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ABSTRACT
Of the dissertation for the degree of Doctor of Philosophy

IMPROVING THE EFFICIENCY OF BUSINESS PROCESSES BASED ON FUZZY DECISION-MAKING METHODS

Specialty: 5304.01 - "Types of Economic Activities"

Field of science: Economy

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GENERAL CHARACTERISTICS OF RESEARCH WORK

The actuality of the topic. In the modern economy, efficiency criterion is evaluated differently in various economic systems. Increasing efficiency of business processes leads to the growth of the country's economy and the welfare of the population. Increasing of the efficiency of business processes is caused by the influence of factors occurring at both the micro and macroeconomic levels. In order to increase efficiency, firstly the problem areas should be identified. In imprecise information environment, it is necessary to analyze various fuzzy decision-making methods for the development of efficiency in various fields of business. The improvement of efficiency of business processes includes the analysis of the company's work, the strengthening of integration between departments, the analysis of micro and macroeconomic processes. The main goal of every company is not only to maximize revenue, but also to increase profit by reducing cost for improving business efficiency. Factors that directly affect the company's profit are the basis of increasing the efficiency of business processes. In addition to profit growth and cost reduction, the process of improving business efficiency includes the development of human resources, improvement of working conditions, customer satisfaction and utilization of company resources, reduction of negativity and restoration of company image. Business process management is a science that provides development opportunities and existing experience by overseeing the performance of functional work in organizations. Organizations need to be constantly evolving in order to remain competitive. Analyzing business processes, making effective and productive decisions is a process within the responsibility of management. Business processes improvement allows organizations gradually and continuously improve all operations. Improving business processes efficiency and implementing it is a complex issue. Because this process requires the implementation of various business functions. The successful approach to achieving the goal of improving business processes is to

develop quality improvement projects.

There are different approaches in the field of improving efficiency of business processes for different areas in the existing international scientific literature[1,2].However, there is a lack of in-depth research on the application of fuzzy logic. The actuality of the topic is related to the need to create decision-making methods in the existing business environment based on the linguistic knowledge of experts, using decision-making methods based on fuzzy logic in improving efficiency of business processes. In addition, the research topic focuses on marketing activities in business environment, the human resource selection process and the process of making the right decisions in a fuzzy information environment in the investing processes.

Thus, in modern conditions, the issue of creating decision-making methods based on fuzzy logic to improve the performance of companies in the business environment is one of the current economic problems and this gave rise to the choice of research topic.

The study of fuzzy decision-making methods to improve business processes during the development of the business environment is one of the unexplored areas. Particularly, a new direction for the study is development and application of fuzzy decision-making methods for the aim of analysis of consumer behavior in marketing activities, human resource-related tasks selection and the selection of alternatives in investment.

The purpose of the dissertation is to study the methods of fuzzy decision-making for improvement of efficiency of business processes.

Key research issues. The following issues were considered in the dissertation:

- Investigation of the decision-making process in the fields of

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[1]Alshaibi, A. K., Kahraman, G.D. and Qasim, A.I. Analytic Hierarchy Process (AHP) as criteria in business decision making and their implementation in practice // International Journal of Management and Business Studies, - February, 2016 Vol. 6 (2), -p. 209-220.*

[2]Hudson, I., Reinerman, J.-L., Teo, G.: A review of personnel selection approaches for the skill of decision making Augmented Cognition // Enhancing Cognition and Behavior in Complex Human Environments, -2017, -p. 474–485.

management and marketing;
- Research of conceptual model of consumer behavior and it's application in fuzzy information environment;
- Analysis of the process of determining the best alternatives in the current market conditions, using various decision-making methods based on a fuzzy model of consumer behavior;
- Research on the self-confidence preference model and analysis of consistency of preferences in the selection of personnel which is the main point in business processes;
- Determining the importance of investing in the business environment and using the AHP method to determine the appropriate investment site;
- Investigation of the decision-making process based on combined states;
- Analysis of the sensitivity of the proposed models in the study;
- Comparative analysis of various decision-making methods used in the research;

Research methods. AHP method, TOPSIS method, reasoning with fuzzy IF-THEN rules, linear programming methods were used as research methods in the dissertation, the interval calculations-based method of combined states were applied, eigenvectors and eigenvalues were calculated. Computer simulations were performed in MATLAB, Excel and SPSS environments. The accuracy and effectiveness of the obtained results were confirmed.

Novelty of the research results. The main scientific novelty of the results obtained in the dissertation includes:
- Estimation of Benchmarking Influence in Buyer's Decision Making Process by Using Fuzzy AHP;
- Assessment of consumer Behavior in digital marketing in a fuzzy information Environment;
- A conceptual model of consumer behavior in an uncertain environment has been built;
- The knowledge on preference of consumer in choosing a product under fuzzy information was analyzed;
- Investigation of criteria has been held for choosing marketing channel based on fuzzy matrix;

- The process of self-confidence preference modeling in the selection of internal staff of the enterprise was considered;
- The application of combined state concept in investment problem under interval information has been considered.
- Contrary to classical methods to the classical decision-making methods, the interval-valued joint probabilities of economic situations and the attitude of the decision-maker to risk were used (in application of the combined state concept);
- In the research, the AHP method was applied under uncertainty, and the accuracy of the results were analyzed. Using existing theorem in the literature, the problems of attaining consistency of fuzzy matrix in AHP were solved by dividing matrix into crisp matrices;

Theoretical and practical significance of the work. Research has been conducted on the analysis of efficiency of business processes improvement in uncertain conditions. The conceptual model of the brand product selection process was created and applied to consumer behavior in an ambiguous environment, a fuzzy preference model of consumer was studied here. These processes will have a significant positive impact on the implementation of marketing management decisions. Self-confidence-based preference and consistency of preference model in the selection of personnel which plays an important role in business processes were studied. An investment problem was solved by using the combined states and the multi-criteria AHP decision-making method based on the economic situation and the risk-taker's attitude in uncertain conditions. The analysis of quality of fuzzy models used in the research proves the accuracy of the applied approach. The approach proposed in the study is also relevant to the real environment, as it allows in the fuzzy information environment.

Realization of dissertation work results. The scientific results obtained in the dissertation can be applied to the works in the field of business improvement.

Approbation of the dissertation. Degree of reliability and approbation of results.

Theoretical and practical results of the dissertation were discussed at the following local and international conferences:

- ***ICAFS-2018***- 13th İnternational Conference on Theory and Application of Fuzzy Systems and Soft Computing, Computing, Warsaw, Poland;
- ***WCIS-2018***- 10th World Conference on Intelligent Systems for Industrial Automation, Tashkent, Uzbekistan;
- ***ICSCCW-2019***- 10th International Conference on Theory and Application of Soft Computing, Computing with Word and Perceptions, Prague, Czech Republic;
- ***ICSCCW-2021***- Soft Computing, Computing with Words and Perceptions and Artificial Intelligence;
- ***ICAFS-2022***- Soft Computing and Artificial Intelligence Tools;
- Materials of the scientific conference of young researchers and doctoral students dedicated to the 100th anniversary of the Azerbaijan State University of Oil and Industry (ASOIU) 7-8 May 2020.

Published scientific works. As a result of the research, 12 works were published, including: 9 articles, 7 of them without co-authors, 4 were published abroad; 3 conference proceedings, 2 of them without co-authors and 2 of them were published abroad (Web of Science, including Conference Proceeding bases).

The structure of the dissertation. The dissertation consists of an introduction (15801 characters), 4 chapters (Chapter I - 18792 characters, Chapter II –91639 characters, Chapter III - 28477 characters, Chapter IV –43156 characters), conclusion (4573 characters), and list of 106 references. The total volume of the work is 158 pages (202438 characters), covering 69 tables, 4 diagrams, 8 figures.

BASIC CONTENT OF THE RESEARCH

The introduction substantiates the relevance of the business processes studied, briefly states the main goals and issues that need to be addressed, and provides information on scientific novelty part of the dissertation provides information on the relevance and degree of

development of the topic, research goals and objectives, research methods, the main provisions of the defense, the scientific novelty, the theoretical and practical significance of the research.

The first chapter of the dissertation is called **"Scientific overview of the process of improving the quality of business processes"**. It consists of an overview of the decision-making methods used in management and marketing. The formal statement of the research problem has also been defined. The research object of the first chapter is to study the decision-making process in management and marketing fields in fuzzy information environment.

The process of business development involves the preparation and implementation of various types of decisions. Decisions in each area are made and implemented by professionals. Decision-making is an important part of the management function implemented through the exchange of information in contemporary business environment. There is a need for the decision-making process at all stages of management and the main function of managers is to find a solution to the problems that increase during the decision-making process.

In recent decades, classical decision making has played a key role in the strategic management system. In a strategic management system, decision-making models are conceptualized in terms of the 'dominant conceptual' framework in which decision-makers operate. Theoretical basics and application practice of methods and principles used to increase the activity of the enterprise, the efficiency of production and regularly manage an enterprise development process are the basis of management science. Main function of management decision-making process in enterprise is investigation of the internal and external environment. One of the main functions of management is to study changes in economic, scientific, technical, social, political and fields, which take place in the external environment and to develop a sustainable development strategy to adapt the enterprise to this process. In the management field, decision-making approach covers the following steps:

1. Statement of problem
2. Identifying alternatives
3. Identifying criteria

4. Evaluation of alternatives by criteria
5. Choosing an optimal alternative
6. Implementation of the decision
7. Analysis of results.

Marketing is one of the main areas of entrepreneurship and is part of the decision-making process in business environment. In making a decision, marketers analyze the macro (the macro environment includes economic, technical, social, political processes within the country's economy) and micro (the micro-environment consist of the forces which are close to the company and influence its ability to serve its customers) economic environment.

When marketing is studied as a science, it turns out that it consists of five important concepts:

1. The concept of improving the products and services;
2. The concept of improving the production process;
3. The concept of development of sales processes;
4. Socio-ethical marketing concept;
5. The concept of development of market relations;

In this dissertation, it is discussed the importance of decision-making based on fuzzy information as compared to classical decision-making methods in terms of efficiency of business processes improvement.

The improvement of efficiency of business processes is managed by the decision-maker on the basis of linguistic evaluation. The scientific review shows that decision-making in fuzzy environment in the field of marketing and management is in its infancy in contrast to the classical decision-making processes, there is a great need for the development of a fuzzy approach and the acquisition of new scientific results.

The second chapter of the dissertation is called "Research of fuzzy decision-making methods for the analysis of the process of increasing the efficiency of market activity".

This chapter examines fuzzy decision-making models in marketing activities. One of the most important areas of marketing - factors influencing consumer behavior have been studied. The research

object of the second chapter is the study of decision maker's knowledge preference in consumer behavior and analyzing marketing channel in fuzzy information environment.

In most cases benchmarking approaches give the contrast between financial and operating metrics to those of the industry leader. Analyzing marketplace financial and organizational situations may not be sustainable. The aim of this paper is to define benchmarking influence in buyer's decision-making process by using fuzzy AHP. Benchmarking would provide which businesses are constantly refining and advancing their standards to satisfy the demands of advanced and competitive consumers. Benchmarking is the process which does not provide a stable path and strategies for learning from consumers when initiating value-added suggestions that meet their expectations. The potential customer's buying process is characterized with their purchasing intention. Different variables, particulars and features form an individual's identity as the customer's decision-making process, purchasing intention, shopping experience and other items influence the benchmarking process.

Consumer behavior is impacted by different types of factors and they are classified as 5 major factors which influence consumer behavior.

1. Psychological factors are a major variable of consumer behavior, and these factors are difficult to identify and at the same time have powerful influence on buying behavior;
2. Social factors, individuals are initiated by other humans and want to accept in social environment. Social factors give the shape to humans because they are social beings;
3. Cultural factors influencing consumer behavior are formed on the basis of social classes, subcultures and the behavior of a particular society;
4. Personal factors are special items, situations which influence consumer buying behavior;
5. Economic factors, the consumer purchasing intention and decisions mostly depend on the business cycle of the economy and influence on market processes.

The factors influencing consumer buying behavior are analyzed as criteria which play main role in benchmarking process. Using fuzzy

AHP process we should obtain the best alternative in decision making process. In fuzzy AHP process the pair-wise comparison matrix of both criteria and alternatives are exhibited by linguistics factors that are represented by triangular fuzzy numbers.

MCDM problem involves 5 criteria C_1, C_2, C_3, C_4, C_5 and 5 alternatives A_1, A_2, A_3, A_4, A_5. C_1- Psychological Factors; C_2- Social Factors; C_3- Cultural factors; C_4- Personal Factors; C_5- Economic Factors. The matrix is developed for comparison and consider if is the importance of sub-criteria revenue over safety will be as shown in table 1.

Table 1 cause to know comparison of all judgments under efficiency into triangular fuzzy numbers and final process to calculate consistency ratio of this shown matrix.

Table 1.

Fuzzy matrix of criteria

C	C1	C2	C3	C4	C5
C1	(1,1,1)	(1/3,1/2,1/1)	(1/0.4,1/0.3,1/0.2)	(1,1,1)	(1/4,1/3,1/2)
C2	(1,2,3)	(1,1,1)	(0.55,0.56,0.57)	(1,2,3)	(0.5,0.6,0.7)
C3	(0.2,0.3,0.4)	(0.1,0.2,0.3)	(1,1,1)	(1,2,3)	(0.2,0.3,0.4)
C4	(1,1,1)	(1/3,1/2,1/1)	(1/3,1/2,1/1)	(1,1,1)	(1/1,1/0.9,1/0.8)
C5	(2,3,4)	(1/0.7,1/0.6,1/0.5)	(1/0.4,1/0.3,1/0.2)	(0.8,0.9,1)	(1,1,1)

Eigenvalues of $\overline{C_l}$, $\overline{C_m}$, $\overline{C_u}$ and are obtained with MATLAB software program: $\overline{\lambda_l}$ = 14.57; $\overline{\lambda_m}$ = 33.08; $\overline{\lambda_u}$ = 20.18.

$\lambda_l, \lambda_m, \lambda_u$ are founded as by using following process:

$$\begin{cases} \overline{\lambda_l} = 2\lambda_l + \lambda_m \\ \overline{\lambda_m} = \lambda_l + 4\lambda_m \\ \overline{\lambda_u} = \lambda_m + 2\lambda_u \end{cases} \Leftrightarrow \begin{cases} 14.57 = 2\lambda_l + \lambda_m \\ 33.08 = \lambda_l + 4\lambda_m + \lambda_u \\ 20.18 = \lambda_m + 2\lambda_u \end{cases} \Leftrightarrow \times(-2) \Leftrightarrow \begin{cases} -66.16 = -2\lambda_l - 8\lambda_m - 2\lambda_u \\ 20.18 = \lambda_m + 2\lambda_u \end{cases}$$

$$\Leftrightarrow \begin{cases} -45.98 = -2\lambda_l - 7\lambda_m \\ 14.57 = 2\lambda_l + \lambda_m \end{cases} \Leftrightarrow \lambda_l = 4.68,\ \lambda_m = 5.2,\ \lambda_u = 7.49.$$

Eigenvectors of, $\overline{C_l}$, $\overline{C_m}$ and $\overline{C_u}$ are obtained with MATLAB software program:

$\overline{w_l} = \frac{w_l \lambda_l}{s_l \lambda_m}, \overline{w_m} = \frac{w_m}{s_m}, \overline{w_u} = \frac{w_u \lambda_u}{s_u \lambda_m}$; *where* $s_l = \sum_{i=1}^{n} w_{i,l}$, $s_m = \sum_{i=1}^{n} w_{i,m}$, $s_u = \sum_{i=1}^{n} w_{i,u}$.

$w_l = [0.37, 0.41, 0.23, 0.46, 0.65] \quad S_l = 2.13$

$w_m = [-0.37, -0.44, -0.24, -0.34, -0.71] \quad S_m = -2.09$

$w_u = [-0.36, -0.42, -0.24, -0.31, -0.74] \quad S_u = -2.06$

for example, $w_{l1} = \frac{0.37 * 4.68}{2.13 * 5.2} = 0.06$

$\overline{w_l} = [0.16, 0.17, 0.1, 0.19, 0.28]$, $\overline{w_m} = [0.18, 0.21, 0.12, 0.16, 0.34]$, $\overline{w_u} = [0.25, 0.29, 0.16, 0.22, 0.52]$

In accordance to consistency index and consistency ratio for $\tilde{C}$ matrix are obtained by using following formulas :

$$CI = \frac{5.2 - 5}{5 - 1} = 0.05,\ CR = \frac{0.05}{1.12} = 0.045,\quad CR = 0.045 \le 0.10$$

Table 2.

Vectors of global priorities expected values and standard deviations.

Alternative	Vector g_l	Vector g_m	Vector g_u	Exp.val.$g_{i,e}$	Stand.dev. (%)
A_1	0.16	0.21	0.39	0.98	0.040
A_2	0.15	0.21	0.37	0.94	0.036
A_3	0.10	0.20	0.28	0.77	0.028
A_4	0.13	0.16	0.30	0.75	0.030
A_5	0.22	0.29	0.53	1.33	0.053

$$CV_i = \frac{\sigma_i}{g_{i,e}} \quad i = 1, 2, ...m \quad CV_3 = \frac{0.028}{0.77} = 0.036$$

A3, the alternative with smaller coefficient of variation CV is ranked better and as the best product which influenced on different factors and the suitable after benchmarking for buying process.

This chapter also examines conceptual model has been established based on the factors which influence consumer

behavior. The problem of comparing the criteria for the process of selecting the appropriate marketing channel based on the comparison of criteria in the transportation of consumer products through the AHP method was considered.

Given the errors in obtaining economic data used to optimize the production process, determination of production volumes, determination of which products should be consumed according to market conditions and consumer tastes, we can see how important it is to use fuzzy calculation methods. The set of statistics used for the marketing planning and forecasting process does not fully reflect the current situation. Considering the given situation, it is necessary to use fuzzy numbers for modelling marketing operations.

In this section firstly the conceptual model of consumer behavior is established and the variables affecting it are examined. Conceptual modeling includes five activities:

- Understanding the problem,
- Modeling and defining overall project objectives,
- Determining the probable outcomes of the model,
- Determination of model inputs,
- Identify the content of the model, any assumptions and simplifications,

Although the factors influencing consumer behavior are described by several statistical methods, fuzzy methods are used because those methods do not explain the uncertain, risky situation. According to existing scientific research, the relationship between input and output variables can be explained by using statistical methods. Marketing and general management relationships can be characterized through fuzzy set theory.

In this chapter fuzzy model of consumer behavior is also analyzed. As we know, in contrast to the classical decision-making methods, the advantage of fuzzy decision-making methods is that they focus on the decision-making process based on a fuzzy information environment. This chapter analyzes consumer behavior when choosing a branded product in a fuzzy information environment. It also examines those factors that affect consumer

purchasing behavior. The main variables influencing the conceptual model of consumer behavior during the brand product selection process were identified as fashion consciousness, conservatism, hedonism, consumer experience, brand perception, and purchasing intention and each of them was analyzed separately (in figure 1.).

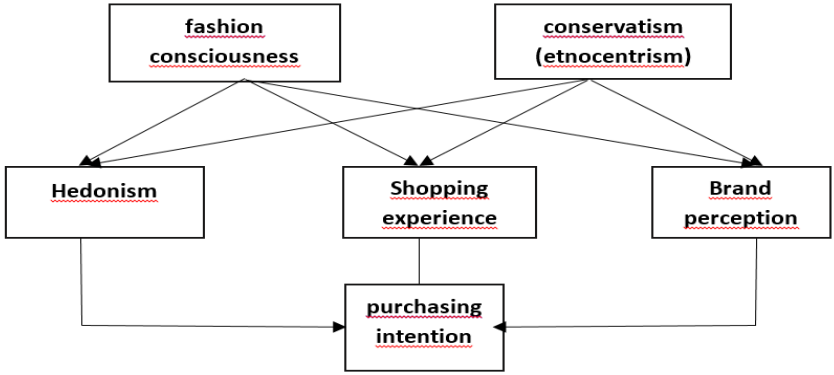

Fig. 1. Conceptual model of consumer behavior

Fuzzy modeling of the impact of fashion consciousness and conservatism on brand perception and also, analyzing impact of hedonism, shopping experience, purchasing experience on consumer purchasing intent in the process of brand product selection process:

1.1. Fuzzy modeling of the impact of fashion consciousness and conservatism to brand perception, hedonism and purchasing practices.

1.2. Fuzzy modeling of the impact of brand perception, hedonism and purchasing practices to consumer purchasing intent in the brand product selection process.

In this chapter, each variable is measured through defined query questions. In addition, the input-output variables of the conceptual model are evaluated by using fuzzy linguistic variables. The fuzzy value estimation of the variables in the conceptual model was performed by using the following formulas.

$$x_1^j = \frac{\sum_{i=1}^{5} x_{1i'}^j}{5} \quad (1)$$

$$x_2^j = \frac{\sum_{i=1}^{10} x_{2i'}^j}{10} \quad (2)$$

$$y_1^j = \frac{\sum_{i=1}^{9} y_{1i'}^j}{9} \quad (3)$$

$$y_2^j = \frac{\sum_{i=1}^{11} y_{2i'}^j}{11} \quad (4)$$

$$y_3^j = \frac{\sum_{i=1}^{14} y_{3i'}^j}{14} \quad (5)$$

$$z^j = \frac{\sum_{i=1}^{5} z_i^j,}{5} \quad (6)$$

The dependence between fashion consciousness and conservatism with hedonism, shopping experience and brand perception was determined by assigning weight ratios. Finally, hedonism, purchasing experience, and the impact of brand perception to purchasing intent were measured using IF-THEN rules.

The dependence between the variables Y1, Y2, Y3, Z is determined by the IF-THEN rules:

IF Y_1 *is* A_{11} *and* Y_2 *is* A_{12} *and* Y_3 *is* A_{13} *THEN* Z *is* B_1

IF Y_1 *is* A_{21} *and* Y_2 *is* A_{22} *and* Y_3 *is* A_{23} *THEN* Z *is* B_2

IF Y_1 *is* A_{31} *and* Y_2 *is* A_{32} *and* Y_3 *is* A_{33} *THEN* Z *is* B_3

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.

IF Y_{1n} *is* A_{1n} *and* Y_{2n} *is* A_{2n} *and* Y_{3n} *is* A_{3n} *THEN* Z *is* B_n

In these formula Y is the input variable, Z is the output variable, and $A = \{A_{ij}, i=1,...,3; j=1,...,n\}$ and $B = \{B_1, B_2 \dots B_n\}$ are membership functions for linguistic terms of values of Yi and Z respectively.

As a result, the study shows that the impact of variables affecting consumer behavior was normally assessed based on the responses obtained from a survey group of consumers during brand product selection.

This chapter also examines investigation of preference knowledge of decision maker on consumer buying behavior in a brand product choosing process. There are several variables which influence consumer behavior in buying process. Different units of measurement is used given variables and the degree of preference over each other can be determined by normalization. For this purpose a fuzzy matrix is constructed, comparison of criteria is carried out, by using linear programming and AHP method consistency is checked.

The solution of consumer knowledge preference problem through linear programming consists of the following steps.

In this issue, the factors influencing consumer behavior when choosing a brand product were identified as C_1-hedonism, C_2-purchasing experience, C_3-brand perception. The aim is to calculate the consistency index and ratio by determining the stability of a given fuzzy matrix based on a comparison of factors.

First, the expert constructs a fuzzy decision matrix consisting of criteria such as hedonism, purchasing experience, and brand perception.

Table 3.

Fuzzy matrix of the criteria ($\tilde{A}$)

Criteria	Hedonism (C_1)	Shopping experience (C_2)	Brand perception (C_3)
Hedonism (C_1)	(1 1 1)	(7 8 9)	(5 6 7)
Shopping experience (C_2)	(0.11 0.13 0.14)	(1 1 1)	(3 4 5)
Brand perception (C_3)	(0.14 0.17 0.2)	(0.2 0.3 0.3)	(1 1 1)

The fuzzy decision matrix is divided by three crisp matrices as left, center, and right matrix: A_l is the left matrix, A_m is the center matrix, and A_u is the right matrix.

Table 4.

A_l matrix

	C_1	C_2	C_3
C_1	1	7	5
C_2	0.11	1	3
C_3	0.14	0.2	1

Weight vectors for the A_l matrix are found by using linear programming:

$$w_1 = 0{,}745, w_2 = 0.106, w_3 = 0.149$$

Objective function

$$Z = (min\left(\left(n_{11} + p_{11}\right) + \left(n_{12} - p_{12}\right) + \left(n_{IJ} - p_{IJ}\right) + \left(n_{IJ} - p_{IJ}\right)\right) = 0.856$$

Table 5.

A_m matrix

	C_1	C_2	C_3
C_1	1	8	6
C_2	0.13	1	4
C_3	0.17	0.3	1

The objective function and weight vectors for the A_m matrix are obtained:

$$Z = 0.526,\ w_1 = 0,774,\ w_2 = 0.097,\ w_3 = 0.129$$

Table 6.

A_u matrix

	C_1	C_2	C_3
C_1	1	9	7
C_2	0.14	1	5
C_3	0.2	0.3	1

The objective function and weight vectors are obtained for the A_l

matrix:

$Z = 0,637,\ w_1 = 0,797,\ w_2 = 0,088,\ w_3 = 0,114$

The results in Table 4 are obtained using the weight vectors of the 3 matrices.

Table 7.

Ratio matrix

Weight vector	Ratio-matrix
$\begin{bmatrix} 0.745 \\ 0.106 \\ 0.149 \end{bmatrix}$	$\begin{bmatrix} 1,00 & 7,02 & 4,99 \\ 0,14 & 1,00 & 0,71 \\ 0,20 & 1,41 & 1,00 \end{bmatrix}$
$\begin{bmatrix} 0.774 \\ 0.967 \\ 0.129 \end{bmatrix}$	$\begin{bmatrix} 1,00 & 0,80 & 6,00 \\ 1,25 & 1,00 & 7,50 \\ 0,17 & 0,13 & 1,00 \end{bmatrix}$
$\begin{bmatrix} 0.797 \\ 0.088 \\ 0.114 \end{bmatrix}$	$\begin{bmatrix} 1,00 & 9,06 & 6,99 \\ 0,11 & 1,00 & 0,77 \\ 0,14 & 1,30 & 1,00 \end{bmatrix}$

The consistency index and the consistency ratio for A_L, A_m, A_u matrices were calculated. An optimal solution is considered if the calculated CR is <10%. The proposed method helps to solve decision-making issues in various areas of marketing management. In multi-criteria decision-making, the use of the AHP method is the most appropriate to ensure a hierarchy between goals, criteria and alternatives. The advantage of the calculation used is to find a solution to the problem through linear programming using a new method.

In addition, the comparison of the criteria for selecting the appropriate marketing channel during the delivery of products, which is one of the main processes of marketing activities, was considered. The fuzzy decision matrix given for the comparison of criteria in solving the problem was solved by the AHP method.

In a market environment, few manufacturers sell their products

directly to end users and most of them use intermediaries to bring their products to market. A set of organizations that provide access to the goods and services available in the market or the availability of products is called a marketing or distribution channel. One of the most important decisions for the management is to ensure that products are delivered to consumers in time. Choosing the right marketing channel during delivering process reduces conflict between producer and buyer, improves the transportation process and leads to consumer satisfaction. When choosing a marketing channel, different criteria are compared and this process is reflected through a fuzzy matrix.

In this problem the criteria for selecting the appropriate marketing channel are revenue, delivery, security, product range and branch network. The given fuzzy matrix is divided into 3 crisp matrices. $\tilde{c}_{ij} = (c_{ij,l}, c_{ij,m}, c_{ij,u}), (i, j = 1,2,...,n)$

Table 8.

$\tilde{C}$ fuzzy matrix

$\tilde{C} =$

Criteria	Revenue(C_1)	delivery (C_2)	safety (C_3)	product variable (C_4)	branch network (C_5)
revenue (C_1)	(1,1,1)	(1/5,1/3,1)	(1/4,1/2,1)	(1/5,1/3,1)	(1/6,1/4,1)
delivery (C_2)	(1,3,5)	(1,1,1)	(1,2,4)	(1/5,1/3,1)	(1/4,1/2,1/1)
safety (C_3)	(1,2,4)	(1/4,1/2,1)	(1,1,1)	(1/4,1/2,1)	(1/4,1/2,1)
product variable (C_4)	(1,3,5)	(1,3,5)	(1,2,4)	(1,1,1)	(1/5,1/3,1)
branch network (C_5)	(2,4,6)	(1,2,4)	(1,2,4)	(1,3,5)	(1,1,1)

Eigenvalue and eigenvector of $\overline{C_l}$, $\overline{C_m}$ and $\overline{C_u}$ matrices derived from $\tilde{C}$ fuzzy matrix is obtained by using "MATLAB" program.

It is suitable to use the AHP method for the problem which has a hierarchy between criteria, sub-criteria and alternatives in multi-criteria decision-making. The AHP method offers more

comprehensive, flexible, and practical results for quality decision criteria. The main advantage of this study is that it is based on eigenvalue, eigenvector, consistency index and ratio in fuzzy AHP. The topic of research is to determine the priority of the criteria for the existing marketing channel during the delivering of consumer products. In the research, a comparison of the criteria for selecting a marketing channel was performed and the consistency ratio CR = 0.075 ≤ 10% of fuzzy matrix was calculated. If the consistency ratio is less than 0.075 %, it is acceptable to continue the calculation process.

The third chapter of the dissertation is called **"Fuzzy models used to study the role of staff selection in the process of efficiency improvement"**. The research object of the third chapter is the study of staff selection in fuzzy information environment. This chapter examines the decision-making process in personnel selection, which is the main object of personnel policy within the enterprise.

Recruitment involves a number of specialized processes that begin with the need for a personnel and end with the recruitment of the selected person to the organization. Personnel selection in organizations and enterprises is a process related to the selection of a person who can meet the requirements of this job, mostly among the candidates applying for the vacant position. The selection process is a very difficult and costly process for businesses. The business plan and its implementation have a significant impact on the selection of a suitable person for the vacancy. Failure in the selection the right personnel is a material and moral loss for the organization. Examining self-confidence preference model the selection of a suitable candidate for the vacant position was analyzed. Multicriteria decision making and multicriteria analysis approaches allow recipients to support the views of a number of variables, conflicting assessments and to make a number of changes. Both approaches can be applied separately in different ways and contexts, taking into account all possible changes. This process involves identifying relevant criteria by assessing key elements and assigning values to show the importance of the criteria

as they relate to the desired outcome of the decision-making process.

Preference relations are used for the comparison of alternatives in decision-making. The existence of a level of self-confidence in theory and practice and its application in mathematical ways is important.

In this chapter, the task is to select the best candidate for the vacant faculty position. The following criteria are used to make a decision:

- Publication results (C_1);
- Industrial experience (C_2);
- Teaching quality (C_3);
- Grant taking ability (C_4);
- Intelligence level (C_5)

Assume that there are 5 alternatives (candidates): $A=\{a_1, a_2, a_3, a_4, a_5\}$

Table 9.

Fuzzy preference relation with respect C_1

C1	A1	A2	A3	A4	A5
A1	0.5	p12	p13	p14	p15
A2	p21	0.5	p23	p24	p25
A3	p31	p32	0.5	p34	p35
A4	p41	p42	p43	0.5	p45
A5	p51	p52	p53	p54	0.5

For calculation of the consistency the following formula index is used:

$$CI = \frac{5.38 - 5}{5 - 1} = 0.095$$

$$CR = \frac{C\dot{I}}{R\dot{I}} = \frac{0.095}{1.12} = 0.08 < 0.1$$

As CR= 0.08 <01 preference relation in Table 7 is consistent.

After fuzzy consistent preference value obtaining decision maker provides the self-confidence levels associated to the preference values. Self-confidence is explained by linguistic variables.

S^{SL}={l_0=very low, l_1=low, l_2=poor, l_7=high, l_8=very high}

The results are :

$z = \min (z_{12} + z_{13} + z_{14} + z_{15} + z_{23} + z_{24} + z_{25} + z_{34} + z_{35} + z_{45}) = 6.9$

$w_1 = 0.4; w_2 = 0; w_3 = 0; w_4 = 0.6; w_5 = 0$

So the best alternative is A_4.

The selection and use of effective evaluation methods in personnel selection can significantly increase the quality and productivity of an organization's workforce. Unfortunately, many human resources professionals have misconceptions about both the value and types of formal assessments. Along with the fact that the selection process is essentially technical and difficult to understand through multi-criteria decision-making methods, the solution of problems such as formal assessment in organizations has been investigated. By providing a basic understanding of the key criteria for evaluating methods and sources for access to information and practices related to the recruitment problem, we hope that this report will be seen as a positive step towards better equipping organizational decision-makers and human resources professionals to apply effective assessment methods.

The fourth chapter of the dissertation is entitled **"Investment decision-making in a business environment".** The research object of the fourth chapter is the study of investment problem based on a combined state in uncertain information environment. This chapter focuses on investing, which is an important area of business processes in an uncertain information environment. Criteria and alternatives for investment have been identified and a decision matrix has been established.

Table 10.

Comparison Matrix for criteria

	Rapid growth (C_1)	Static situation (C_2)	Recession (C_3)
Rapid growth (C_1)	1	1/3	2
Static situation (C_2)	3	1	3
Recession (C_3)	1/2	1/3	1

The consistency index is calculated by this way:

$$CR = \frac{CI}{RI} < 0.1 \rightarrow 10\%$$

CI for comparison of alternatives (Rapid growth situation) based on

is,

CR=0.082 $CR = \frac{CI}{RI} < 8.2 \rightarrow 10\%$

CI for comparison of alternatives (Static situation) based on is,

CR=0.0115 $CR = \frac{CI}{RI} < 1.15 \rightarrow 10\%$

CI for comparison of alternatives (Recession situation) based on is,

CR=0.0055 $CR = \frac{CI}{RI} < 0.55 \rightarrow 10\%$

The ranking of alternatives for each criterion was carried out according to the results obtained.

Table 11.

Ranking of alternatives for each criterion

	C_1	C_2	C_3	Total
Weights	0,25	0,59	0,16	
A_1	0,27	0,19	0,53	0,26
A_2	0,32	0,56	0,12	0,43
A_3	0,3	0,16	0,54	0,26

AHP model is used to solve the investment problem of a company or investor who should determine the best alternative. AHP is accomplished in several steps and they explained here.

First step. Determine the problem, the main goal, criteria and alternatives.

Second step. Determine the hierarchy structure from top level to the lowest level.

Third step. Define the statement of problem and formulate pair-wise comparison, using formulas to obtain priority vectors, calculate eigenvalue and consistency index. At the end of calculation the alternatives are ranked by using all criteria and the best alternative is defined.

According to the results obtained, in the given economic situation, the best alternative is to invest in shares A_2.

In this chapter, decision-making based on the combined states method is also considered. Along with the state of the economic period, the decision-maker's attitude to risk was taken

into account in the investment problem. Investment decision-making is based on strategic, economic and behavioral motives. However, a decision must be made after a thorough study of the area to be invested. This is because the amount of capital expended must be determined after taking into account the risks that can arise. Alternatively, various foreign investments are offered to investment decision makers to evaluate and choose from the given alternatives.

The economic and financial environment affects investment, so the expected results are uncertain. An investment is an amount spent to obtain a forecasted return. Investment can be divided into three types: entrepreneurship, debt and cash equivalent.

We have 3 alternatives for entrepreneurial investment:

1. Small business (f_1)
2. Tourism sector (f_2)
3. Transport (f_3)

Current economic situation: s_1 - period of growth, s_2 - period of stability, s_3 - period of recession, and the states of decision-maker: h_1 - risk-taking, h_2 - risk-averse and h_3 - risk-neutral.

Table 12.

Combined states space

	s_1	s_2	s_3
1	(s_1,h_1)	(s_i,h_1)	(s_n,h_1)
2	(s_1,h_j)	(s_i,h_j)	(s_n,h_j)
3	(s_1,h_1)	(s_i,h_m)	(s_n,h_m)

Assume probabilities of states of nature are as follows:

$$P(s_1) = [0.3, 0.4]$$

$$P(s_2)= [0.3, 0.5]$$

For computing probability $P(s_3)$ probabilities $P(s_1)$ and $P(s_2)$ are used:

$$P(s_3) = [0.1, 0.4]$$

Assume probabilities of states of decision maker are as follows:

$$P(h_1) = [0.1, 0.3]$$

$$P(h_2) = [0.5, 0.6]$$

Probability $h_3$is calculated as follows:

$$P(h_3) = [0.1, 0.4]$$

There are positive and negative dependence between s and h. For example, dependence between h_1 (risk averse) and s_1, s_2, s_3 is described as :

$$P(H_1, S_1) = \left[max\left(P_1(H_1) + P_1(S_1) - 1, 0\right),\ P_2(H_1) P_2(S_1) \right] =$$

$$= \left[max((0.1+0.3)-1, 0), 0.3 \times 0.4 \right] = [0; 0.12]$$

$$P(H_1, S_2) = \left[P_1(H_1) \times P_1(S_2),\ min\ P_2(H_1) P_2(S_2) \right] =$$

$$= \left[(0.1 \times 0.3)\ min(0.3; 0.5) \right] = [0.03; 0.3]$$

$$P(H_1, S_3) = \left[max\left(P_1(H_1) + P_1(S_3) - 1, 0\right), P_2(H_1) P_2(S_3) \right] =$$

$$= \left[max\left((0.1+0.2)-1, 0\right),\ (0.3 \times 0.3) \right] = [0; 0.06]$$

Table 13.

Joint probabilities

			Growth		Stagnation		Decline	
			0.3	0.4	0.3	0.5	0.1	0.4
Risk averse	0.1	0.3	0	0.12	0.03	0.3	0	0.06
Risk seeking	0.5	0.6	0.15	0.4	0	0.3	0.1	0.3
Risk neutral	0.1	0.4	0.06	0.3	0	0.15	0	0.09

The values of utility of outcomes for combined states as shown in tables12-14. Utility for all business types is given with different percentage.

Table 14.

Utility of outcomes for small business

Small business	Growth (C_1)	Stagnation (C_2)	Decline (C_3)
	(25% profit)	(10% profit)	(5% profit)
Risk averse	U(x)= √(10×25%)=1.6	U(x)= √(10×10%)= 1	U(x)= √(10×5%)= 0.7
Risk seeking	U(x)= (10×25%)^2= 6.3	U(x)= (10×10%)^2= 1	U(x)= (10×5%)^2= 0.3
Risk neutral	U(x)= (10×25%)=2.5	U(x)= (10×10%)=1	U(x)= (10×5%)=0.5

Table15.

Utility of outcomes for tourism

Tourism	Growth (C_1)	Stagnation (C_2)	Decline (C_3)
	(23% profit)	(15% profit)	(3% profit)
Risk averse	U(x)= √(10×23%)= 1.5	U(x)= √(10×15%)= 1.2	U(x)= √(10×3%)= 0.5
Risk seeking	U(x)= (10×23%)2= 5.3	U(x)= (10×15%)2= 2.3	U(x)= (10×3%)2= 0.1
Risk neutral	U(x)= (10×23%)=2.3	U(x)= (10×15%)=1.5	U(x)= (10×3%)=0.3

Table 16.

Utility of outcomes for transport

Transport	Growth (C_1)	Stagnation (C_2)	Decline (C_3)
	(20% profit)	(12% profit)	(10% profit)
Risk averse	U(x)= √(10×20%)=1.4	U(x)= √(10×12%)= 1.1	U(x)= √(10×10%)= 1
Risk seeking	U(x)= (10×20%)^2= 4	U(x)= (10×12%)^2= 1.4	U(x)= (10×10%)^2= 1
Risk neutral	U(x)= (10×20%)=2	U(x)= (10×12%)=1.2	U(x)= (10×10%)=1

The utility of the alternatives is calculated by the Choquet integral:

$$U(f) = (U_{(1)} - U_{(2)})*\eta(\{w_{(1)}\}) + (U_{(2)} - U_{(3)})*(\{w_{(1),}w_{(2)}\}) + \ldots\ldots +$$

$$+(U_{(8)} - U_{(9)})*(\{w_{(1),}w_{(2),}w_{(3),}\ldots w_{(8)}\}) + (U_{(9)} - U_{(10)})*(\{w_{(1),}w_{(2),}w_{(2),}\ldots w_{(9)}\})$$

1. U(f1)= [1.73;2.78]
2. U(f2)= [1.71;2.7]
3. U(f3)= [1.62;2.18]

As a result of the study, the best alternative for investment in the mentioned economic conditions is the f1. Changes in the likelihood of states of decision maker are investigated by analyzing sensitivity to risk attitude.

The results obtained are as follows:

We can see that some changes of P (h_2) doesn't influence the best alternative.

P (h_2) is changed from [0.5; 0.6] to [0.4;0.5]

The final result :

1. $U(f_1)$= [1.73; 2.78]
2. $U(f_2)$= [1.71; 2.7]
3. $U(f_3)$= [1.62; 2.18]

We can see that some change of P (h_2) doesn't influence the best alternative.

Let us now change P (h_1) from[0.1;0.3] to [0.5;0.6],

The obtained results :

1. U(f1)= [0.53; 0.72]
2. U(f2)= [1.16; 1.9]
3. U(f3)= [1.31; 1.69]

We see that P (h_1) has a significant effect on the best alternative. According to the results, the best alternative is the transport sector. The combined states approach was used in the behavioral decision-making for the investment issue. Three possible situations involving the risk relationship are considered.

An estimated interval probability is used to model the uncertainty associated with a person's behavioral conditions and economic status. The utility based on Choquet integral is used to describe non-additivity of preferences under uncertainty. A sign of

dependence between decision maker state and state of economy is taken into account. Sensitivity analysis of obtained solution illustrates validity of the proposed work.

In addition, the sensitivity analysis of the methods used in the dissertation and a comparative analysis of the methods was carried out. The fuzzy multi-criteria decision-making software is used to test sensitivity in the process of selecting the appropriate marketing channel for consumer behavior.

Although the AHP method is used in multi-criteria decision-making, the method of sensitivity analysis is not widely used. The Expert Selection Software Package for the AHP method has limited sensitivity-analysis capabilities. The criteria for selecting a marketing channel are: revenue, delivery, safety, product variety and branch network, and three alternatives are defined as A, B, C. With the help of fuzzy multi-criteria decision-making software, the best alternative is selected according to the given criteria and the sensitivity of the problem to the weight changes of the criteria is investigated. One of the main methods proposed in the dissertation is the application of the AHP tool. This chapter examines the comparative analysis of AHP and TOPSIS multicriteria decision-making methods.

Main Scientific Results of the Work

In order to improve business processes in enterprises and organizations, decision-making methods based on fuzzy information have been developed and the following main scientific results have been obtained in the research work:

1. Using the fuzzy AHP method the decision-making process of consumer behavior was studied.
2. Factors affecting consumer behavior during online sales were studied in a fuzzy environment.
3. In constructing a conceptual model of consumer behavior, the relationship between variables of the model was investigated on the basis of fuzzy information.
4. The preference of consumer behavior in a fuzzy information environment has been investigated.

5. The marketing channel selection problem for the distribution of products in a fuzzy environment was analyzed.

6. The problem of self-confidence preference in the selection of personnel, which is an important part of the activities of business enterprises, was investigated.

7. The issue of investment, which is an important part of risky and profitable business in modern times, has been studied on the basis of the combined states and the best option for investment has been selected.

8. Sensitivity analysis of the solutions was conducted.

9. A comparison analysis of methods used to study business processes was conducted.

The complexity of the process of increasing the efficiency of business operations does not have its effect during the research indicated in the classical and neoclassical approaches. Fuzzy approach assesses the current economic situation and the opinions of the decision-maker, enabling the improvement of efficiency in business processes in a fuzzy information environment. Therefore, the application of fuzzy approaches can have a positive effect on the efficiency and acceleration of operations in business processes.

The main content of the dissertation was published in the following works:

1. Khatira J. Dovlatova Application of the combined state concept to behavioral investment decisions under interval-valued information // Advances in Intelligent Systems and Computing, Springer, - 2019, - p. 774-780.

2. Dovlatova Khatira .J. Decision-making in investment by application of the analytic hierarchy process (AHP) .10th World Conference “Intelligent Systems for Industrial Automation”, B-quadrat verlags, Uzbekistan, WCIS-2018, - 2019, p.226-228.

3. Khatira J. Dovlatova Estimation of consumer buying behavior for brand choosing by using fuzzy IF-THEN rules //Advances in Intelligent Systems and Computing, Springer, -2019, p.805-812.

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5. Khatira J. Dovlatova Estimation of the Consistency Index in Fuzzy AHP Based Marketing Channel Selection Problem . Science-technical journal, Baku. Azerbaijan Technical University 2019, №3, p.1-8.

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8. Khatira J. Dovlatova Analysis Of Factors İnfluencing To Consumer Behavior İn Online Shopping // Proceedings of Azerbaijan High Technical Educational Institutions, 2021, №5, p.42-51.

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10. Khatira J.Dovlatova Analyzing the digital marketing strategies role in post pandemicrecovery period // Lecture Notes in Networks and Systems, -2022, p.139-146.

11. Khatira J.Dovlatova Z-preferences in consumer buying behavior // Lecture Notes in Networks and Systems, -2022, p.211-217.

12. Khatira J.Dovlatova Rəqəmsal marketinqdə istehlakçı davranışının qeyri-səlis informasiya mühitində İnterval-TOPSİS metodu vasitəsilə qiymətləndirilməsi // Transactions of Azerbaijan İnstitutes of Technology Baku, 2022, No 16, Vol. 05 p.157-162.

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