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Prioritization of Influential Factors in the Selection of Advanced Technologies in the Automotive Polymer Parts Industry Using Fuzzy AHP Method (Case Study: Iran Khodro Company)

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ARTICLE INFO	ABSTRACT
<p>Article History: Received 24 June 2021 Received in revised form 6 September 2021 Accepted 7 December 2021 Available online 9 December 2021</p>	<p>Given the rapid globalization and the need for companies and countries to compete closely in the global market, new and superior technologies have emerged as a competitive advantage for global market presence. The identification and prioritization of factors influencing technology selection depend on the technology provider's willingness to offer it in a specific way, as well as the technology recipient's inclination and ability to acquire and assimilate it. For emerging technologies, factors such as high costs of obtaining new technology, high installation and startup costs, and maintenance, repair, and training costs are just a few of the numerous considerations that must be taken into account in the selection of innovative technologies. In this research, first, the effective criteria in selecting new technologies in the automotive polymer parts industry are identified. Fuzzy Analytical Hierarchy Process (AHP) is then used to rank these criteria. To identify the factors influencing the selection of new technologies in automotive parts manufacturing companies, a screening questionnaire was designed. Initially, out of 40 criteria collected from the literature, 19 criteria were finalized using a one-sample t-test with the participation of 133 automotive industry professionals. The reliability results, calculated using Cronbach's alpha, yielded a value of 0.82. In the next step, using 19 automotive industry experts (with a minimum of 15 years of experience and familiarity with technology selection issues), the fuzzy Analytical Hierarchy Process (AHP) was applied to prioritize the criteria influencing the selection of new technologies. Four prioritized options include technology complexity levels, quality, environmental pollution levels, and ease of implementation. The reliability obtained from the questionnaire "Assessment of the relative importance of factors influencing the selection of new technologies in the automotive polymer parts industry" was calculated separately for each matrix using pairwise comparisons, and CR <0.1.</p>
<p>Keywords: Innovative Technologies, Technology selection, Polymer parts, Fuzzy Analytical Hierarchy Process (AHP)</p>	

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1. INTRODUCTION

In today's dynamic business environment, the choice of technology can play a crucial and vital role in the business strategies of a company. Companies, to confront the increasing complexities of production, attract more customers, meet the required quality for specialized and improved services, and cope with competitive pressures, rely on the selection and transfer of technology [1].

Policy-makers and planners must view technology as a crucial variable in national development that is necessary for improving the fulfillment of national needs. In fact, the only practical way to compensate for the lagging behind of a country or an economic entity is to utilize the successful experiences of others in new areas. In other words, there are not enough human resources, capital, and time to traverse the path that others have traveled over one or two centuries, with many trials and errors and the expenditure of substantial resources. Choosing and transferring technology is a shorter path to achieving the results of research conducted by other countries in solving the industrial problems of a country [2].

The successful experience of developed countries has shown that widespread adoption and extensive use of appropriate and modern technologies in these countries have enabled them to increase their productivity and, consequently, lead to the rapid industrial development of these countries. The selection of each innovative technology depends on various factors, including the status of technology in the relevant industry, requirements, capabilities, facilities, and weaknesses of the technology, the status of technology in other countries, national strategies, and the like. Choosing an appropriate method is a fundamental factor in selecting technology and is the primary requirement for achieving the ultimate goal of the process [3].

Given the rapid globalization and the need for companies and countries to compete closely in the global market, new and superior technologies have emerged as a competitive advantage for global market presence [4].

The process of choosing and transferring technology can be divided into three main sections: 1) Choosing and acquiring technology, 2) Adaptation, application, and absorption of technology, 3) Development and dissemination of technology [5].

The importance and impact of each of the factors influencing the selection and transfer of technology depend on factors such as the nature of the required technology and the capacity of the recipient country for learning and absorbing technical and technological knowledge. Prioritizing the factors influencing the selection of technology depends on the willingness of the technology provider to offer it in a specific manner, as well as the willingness and capability of the technology recipient to acquire and absorb it. Therefore, various factors influencing technology transfer can be identified through some important factors such as the goals of the technology provider and recipient, the level of management capabilities and technological capacities, the political and economic conditions of the recipient country, the size of the accessible market, and the speed of technological changes [6].

2. THEORETICAL FOUNDATIONS OF RESEARCH

2.1. Concept of Technology

Technology encompasses two main components: 1) the physical component, which includes products, tools, equipment, blueprints, methods, and processes, and 2) the informational component, which involves knowledge in areas such as management, marketing, production, quality control, reliability, skilled personnel, and functional domains. Kumar and colleagues regard technology as a "configuration" based on a mental definition but allocatable to processes and productions [7]. Typically, technology is associated with significant results, solving major problems, completing core functions through specific skills, utilizing knowledge, and leveraging assets. The concept of technology extends not only to the technology present in productions but also to the application and development of productions [8]. McKenzie defines technology as a combination of physical products or artifacts, production processes, and tools associated with physical products, forming an integrated network within technology recipients [9]. Innovative technologies can create opportunities for differentiation, new businesses, and the careful selection of technology is imperative for the survival of each company [10].

This concept constitutes a set of hardware and software that must be appropriately integrated to be fully effective. When technology is developed for a system or production set, its initial forms include:

Physically, such as materials, production tools, equipment, and machine types.

Human-wise, fundamentally explaining why it includes the skills and individual experiences of humans or groups.

In terms of data, including the type of knowledge, such as processes, techniques, methods, and the like.

Organizationally, increasingly recognized as an accelerating factor in assisting the entire system, interacting with the environment, and making the system functional.

2.2. Technology Selection

Technology selection is a strategic decision and must be carried out within the framework of the strategic plan of the organization. Since evaluating and choosing suitable technology is one of the most sensitive stages in the technology transfer process, this stage requires careful study, analysis, and utilization of specialized research and methods. The factors influencing technology selection can be diverse, covering a wide range of conditions and elements. It is essential to note that the important and fundamental criteria for each technology-receiving country differ, depending on the economic and cultural factors of that country. In each case, the opinions of relevant experts and stakeholders should be considered, and specialized decision-making methods should be used.

In the present era, access to new technologies has provided various aspects for technology selection. Due to the differences in environmental conditions and internal conditions of organizations, one technology cannot be considered suitable for everyone. The selection of suitable technology is a crucial issue that manufacturing enterprises face, and sometimes choosing inappropriate technology has irreparable consequences. Professor Abdul Salam stated in one of his lectures: "In Egypt, three million dollars were spent to establish a factory to produce ion lamps. This factory was established in the same year that more complete transistors came into existence and entered global markets. Foreign consultants had recommended the establishment of such a factory, but the officials executing the project had a specific lack of understanding of how the knowledge worked, and without consulting qualified physicists from their own country, they accepted this recommendation".

2.3. Technology Transfer

Definitions related to technology transfer differ depending on the research fields and the research objectives; the method of technology transfer refers to a predefined set of activities through which the required technology is made available to the applicant [11]. Technology transfer, as a multidimensional process involving producers and consumers of ideas and capabilities, includes formal and informal participatory activities between governmental research departments, private sectors, and the public. Since the term "technology transfer" encompasses many dimensions, often it refers to the process through which ideas and concepts are transferred from the laboratory to the job market [13]. The transfer of knowledge and concepts from a developed country to a less developed country and the transfer of innovative activities to second-hand users are used in these fields [14]. This concept not only focuses on the transfer of technical knowledge or information but also considers the ability of the technology recipient to learn and absorb technology in productive functions.[15]

According to Razman, in extensive research based on previous articles, economists often define technology transfer based on the general properties of knowledge, focusing on variables related to production and design. Sociologists prefer to consider technology transfer related to innovations and view technology as a desirable output. Anthropologists widely perceive technology transfer in the context of cultural changes and how it influences these changes. According to Zahra and Razman, most of the existing articles on technology transfer have attracted the attention of management scholars. They admitted that business areas tend to focus on ideas such as the transfer stages, related design, and sales, in other words, management researchers concentrate on internal transfer sections and the communication between transfer sections and the strategy.[16]

According to the United Nations, technology transfer is defined as the introduction of specific technological factors from developed countries to developing countries, enabling these countries to acquire and use new production tools and expand and develop existing tools [17]. Technology transfer is a way for developing countries to acquire newer technology. These countries must use technology transfer as a basis to complement their technological capabilities. These capabilities not only involve limited physical equipment but also include science, knowledge, educational abilities, and skills of individuals. In the industrial sector, these capabilities include the selection, standardization, adoption, improvement, and creation of new technology [18]. Technology transfer to the recipient is a complex process involving technological complexity, the complexity of interaction between two sections, the training ability of the technology provider, and the learning ability of the recipient.[19]

2.4. Technology Selection in the Automotive Industry

The three main changes in the automotive industry have fundamentally impacted buyer-supplier relationships. Firstly, many suppliers took on the responsibility of designing entire products. Secondly, suppliers were expected to provide more complete systems or products instead of specific components. Thirdly, as a result, buyers increasingly collaborated with suppliers to enhance product quality, reduce defects, and ensure timely fulfillment of their production needs.

Since the choice of appropriate technology can significantly influence an organization's success or failure, limited studies have been conducted in this field. In this context, the Environmental Protection Agency (EPA) has examined the comprehensive process of technology transfer and introduced two important tools called Technology Specification Checklist and Environmental Specification Checklist for technology selection and transfer.

One study focused on the recycling process of fluorescent lamps in the lighting industry at Pars Shahab Company [20]. In this study, a mathematical model was chosen, and the prioritization of suitable technology was presented using multi-criteria decision-making theory based on criteria such as minimum cost, maximum technology absorption, minimum transfer time, maximum market access, and maximum alignment with technological developments.

Another study examined the selection of suitable solar technology for electricity generation. The analysis of technological advancements in the power industry highlighted a high level of innovation. The discussion on technological development in renewable energy focused on various aspects.[21]

2.5. Technology Transfer in the Automotive Industry

In Mascus's (2013) study on the factors influencing knowledge transfer and technology selection in the Turkish automotive industry, various methods of transfer and selection by major automobile manufacturers towards parts suppliers were identified. Some of these methods, depending on the production approach, in order of impact, include collaboration in quality control methods, participation in research and development activities, sending specialists to address production process issues, involvement in design, machinery, tools and equipment procurement, collaboration of manufacturer experts in supplier production plan creation, licensing knowledge or technology, and cooperation in implementing marketing management at the supplier company.[22]

3. RESEARCH BACKGROUND

Research conducted on technology selection and transfer, as well as international technology transfers, has expanded across various fields such as political science, economics, sociological studies, public policy, marketing, and technology management. The examined ideas encompass the technology transfer process, technology appropriateness, coordination and conflicts among involved countries, the success of technology transfer, and the economic and social benefits of technology transfer for both the supplying and receiving parties.[23]

Potranto and colleagues, in their research, explored the influential factors in the transfer of information systems technology, focusing on their role in Iranian organizations. Using the Pasteur and Markus model, they presented a model that examined the key success factors in the transfer of these systems in automotive companies, employing the Freeman test [24]. Their findings are summarized in Table 1.

Table 1: Rank Section Y Factors Effective In Choice and Transfer Technology Yes Information In Organization Yes Iran

Rank	Agent	Category of factors
5/69	Having the commitment and support of senior managers	Organizational factors
4/53	Clear understanding of business goals and requirements	
17/4	Readiness in terms of having appropriate infrastructure	
4/06	Sufficient financial resources	
3/89	Readiness for change management and process reengineering	
2/09	Political factors and legal requirements	
4/94	Effective management of the transfer process	Tactical factors
33/4	Forming the right team from different fields	

97/3	,Coordination between project elements, proper management of information transfer effective communication	Technical factors
3/95	Existence of a suitable implementation strategy	
3/72	Choosing the right technology	
97/2	Having a proper and documented plan for implementing the process	
4/70	Adequate training for project staff and users	
4/66	User participation and their lack of resistance in implementing the plan	
45/4	The continued presence of specialized and trained personnel	
25/4	Developing and adapting technology to the organization's needs and testing and debugging it	
16/4	Creating motivation among project members and employees	
3/64	Documentation	
2/14	Appropriate use of consultants	

3.1. Jafarnejad and Colleagues' Research: AHP Method for Technology Selection

In their study, Jafarnejad and colleagues (2013) defined and examined various methods for technology selection using the Analytic Hierarchy Process (AHP). Their research population consisted of 120 technology selection specialists familiar with the conditions of the National Gas Company of Iran. Among the factors considered for technology selection, the researchers emphasized elements such as the type of technology, technological competition, human resource skills, training and empowerment of these resources, the level of investment, and the levels of technological selection risks [10].

3.2. Faghih's Research: Combining Fuzzy Delphi, ANP, and FAHP for OLED Technology Selection

Faghih conducted a study on technology selection using a combination of Fuzzy Delphi, Analytic Network Process (ANP), and Fuzzy Analytic Hierarchy Process (FAHP). The focus of their research was the selection of OLED technology. According to their perspective, technology selection is comprised of two main sections: (1) constructing a model based on critical economic and technical factors, and (2) identifying areas of technological importance. Based on their findings, methods assuming criteria as independent of each other (such as AHP) are not suitable for reflecting reality. Therefore, a combination of FAHP and ANP methods is used to provide a model for technology selection, taking into account economic and technical criteria [25].

3.3. Amini's Research: Using Fuzzy Analytic Hierarchy Process for Technology Selection with Uncertain Data

Amini utilized uncertain data and weighting constraints in their research on technology selection. The goal of this article is to present a new method that combines limited range analysis of surrounding data with Fuzzy Analytic Hierarchy Process for technology selection [26].

3.4. Gajendaran's Research: FAHP for Evaluating Innovation Aspects in Taiwanese Technology-Centric Companies

Gajendaran evaluated the innovation aspects and conditions of technology adoption in Taiwanese technology-centric companies using the FAHP method. They explained the interrelationships and causal relationships among these aspects [27].

4. RESEARCH METHODOLOGY

The present research is considered applied in terms of its objective, and the data collection approach is descriptive. The type of data for decision-making in multi-criteria problems is discrete data. Multi-criteria models can be categorized into two types based on the nature of options: discrete and continuous. If the number of acceptable solution sets is countable, the multi-criteria problem is called discrete.

Some authors, such as Chissa and Cho, have referred to this type of problem as Multi-Attribute Decision Making (MADM). If the number of acceptable solution sets is uncountable, the problem is then called continuous [8] and [28].

Data collection will involve library studies (books, articles, internet, etc.), questionnaires, interviews, and document examination. In this research, after reviewing library resources and literature on the topic, a research questionnaire will be developed. After designing the research questionnaire, its validity and reliability will be

assessed. Finally, various descriptive and inferential statistical methods, as well as fuzzy logic theory, will be employed to analyze the collected data. The questionnaires will be completed by a team of senior and mid-level managers and experienced staff members who are informed about the organization's performance in various areas and will be finalized in a joint session.

4.1. Population and Sampling

In this study, for the first part, a sample of 133 experts, including managers, specialists, and employees of Iran Khodro Company, has been selected. For the second part, a questionnaire was utilized with the participation of 19 industry experts responsible for the transfer of polymer automotive technology.

4.2. Study Scope

The research framework provides a framework for the researcher to conduct studies and tests within a specific scope during which the research is more credible.

4.3. Geographical Scope

The geographical scope of this research is Tehran city, specifically Iran Khodro Company.

4.4. Temporal Scope

The time span of this research, considering the availability of information on the number of employees, is from February 2017 to March 2018.

4.5. Thematic Scope

The thematic scope of the research includes technology selection, polymer parts, and fuzzy analytic hierarchy process analysis.

4.6. Data Collection Method and Tools

Data collection includes library studies (books, articles, internet, etc.), questionnaires, interviews, and document examination. After reviewing library resources and literature, a research questionnaire will be developed. The library method will mainly be used to study the literature and investigate the research background. After designing the research questionnaire, its validity and reliability will be assessed. Finally, various descriptive and inferential statistical methods, as well as fuzzy logic theory, will be employed to analyze the collected data. The questionnaires will be completed by a team of senior and mid-level managers and experienced staff members in a joint session.

As mentioned, the data collection method involves both the study of documents and the use of questionnaires. To collect theoretical data for the research, document examination tools will be employed. For describing the community's perspective, a survey method (questionnaire) will be used. The measurement tool in this research is a questionnaire, and the study population is the polymer automotive parts industry (Iran Khodro Company).

In this research, two questionnaires have been used as data collection tools, both of which are designed as closed-ended. The first questionnaire focuses on identifying indicators, and the second questionnaire is designed to measure causal relationships based on fuzzy FAHP.

4.7. Sampling Method and Sample Size

Since our comprehensive statistical framework is limited and accessible, the Cochran formula is used to determine the minimum required sample size for the limited population:

where:

$$n = \frac{Nz_{\alpha/2}^2 p(1-p)}{(N-1)d^2 + z_{\alpha/2}^2 p(1-p)} \quad (1)$$

n = The minimum required sample size

N = the population size

p = The relative frequency of the trait distribution within the population.

Using this formula, a minimum sample size of 133 individuals has been determined. For the second questionnaire, due to the deliberate or judgmental non-random sampling method, individuals were selected based on predefined characteristics, resulting in a sample size of 19.

5. STATISTICAL METHODS

A. Descriptive Statistics:

For presenting the findings, especially the characteristics of the population variables, frequency tables, and bar charts will be used. Additionally, central tendency indices such as mean and median, as well as dispersion indices like standard deviation, will be utilized to provide a better description of the data.

B. Inferential Statistics:

The inferential statistical tests used in this research include:

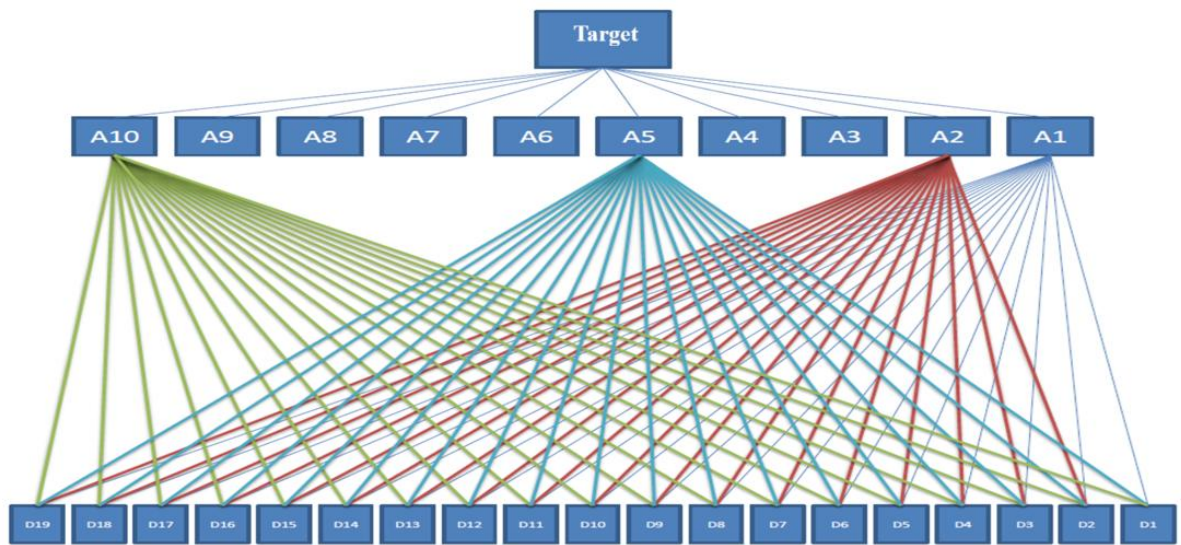


Fig. 2. Structure of the hierarchical research process (researcher's findings)

Independent Samples t-test: To examine the presence or absence of a significant difference among influential factors on technology selection, the independent samples t-test (comparison of means) will be employed.

5.1. Fuzzy Analytic Hierarchy Process (FAHP) Analysis

FAHP is used for prioritizing factors. In this section, an explanation of this method is provided. The first step in the fuzzy analytic hierarchy process involves breaking down the problem into a hierarchical structure, consisting of goals, criteria, sub-criteria, and options. A hierarchical structure is illustrated below:

The next step in the FAHP process is to determine the pairwise comparisons between the factors at each level of the hierarchy. This involves assigning linguistic values, converting them into fuzzy numbers, and establishing the fuzzy comparison matrix. The priority vector for each level is obtained, and the final weights are calculated through the defuzzification process. This methodology aids in decision-making and prioritization based on the identified criteria and sub-criteria related to technology selection in the automotive industry.

In the above hierarchy, there are n criteria for decision-making, and each criterion has its own sub-criteria. For instance, Criterion 1 has 1 sub-criterion, and Criterion 2 has m sub-criteria. Following the establishment of this structure, pairwise comparisons between elements are conducted by decision-makers. Professor Saaty suggests a scale of 1 to 9 for judgment scoring between two elements based on Table 2 below :[29]

Table 2. (2009 , Ataei) Judgment Hey

Description	Judgment	Numerical value
.The two options have the same priority	Equal power	1
.One option has somewhat higher priority than the other	Relatively more power	3
.One option has higher priority than the other	More power	5
.One option has a much higher priority than the other	.Much more power	7
.One option has a much higher priority than the other	More superpowers	9
Even numbers indicate a strength between the above.	Interrogative judgments	even values (2, 4, 6, and 8)

In this stage, decision-makers, in each judgment, directly compare two elements and assign a score based on the above table to indicate the extent of the superiority of the first option over the second.

5.2. Validity and Reliability Assessment

a) Determining the Validity of the Questionnaire:

The concept of validity addresses the extent to which a measurement tool accurately measures the intended characteristic. Without awareness of the validity of a measurement tool, confidence in the accuracy of the obtained data cannot be assured. One of the methods for determining the validity of a questionnaire is content validity.

Content Validity: Content validity is a type of validity used to examine the components forming a measurement tool. The content validity of a test depends on whether the questions of the questionnaire represent the selected content components. To ensure content validity, the questionnaire for the first phase underwent expert testing, consultation with the esteemed advisors and consultants, as well as obtaining the opinions of experts in the field of polymer automotive parts technologies. This process ensured that the questionnaire measures the intended characteristic according to the researcher.

b) Determining the Reliability (Consistency) of the Questionnaires:

Reliability: Reliability is a technical characteristic of a measurement tool. It refers to the extent to which a measurement tool produces consistent results under consistent conditions. The reliability coefficient ranges from zero (no correlation) to 1+ (perfect correlation). The reliability coefficient indicates how well the measurement tool measures stable and temporary features of the subject.

In this study, Cronbach's alpha method was used to determine the reliability of the test. This method is used to calculate internal consistency in a measurement tool that measures various features. Therefore, to measure reliability, the Cronbach's alpha method was applied using SPSS 18 software. For this purpose, an initial sample of 10 questionnaires was pre-tested, and using the data obtained from the questionnaires, the reliability coefficient was calculated using the Cronbach's alpha method by SPSS software. The obtained Cronbach's alpha coefficient for the questionnaire was 0.82, as shown in Table 3 below. The figures obtained indicate that the questionnaire is reliable and, in other words, has the necessary consistency.

Table 3. Questionnaire reliability (Source: Research findings)

Cronbach's alpha	Number of questions
0/82	40

6. MEASUREMENT SCALE

In general, scales are commonly used to measure qualitative characteristics such as attitudes, judgments, beliefs, and other qualitative traits that are not easily measurable. By using measurement scales, data obtained during the research are transformed from qualitative to quantitative form, making them suitable for statistical analysis [26].

In this study, considering the research objectives, the type of questionnaire, and the ease of constructing and interpreting results, a Likert spectrum scale was employed for evaluating options in the first questionnaire. For the paired comparisons questionnaire, fuzzy triangular numbers were used [29].

The use of a Likert spectrum scale allows participants to express their agreement or disagreement on a set of statements or items related to the research topic. This scale typically ranges from strongly disagree to strongly agree, providing a quantifiable measure of participants' opinions.

On the other hand, the fuzzy triangular numbers used in the paired comparisons questionnaire facilitate the assessment of the relative importance of different factors or options in a fuzzy environment. These numbers are particularly useful when dealing with imprecise or uncertain information, allowing respondents to provide judgments on the relationships between elements.

Overall, the chosen measurement scales align with the research goals and provide a structured and quantifiable basis for data collection and analysis in both questionnaires.

Table 4. Verbal expressions used in the research and their related fuzzy numbers (Ataei, 2010)

Verbal variables (classical)	Verbal variables (fuzzy)	Fuzzy number
.Very bad	Equal importance	$\tilde{1} = (1, 1, 3)$
Bad	.Almost a little more important	$\tilde{3} = (1, 3, 5)$
Medium	More important	$\tilde{5} = (3, 5, 7)$
Good	.Very important	$\tilde{7} = (5, 7, 9)$
Very good	.Definitely more important	$\tilde{9} = (7, 9, 9)$

7. RESEARCH FINDINGS

7.1. Analysis of Factors Influencing the Selection of New Technologies

To identify the factors influencing the selection of new technologies in automotive component manufacturing companies, respondents were asked to indicate the level of importance for each of the 40 items mentioned in the study by Ansari and Zare [30]. Participants assigned importance scores of 4, 3, 2, 1, and 5 to each item in order to determine their significance.

Table 5. Summary of the results of the criteria questionnaire (research data)

Confirm/reject indicator	Critical limit	Test statistic	Standard deviation	Average	Total number	Benefits					Factors
						5	4	3	2	1	
Confirmation	1/645	9/390	1/080	3/880	133	49	37	32	12	3	The organization's level of knowledge in startup
Confirmation	1/645	6/988	1/166	3/707	133	41	41	28	17	6	The level of knowledge of the organization's employees in operation (user ease of use)
Confirmation	1/645	9/478	1/089	3/934	122	46	38	28	4	6	"The level of managers support for new technologies
Confirmation	1/645	10/285	0/944	3/842	133	37	49	38	7	2	Technology purchase cost
Reject	1/645	-5/315	1/158	2/466	133	5	22	38	33	35	Costs of creating technology implementation infrastructure
Reject	1/645	-7/969	1/164	2/195	133	6	14	27	39	47	Costs of establishing a production line in the country
Reject	1/645	-7/150	1/140	2/293	133	7	12	33	42	39	The cost of human resources to set up the system
Reject	1/645	-8/634	0/964	2/278	133	0	13	46	39	35	User training cost
Reject	1/645	0/442	1/115	3/049	103	7	33	33	18	12	Cost of supporting hardware and software equipment
Confirmation	1/645	3/132	1/191	3/323	133	24	41	31	28	9	Cost of human resources supporting equipment
Reject	1/645	-7/279	1/156	2/271	133	8	10	33	41	41	Future upgrade and development costs
Confirmation	1/645	2/485	1/256	3/271	133	25	38	32	24	14	Return on investment time
Reject	1/645	-3/925	1/281	2/564	133	14	18	29	40	32	Trading costs (orders, broker (.commissions, etc

Confirmation	1/645	2/871	1/238	3/308	133	27	36	32	27	11	No entry ban
Reject	1/645	-3/427	1/214	2/639	133	10	25	32	39	27	Ability to produce domestically
Confirmation	1/645	4/708	1/220	3/500	132	33	36	39	12	12	In-country support capability
Reject	1/645	-3/201	1/165	2/677	133	9	23	42	34	25	Dependency level
Reject	1/645	-7/856	1/104	2/248	133	7	7	38	41	40	Level of advancement and competitiveness
Reject	1/645	-7/750	1/063	2/286	133	5	12	33	49	34	Ability to upgrade and develop in the future
Reject	1/645	-5/649	1/213	2/406	133	6	22	33	31	41	Ability to provide and secure production resources
Confirmation	1/645	5/076	1/281	3/564	133	42	30	33	17	11	Ease of implementation
Reject	1/645	-6/656	1/159	2/331	133	6	14	40	31	42	Speed of implementation
Confirmation	1/645	10/550	0/962	3/880	133	41	46	37	7	2	Quality
Reject	1/645	-7/760	1/117	2/248	133	5	14	31	42	41	Sustainability level
Confirmation	1/645	5/853	1/156	3/586	133	36	37	34	21	5	Impact on quality
Reject	1/645	-6/130	1/075	2/429	133	4	18	39	42	30	Competitors' reaction
Confirmation	1/645	6/363	1/145	3/632	133	35	42	36	12	8	Environmental pollution level
Reject	1/645	-4/420	1/157	2/556	133	9	20	32	47	25	Resource consumption rate
Confirmation	1/645	3/444	1/234	3/368	133	30	33	37	22	11	Material conversion rate
Reject	1/645	-6/680	1/103	2/361	133	3	20	35	39	36	Ease of copying technology
Reject	1/645	-5/538	1/049	2/496	133	7	12	44	47	23	Technology Lifecycle
Confirmation	1/645	4/015	1/188	3/414	133	26	41	41	12	13	The effect of technology on the development of entrepreneurship in industry and the country
Reject	1/645	-8/361	1/099	2/203	133	5	11	33	41	43	The effect of technology on industrial self-reliance
Confirmation	1/645	3/775	1/286	3/421	133	35	30	38	16	14	The potential impact of technology on the future of industry
Reject	1/645	-16/342	0/812	1/850	133	0	4	23	55	51	Reconstruction of technology
Confirmation	1/645	4/120	1/221	3/436	133	30	39	34	19	11	Levels of technological complexity
Reject	1/645	-13/489	0/887	1/978	137	0	7	31	51	48	Production capacity and power
Confirmation	1/645	7/607	1/072	3/707	133	36	44	35	14	4	Tariff and customs policies
support	1/645	3/198	1/274	3/353	133	30	35	34	20	14	Impact on countering sanctions
support	1/645	4/011	1/340	3/466	133	39	33	26	21	14	Hazina Taamirat and Naghadari

7.2. Pairwise Comparisons of Criteria

In this stage, the average opinions of experts are used as the pairwise comparison matrix for the criteria. Each expert compares pairs of criteria, and the average opinions are then reported as the pairwise comparison matrix. In the present study, the questionnaire designed by 19 experts was completed according to Table 4-5. After calculating the mean and standard deviation of the responses and conducting a one-sample t-test for the 40 examined criteria, only 19 criteria remained in the prioritization list of factors influencing the selection of new technologies in automotive component manufacturing.

Table 6. Prioritization of factors (options) affecting the selection of new technologies in automotive parts manufacturing companies (research data)

Abbreviation symbol	Agent title (optional)
D 1	The organization's level of knowledge in startup
D 2	Impact on countering sanctions
D3	In-country support capability
D 4	The effect of technology on the development of entrepreneurship in industry and the country
D5	Tariff and customs policies
D 6	Technology purchase cost
D 7	The level of knowledge of the organization's employees in operation (user ease of use)
D 8	Material conversion rate
D 9	The potential impact of technology on the future of industry
D10	Ease of implementation
D 11	The level of managers' support for new technologies
D 12	Quality
D 13	Levels of technological complexity
D 14	Environmental pollution level
D 15	No entry ban
D 16	Impact on quality
D 17	Return on investment time
D18	Repair and maintenance costs
D 19	Cost of manpower supporting equipment (24×7)

The criteria for technology selection have been categorized, as shown in Table 7:

Table 7.Criteria affecting the selection of new technologies in automotive parts manufacturing companies (research data)

Name	Criteria title	Row
A 1	Technology purchase cost	1
A 2	Cost of supporting human resources	2
A 3	No entry ban	3
A 4	In-country support capability	4
A 5	Ease of implementation	5
A 6	Quality	6
A 7	Impact on quality	7
A 8	Environmental pollution level	8
A 9	Material conversion rate	9
A 10	Levels of technological complexity	10

7.3. Prioritizing options and criteria

Through the formulas in Table 8 and Table 9 , the direct relationship matrixZ can be converted into a normal direct relationship matrix. That is, we calculate the maximum for all rows and columns and then use the above

equation. The incompatibility coefficient was calculated by the software as 0.01. The matrix of pairwise comparison of criteria for each option is given below

Chart No. 3 - Weight of criteria relative to optionD 2

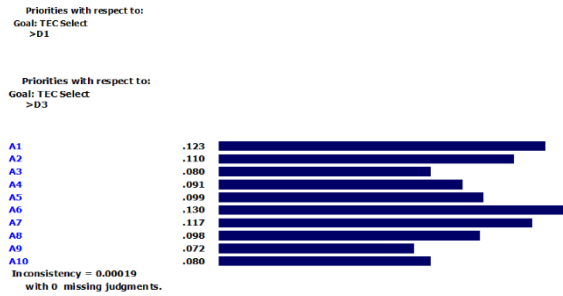


Chart No. 2 - Weight of criteria relative to option D 1

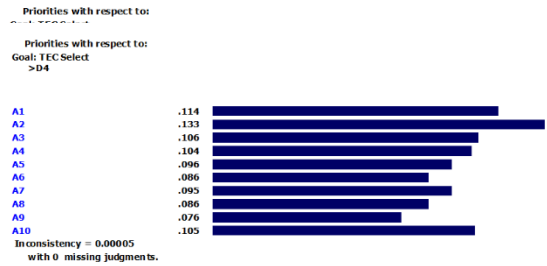


Chart No. 5 - Weight of criteria relative to optionD 4

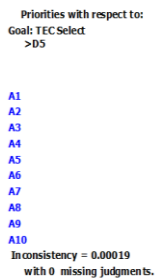


Chart No. 4 - Weight of criteria relative to optionD 3

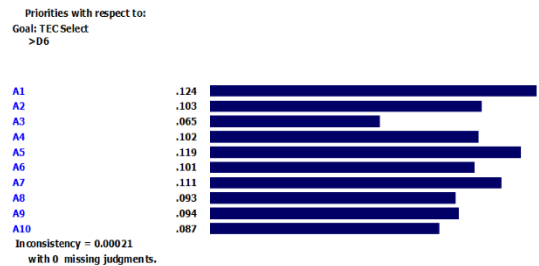


Chart No. 7 - Weight of criteria relative to optionD 6

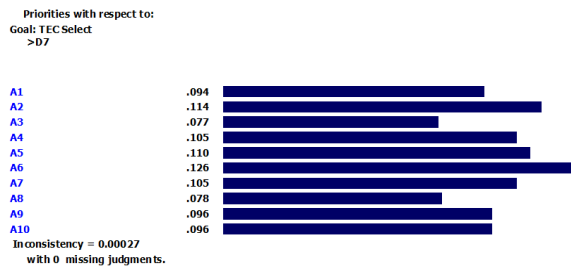


Chart No. 6 - Weight of criteria relative to optionD 5



Chart No. 9 - Weight of criteria relative to optionD 8

Chart No. 8 - Weight of criteria relative to optionD 7

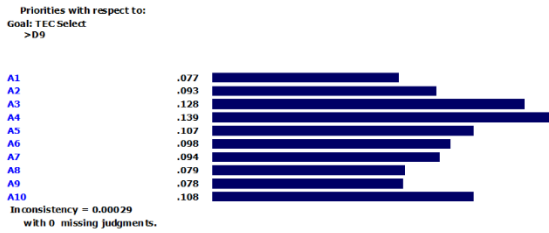


Chart No. 11 - Weight of criteria relative to optionD 10

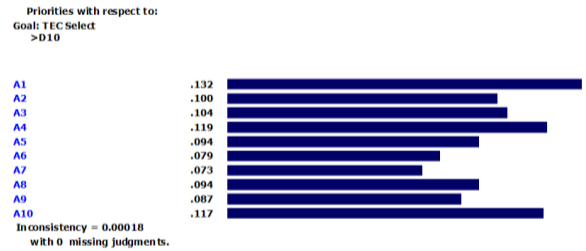


Chart No. 10 - Weight of criteria relative to optionD 9

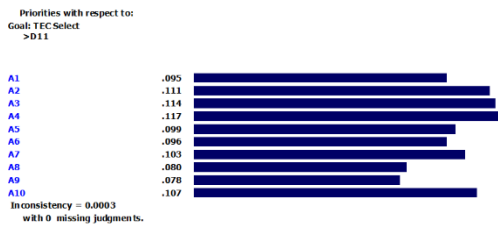


Chart No. 13 - Weight of criteria relative to optionD 12

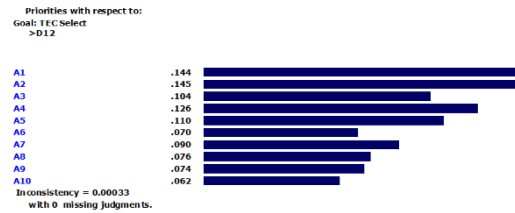


Chart No. 12 - Weight of criteria relative to optionD 11

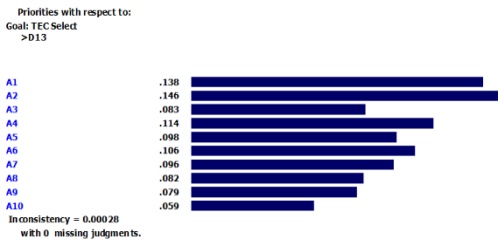


Chart No. 15 - Weight of criteria relative to optionD 14

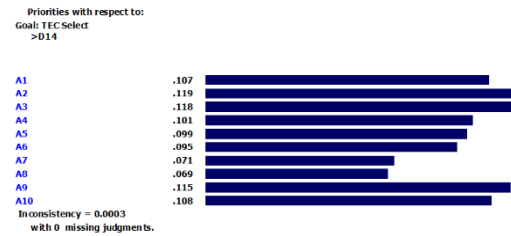


Chart No. 14 - Weight of criteria relative to optionD 13

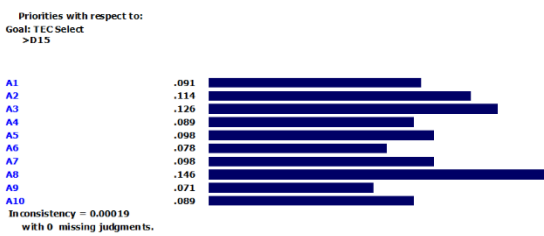


Chart No. 17 - Weight of criteria relative to optionD 16

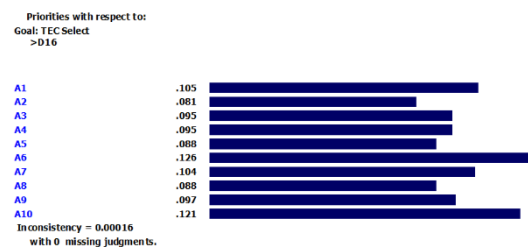


Chart No. 16 - Weight of criteria relative to optionD 15

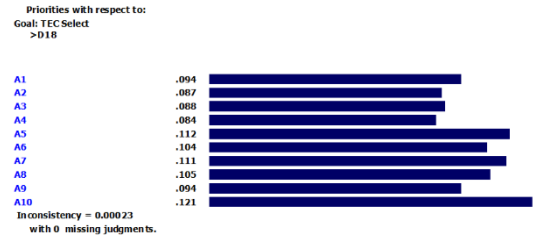
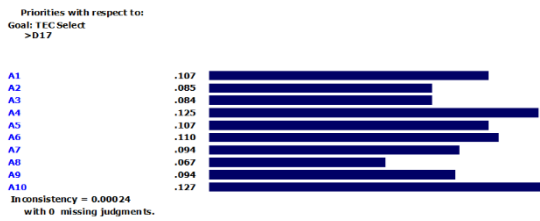


Chart No. 19 - Weight of criteria relative to optionD 18 Chart No. 18 - Weight of criteria relative to

	Ideal mode	Pairwise	Pairwise	Pairwise	Pairwise	Pairwise	Pairwise	Pairwise	Pairwise	Pairwise	Pairwise	Pairwise	Pairwise	Pairwise	Pairwise	Pairwise	Pairwise	Pairwise	Pairwise	Pairwise
AID	Alternative	D1 (L: .054)	D2 (L: .049)	D3 (L: .056)	D4 (L: .026)	D5 (L: .052)	D6 (L: .055)	D7 (L: .027)	D8 (L: .065)	D9 (L: .012)	D10 (L: .074)	D11 (L: .024)	D12 (L: .079)	D13 (L: .083)	D14 (L: .079)	D15 (L: .064)	D16 (L: .067)	D17 (L: .035)	D18 (L: .039)	D19 (L: .058)
A1	<input checked="" type="checkbox"/> A1	.900	.913	.945	.861	1.000	1.000	.743	.756	.551	1.000	.816	.991	.946	.901	.626	.830	.843	.776	1.000
A2	<input checked="" type="checkbox"/> A2	1.000	.925	.845	1.000	.822	.830	.902	.981	.665	.756	.955	1.000	1.000	.784	.645	.673	.716	.697	
A3	<input checked="" type="checkbox"/> A3	.900	1.000	.615	.798	.763	.519	.607	.669	.918	.790	.982	.715	.567	.991	.863	.753	.666	.730	.745
A4	<input checked="" type="checkbox"/> A4	.982	.676	.697	.783	.831	.818	.829	.757	1.000	.902	1.000	.871	.786	.849	.615	.752	.988	.698	.836
A5	<input checked="" type="checkbox"/> A5	.831	.979	.760	.722	.969	.954	.869	1.000	.768	.715	.846	.761	.670	.832	.674	.698	.842	.931	.894
A6	<input checked="" type="checkbox"/> A6	.726	.731	1.000	.646	.817	.812	1.000	.833	.701	.600	.821	.486	.727	.798	.533	1.000	.866	.860	.967
A7	<input checked="" type="checkbox"/> A7	.688	.731	.895	.718	.831	.894	.829	.833	.675	.551	.883	.619	.657	.599	.674	.820	.746	.920	.841
A8	<input checked="" type="checkbox"/> A8	.826	.544	.749	.646	.831	.751	.621	.833	.569	.708	.686	.525	.560	.579	1.000	.697	.526	.872	.457
A9	<input checked="" type="checkbox"/> A9	.578	.345	.556	.575	.627	.757	.759	1.000	.563	.658	.673	.510	.544	.971	.490	.764	.741	.776	.771
A10	<input checked="" type="checkbox"/> A10	.496	.493	.615	.790	.569	.701	.759	.833	.774	.885	.917	.427	.405	.910	.613	.960	1.000	1.000	.376

7.4. Ranking Options Based on FAHP Method

By entering the defuzzified data into the Expert Choice software and analyzing it using the Analytic Hierarchy Process (AHP) method, the priority ranking of the alternative options for automotive polymer component technology is determined as follows :

Model Name: EC

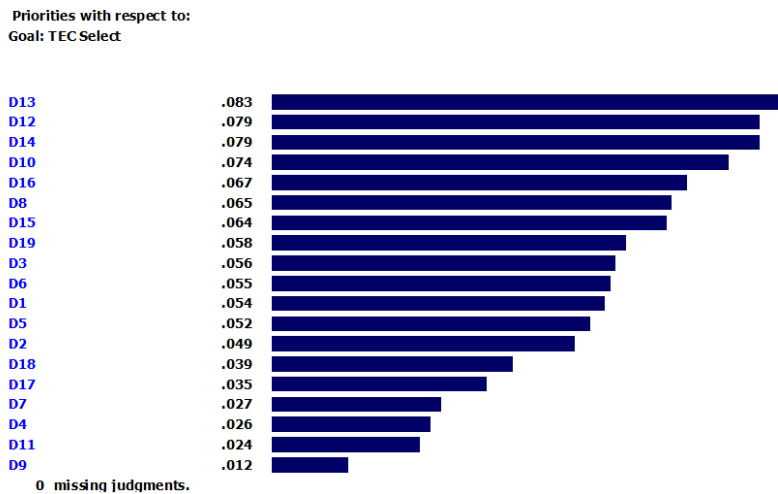


Chart No. 21 - Priority Weight of Options

Considering the results of fuzzy hierarchical analysis presented in Figure (4-24), the top five priorities among the influential factors in choosing innovative technology in the automotive polymer component industry include

technology complexity levels, quality, environmental pollution levels, ease of implementation, and impact on quality.

8. CONCLUSION

Main Question: Which factors are prioritized in the selection of innovative technologies in the automotive polymer component industry?

As determined through the calculation of means, standard deviations of responses, and conducting a one-sample t-test on the 40 examined indices, only 19 factors remained identified in the prioritization list of influential factors in the selection of innovative technologies in automotive component manufacturing. companies.

Table 11 - Prioritization of factors (options) affecting the selection of new technologies in automotive parts manufacturing companies (research data)

Abbreviation symbol	Agent title (optional)
D 1	The organization's level of knowledge in startup
D 2	Impact on countering sanctions
D3	In-country support capability
D 4	The effect of technology on the development of entrepreneurship in industry and the country
D5	Tariff and customs policies
D 6	Technology purchase cost
D 7	The level of knowledge of the organization's employees in operation (user ease of use)
D 8	Material conversion rate
D 9	The potential impact of technology on the future of industry
D10	Ease of implementation
D 11	The level of managers' support for new technologies
D 12	Quality
D 13	Levels of technological complexity
D 14	Environmental pollution level
D 15	No entry ban
D 16	Impact on quality
D 17	Return on investment time
D18	Repair and maintenance costs
D 19	Cost of manpower supporting equipment (24×7)

Second Question: What is the weight and importance of each factor influencing the selection of new technologies in the automotive polymer component industry? (What is the priority of each?)

After performing the calculations in the fuzzy hierarchical analysis process, the weight and importance of each factor are presented in Table No. 12.

Table 12 - Ranking of each factor affecting the selection of new technologies in the automotive polymer parts industry

Weight	Rank	Agent title (optional)	Abbreviation symbol
0/083	1	Levels of technological complexity	D 13
0/079	2	Quality	D 12
0/079	3	Environmental pollution level	D 14
0/074	4	Ease of implementation	D10
0/067	5	Impact on quality	D 16
0/065	6	Material conversion rate	D 8
0/064	7	No entry ban	D 15
0/058	8	Cost of manpower supporting equipment (24×7)	D 19
0/056	9	In-country support capability	D3
0/055	10	Technology purchase cost	D 6
0/054	11	The organization's level of knowledge in startup	D 1

0/052	12	Tariff and customs policies	D5
0/049	13	Impact on countering sanctions	D 2
0/039	14	Repair and maintenance costs	D18
0/035	15	Return on investment time	D 17
0/027	16	The level of knowledge of the organization's employees in operation (user ease of use)	D 7
0/026	17	The effect of technology on the development of entrepreneurship in industry and the country	D 4
0/024	18	The level of managers' support for new technologies	D 11
0/012	19	The potential impact of technology on the future of industry	D 9

(Source: Research data)

Transparency Statement

The data supporting this study are available upon reasonable request to the corresponding author, subject to ethical and confidentiality considerations.

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Declaration of Interest

The authors declare that they have no competing interests.

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