaptive economic decision preferences using specific solutions has been solved;

- A new approach free from “rank-reversal” in economic group decision-making under conditions of deep uncertainty has been studied, unlike classical decision-making methods;

The proposed Z-group decision-making approach in selecting appropriate IT specialists in enterprises with a digital economic environment has been analyzed and its effectiveness has been demonstrated.

Theoretical and practical significance of the research. The theoretical significance of the research is related to the development of scientific foundations of multi-criteria group decision-making processes in the digital economic environment. The dissertation focuses on applying modern decision-making methods in economic management, such as the use of the Z-lab package based on operations on Z-numbers, which is a leading area of fuzzy logic, and rank reversal. Existing conceptual theoretical models in this field were analyzed from a scientific point of view and new approaches were considered. As a result, scientific results were obtained that justify the methodology of optimal decision-making in digital enterprises.

The practical significance of the study is related to the development of an application-oriented solution for a specific decision-making problem, such as the selection of an IT specialist in digital enterprises, by modeling it within a multi-criteria and fuzzy environment. The methodology proposed in the work is important because it enhances the increasing efficiency of decision-making in real conditions, systematizing expert opinions, and expanding the possibilities of evaluating alternatives. Additionally, the proposed sensitivity analysis and ranking approaches can be applied as practical tools to improve the quality of decision-making in various fields, and in the areas of human resource management in the digital economy. Above all, the approach proposed in the dissertation aligns more relevant to real life, as it allows taking into account uncertainty in fuzzy information conditions.

Realization of dissertation work results. The scientific findings obtained in the dissertation can be applied to enhance the efficiency of decision-making in the digital economic environment.

Approbation of the dissertation. Degree of reliability and approbation of results. The theoretical and practical results of the dissertation were discussed at the following local and international conferences:

- Scientific conference of young researchers dedicated to the 99th

- anniversary of the birth of national leader Heydar Aliyev, Baku, 2022
- 15th International Conference on Applications of Fuzzy Systems, Soft Computing and Artificial Intelligence Tools – ICAFS-2022, Budva, Montenegro;
 - ATLAS 12th International Congress On Advanced Scientific Studies

and Interdisciplinary Research / July 1-3, 2024 Paris, France

The name of the organization where the dissertation work was performed: The research was carried out at the Azerbaijan State Oil and Industry University, “Intelligent Control and Decision-Making Systems in Industry and Economy” scientific research laboratory.

Published scientific works. As a result of the research conducted, 9 works were published, including: 6 articles without co-authorship, 2 of which were published abroad (included in the SCOPUS database); 3 conference materials, 2 of which were published abroad, 4 articles were published in local journals without co-authorship.

The volume of the dissertation’s structural sections separately and the general volume. The dissertation consists of an introduction (12391 characters), 5 chapters (Chapter I – 66459 characters, Chapter II – 36856 characters, Chapter III – 34579 characters, Chapter IV – 21505 characters, Chapter V – 41323 characters), conclusion (5454 characters), and a list of 126 references. The volume of the dissertation work consists of 158 pages (218,567 characters), excluding tables, graphs, images, and bibliography.

THE MAIN CONTENT OF THE RESEARCH

The introductory part of the dissertation presents information on the importance and extent of the topic's development, the research goals and objectives, research methods, the main points to defend, the scientific novelty of the research, and its theoretical and practical significance.

The first chapter of the dissertation is entitled “The Main Platform of Digital Enterprise in Economic Activity.” The research object of this chapter is to examine the innovations occurring

in the economy in the period after transitioning to the fourth industrial revolution, the impact of the transformation on the digital economic environment and the decision-making process.

The main platform of the digital economy is the hyper-connectivity created by the Internet, mobile communications, blockchain, the Internet of Things (IoT) and data analytics, which creates a new value chain formed by billions of daily online connections between economic entities and processes.³ The digital economy is fundamentally reshaping traditional economic structures, transforming them. Consequently, digitalization is becoming one of the main driving forces of modern economic development.

Along with the positive effects of the transitioning to a digital enterprise, this transformation process is accompanied by a number of serious challenges and obstacles. These challenges include the lack of infrastructure and internal systems that fail meet modern requirements, difficulties in managing change and risks, a shortage of human resources with digital knowledge, cybersecurity risks, financial constraints, as well as insufficient formation of digital mindset and culture within the enterprise.

Digital transformation in Azerbaijan has become a priority issue at the state level, a legislative framework has been formed, and the “Center for Analysis and Coordination of the Fourth Industrial Revolution” has been established.³ The country is developing telecommunications infrastructure and online public services, the ICT sector is expanding, broadband internet coverage is expanding, and the introduction of 5G technology is planned. Through digital systems, more than 400 public services have been converted to online form, cashless payments and electronic document circulation have expanded, and the overall living standards of the population has increased.

The growth of Azerbaijan's digital ecosystem contributes to the economic and social development of the country, enhances its international reputation.

³ <https://www.weforum.org/stories/2024/07/azerbaijan-digital-transformation/>

In 2024, our country ranked among the top in the cybersecurity index within the CIS countries.

Digital transformation involves not just applying technological tools but also developing digital expertise, training talent, and implementing innovations in management. In the modern business environment, hiring requirements have changed, and digital skills have become a prerequisite for the broad majority of positions.

Human resources departments must adapt to current economic conditions and use innovative transformation tools to make better decisions.

The second chapter of the dissertation is entitled "Theoretical tools used in multi-criteria group decision-making in the economic activity of a digital enterprise." This chapter provides a theoretical and practical overview of fuzzy logic and its components in group decision-making in enterprises. The theory of fuzzy logic was introduced by Lotfi Zadeh in 1965 and established the mathematical foundation for fuzzy sets. In fuzzy sets, the degree of membership of each element varies between 0 and 1 and is represented through a membership function. In fuzzy set theory, there are traditional set operations - insertion, union, intersection, completion, and these operations are interpreted in accordance with the characteristics of the fuzzy environment. In fuzzy logic, the membership function is a function that determines the degree to which a given element in a fuzzy set belongs to that set. This function assigns a real number between 0 and 1 to each element: If the membership function is 0, the element is not part of the set. If it is 1, the element is considered to be fully included in the set. If it takes a value between 0 and 1, it indicates partial membership of the element. The membership function is written as follows.

$$\mu_B : [0,1] \rightarrow [0,1] \quad (1)$$

Here $\mu_A(x)$ - x is the degree of membership of an element in the fuzzy set A. This function plays an important role in the analysis of decision-making processes, allowing to model uncertainty and

imprecision in human thinking.⁴

However, fuzziness alone is not sufficient to fully evaluate accuracy, naturally; we often describe them with words like “high”, “approximately”, “very”.

The facts observed in the real world are described with complete information. The reliability of the information must also be considered. Its reliability varies depending on the characteristics of the source. To model both aspects together, Lutfi Zadeh introduced the concept of Z-number. The fuzzy number Z combines two fuzzy numbers, represented as A and B , and is written as $Z = (A, B)$. A is a fuzzy number describing the variable's value, while B is a fuzzy probability measure indicating how reliable A is. This approach enables us to create a mathematical model that reflects reality more accurately by considering fuzzy information about the value itself and its degree of certainty.^{5,6} In this part of the dissertation, key operations such as calculating Z numbers, Z decision making, aggregation, and the calculation of eigenvalues and vectors are performed using a tool called Z-lab.

The Z-lab package was developed by a professional team led by Professor Rafiq Aliyev, the scientific successor of Lutfi Zadeh, based on his theory. Currently, the tool is presented in an improved version and an efficient environment has been created for performing many operations. The user interface is designed to be accessible for researchers across various scientific fields.

Nowadays, decision-making is a fundamental and complex systematic issue in all areas, regardless of the activity type. The key condition for successful management of an enterprise in digital economy demanded and developed by the modern world is the adoption and implementation of correct decisions.

⁴ L.A. Zadeh, Fuzzy sets, Information and Control, V- 8, Issue 3, 1965, p.338-353

⁵ Aliev R.A, The arithmetic of discrete Z-numbers, Information Sciences / A.V. Alizadeh, O.H. Huseynov, -2015, -v.290, -p.134-155

⁶ Aliev,R.A The Arithmetic of Z-Numbers. Theory and Applications / O.H Huseynov, R.R. Aliyev, and A.A. Alizadeh, -2015, -p.24

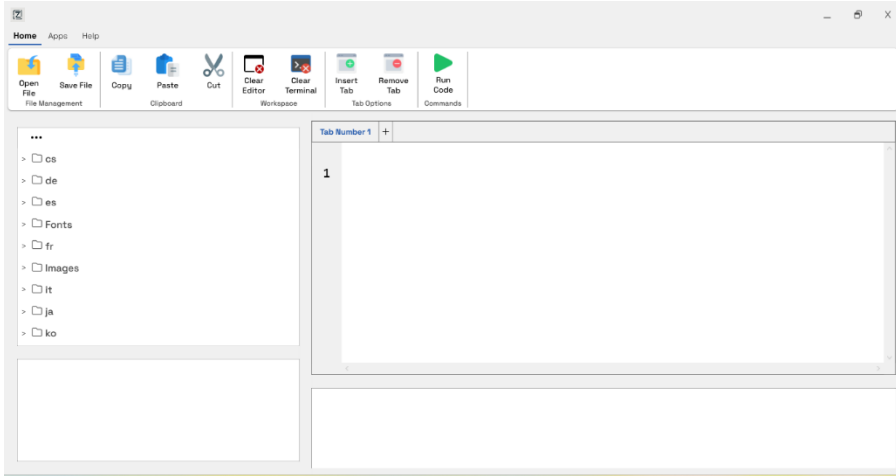


Fig. 1. Z-lab tool interface.

Management decisions include issues such as management, production process, marketing, selection of personnel, investments and expenses, identification of customers and partner enterprises to cooperate with, organizing recurring operations, ways to improve the current workforce and etc. Looking at the existing literature and global practice, we can clearly observe that a number of decision-making methods exist and are applied. These include Delphi, Promete, Topsis, AHP, Vikor and others. Enterprise leaders and managers assess most methods individually and choose based on available options, preferences, and criteria. The main basis of this dissertation is group decision-making. Group decision-making is the process of choosing the best options from alternatives in any field and making general decisions based on the specific knowledge, skills, and experience of a defined group involved in problem-solving. A group consists of individuals working together toward a common goal, interacting and making decisions as a single entity. The number of individuals in a group varies depending on the structure and size of the organization in which they operate.⁷ Advantages of the group decision-making approach applied in solving the problem should be noted.

⁷ Gomathy C.K., Group decision making in an organization / International journal of scientific research in engineering and management, - 2023,- v. 07(05) - p.1-12

This approach is important in terms of a wider exchange of ideas, the formation of innovative approaches and a more complete justification of decisions, unlike individual decision-making. The presence of different ideas and points of view within the group allows for a complex and multifaceted assessment of decisions. Discussions conducted in a group also allow individuals to become more familiar with the decision and approach its implementation more responsibly. In this process, factors such as cooperation, reaching consensus, collective responsibility and consideration of common interests come to the fore. The fact that group members have different knowledge and experience allows for a more objective assessment of alternatives and the selection of optimal solutions.

The group decision-making model allows for a more accurate assessment of the probabilities of the decisions outcomes, which increases the likelihood of successful decision implementation. As a result, more effective and comprehensive solutions are formed different approaches and discussions put forward by group members.

The decision-making process is typically carried out in the following stages: problem identification, formulation of alternatives, selection of the optimal option, implementation of the decision and evaluation of the results. Each of these stages can be carried out in a more systematic and qualitative manner with the active group participation.

The third chapter of the dissertation is entitled "Development of a new methodology for selecting an information technology specialist in a digital enterprise". In the modern era of digital transformation, the need for qualified IT specialists is constantly increasing for enterprises can keep up with technological innovations. The selection of these specialists is of strategic importance not only in terms of technical knowledge, but also for qualities like such as analytical thinking, problem solving and compatibility with teamwork. The research addresses the challenge of selecting a high-quality specialist with the necessary knowledge and skills in the field of Traditional selection criteria, while accurate, may not always capture the real situation. For this reason, the study proposes a new approach based on the concept of Z-information. Z-numbers enable more informed and reliable decisions under uncertain conditions.

A commission consisting of three experts specializing in the relevant field was formed for the dissertation work. The three candidates who successfully passed the interview and gained the right to proceed to the final stage are evaluated by the mentioned experts.⁸ In modern organizations, the selection of an IT specialist is not limited to the assessment of technical knowledge and skills. This selection acts as a strategic decision that ensures the long-term security, functional efficiency and flexible development opportunities of the organization's digital infrastructure. In this regard, the process of selecting an IT specialist is justified by a multi-criteria decision-making approach.

Within the framework of the dissertation, a comprehensive approach was applied to this issue and five main criteria (C1–C5) that should be considered when choosing an IT specialist were identified.

The analytical part of the study was carried out on the basis of these criteria, and a multi-criteria evaluation method was applied to make the optimal decision in choosing a specialist. The selection process was performed on the basis of the following criteria.

1. Knowledge of various operating systems (C1). A specialist working in the field of information technology must have in-depth knowledge of operating systems that operate on various platforms. This includes the most commonly used desktop operating systems such as Windows, macOS, Unix, Linux, as well as mobile operating systems such as Android and iOS. This knowledge ensures that the specialist is agile in addressing inter-system compatibility, fault diagnosis, and security issues.

2. Networking skills (C2). An IT specialist must also have knowledge and skills in the field of proper installation, configuration and constant monitoring of network infrastructure. Key concepts in this field include IP addressing, subnet masks, DHCP and DNS configuration, router and switch management, as well as the design

⁸ Huseynzada, G.A, Decision-Making on IT Engineer Selection // Lecture Notes in Networks and Systems – Switzerland, 2023, Vol. 1, p 258–265

and optimization of network types such as LAN (Local Area Network), WAN (Wide Area Network), WLAN and MAN. Also, managing security and performance issues in modern networks based on Ethernet, Wi-Fi and 5G technologies is the basis of this skill.

3. Cyber Security knowledge (C3). Increasing cyber attacks on a global scale make the security of organizations' digital systems a priority. Therefore, hiring IT specialists with medium or high-level cybersecurity expertise is important. Key skills in this area include working with Firewall and Intrusion Detection/Prevention Systems (IDS/IPS), encryption technologies and protocols (AES, RSA, SSL/TLS, etc.), network analysis tools, and knowledge and practical skills such as preventing dangerous types of cyber attacks such as SQL Injection, XSS, CSRF. Additionally, detecting and analyzing vulnerabilities in operating systems and enterprise software, creating threat models, and preparing cyber incident response plans are also covered by this criterion.

4. Problem diagnosis and solution skills – Troubleshooting (C4). Correctly identifying and quickly eliminating technical failures that may occur in IT systems and equipment is one of the important competencies. The specialist must be able to analyze the problem that arises in the system, identify the source of the problem and determine ways to solve it. Within the scope of this skill, analyzing user reports and technical issues, conducting comparative tests on different versions of the system and software, and performing formal documentation and reporting procedures are the main conditions.

5. Ability to work in a collaborative environment (C5). In addition to advanced technical knowledge, an IT specialist must also have the ability to communicate and collaborate effectively within a team. This skill involves not just to explaining technical terms, but also includes soft skills such as oral and written presentation skills, establishing proper communication with customers and colleagues, active participation in team projects, and adapting to different project requirements. The transition to a digital economy increases the strategic importance of highly qualified IT personnel in enterprises. This selection is not only a decisive factor for filling vacancies, but also for the competitiveness, sustainability and innovation capacity

organization. The Z-information approach improves the quality of decisions made in an uncertain environment by considering both the value and reliability of information. Effective results can be achieved through the Z-Lab package applied for calculation. The multi-criteria, Z-information-based and rank reversal tested selection model allows the enterprise to attract technically mature, analytical and team-compatible IT specialists on a scientific basis. This significantly increases the probability of digital transformation projects success and contributes to the long-term digital sustainability of the organization.⁹

The fourth chapter of the dissertation is entitled "Systematic solution of the problem of choice and decision-making." This chapter develops a methodology designed to convert experts' linguistic (natural language) opinions into a unified assessment in the decision-making process regarding the selection of an IT specialist. The aim of the approach is to generalize the opinion of the expert group, which evaluates the three candidates (A1, A2, A3) remaining for the final selection stage on the basis of five main criteria, based on fuzzy information. Experts evaluate the candidates on the basis of the five main criteria identified. An approach based on pairwise comparison of criteria is applied within the decision-making framework.

The necessity of linguistic evaluation. Opinions and assessments given in natural language are often imprecise. For example, one criterion can be expressed as "very important", another criterion as "partially important". Because such expressions cannot be represented precisely with exact numerical values, fuzzy logic and its extended form, Z-numbers, are a convenient tool for transforming such linguistic assessments into a mathematical model. Fuzzy Z-numbers allow us to consider not only the variable itself, but also the degree to which this value is reliable.

⁹ Sascha Kraus, Susanne Durst, João J. Ferreira, Pedro Veiga, Norbert Kailer, Alexandra Weinmann, Digital transformation in business and management research: An overview of the current status quo, International Journal of Information Management, V-63, 2022, 102466,

This makes the decision-making process more sustainable, especially in conditions of uncertain and incomplete information.

At this stage, the pairwise comparison matrices for for each expert's criteria are summarized and aggregated. The aggregation process aims to eliminate the diversity in expert opinions and obtain a more objective decision. For this purpose, the functional capabilities of the Z-lab software are used. The method is applied in the following stages:

In the initial stage, a pairwise comparison analysis of the matrices presented by the experts is performed. The pairwise comparison matrix expressed in Z-numbers is as follows: ¹⁰:

$$(Z_{ij} = (A_{ij}, B_{ij})) = \begin{pmatrix} Z_{11} = (A_{11}, B_{11}) & \dots & Z_{1n} = (A_{1n}, B_{1n}) \\ \cdot & \dots & \cdot \\ Z_{n1} = (A_{n1}, B_{n1}) & \dots & Z_{nn} = (A_{nn}, B_{nn}) \end{pmatrix} \quad (2)$$

Z-number $Z_{ij} = (A_{ij}, B_{ij})$, $i, j = 1, \dots, n$ describes partially valid information about the degree of superiority of criterion i over criterion j . Below are the comparative indicators of the experts according to the criteria. The dimensions proposed for the criteria by the first expert (E1):

	C ₁	C ₂
C ₁	((1.7, 1.9, 2.0, 2.1), (0.7, 0.8, 0.86, 0.9))	((1.7, 1.9, 2.0, 2.1), (0.7, 0.8, 0.86, 0.9))
C ₂	((0.48, 0.5, 0.53, 0.63), (0.7, 0.8, 0.86, 0.9))	((0.8, 0.9, 0.94, 1.0), (0.75, 0.8, 0.86, 0.9))
C ₃	((0.32, 0.33, 0.34, 0.37), (0.7, 0.8, 0.86, 0.9))	((0.48, 0.5, 0.53, 0.63), (0.7, 0.8, 0.86, 0.9))
C ₄	((0.24, 0.25, 0.26, 0.27), (0.7, 0.8, 0.86, 0.9))	((0.24, 0.25, 0.26, 0.28), (0.7, 0.8, 0.86, 0.9))
C ₅	((0.24, 0.25, 0.26, 0.27), (0.7, 0.8, 0.86, 0.9))	((0.2, 0.2, 0.2, 0.22), (0.7, 0.8, 0.86, 0.9))

¹⁰ R. A. Aliev, B. G. Guirimov, O. H. Huseynov and R. R. Aliyev, A consistency-driven approach to construction of Z-number-valued pairwise comparison matrices, Iranian Journal of Fuzzy Systems Volume 18, Number 4, (2021), pp. 37-49

C_3	C_4	C_5
C_1 ((2.7, 2.9,3, 3.1), (0.7, 0.8, 0.86,0.9))	((3.7, 3.9, 4.0, 4.1), (0.7, 0.8, 0.86, 0.9))	((3.7, 3.9, 4.0, 4.1), (0.7, 0.8, 0.86, 0.9))
C_2 ((1.7, 1.9,2.0, 2.1), (0.7, 0.8, 0.86, 0.9))	((3.6, 3.9, 4.0, 4.1), (0.7, 0.8, 0.86, 0.9))	((4.6, 4.9,5.0, 5.1), (0.7,0.8, 0.86, 0.9))
C_3 ((0.8,0.9, 0.94,1.0), (0.75, 0.8, 0.86,0.9))	((2.8, 2.9, 3, 3.1), (0.7, 0.8, 0.86, 0.9))	((1.7,1.9, 2.0,2.1), (0.7,0.8, 0.86,0.9))
C_4 ((0.32,0.33,0.34,0.38), (0.7,0.8,0.86,0.9))	((0.8, 0.9,0.94,1.0), (0.75, 0.8, 0.86,0.9))	((2.6, 2.9, 3, 3.1), (0.7, 0.8, 0.86, 0.9))
C_5 ((0.48, 0.5,0.53,0.59), (0.7, 0.8,0.86,0.9))	((0.32,0.33,0.34,0.38), (0.7,0.8,0.86,0.9))	((0.8,0.9,0.94,1.0), (0.75,0.8,0.86,0.9))

The dimensions proposed by the second expert (E2) for evaluating the criteria:

C_1	C_2
C_1 ((0.8, 0.9,0.94, 1.0), (0.75, 0.8, 0.86, 0.9))	((1.6, 1.9,2.0, 2.1), (0.6, 0.64, 0.7, 0.8))
C_2 ((0.48, 0.5, 0.53, 0.63), (0.6, 0.64, 0.7, 0.8))	((0.8, 0.9, 0.94, 1.0), (0.75, 0.8, 0.86, 0.9))
C_3 ((0.49, 0.5, 0.53, 0.56), (0.6, 0.7, 0.8, 0.88))	((0.16, 0.18, 0.19), (0.22, 0.6, 0.7, 0.8, 0.88))
C_4 ((0.83, 1.0, 1.11, 1.6), (0.6, 0.7, 0.8, 0.88))	((0.49, 0.5, 0.51, 0.53), (0.6, 0.7, 0.8, 0.88))
C_5 ((0.91, 1.0, 1.06, 1.1), (0.6, 0.7, 0.8, 0.88))	((0.48, 0.5, 0.51, 0.53), (0.6, 0.7,0.8, 0.88))

C_3	C_4	C_5
C_1 ((1.8, 1.9,2.0, 2.05), (0.6, 0.7, 0.8, 0.88))	((0.9, 0.94, 1.0, 1.2), (0.6, 0.7, 0.8, 0.88))	((0.9, 0.94, 1.0, 1.2), (0.6, 0.7, 0.8, 0.88))
C_2 ((4.9, 4.95, 5.0, 5.2), (0.6, 0.7, 0.8, 0.88))	((1.9, 1.95, 2.0, 2.05), (0.6, 0.7, 0.8, 0.88))	((1.9, 1.96, 2.0, 2.08), (0.6, 0.7, 0.8, 0.88))
C_3 ((0.8, 0.9, 0.94, 1.0), (0.75, 0.8, 0.86, 0.9))	((1.86, 1.92, 2.0, 2.4), (0.6, 0.7, 0.8, 0.88))	((1.0, 1.02, 1.06, 1.11), (0.6, 0.7, 0.8, 0.88))
C_4 ((0.42, 0.5, 0.52,0.54), (0.6, 0.7, 0.8, 0.88))	((0.8, 0.9, 0.94, 1.0), (0.75, 0.8, 0.86, 0.9))	((1.0, 1.04, 1.77, 1.9), (0.6, 0.7, 0.8, 0.88))
C_5 ((0.9, 0.94,0.96, 1.0), (0.6, 0.7, 0.8, 0.88))	((0.9, 0.92, 0.96, 1.0), (0.6, 0.7, 0.8, 0.88))	((0.8, 0.9, 0.94, 1.0), (0.75, 0.8, 0.86, 0.9))

The dimensions proposed by the third expert (E3) for evaluating the criteria are:

C_1	C_2
C1 ((0.8, 0.9, 0.94, 1.0), (0.75, 0.8, 0.86, 0.9))	((1.9, 1.94, 2, 2.1), (0.5, 0.52, 0.6, 0.7))
C2 ((0.48, 0.52, 0.53, 1.0), (0.5, 0.52, 0.6, 0.7))	((0.8, 0.9, 0.94, 1.0), (0.75, 0.8, 0.86, 0.9))
C3 ((0.16, 0.17, 0.18, 0.27), (0.5, 0.52, 0.6, 0.7))	((0.24, 0.25, 0.26, 0.3), (0.5, 0.52, 0.6, 0.7))
C4 ((0.24, 0.25, 0.26, 0.29), (0.5, 0.52, 0.6, 0.7))	((0.32, 0.33, 0.34, 0.4), (0.5, 0.52, 0.6, 0.7))
C5 ((1.0, 1.06, 1.11, 1.25), (0.75, 0.8, 0.86, 0.9))	((1.0, 1.09, 1.11, 1.2), (0.75, 0.8, 0.86, 0.9))

C_3	C_4	C_5
C1 ((5.9, 5.94, 6.0, 6.1), (0.5, 0.52, 0.6, 0.7))	((3.8, 3.88, 4.0, 4.1), (0.5, 0.52, 0.6, 0.7))	((0.8, 0.9, 0.94, 1.0), (0.75, 0.8, 0.86, 0.9))
C2 (3.86, 3.9, 4.0, 4.1), (0.5, 0.52, 0.6, 0.7))	((2.9, 2.94, 3.0, 3.1), (0.5, 0.52, 0.6, 0.7))	((0.82, 0.9, 0.92, 1.0), (0.75, 0.8, 0.86, 0.9))
C3 (0.8, 0.9, 0.94, 1.0), (0.75, 0.8, 0.86, 0.9))	((3.9, 3.95, 4.0, 4.1), (0.5, 0.52, 0.6, 0.7))	((0.77, 0.84, 0.96, 1.0), (0.75, 0.8, 0.86, 0.9))
C4 (0.24, 0.25, 0.25, 0.26), (0.5, 0.52, 0.6, 0.7))	((0.8, 0.9, 0.94, 1.0), (0.75, 0.8, 0.86, 0.9))	((5.9, 5.93, 6.0, 6.1), (0.5, 0.52, 0.6, 0.7))
C5 (1.0, 1.04, 1.19, 1.3), (0.75, 0.8, 0.86, 0.9))	((0.16, 0.17, 0.18, 0.2), (0.5, 0.52, 0.6, 0.7))	((0.8, 0.9, 0.94, 1.0), (0.75, 0.8, 0.86, 0.9))

The degree of inconsistency is assessed on the criteria comparison matrices. The inconsistency index not exceeding 0.5 allows us to determine that the assessments have a logical sequence and are reliable. The inconsistency index for a pairwise comparison matrix of Z-values is determined as follows:¹⁰

$$K((Z_{ij})) = \max_{i < j < k} \min \left\{ D \left(Z(1), \left(\frac{Z_{ik}}{Z_{ij}Z_{jk}} \right) \right) D \left(Z(1), \left(\frac{Z_{ij}Z_{jk}}{Z_{ik}} \right) \right) \right\} \quad (3)$$

where the components of the number $Z Z(1)=(A,B)$ are fuzzy $A=1$ and $B=1$. D - indicates the distance between the Z-numbers.

In the process of evaluating the criteria for selecting an IT specialist using the Z-lab tool, the aggregation of pairwise comparison matrices provided by experts is an important stage. Inconsistency analysis not

only enhances the quality of decision-making, but also helps to determine the extent to which expert opinion is systematic and consistent. Consistent matrices provided by experts In the Z-Lab environment, consistent matrices are aggregated by criteria using the numerical average principle:

$$z\text{Matr}=(z\text{Matr1}+z\text{Matr2}+z\text{Matr3}) /3 \quad (4)$$

Based on the values given by 3 experts, we obtain the preference matrices:

C_1	C_2
C1 ((0.95, 0.975, 1.025, 1.05) (0.95, 0.97, 0.98, 1.0))	((1.167, 1.198, 1.259, 1.29) (0.95, 0.97, 0.98, 1.0))
C2 ((0.775, 0.794, 0.835, 0.857) (0.95, 0.97, 0.98, 1.0))	((0.95, 0.975, 1.025, 1.05) (0.95, 0.97, 0.98, 1.0))
C3 ((0.381, 0.39, 0.41, 0.421) (0.95, 0.97, 0.98, 1.0))	((0.468, 0.48, 0.504, 0.517) (0.95, 0.97, 0.98, 1.0))
C4 ((0.341, 0.349, 0.367, 0.377) (0.95, 0.97, 0.98, 1.0))	((0.419, 0.429, 0.451, 0.463) (0.95, 0.97, 0.98, 1.0))
C5 ((0.328, 0.336, 0.353, 0.363) (0.95, 0.97, 0.98, 1.0))	((0.403, 0.413, 0.434, 0.445) (0.95, 0.97, 0.98, 1.0))
C_3	C_4
C ₁ ((2.375,2.437,2.562,2.625) (0.95, 0.97, 0.98, 1.0))	((2.655,2.725,2.865,2.934) (0.95, 0.97, 0.98, 1.0))
C ₂ ((1.933,1.984,2.085,2.136) (0.95, 0.97, 0.98, 1.0))	((2.161,2.218,2.332,2.388) (0.95, 0.97, 0.98, 1.0))
C ₃ ((0.95, 0.975, 1.025,1.05) (0.95, 0.97, 0.98, 1.0))	((1.062,1.09,1.146,1.174) (0.95, 0.97, 0.98, 1.0))
C ₄ ((0.852,0.873,0.917,0.941 (0.95, 0.97, 0.98, 1.0))	((0.95, 0.975, 1.025, 1.05)(0.95,0.97,0.98,1.0)
C ₅ ((0.82, 0.84, 0.883,0.906) (0.95, 0.97, 0.98, 1.0))	((0.917,0.939,0.987,1.013) (0.95, 0.97, 0.98, 1.0))
C_5	
C ₁ ((2.758,2.831,2.976,3.049) (0.95, 0.97, 0.98, 1.0))	
C ₂ ((2.245,2.304,2.422,2.481) (0.95, 0.97, 0.98, 1.0))	
C ₃ ((1.103, 1.132, 1.191,1.22) (0.95, 0.97, 0.98, 1.0))	
C ₄ ((0.987,1.013,1.065, 1.091) (0.95,0.97, 0.98, 1.0))	

$$C_5 ((0.95,0.975,1.025, 4.578) (0.95, 0.97, 0.98, 1.0))$$

To evaluate the importance coefficients of the criteria, its Z-value eigenvector $(Z_x) = (Z_{x_1} = (A_{x_1}, B_{x_1}), \dots, Z_{x_5} = (A_{x_5}, B_{x_5}))^T$, that is (4) the vector satisfying the condition is calculated.^{11,12:}

$$(Z') \cdot (Zx) = Z\lambda \cdot (Zx) \quad (4)$$

Here (Z') is the consistent pairwise comparison matrix, Zx is the eigenvector, and $Z\lambda$ is the eigenvalue. The eigenvector is defined as follows.

$$Z_{x_1} = (((0.0205, 0.0779, 0.1509, 0.6454), (0.0242, 0.0254, 0.0427, 0.0582))$$

$$Z_{x_2} = ((0.0167, 0.0634, 0.1228, 0.5256), (0.1137, 0.1473, 0.1561, 0.2162))$$

$$Z_{x_3} = ((0.0082, 0.0312, 0.0605, 0.2589), (0.064, 0.0894, 0.101, 0.1358))$$

$$Z_{x_4} = ((0.0073, 0.0279, 0.054, 0.2315), (0.1431, 0.153, 0.1711, 0.2274))$$

$$Z_{x_5} = ((0.0071, 0.0268, 0.052, 0.2227), (0.0927, 0.1312, 0.1425, 0.1995))$$

Next, the importance vector of the criteria weights should be determined (in the form of a normalized eigenvector):¹⁰

$$(Z_{w_1} = (A_{w_1}, B_{w_1}), Z_{w_2} = (A_{w_2}, B_{w_2}), Z_{w_3} = (A_{w_3}, B_{w_3}), Z_{w_4} = (A_{w_4}, B_{w_4}), Z_{w_5} = (A_{w_5}, B_{w_5}))^T \quad (5)$$

Accordingly, the weight vectors of the criteria are obtained:

¹¹ R.A.Aliev, B.G. Guirimov, O.H. Huseynov, Rafiq R. Aliyev, Country selection problem for business venturing in Z-information environment Information Sciences: Volume 597: June 2022, Pages 230-243

¹² Y.-M. Wang, and K.-S. Chin, An eigenvector method for generating normalized interval and fuzzy weights, Appl. Math. Comput. 181(2) (2006) 1257–1275 doi: 10.1016/j.amc.2006.02.026.

For this purpose, we use trapezoidal Z-numbers and calculate the weights described.

$$w_{Z1} = ((0.3422, 0.3427, 0.3428, 0.3435), (0.0242, 0.0254, 0.0427, 0.0582))$$

$$w_{Z2} = ((0.2786, 0.279, 0.2791, 0.2797), (0.1137, 0.1473, 0.1561, 0.2162))$$

$$w_{Z3} = ((0.1373, 0.1374, 0.1374, 0.1378), (0.064, 0.0894, 0.101, 0.1358))$$

$$w_{Z4} = ((0.1226, 0.1228, 0.1228, 0.1232), (0.1431, 0.153, 0.1711, 0.2274))$$

$$w_{Z5} = ((0.1181, 0.1181, 0.1181, 0.1185), (0.0927, 0.1312, 0.1425, 0.1995))$$

These weights represent the priorities of the criteria and are passed on to the next decision-making stage - ranking of alternatives.

The next stage involves constructing the decision matrix, the evaluating alternatives. At this time, the decision matrix is constructed using the linguistic variables specified below for sides A and B of the Z-numbers. The linguistic evaluations for side A of the Z-number are listed below:

Linguistic variables	A component
Very Low-VL	(0.9,1,1,1.10)
Low -L	(1.8,2.0,2.0,2.08)
Medium-M	(1.9,2.0,2.0,2.1)
Medium High-MH	(2.90,3.0,3.0,3.10)
High -H	(3.90,4.0,4.0,4.10)
Very High-VH	(4.90,5.0,5.0,5.10)

The linguistic evaluations for the B side of the Z-number are listed below:

Linguistic variables	B component
Not Sure-NS	(0.1,0.2,0.24,0.3)
Neutral-N	(0.3,0.4,0.42,0.5)
Somewhat Sure-SS	(0.5,0.6,0.62,0.7)
Moderately Sure-MS	(0.5,0.6,0.6,0.75)
Fairly Sure-FS	(0.72,0.8,0.8,0.88)
Quite Sure-QS	(0.7,0.8,0.8,0.9)
Very Sure-VS	(0.8,0.9,0.96,1)

The linguistic evaluations of the decision matrix were determined in order to formulate the next step.

Table 1. Linguistic evaluations of the decision matrix.

	C_1	C_2	C_3	C_4	C_5
A_1	(M,SS)	(VH,QS)	(VH,QS)	(VL,FS)	(M,MS)
A_2	(MH,SS)	(H,QS)	(H,QS)	(VH,FS)	(L,MS)
A_3	(M,SS)	(H,QS)	(H,QS)	(VL,FS)	(VL,MS)

Table 2. Decision matrix.

	C_1	C_2	C_3
A_1	(1.9,2.00,2.00, 2.1),(0.5,0.6, 0.62,0.7)	(4.9,5.00,5.00, 5.1), (0.7, 0.8, 0.8, 0.9)	(4.9,5.00,5.00, 5.1),(0.7, 0.8, 0.8, 0.9)
A_2	(2.9,3.00,3.00, 3.1),(0.5,0.6, 0.62,0.7)	(3.9,4.00,4.00, 4.1), (0.7, 0.8, 0.8, 0.9)	(3.9,4.00,4.00, 4.1), (0.7, 0.8, 0.8, 0.9)
A_3	(1.9,2.00,2.00, 2.1),(0.5,0.6, 0.62, 0.7)	(3.9,4.00,4.00, 4.1),(0.7,0.8, 0.8, 0.9)	(3.9,4.00,4.00, 4.1),(0.7,0.8, 0.8, 0.9)

The decision matrix is normalized:

Table 3. Normalized decision matrix.

	C_1	C_2	C_3
A_1	((0.0,0.1429, 0.2857,0.4286), (0.9,1.0,1.0,1.0))	((0.0,0.1429, 0.2857,0.4286), (0.9,1.0,1.0,1.0))	((0.0,0.1429, 0.2857,0.4286), (0.9,1.0,1.0, 1.0))
A_2	((0.2857,0.4286, 0.5714,0.7143), (0.9,1.0,1.0,1.0))	((0.2857,0.4286, 0.5714, 0.7143), (0.9,1.0,1.0,1.0))	((0.2857, 0.4286, 0.5714, 0.7143),(0.9,1.0, 1.0, 1.0))
A_3	((0.5714,0.7143, 0.8571, 1.0), (0.9, 1.0, 1.0, 1.0))	((0.5714,0.7143, 0.8571,1.0), (0.9,1.0,1.0,1.0))	((0.5714,0.7143, 0.8571, 1.0), (0.9,1.0,1.0,1.0))

	C ₄	C ₅
A1	((0.0,0.1429,0.2857, 0.4286), (0.9, 1.0, 1.0, 1.0))	((0.0,0.1429, 0.2857, 0.4286), (0.9, 1.0, 1.0, 1.0))
A2	((0.2857, 0.4286, 0.5714,0.7143), (0.9,1.0, 1.0, 1.0))	((0.2857,0.4286, 0.5714, 0.7143),(0.9, 1.0, 1.0, 1.0))
A3	((0.5714,0.7143, 0.8571, 1.0),(0.9, 1.0, 1.0, 1.0))	((0.5714,0.7143, 0.8571,1.0), (0.9, 1.0, 1.0, 1.0))

To rank alternatives, a positive ideal solution must be found and the distances of each alternative from that ideal solution must be calculated. The distance between two Z-numbers is calculated using the following formula.¹¹

$$D(a_i, a^*) = \sqrt{\sum_{j=1}^4 D^2(Z_{ij}, Z^*)} \quad (6)$$

The distance from the alternatives to the ideal solution is calculated through the calculation. The candidate with the lowest distance is considered the candidate closest to the ideal. The calculation shows that the third alternative is the optimal candidate. The validity of the obtained result is examined in Chapter 5 through rank reversal and sensitivity analysis.

Table 4. The obtained distance indicators.

Alternative	Distance ($D(a_i, a^*)$)
A_1	2.07
A_2	2.35
A_3	1.33

Then, the distances are ranked. The shortest distance to the ideal solution is shown as the result of the third alternative. The ranking is recorded as follows.

$$A_3 \succ A_1 \succ A_2$$

The fifth chapter of the dissertation is entitled "Analysis of the effectiveness of the choice model in decision-making." In this part

of the dissertation, the rank reversal method was applied. Its essence is to add or remove a new alternative to the existing alternatives or to apply new information to existing alternatives in order to check the decision's optimality. Although the issue of rank reversal in economic decision-making has been developed and studied in a number of scientific research works with crisp numbers, fuzzy numbers and sets, the application of the current method through Z- numbers remains minority in the literature. In the dissertation, the method mentioned above was studied using the concept of Z-number for the selection of an IT specialist. In accordance with the requirements of the rank reversal method, the optimality of the decision was carried out by adding a new alternative (A4) and re- evaluating. The decision matrix for the criteria of the alternatives is shown below.

Table 5. Decision matrix with new alternative added.

	C ₁	C ₂
A ₁	((1.90,2.00, 2.00, 2.10), (0.50,0.60,0.62, 0.70))	((4.90,5.00,5.00,5.10), (0.70,0.80,0.80,0.90))
A ₂	((1.90,2.00,2.00,2.10), (0.50,0.60,0.62,0.70))	((3.90,4.00,4.00,4.10), (0.70,0.80,0.80,0.90))
A ₃	((2.90,3.00,3.00,3.10), (0.50,0.60,0.62,0.70))	((3.90,4.00,4.00,4.10), (0.70,0.80,0.80,0.90))
A ₄	((2.00,2.30,2.50,3.00), (0.50,0.60,0.62,0.70))	((3.00,3.40,3.40,4.00), (0.70,0.80,0.80,0.90))

	C ₃	C ₄
A1	((4.90,5.00,5.00,5.10), (0.70,0.80,0.80,0.90))	((0.90,1,1,1.10), (0.72,0.80,0.80,0.88))
A2	((3.90,4.00,4.00,4.10), (0.70,0.80,0.80,0.90))	((0.90,1,1,1.10), (0.72,0.80,0.80,0.88))
A3	((3.90,4.00,4.00,4.10), (0.70,0.80,0.80,0.90))	((4.90,5,5,5.10), (0.72,0.80,0.80,0.88))
A4	((3.20,3.40,3.50,4.00), (0.70,0.80,0.80,0.90))	((2.00,2.50,3.00,3.10), (0.72,0.80,0.80,0.88))

	C ₅
A1	((1.90,2,2,2.10), (0.50,0.60,0.60,0.75))
A2	((0.90,1.00,1.00,1.10), (0.50,0.60,0.60,0.75))
A3	((1.80,2,2,2.08), (0.50,0.60,0.60,0.75))
A4	((1.00,1.20,1.20,2.00), (0.50,0.60,0.60,0.750))

The calculated values of the alternatives are as follows:

$$v_1 = ((0.21, 0.24, 0.26, 0.26), (0.3407, 0.4889, 0.5037, 0.6963))$$

$$v_2 = ((0.18, 0.22, 0.29, 0.32), (0.2963, 0.4889, 0.4889, 0.8))$$

$$v_3 = ((0.42, 0.52, 0.68, 0.75), (0.2667, 0.4, 0.4, 0.6222))$$

$$v_4 = ((0.33, 0.4, 0.58, 0.67), (0.4444, 0.5481, 0.5481, 0.7704))$$

Since the location of the ideal solution does not change even when a new alternative, A4, is added, it is confirmed that the method used is free from rank reversal.

$$A_3 > A_4 > A_1 > A_2$$

Based on the method based on Z-information, the manager can apply the initial choice without changing it, even if additional candidates for the vacancy appear; this creates efficiency and maintains strategy stability in the selection process. The Z-number approach models the uncertainty in criterion-intervals and linguistic values close to the real environment. As a result of the rank reversal analysis, the ranking of alternatives is preserved even if a new alternative is added, which scientifically proves that the decision made is the optimal choice.

In this part of the dissertation, sensitivity analysis was applied to evaluate the robustness and reliability of the results obtained at the end of the research. Sensitivity analysis consists of implementing the reports made by making partial changes to the data and conducting a comparative analysis of the obtained scientific results. In this direction, several iterations were carried out in the following sequence:

Iteration 1. We replace the initial values of the B components of A₁ with the linguistic value QS.

Table 6. Result of the 1st iteration.

Alternative	Distance ($D(a_i, a^*)$)
A_1	1.89
A_2	2.43
A_3	1.23

Iteration 2. We replace the initial values of the B components of A_2 with the linguistic value of QA.

Table 7. Result of the 2nd iteration.

Alternative	Distance ($D(a_i, a^*)$)
A_1	2.18
A_2	2.28
A_3	1.24

Based on several experiments, it was confirmed that the problem was free from rank reversal and the relationship $A_3 > A_1 > A_2$ remained unchanged, and at the same time, the third alternative (A_3) selected did not change in the results despite partial changes in the weights based on six iterations, which confirmed that the candidate was the optimal choice for the vacancy. The chosen alternative is the optimal decision in accordance with the objectives of the study. The fact that the alternatives maintained their superiority in each iteration as a result of changing the weights in different scenarios and repeating the relevant operations confirmed the stability and reliability of the decision. This outcome confirms that the study is based on a decision-making model that is based on scientific foundations and can be applied in practice.

The main drawback of traditional economic decision-making methods is the phenomenon of rank reversal. This problem leads to a breakdown of the decision process when new scenarios are added or removed. In the study, a multi-criteria group decision-making method

free of rank reversal was developed and analyzed in both ordinary and Z-information environments.

The proposed scientific results were applied to the analysis of human resources in a digital environment, and the sensitivity, stability, and robustness of the proposed group decision-making models were assessed.

MAIN SCIENTIFIC RESULTS OF THE WORK

1. Given the high demand for forecasting, managing economic processes, and creating new types of technical, scientific, and personnel resources in the digital economic environment, the criteria for personnel selection processes were analyzed and selected in the considered work;
2. Since the digital economic environment is characterized by deep uncertainties, especially probabilistic and fuzzy uncertainties, the problem of group decision-making in bimodal information conditions for the analysis of new decisions was formulated, and Z-matrix forms of decision preferences were created. This enables for the formation of more accurate, adaptive decision preferences using appropriate mathematical methods;
3. The main drawback of classical economic decision-making methods is the presence of the phenomenon of rank reversal. This means that if new scenarios are added or removed from the set of considered scenarios in the management or forecasting of economic processes, the entire decision-making process is disrupted. In this scientific work, a method free from rank reversal was developed and analyzed in group decision-making not only in the usual environment, but also in the Z-information environment;
4. In order to streamline decision-making, which is the core of the analysis of economic processes, and in particular, group decision-making processes, the scientific results proposed and obtained in this scientific work were applied to the analysis of human resources in a digital environment.

The outcomes obtained showed the usefulness of the sensitivity,

stability and effectiveness of the proposed group decision-making models.

The main content of the dissertation has been published in the following works:

1. Gunay Huseynzade, Issues of determining uncertainty in economic decisions // Institute of Economics, Ministry of Science and Education of the Republic of Azerbaijan, "Economic Growth and Social Welfare" scientific journal, №3, 2022, p 170-175

2. G.A.Huseynzada, the significance of choosing the best IT engineer in digital enterprises // Scientific conference of young researchers and doctoral students dedicated to the 99th anniversary of the birth of national leader Heydar Aliyev, Baku, 2022,

3. Gunay A. Huseynzada, Z-Decision Making for the Selection of IT Engineers // Lecture Notes in Networks and Systems – Switzerland, 2023, p 226–233

4. Huseynzada, G.A, Decision-Making on IT Engineer Selection // Lecture Notes in Networks and Systems – Switzerland, 2024, Vol. 1, p 258–265

5. Gunay Huseynzada, Application of Z-numbers in decision making methods // NEWS magazine of Azerbaijan Higher Technical Schools, 2024 , p 45-50

6. Gunay Huseynzada Arzu, Employee selection under Z information // ATLAS 12th International Congress On Advanced Scientific Studies And Interdisciplinary Research / July 1-3, 2024 Paris, France, p- 77

7. Gunay Huseynzade, Sensitivity analysis in economic decision making // Institute of Economics, Ministry of Science and Education of the Republic of Azerbaijan, "Economic Growth and Social Welfare" scientific journal, 2024 №3, p 156-160

8. Gunay Huseynzada Arzu, The significance of choosing the best IT engineer for your business // ATLAS 12th International Congress On Advanced Scientific Studies And Interdisciplinary Research / July 1-3, 2024 Paris, France, p- 78

9. Gunay Huseynzada, Rank reversal in economic decision making // NEWS magazine of Azerbaijan Higher Technical Schools, 2024,p.85-90

A handwritten signature in black ink, appearing to read "Sheef G". The signature is written in a cursive, flowing style with a large initial 'S' and a distinct 'G' at the end.

The defense will be held *on “28” october 2025* at BFD 4.26 Dissertation council of Supreme Attestation Commission under the President of the Republic of Azerbaijan operating at Azerbaijan State Oil and Industry University.

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