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Explanation of Digital Equipment Model and Process Technology in Downstream Petrochemical Industrial Units

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Abstract

Purpose: Technology plays an essential role in any country to achieve sustainable development. Choosing appropriate and advanced technology is one of the strategic decisions of industrial managers. This research discusses the critical factors that should be considered in the process of choosing new technologies based on the competitive mechanism, and accordingly, designs and explains the technology selection model for equipping downstream petrochemical industrial units to create a competitive advantage.

Method: The research method is an applied one and in terms of data type, it is a partly qualitative and quantitative research. In the quantitative phase, research data was collected based on the data obtained from the qualitative phase, and using the questionnaire tool. The research data was analyzed using thematic analysis and MaxQda software in the qualitative phase and they were also analyzed using

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the TOPSIS technique and meta-heuristic algorithm in the quantitative phase for modeling.
Findings: Thirty-four concepts and five categories were identified as technology selection criteria for equipping downstream petrochemical industrial units to create a competitive advantage. The "technical criteria" factor was identified as the foremost priority in equipping downstream petrochemical industrial units to create a competitive advantage. The ranking of the determined categories from one to five were the factors of competitive criteria, strategic criteria, internal criteria, and external criteria, respectively.
Conclusion: Finally, using the TOPSIS fuzzy technique, the model of equipping industrial units was presented to help decision-makers and policy makers of downstream petrochemical industries.

Keywords: Technology, Downstream Industrial Units, Petrochemical, Competitive Advantage.

1. Introduction

Technology is a highly essential part of human life today and is one of the most important factors in the production of goods and services. Technology creates a competitive advantage for industrial units, which is the determining factor of performance. This superiority depends on the resources with which an industrial unit can maintain its productivity advantage. As a result, leading industries tend to focus on resources from which they can take advantage and this opportunity leads to maintaining performance superiority against competitors and their superior position in the respective industries (Zhenhua, G. & Yao, S, 2015). In this regard, advanced technologies are one of the important sources of success in industries that tend to be present in the global arena. Therefore, developing countries such as Iran, which lack many technologies, have two ways. One is to reinvent everything and the second is to introduce new technology. Obviously, the second solution is much more reasonable and less expensive. In today's business environment with intense competition, industries that want to excel in their respective sectors must create appropriate capabilities to gain and maintain a competitive advantage. In this regard, choosing technology to create capabilities helps industrial units to have superior performance in the market (Appiah-Adu K, Okpattah & Djokoto, 2016). In the current competitive market, business succeeds or survives only when industrial units are capable of competitive advantage and must constantly upgrade technological strategies to improve uptime and performance. (Oshri, I., Kotlarsky, J., & Willcocks, L. P., 2015).

The choice of technology is an important decision to achieve a competitive advantage among competitors. Organizations must select the proper technology, or discover a low-cost way to conduct operations or work with the latest technical innovations. Maintaining a competitive advantage in a high-tech industry requires continuous updating of existing technologies and the development of new technologies. In addition, the appropriate selection and development of technology asset countries to create very competitive advantages in the present chaotic world. (Akhundzadeh M, Shirazi B, 2016).

The selection of technology is a multiple decision influenced by the profitability of the industry or country. The organization should invest in the most suitable technological choices among all the choices according to several economic, technological, and social criteria

(Shen, Y.C., Chang, S.H., Lin, G.T.R., Yu, H.C., 2010). In this regard, companies make many decisions every day to remain in a competitive and dynamic environment. In downstream industries, optimization decisions are constantly being made and are becoming more complex with current technological advances. The reason for the increase in this complexity can be attributed to the growth in the number of desired variables (D. Fogel, 2000). Therefore, providing a technology selection model allows the decision-makers of this industry to adopt a competitive advantage in shorter periods. From an academic point of view, these approaches help to develop new or advanced procedures for downstream industries (E.G. Talbi, 2009).

Furthermore, it should be considered to increase the capabilities and abilities of designing, procurement, and manufacturing industrial equipment and machinery and their optimal selection to improve the level of competitiveness of the country's downstream industries and develop technological capabilities, transfer the fulcrum of relative advantages from raw materials to technological capabilities, create competitive advantages and diversify the industrial export base and increase the share of products with more processing in the export of processing industries.

Therefore, providing the technology selection model and knowledge of the technology situation in the country and determining the difference and gap between the technology of this industry and the optimal model of superior technologies provided the necessary background for planning this research in the petrochemical industry. For this purpose, the current research aims to answer the following question. ‘ what is the optimal model for digital equipment and application of process technology in downstream petrochemical industrial units?’

2-Research literature

To access the research literature, foreign and domestic databases were searched, such as Google Scholar, Emerald, Science Direct, Springer, ProQuest, etc.; the National Library of Iran, Noormagz, Magiran, comprehensive humanities portal, Irandoc, the digital library of Allameh Tabatabai University, etc. The search results showed that few studies have been conducted on the topic of the current research and there is an obvious study gap in the field of digital equipment and application of process technology in downstream petrochemical industrial units in the country. First, we examine some key terms related to the subject, and then we refer to some related research.

Process technologies refer to those technologies that are used to realize key functions and activities of a process in the form of manufacturing and production systems. The described technologies play a role during the processes of making the final product or providing the service, and the customer/consumer does not see them and as a result, does not demand them. These technologies are located in the processes and production systems of companies. There are cases when technology is considered a product from the company's viewpoint, while the same technology is considered a process technology from another company's viewpoint.

For example, a lathe is considered a process technology for a machine manufacturing company, and it is considered a process technology for an automobile company using that machine to produce another product. (2013, Stock & Tatikonda).

Petrochemical downstream industries are divided into upstream and downstream in the general classification. Upstream industries produce basic petrochemical products such as methanol, ethylene, polyethylene, and polyvinyl chloride. While the downstream industries take their raw materials directly from the upstream petrochemical industries and in most cases they deliver their products to consumer industries. For example, we can mention the polyethylene pipes production industry (Strategic Studies of Petrochemical Industries, 2014). Preparation of raw materials such as naphtha, propane, ethane, and methane as feed for basic units to prepare materials such as ethylene, propylene, gasoline, and toluene is one of the most important tasks of upstream units. In these units, saturated or unsaturated light linear cyclic hydrocarbons present in crude oil or natural gas are separated. These units, such as refineries, factories for the separation of gas from crude oil, and factories for the separation of light petroleum liquids from natural gases, may be built in the vicinity or far from other petrochemical units. These units, such as refineries, factories for the separation of gas from crude oil, and factories for the separation of light petroleum liquids from natural gases, may be built in the vicinity or far from other petrochemical units.

Converting the final products into commodity and consumer products that the general public is in direct contact with is the responsibility of the lower-level units. Factories producing synthetic and textile fibers, industrial oils, paints, protective coatings, poisons, pesticides, sanitary detergents and chemical fertilizers, plastic containers, rubber parts, sports equipment, toys, and all kinds of clothes are considered such units. These units are sometimes built next to petrochemical industries and mostly in cities near and far from the final units next to the consumer market. In the chain of petrochemical products, the final products act as input feed for these units (Bosari, 2019).

The term **competitive advantage** was popularized by Porter. The idea of competitive advantage is basically to measure the success of the company compared to its competitors. Relative success can be determined by the "economic value" that the firm can generate.

This economic value refers to the differences between the perceived benefits of buyers and the economic cost of the organization through the provision of products and services. Since competitive advantage focuses on describing the company's relative success, the company does not need to be the best player in the industry to gain a competitive advantage (Ong, J.W., Ismail, H.B, 2008). A company has a competitive advantage when it acquires specific resources and capabilities that are unique and difficult to imitate and when it can provide services to the market that provide more value to its customers than competitors (Navarro, A., Losada, F., Ruzo, E., Dı´ez, J.A, 2010).

Song, Park, and Soo Park (2018) studied the factors influencing business decisions in the field of R & D marketing when technology is transferred from GRI public research institutions to SMEs. They selected 353 SMEs that carried out technology transfer. The dependent variable is whether the intention to transfer technology causes the pursuit of international marketing licenses. Independent variables, divided into previous factors and subsequent factors, include the participation of SMEs in international marketing, the level of readiness for technology, dependence on existing technologies, and the share of sales revenue and upgrading existing technologies. The results of the study show that existing technologies have a positive effect on international marketing experiences. However, contrary to our expectation, the share of income in sales, the participation of SMEs in international marketing, the level of technological readiness, the connection with existing technologies, and the transferred technology did not affect the pursuit of a license for international marketing.

Scanlan (2017) studied the ability of SMEs in technology transfer in terms of innovation. This study provides a review of the works reviewed on the impact of technology transfer in SMEs and the existing barriers to achieving technology transfer. This study concluded that there are characteristics such as building personal relationships and communication that allow SMEs to overcome these barriers and contribute to the success of the company's technology transfer. This paper expands on the study of technology transfer based on innovation theory in SMEs by providing more insight into how to create environments that facilitate technology transfer.

Zaichenko (2018) examined science-based technology transfer by RTO research and technology organizations whose mission is to integrate R&D and develop internal technology for industrial application. This paper is based on a unique database of Russian RTOs that relates their scientific activity to technology transfer performance. The results show that there is a positive relationship between the scientific publication of RTO and technology transfer activity. In addition, science-based outputs are often supported by researchers who have attended RTO universities.

In 2018, Gong and Li conducted a research entitled ‘optimization of petrochemical product logistics system problem with PSO method’. The results of the research showed that the production modeling was done in the form of non-linear planning for cost minimization and optimization using a particle swarm in search of the solution space to optimize distribution decisions and the amount of supply.

Research method

The current research is an applied one and it is a partly qualitative and quantitative research. First, using the interview tool in the qualitative phase, and based on the data obtained from it in the quantitative stage the researcher collected research data using the questionnaire tool. In this research, 8 specialists and experts were selected in various sectors of the university, industry, and government with working experience in downstream petrochemical companies and experts in the field of technology selection and competitive advantage in the petrochemical industry, as focal members by sampling method. Table 1 shows the characteristics of the participants in the focus group meeting.

Table 1 - Details of the participants in the focus group meeting

No.	Organizational position	Specialty	Company	Tasks related to technology selection
1	Director of the strategy formulation	Technology strategy	Hengam Petrochemical Complex	Formulating the strategy of petrochemical companies' technologies
2	Technology management	Technology strategy	Arya Sasol Polymer Petrochemical Complex	Formulating the strategy of product and process technologies
3	Head of technical and technology services		Arya Sasol Polymer Petrochemical Complex	Product and technology engineering
4	CEO of Petrochemical Research and Technology Company	Process design	Petrochemical research and technology	Design of product development processes, design of technology management processes
5	Head of Commercialization of Petrochemical Research and Technology Company	Product and technology engineering, commercialization	Polymer technology growth center	Defining product specifications, designing manufacturing processes, installing production lines
6	Director of planning and development	Polymer marketing and operations	Polymer and Petrochemical Research Institute of Iran	Head of information resources and analysis
7	Vice President of Petrochemical Complementary Industries Development	Marketing and operation of downstream petrochemical products	Petroshemiran Petrochemical Complex	supervisor of process engineering supervision. and engineering estimate
8	Head of Development Vice President	Design engineering support, systems affairs	Amirkabir, Farabi	Head of technical systems design

The quantitative statistical population of the research was made up of professionals, specialists, and experts in the field of technology selection and competitive advantage in the petrochemical industry, all employees and managers with expertise and experience in technology selection in downstream petrochemical industries. The statistical population was selected based on criteria such as knowledge and practical experience in the field of technology selection and competitive advantage.

The research was conducted in the qualitative phase using grounded theory and thematic analysis of interviews with a thematic analysis approach and finally, the final model was presented. The grounded theory requires the use of several stages of information gathering, refining, and examining the relationships between information categories. Data analysis was done according to the grounded theory method, during three stages of coding. The first step was to find conceptual categories in the data at a basic level of abstraction. The second step is to find connections between these categories, and the third step is to conceptualize and report these connections at a higher level of abstraction. Therefore, triple coding, i.e., open coding, categorical coding, and selective coding was done at the core of the analysis of the context theory, and it was implemented and executed in MaxQda software. During the selective coding and integration process, the text of the conducted interviews was examined several times, and the expressions and ideas that expressed the relationships between the main and subcategories were taken into consideration. Accordingly, the relationships between the main categories of competitive and strategic criteria of technology and technical infrastructure and the paradigm model of digital equipment and application of process technology in downstream petrochemical industrial units were constructed.

Data analysis method

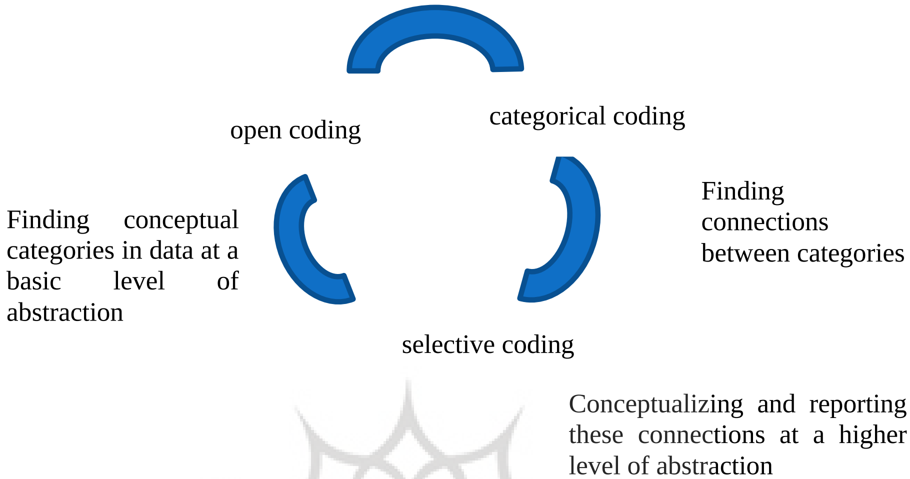


Figure 1: General diagram of data analysis method in grounded theory method.

In the quantitative stage, to determine the importance and prioritization of the factors identified in the selection of technology to reach the optimal model, a questionnaire was designed containing various technical, strategic, competitive factors, etc. based on the 5-point Likert scale. The questionnaire was distributed among the research population and completed by experts, consultants, managers, and assistants working in downstream petrochemical complexes and units. The data was analyzed in the quantitative stage using the fuzzy TOPSIS technique for modeling purposes.

Research findings

Findings of the qualitative section

In order to identify indicators of technology selection for competitive advantage in downstream petrochemical industries, these factors were collected through a qualitative survey of experts, consultants, managers, and assistants working in petrochemical complexes in downstream petrochemical industries. With the "thematic analysis" strategy, 34 concepts were identified and classified into five categories during three stages of coding, i.e., open coding, categorical coding, and selective coding. These categories can be seen in table 2.

Table 2. Selective coding

No.	Concept	category	Number of related concepts
1	(S1) Increasing the company's technological competence	Strategic criteria for technology selection	7
2	(S2) creating the potential for production expansion		
3	(S3) Increasing the reputation of the company		
4	(S4) Creation of synergies with existing operations		
5	(T1) The current stage of the technology life cycle and subsequent technologies		
6	(T2) stage of the product life cycle	Technical criteria for technology selection	30
7	(T3) Probability of technical success and suitability of the site for applying technology		
8	(T4) The history of the technology owner in the industry and its technological competencies		
9	(T5) environment and work safety (use of high temperature and pressure):		
10	(T6) Suitability of raw materials (feed)		
11	(T7) Aspects of transportation of raw materials		
12	(T8) Energy intensity used in technology		
13	(T9) Other process facilities such as air		
14	(T10) Related design and layout		
15	(T11) Scale factors in capacity change		
16	(T12) Life and length of operation of the equipment		
17	(T13) Maintenance and repairs (overhaul periods and return to production):		
18	(I1): Matching the company's resources and its level of sourcing		
19	(I2) Skill level and number of personnel required		
20	(I3) Financial risks	Internal criteria for technology selection	19
21	(I4): Supply responsibilities in the financial and international sectors		
22	(I5) Education of technology owners and		

No.	Concept	category	Number of related concepts
	how to improve national skill levels		
23	(C1) Increasing the company's competitiveness		
24	Criterion 2 (C2) costs and benefits resulting from technology implementation		
25	Criterion 3 (C3) Support of research activities by the technology owner	Competitive criteria for technology selection	15
26	Criterion 4 (C4): Access to the technology owner's latest process/product design improvements		
27	Criterion 5 (C5) product sales in different national and international markets and its benefits		
28	Criterion 1 (E1) Ability to meet current and future legal requirements		
29	Criterion 2 (E2) meeting national and international requirements and standards of similar products		
30	Criterion 3 (E3) effects on the environment (such as society, pollution, etc.)		
31	Criterion 4 (E4) Government policies in legal frameworks	External criteria for technology selection	21
32	Criterion 5 (E5) of the country's economic and political conditions (the presence of sanctions, etc.):		
33	Criterion 6 (E6) the effects of global trends (such as economic crises, etc.)		
34	Criterion 7 (E7) Risk potential (explosions, leakage of toxic substances, etc.)		

As It can be seen in Table 2, after coding and analyzing the data extracted from the interviews, the researcher classified the data into five categories. The data was classified into the first category, the strategic factor of technology selection, in 4 criteria; based on the technical criteria, technology selection was classified into 13 criteria; the internal category of technology selection was classified into 5 criteria; the internal category of technology selection was classified into 5 criteria, and the external criterion was categorized into 7 criteria.

Findings of the quantitative section

In the quantitative part of the research, data was collected through a questionnaire in order to determine the importance and prioritization of the factors identified in the selection of technology to reach the optimal model scenarios. The research findings led to the identification of technology selection indicators for competitive advantage in downstream petrochemical industries, and the prioritization of technology selection indicators for competitive advantage in downstream petrochemical industries to achieve technology selection scenarios. The TOPSIS technique was used to prioritize technology selection indicators for competitive advantage in downstream petrochemical industries. First, the decision matrix was formed and then normalized. A normalized weighted matrix was prepared and a positive ideal (A^+) and a negative ideal (A^-) were calculated for each index. To calculate the relative closeness of each option to the ideal solution, the Euclidean distance of each option from the positive and negative ideal was calculated with the following formula:

$$d_i^+ = \sqrt{\sum_i^n = 1^{(vij - v_j^+)^2}}$$

$$d_i^- = \sqrt{\sum_i^n = 1^{(vij - v_j^-)^2}}$$

And in the final step, the relative closeness of each option to the ideal solution was calculated. For this, the following formula was used:

$CLi = d^-_i / d^-_i - + d^+_j$

The value of CL is between zero and one. The closer this value is to one, the greater is the impact that the factor has on the success of technology selection indicators for competitive advantage in downstream petrochemical industries. These values and the rank of each factor related to the indicator are shown in Table 3.

Table 3. Determining the rank of indicators

No.	Concept	D+	D-	CL	Rank
1	(S1) Increasing the company's technological digital competence	0.0051	0.0283	0.8475	1
2	(T5) environment and work safety (use of high temperature and pressure):	0.0069	0.0280	0.8020	2

No.	Concept	D+	D-	CL	Rank
3	(T2) stage of the product life cycle	0.0070	0.0267	0.7923	3
4	(S4) Creation of synergies with existing operations	0.0075	0.0263	0.7782	4
5	(T10) Related design and layout	0.0083	0.0250	0.7498	5
6	(S3) Increasing the reputation of the company's electronic space	0.0101	0.0251	0.7122	6
7	(T3) Probability of technical success and suitability of the site for applying technology	0.0119	0.255	0.6822	7
8	(T13) maintenance and repairs (maintenance periods and return to production)	0.112	0.234	0.6760	8
9	(S2) creating the potential for production expansion	0.0113	0.0235	0.6755	9
10	(I4): Supplying responsibilities in the financial and international sectors using digital	0.0103	0.0213	0.6738	10
11	(T7) Aspects of transportation of raw materials	0.0113	0.0218	0.6586	11
12	(T12) Life and length of operation of the equipment	0.0135	0.0234	0.6343	12
13	(T9) Other process facilities such as air	0.0131	0.0221	0.6289	13
14	(I3) Financial risks	0.0144	0.0234	0.6183	14
15	(T11) Scale factors in capacity change	0.0136	0.0221	0.6182	15
16	(T8) Energy intensity used in technology	0.0137	0.0216	0.6110	16
17	(T1) The current stage of the technology life cycle and subsequent technologies	0.0138	0.0217	0.6104	17
18	(I1): Matching the company's resources and its level of sourcing	0.0140	0.0217	0.6080	18
19	(I2) Skill level and number of personnel required	0.0137	0.0211	0.6062	19
20	(T4) The history of the technology owner in the industry and its technological competencies	0.0152	0.0205	0.5745	20
21	(T6) Suitability of raw materials (feed)	0.0158	0.0208	0.5684	21
22	Criterion 3 (C3) Support of research activities by the technology owner	0.0150	0.0191	0.5593	22
23	(C1) Increasing the company's competitiveness	0.0152	0.0186	0.5506	23
24	Criterion 5 (E5) economic and political conditions of the country (presence of sanctions)	0.0161	0.0191	0.5423	24
25	(I5) Education of technology owners and how to improve national skill levels	0.0185	0.217	0.5396	25

No.	Concept	D+	D-	CL	Rank
26	Criterion 3 (E3) effects on the environment (such as society, pollution)	0.192	0.219	0.5327	26
27	Criterion 5 (C5) product sales in different national and international markets and its benefits	0.0163	0.0183	0.5290	27
28	Criterion 1 (E1) Ability to meet current and future legal requirements	0.0194	0.0211	0.5201	28
29	Criterion 6 (E6) Effects of global trends (economic crises)	0.0162	0.0175	0.5196	29
30	Criterion 2 (C2) costs and benefits resulting from technology implementation	0.0167	0.0167	0.4995	30
31	Criterion 7 (E7) Risk potential (explosions, leakage of toxic substances)	0.0174	0.0174	0.4947	31
32	Criterion 4 (C4): Access to the technology owner's latest process/product design improvements	0.0177	0.0172	0.4917	32
33	Criterion 2 (E2) meeting national and international requirements and standards of similar products	0.0192	0.0166	0.4627	33
34	Criterion 4 (E4) Government policies in legal frameworks	0.0192	0.0158	0.4506	34

After determining the priority of each factor, the researcher also prioritized the defined categories. The prioritization of the mentioned categories is the result of the calculated average CL of the concepts of that category, and the result is shown in Table 4:

Table 4. Ranking of research categories

category	Average CL calculated	rank
Technical criteria	0.66207603	1
Competitive criteria	0.60465599	2
Strategic criteria	0.54571109	3
Internal standards	0.52431814	4
External criteria	0.51962482	5

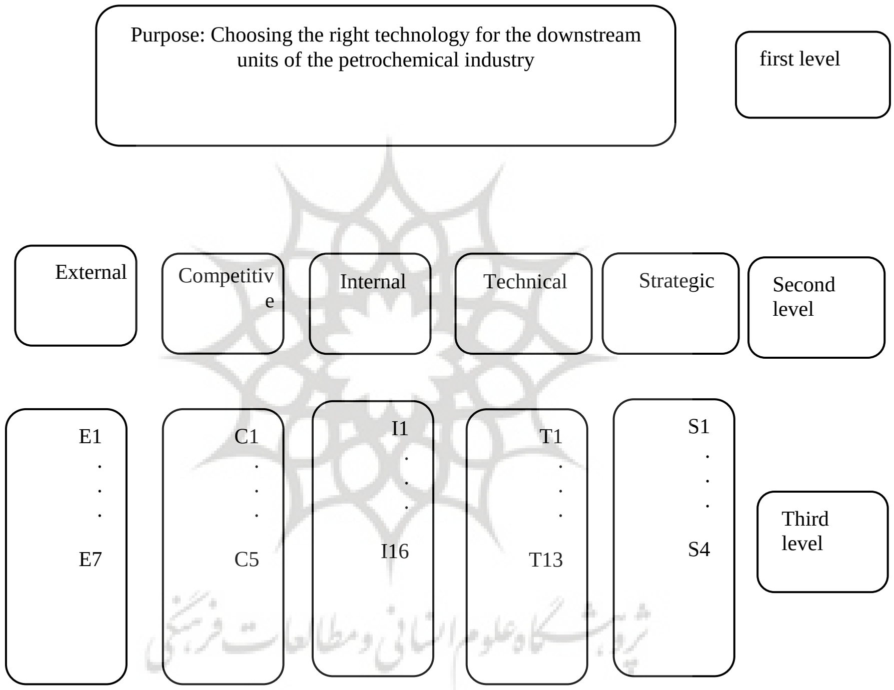
The present research has used the process of fuzzy hierarchical analysis criteria to select the right technology for the pairwise comparison of the indicators of selecting the right technology. This method allows the decision-maker to structure complex problems hierarchically. It also enables a simple and flexible way to analyze options. Therefore, the researcher has considered four levels for his hierarchy:

1) The first level: is the major goal of choosing the right technology for the production of polymer products in the downstream petrochemical units of the country.

2) Level two: which includes the main criteria

3) Level three: which includes the sub-criteria of each of the main criteria.

4) Level four: which includes technology options.



Presumptions in the model

1. Decision-making is a goal-oriented process. However, the researcher believes that individual values play a role in decision makers' judgments.
2. Preferences and perceptions are affected by all the environmental elements and conditions of the decision-making problem.
3. Preferences may change over time, and the elements and organization of the problem may change similarly and it should be updated according to the new conditions.

4. There are linear and chain relationships between different layers of the decision hierarchy for selecting the right technology.

Pairwise comparisons to calculate the relative weight of model criteria

Before doing pairwise comparisons, it is necessary to mention some points. First of all, based on the material presented, the necessary data to perform pairwise comparisons of the respondents to the second questionnaire has been obtained in the form of language variables. Therefore, it has been necessary to convert these linguistic variables into triangular fuzzy numbers. For this purpose, the researcher has considered many methods to convert linguistic terms into fuzzy numbers. But he chose the method that Kim and Park presented in 1990 (Kim and Park, 1990). According to this method, the membership function for linguistic values is as follows:

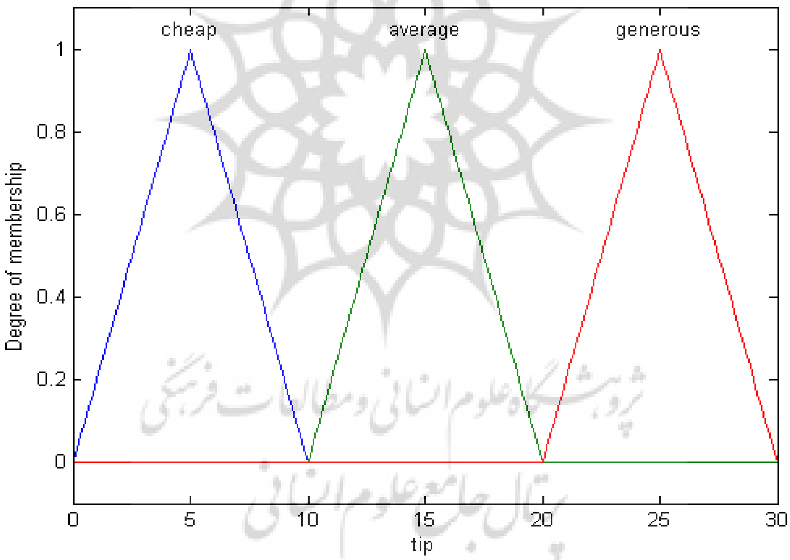


Figure 2 membership function used in the research for linguistic values

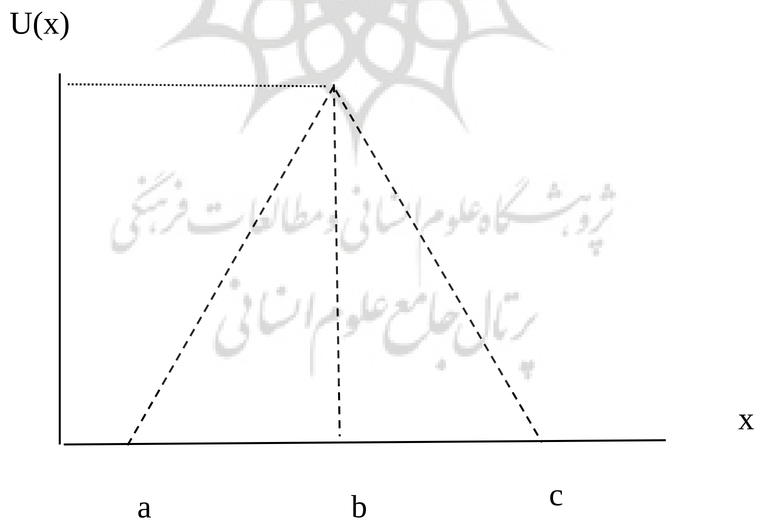
Seconly, the researcher used the geometric mean method to collect the opinion of 7 experts who completed the pairwise comparison questionnaire. Thirdly, the reason for choosing triangular fuzzy numbers was the nature of the criteria that were evaluated by the researcher. Fourthly, the inverse principle of hierarchical analysis prevails in comparison matrices. In this way, for each group of criteria, based on the collected data and their conversion into triangular fuzzy numbers and geometric averaging, these comparison matrices were obtained:

Pairwise comparisons of strategic technology selection criteria

It should be noted that each of the elements above the diameter of the cells in this table is the result of the geometric mean of the opinion of 7 experts who completed the pairwise comparison questionnaire in the main data collection stage. For example, the value of cell S1:S2 is calculated as follows:

Table 5- Pairwise comparisons of strategic technology selection criteria

	A	b	C
S1:S2	1/5	1/3	1
	1/5	1/3	1
	1/5	1/3	1
	1/5	1/3	1
	1/5	1/3	1
	1	1/3	1
	1/5	1/3	1
G.mean	0/25	0/39	1/00



In this step, to calculate the relative weight of each technology selection criterion, Kim and Park's method is used in such a way that first the geometric mean is taken from the values of each row and then it is normalized so that each fuzzy numerical row is equal to the relative weight of each of determined criteria.

Therefore, based on the mentioned method, calculations can be made for 4 strategic criteria of technology selection and the relative weight of each can be calculated in a fuzzy manner.

Table 6- Pairwise comparisons of strategic technology selection criteria

		A	B	C
S1	W1	0.05	0.10	0.26
S2	W2	0.13	0.28	0.67
S3	W3	0.09	0.20	0.52
S4	W4	0.17	0.43	0.80

Pairwise comparisons of technical criteria for technology selection

Based on the same procedure that was mentioned in the case of strategic criteria, the calculations related to technical criteria are done so that finally, these relative weights for technical criteria are determined from the pairwise comparisons made among the technical criteria:

Table 7- Pairwise comparisons of technical criteria for technology selection

		A	**B**	**C**
T1	W1	0.03	0.07	0.20
T2	W2	0.03	0.13	0.34
T3	W3	0.04	0.12	0.31
T4	W4	0.02	0.05	0.16
T5	W5	0.02	0.04	0.15
T6	W6	0.03	0.09	0.25
T7	W7	0.01	0.03	0.11
T8	W8	0.02	0.06	0.19
T9	W9	0.02	0.04	0.14
T10	W10	0.03	0.11	0.32
T11	W11	0.02	0.05	0.19
T12	W12	0.04	0.11	0.28
T13	W13	0.04	0.10	0.24

Based on the same procedure that was mentioned in the case of strategic criteria, the calculations related to internal criteria are done so that finally, from the pairwise comparisons made among the internal criteria, these relative weights for the internal criteria are determined:

Table 8. Pairwise comparisons of competitive technology selection criteria

		A	B	C
I1	W1	0.05	0.13	0.36
I2	W2	0.05	0.11	0.26
I3	W3	0.05	0.12	0.31
I4	W4	0.08	0.024	0.61
I5	W5	0.05	0.16	0.56
I6	W6	0.05	0.12	0.38

Based on the same procedure that was mentioned in the case of strategic criteria, the calculations related to competitive criteria are done so that finally, from the pairwise comparisons made among the competitive criteria, these relative weights for the competitive criteria are determined:

Table 9. Criteria for choosing the right technology in the form of fuzzy numbers

		A	B	C
I1	W1	0.05	0.11	0.29
I2	W2	0.14	0.33	0.70
I3	W3	0.05	0.14	0.40
I4	W4	0.06	0.14	0.38
I5	W5	0.13	0.28	0.54

In this way, the relative weight of all criteria for choosing the appropriate technology was obtained in the form of fuzzy numbers. To rank the company in 5 technology selection criteria, three companies, Eva Polymer Pooya, Electrohydraulican, Pavion Polymer were used. The qualified team of Eva Polymer Pooya, Electrohydraulican, Pavion Polymer includes experienced engineers and professional staff committed to the quality management system with a deep understanding of the knowledge of the equipment and chemicals. The data collected from the experts about the different criteria of these three downstream petrochemical companies were in the form of linguistic variables that the researcher converted into fuzzy values with the help of Kim and Park's membership function. These values are then normalized based on the fuzzy TOPSIS solution method and then multiplied by the relative weights of the criteria, and then based on the fuzzy TOPSIS method, positive and negative ideal solutions are calculated, and then the distance of each option to that path , and the solutions are measured. Then the closeness index is calculated and the options are ranked as follows.

Table 10. Real data related to three companies: Eva Polymer Pooya, Electrohydraulican, Pavion Polymer

	Si+	Si-	Ci+	RANK
Eva Polymer Pooya	1.81	15.56	0.10	1
Electrohydraulican	12.72	3.72	0.77	2
Pavion Polymer	7.15	8.60	0.45	3

Conclusion

In the present study, technology was presented in its industrial form, its main audience being managers and decision-makers in the field of technology selection in downstream units of petrochemical industries. Therefore, we consider technology as a technical tool that can be used for the production of commercial goods. The present study identified 40 primary criteria, which after conducting the pre-test and preliminary questionnaire, were reduced to 35 and divided into 5 groups of criteria. Strategic, technical criteria, internal criteria, competitive criteria, and external criteria were divided. The researcher first studied the technology selection criteria and counted their advantages and disadvantages. To determine the relative importance (weight) of each of his criteria, he chose the method of paired comparisons and went to the experts to prepare the space for solving the model after calculating these values. The researcher has used the combination of TOPSIS methods and hierarchical analysis in the fuzzy space. Because the hierarchical analysis method, as stated in the studies of the theoretical foundations of the research, has good stability when the decision criteria are increased, and the fuzzy TOPSIS method benefits from a strong mathematical proof and provides the possibility of comparison with the ideal.

Then, according to the needs of the industry, the researcher turned to provide an optimal and specialized model and started the modeling process using the particle swarm algorithm. In the end, the researcher put the model built into reality, and by putting real data related to companies that have previously had a history of choosing technology for polymer products, different scenarios were created. Of course, the researcher has tried to include the limitations of technology selection for the downstream petrochemical units of Iran in the form of his study and consider them in the section of external criteria for the selection of technology for the downstream petrochemical units under study.

Conceptualization of advanced technologies of downstream petrochemical units on a large scale, as well as identification of key technologies related to different categories of products of downstream industries and reaching the optimal technology selection model are among the findings of the research. Counting 35 criteria in the selection of technology for downstream units in the country's industry in the field of polymer products in three companies, Eva Polymer Pooya, Electrohydraulican, Pavion Polymer, and identifying the level of attention of industry, government, and university experts to each of the criteria for selecting technology in three downstream companies Petrochemicals (Eva Polymer Pooya, Electrohydraulican, Pavion Polymer) also extracting the relative weight of each of the technology selection criteria for the downstream units of the petrochemical industry based on pairwise comparisons in fuzzy space is another research finding. The presented model based on the real data of three companies, Eva Polymer Pooya, Electrohydraulican, Pavion Polymer, displayed different scenarios.

The downstream industries of petrochemical products in Iran should be considered one of the most important industries. Because, on the one hand, it helps the value chain in the large upstream petrochemical industries, and on the other hand, it engenders many job opportunities in all parts of the country. Due to the high production volume of the petrochemical industry, especially polymers, the downstream industry has grown rapidly to the point where its installed capacity is much greater than the supply of raw materials. Experience has shown that the downstream industries of petrochemicals, such as the polymer industry, are very sensitive to several factors in the domestic market, such as the price of raw materials and their availability. These two seemingly simple factors provide great data regarding production and sales conditions for Iranian products in the domestic market or regional export markets. But the discussion of technology and its related processes is the main part of every industry, especially at the level of petrochemical industries. Appropriateness of technology is a mixture of maximizing the positive effects and minimizing the negative effects of technology for the present and future. In general, it can be said that appropriate technology does not necessarily mean traditional or advanced technology, on large or small scale, the user or capital-intensive, but this suitability is based on goals, environmental factors, facilities, and needs at certain times. Also, the practicality of the plan from the competitive and economic aspects should be taken into consideration.

According to the results obtained from this research, it is suggested:

- Downstream petrochemical companies in the research and technology sector, in cooperation with the Petrochemical Complementary Industries Development Office, try to develop decision-making models in the fields of license selection and upgrade them to the level of a decision support system (DSS).

- they provide a system to monitor the performance of the purchased licenses for 3 years and in a precise way in the management and development department of the downstream companies of the petrochemical industry, so that the accumulation of this data can be used to create patterns and conduct future studies.

- Downstream companies should form an office with the name of technology management in their structure so that technological studies of licenses can be carried out in that office in a specialized manner.

- Efforts should be made to grow the company's technological competence, create the potential to expand production, increase the company's reputation, and create synergy with existing operations as the main priorities of downstream companies in the petrochemical industry.

-the gap between the existing and the desired situation in the stage of adaptation and absorption of advanced technology and especially in the stage of acquisition and selection of technology should be reduced as one of the main priorities of downstream units.

- The technology tree for the production of various downstream products, including plastic, rubber, paint and resin, glue, composite, and detergents, should be drawn at different levels, and in the meantime, based on a correct methodology, key advanced technologies should be identified so that Bachelor's study should be the main focus.

- According to the technical criteria in the selection of technology, that these units should pay more attention to the current stage of the technology life cycle and subsequent technologies, the product life cycle stage, the probability of technical success, and the suitability of the site to apply the technology, the history of the technology in the industry and its technological competences. , environment and safety (use of high temperature and pressure): suitability of raw materials, aspects of raw material transportation, energy intensity used in the technology, other process facilities such as climate, related design, and layout, scale factors in change capacity, life and length of operation of the equipment; Maintenance and repairs (maintenance periods and return to production).

- According to external criteria in the selection of technology, these units should pay more attention to the ability to meet current and future legal requirements, meet national and international requirements and standards of similar products, and effects on the environment (such as society, pollution), government policies in legal frameworks, economic and political conditions of the country (the existence of sanctions): the effects of global trends (such as economic crises) as potential risks (explosions, leakage of toxic substances).

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