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Identification And Prioritization Of Technological Factors In Iran's Pars Petrochemical Company Using THIO Model And Application Of Multi-Criteria Methods

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Abstract:

The Iranian petrochemical industry, as one of the main pillars of the country's economic development, plays a vital role in creating competitive advantages due to its access to abundant resources, a skilled workforce, and regional markets. This industry is highly dependent on technology, which must be given serious consideration. Therefore, in this research, a combined quantitative and qualitative approach was used, employing fuzzy DEMATEL-ANP and AHP techniques, along with the Technology Organization (THIO) model. By identifying and prioritizing the factors affecting technology assessment in Pars Petrochemical Company, the different dimensions of technology, including hardware, humanware, infoware, and orgaware, the Technology Contribution Coefficient (TCC) was calculated. The results showed that the humanware dimension is the main driver of technology in the company, followed by orgaware, hardware, and finally infoware, which are the most influential factors in technology assessment in this company. The final calculated value for the Technology Contribution Coefficient was 0.489, indicating that the petrochemical company is classified at a medium technology level, in which the humanware component plays the most important role. Therefore, the continuity of technology's role in gaining a competitive advantage and higher readiness to improve efficiency and enhance the resilience of this industrial enterprise depends on the company's management commitment to maintaining a skilled and creative workforce, management actions, communications, and improving organizational arrangements, upgrading equipment, improving production methods, suitable physical infrastructure, and ultimately guidelines and process relationships.

Keywords: Technology assessment, THIO model, DEMATEL, ANP, AHP, Multi-Criteria Decision Making (MCDM), Petrochemical industry

-Introduction:

The petrochemical industry, as one of the main downstream sectors of the oil industry, plays a significant role in the economies of countries. In Iran, the petrochemical industry, with the highest rank in creating added value and non-oil exports, holds a special position (Naeimi & Varahrahami, 2023). According to experts, after seventy years of the birth of this industry in Iran, it still has a bright future, and Iran, due to access to the required feedstock, a skilled workforce, and suitable regional markets, has international and regional competitive advantages in this industry. According to existing studies, Iran accounts for 4.2% of global petrochemical production (Shirazi et al., 2023). Currently, 68 petrochemical complexes are operating in Iran, and 70 new development projects are underway. These complexes, with a production capacity of 90 million tons, are expected to reach 200 million tons in the next 10 years, indicating the significant growth of this industry in Iran (Eghtesad news, 2023).

Pars Petrochemical Company was established in 1999 and registered as **Asalouyeh** Petrochemical Company. Its effective activities began in 1999 with the formation of a new board of directors, and every year, based on its performance, it has had a significant share in the total production and export of petrochemical products in Iran. Pars Petrochemical Company is among the active companies in the production of ethane, propane, butane, pentane plus, styrene monomer, ethylbenzene, and toluene benzene in Iran, with a nominal capacity of 4,246 thousand tons per year, ranking first in this industry and petrochemical company in the world (Pars Petrochemical Company, 2022).

From the initial design and during the various stages of material procurement, construction, and operation of this industrial unit, process technology for production lines has been obtained from companies such as Linde of Germany, Polimeri Europa of Italy, and IUI of Germany, and production line machinery and equipment, including compressors, turbines, pumps, C/B exchangers, and control systems, have been obtained from world-renowned technology manufacturers such as Siemens and Linde of Germany, Mitsubishi and Yokogawa of Japan, and General Electric of the United States (Pars Petrochemical Company Technology Management Implementation Method, 2020). Over time, due to sanctions, the severance of relations with foreign companies, and limitations in access to spare parts and specialized training, challenges have arisen that ultimately highlighted the need to use new technologies and to identify and prioritize the factors affecting the existing technology in this industrial complex, which is part of the country's petrochemical industry. Therefore, to strengthen the relative advantage of this industry and have a sustainable success factor and competitive advantage, increase added value, optimally manage the total cost of products, and improve production lines and processes, it is possible to achieve a suitable competitive level at the regional and global levels by developing research and improving and upgrading technology. Experience has shown that companies and countries that have considered technology as an important factor in competition have conducted appropriate research for technology development and, consequently, adopted coherent programs (Gheysarian-Fard, 2021).

Using technology can optimize processes and reduce production costs, which contributes to greater competitiveness in this industry (Dashti & Kordlouie, 2012). Therefore, assessing and identifying the factors affecting it will be very important, as technology assessment provides the opportunity for better management of innovations and strengthening the value chain in the petrochemical downstream industries (Doumani et al., 2020). In the existing research literature, various models and methods have been introduced for this purpose. Given the breadth and diversity of technologies in Pars Petrochemical, we can use the comprehensive Technology Organization (THIO) model, which is used in the petrochemical industry to identify strengths and weaknesses in the use of technologies, using four components: hardware (machinery, ...), humanware (employee capabilities, ...), infoware (documents, ...), and orgaware (systems, ...) to evaluate ourselves. This technique helps companies to: improve their technological capabilities; increase coordination between technology and organizational processes; and ultimately make optimal decisions for investment and technology upgrade. This model considers all dimensions related to technology, including equipment, skills, data, and organization, while many other models only focus on technical aspects (Marlyana et al, 2018).

Therefore, considering the four dimensions of technology in Pars Petrochemical, identifying and prioritizing appropriate criteria to assess the impact of internal factors (strengths and weaknesses) and external factors (opportunities and threats) is the focus of this research. For the first time in this research, by identifying technological priorities and determining operational strategies and plans with the criteria of attractiveness-capability, it will be carried out. Therefore, achieving the most appropriate technology assessment tool will be the main challenge of this study, which requires defining and developing factors and criteria that enable multidimensional and comprehensive evaluation (Jolly, 2012). In this regard, in this research, to identify and prioritize the factors affecting technology assessment in Pars Petrochemical, the different dimensions of technology, hardware, software, infoware, and orgaware, with appropriate criteria for achieving a balanced technology portfolio of Pars Petrochemical, will be measured and evaluated.

-Theoretical Framework:

-Technology:

Numerous definitions have been provided for technology. These definitions can be summarized as follows: "Technology is the application of science, experience, and human skills to meet human needs. Technology is a set of tools, skills, knowledge, and information known as technology components. Not only the absence of one of these components, but also the lack of coordination among them affects the efficiency and effectiveness of technology" (Arabi & Menati, 2009). Technology is one of the key factors in achieving a competitive advantage for an organization (Indriartiningtias et al., 2020). Technology is the knowledge, expertise, and skills required to produce goods or provide services, originating from human intellectual power and understanding of the laws governing nature and combining them (Haines & Sharif, 2006). In simpler terms, technology is the ability to perform work, consisting of both skill and knowledge aspects. Numerous studies have shown that the lack of focus of senior managers on technology and ignoring organizational issues in the application of new technologies, the lack of a correct understanding by senior managers of the interactions between technology and business, and the strategic importance of technology, as well as the lack of appropriate coordination between technology and business objectives, further highlight the shortcomings of traditional technology management (Markus et al., 2017).

-Technology Assessment:

Technology assessment in an organization is a process used to predict and identify the direct or indirect consequences of various technologies on the organization's business. In other words, it examines and evaluates the consequences and effects that various technologies have on the organization and predicts their results and impact. Based on the direct and indirect impacts and the results of the organization's technology level assessment, the necessary goals and policies are determined to improve and enhance the desired outcomes and be in line with the organization's strategies and to minimize the undesirable and non-aligned outcomes with the organization's strategies and manage their negative impacts on the organization's business (Faeghi Farhamand, 2004).

Therefore, based on this, technology capability assessment will be a process in which the level of the organization's technological capabilities and abilities is measured, and by identifying the organization's strengths and weaknesses and areas for improvement, technological capabilities in the organization can be compared with the actual and potential technological capabilities and even the future of competitors, and the ideal level of the industry, and planning and taking action to improve weaknesses (Tabatabaian & Gharibi, 2009). Technology assessment includes activities such as expanding information resources, helping to create long-term policies, being aware of potential harmful technological events and results at the initial stages, encouraging public acceptance and increasing awareness of social responsibility, and expanding knowledge.

-Technological Capability and Models:

Based on the resource-based view, a company's competitive advantage lies in its ability to utilize a combination of tangible and intangible assets (Salisu & Bakar, 2019). Therefore, rare, intangible assets must be valuable, inimitable, and non-substitutable. Protecting and managing these assets leads to desirable performance and, due to the difficulty of imitation by competitors, is a source of creating sustainable value (Madhani, 2010). Therefore, it is clear that a company's intangible assets are created by focusing on technical knowledge and organizational capabilities, and these companies need to develop and strongly utilize what is called "technological capabilities". Thus, technological capability can be defined as a set of resources, abilities, knowledge, structures, institutional links, and the accumulation of past experiences that contribute to the process of producing and managing technological change (Bell, M., & Pavitt 1993); it guides a firm or country towards continuous improvement (sustainable development) in processes, projects, and products and leads to the ability to compete in international markets (Tello-Gamarra, & Fitz-Oliveira, 2021). Effectively improving technological capabilities in firms requires creating an open mind for development in a technological environment, continuous accumulation of valuable knowledge, and the effective use of current technologies (Ahmed et al., 2019). Many models have been presented in the field of technological capabilities, which can be summarized in the following table (Planning and Budget Organization, 1991):

Table 1: Classification of technology capability assessment models

Models for determining the technology gap	Models for evaluating the causes of the technology gap	Models for providing solutions to bridge the technology gap
-Ford Model -Lindsey Model Fall Model Garcia-Aroyo Model -Lean Model -Technology Needs Assessment Model -Science and Technology Management Information Systems Model -Technology Needs Management Model	-Ford Model -Lindsey Model -Technology Atlas Model -Floyd Model -Technology Needs Management Model -Technology Capability Levels Model	-Technology Atlas Model -Porter Model -Panda and Ramanathan Model -Floyd Model -Technology Needs Management Model -Technology Content Assessment Model -Technology Position Assessment Model -Economic Value-Added Model

-Technology portfolio model (THIO) and effective factors in technology evaluation:

In the technology management process, the four dimensions of the technology portfolio (THIO) are simultaneously required and continuously interact with each other. No technology management process can be carried out without one of these components.

- **a. Hardware:** Technology based on objects and equipment, tools, machinery, and physical infrastructure.
- **b. Humanware:** Technology based on human capabilities including knowledge, skills, wisdom, creativity, and experience.
- **c. Infoware:** Hidden and implicit technology including methods, instructions, knowledge, observations, data, and process relationships.
- **d. Orgware:** Technology based on the organization. Includes management actions, communications, and organizational arrangements. The position of each component is determined based on criteria such as the performance and quality specifications of machinery and equipment and their relationship with technical knowledge, the needs for upgrading the level of human technology knowledge, information needs, and performance criteria for organizing and managing organizational software (Antesty et al., 2020, Siregar et al., 2016).

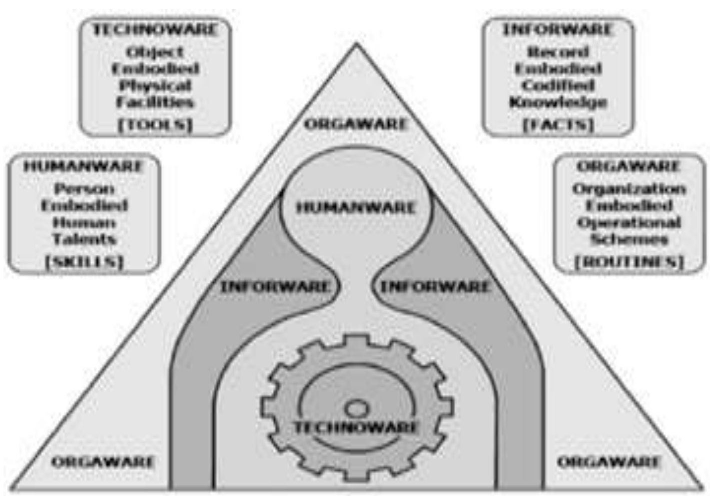

Fig 1. Interaction image of four main components (Smith and Sharif, 2007)

-Research Background:

Numerous related studies have been conducted on technology assessment, some of the most recent of which are mentioned below. Khamseh and Siketkin (2009), in a study aimed at evaluating technological capability levels in the metal industries, concluded that one of the fundamental reasons for the failure of technology adoption to gain a competitive advantage in enterprises in developing countries is the lack of awareness and understanding of the level of technological capabilities of the enterprise and their use for relative advantages. Therefore, in a model with 9 main dimensions, the level of enterprise capability was evaluated and the status of the enterprise was specified in each. Mokhtari and Hooshmandzadeh (2014), in research aimed at evaluating technology, models, and methods, try to examine the concepts and importance of evaluation, areas, approaches, and evaluation methods, and different evaluation models. Finally, they present two examples of technology assessment in the Pura food industry group and Pars Khodro Company to illustrate the application of evaluation methods and the importance of the subject in practice. Habibzadeh et al (2015), in a study aimed at examining the internal organizational factors affecting technological learning in Mobarakeh Steel Company, concluded that the performance of leaders and the appointment of managers with strong strategic goals and training planning have the most significant role. Rashnavadi and Ruhollah (2016), in a study aimed at designing a strategic technology planning model in the Iranian petrochemical industry using the network analysis process, concluded that the presented model is suitable for the petrochemical industry, through which improvement, development, and localization of technology and the production process of olefins and paraffins, polymer nanocomposites, polymeric membranes, and hybrid membrane bioreactors, polyethylene terephthalate, methanol synthesis catalyst, and acetic acid synthesis catalyst have been identified as the technological priorities of the petrochemical industry. Salehi Zaviyeh (2018), in a study aimed at identifying and ranking the risks of the new product development process in the Iranian automotive industry using the combined DEMATEL-ANP method, concluded that for the development of a new product in this company, organizational risk had the highest importance and technical risk had the least importance.

Bitman (2005), aiming at how to manage a research and development portfolio considering the THIO dimensions, emphasizes the use of this model due to its specific characteristics for analyzing and managing research and development project portfolios. The author, using this approach, has examined the various dimensions of technology to identify the strengths and weaknesses of projects. Smith and Sharif (2007), in another study aimed at understanding and utilizing technology assets for global competition, show that according to the THIO model, the four technology components (hardware, humanware, infoware, and orgware) play a key role in creating a competitive advantage. Also, each of these components plays a different role at different stages of the company's life cycle, which can range from competitive differentiation to operational support. Thus, as a technology asset moves from a dominant position to a supporting position, it can also move from a distinctive competence to an operational capability. Ebrahimi (2018), in a study aimed at determining the development strategies of renewable energy technologies in SMEs, using fuzzy DEMATEL and ANP within the framework of SWOT analysis, presented and prioritized technology development strategies in small and medium-sized enterprises active in renewable energies. The results of this research can also be used in the development of similar technologies in petrochemicals and oil. Marlyana et al. (2018), in another study aimed at developing the THIO technology assessment model to THIOCMP, try to develop the THIO model by adding three new components (networking, managementware, and partnershipware). The results of this study showed that these improvements can help increase technological capabilities and competitiveness of industries.

Aghaee et al. (2020), in another study aimed at evaluating technology maintenance strategies in petrochemicals using a combination of fuzzy DEMATEL and ANP methods, evaluated technology maintenance strategies in the petrochemical industry. The final results of this study showed that the "predictive maintenance" strategy is the best method for increasing efficiency and better technology management. In another study (Yulherniwati & Ikhsan, 2020), to assess the readiness of institutions to adopt technology, a technometric model was used to assess the readiness of higher education institutions. The model included four components: hardware, humanware, infoware, and orgware. The results of this study showed that to improve the development of infoware and orgware, there is a need to strengthen human capabilities and organizational leadership. Mozaffari et al. (2021), in a study to evaluate greener petrochemical production technologies, used a two-stage fuzzy DEA model to evaluate sustainable production technologies in the petrochemical industry. The aforementioned model also considered undesirable outputs such as greenhouse gas emissions in the evaluation and proposed a framework for improving efficiency and reducing pollution.

-Research Methodology:

This research is applied in terms of its purpose and descriptive-survey in terms of its implementation method. It seeks to identify and prioritize the factors affecting technology assessment in Pars Petrochemical Company. To collect data, two methods were used: a library method with a note-taking tool to study the literature and a survey method with a tool of interviews and questionnaires to collect the views of experts. The reliability of the questionnaires was also checked with Cronbach's alpha. The statistical population of this research includes all experts and managers specialized in Pars Petrochemical Company, including senior managers, middle managers, supervisors, and members of the research council in the company's technological units, including R&D, technical services, maintenance, operation, HSE, senior management, research and technology, and IT, totaling 24 people. The opinions of all of them were collected through a questionnaire, part of whose questions were based on the United Nations' standard criteria for technology assessment (UNESCAP). To analyze the collected data, three important multi-criteria decision-making (**MCDM**) techniques were used. These methods refer to a set of techniques and models used to solve decision-making problems in the presence of multiple conflicting or synergistic criteria. In these methods, the decision-maker must choose between different options based on a set of criteria. Therefore, the fuzzy Delphi method was used to adjust the criteria, the fuzzy **DEMATEL** technique was used to identify the relationships and influence between the criteria, the fuzzy **ANP** model was used to determine the prioritization and importance coefficients, and finally, the **AHP** method and the Expert Choice software were used to calculate the technology participation coefficient. This research was conducted during the period of December 2021 to September 2022 in the South Pars region, seeking to provide a comprehensive model for technology assessment in Pars Petrochemical Company. The results of this research can be effective in improving decision-making processes in the field of technology in this company.

-Research Findings:

Based on the theoretical framework of the research, initially, 92 factors related to the four dimensions of technology were identified based on the Technology Atlas model and two main criteria of capability and attractiveness through in-depth interviews with experts and a literature review. In the next step, in order to select the most important factors, a questionnaire based on the fuzzy Delphi method was developed and provided to 24 expert sample members. In this questionnaire, which was designed with a 5-point Likert scale, data was collected and after analysis, 24 key factors were identified. In the following, to measure the internal relationships and mutual influence of these selected factors, a second questionnaire was also developed in the form of pairwise comparisons, and the experts' opinions were collected in this regard as well. The validity of the first questionnaire was formally confirmed through interviews with three senior managers in the technology field, and its reliability was confirmed at a high-level using Cronbach's alpha coefficient (**0.945**). To analyze the data of the two questionnaires, a fuzzy range was used and verbal values were converted into fuzzy numbers. Then, using the center of gravity method, the data was defuzzified and the final factors were determined with a threshold coefficient of **0.5**. Finally, the most important influential factors in the components of technology were identified and ranked, providing a solid basis for future analyses.

The initial information obtained from the company's technology management showed that 92 important factors can be identified in the four dimensions of the technology atlas model, including 21 hardware factors, 27 humanware factors, 19 infoware factors, and 25 orgware factors, which are used in the final analyzes in the following stages:

-Fuzzy Delphi results:

In the first stage of the one-step fuzzy Delphi, questionnaire number one, including 92 identified technology factors, was provided to the sample, and they were asked to express their opinions in the form of verbal variables. After summarizing the opinions and fuzzy and defuzzification operations, the results of the fuzzy Delphi calculations and the final 26 selected factors in the dimensions of the technology atlas model are presented in Table 2.

Table 2: Factors affecting the technology level assessment of Pars Petrochemical

status	definite mean (diffuse)	factor/criterion	Code
confirm	0.806	Having advanced equipment and machinery with high technological complexity	CT7
confirm	0.799	The degree of dependence of the company's technologies on external sources	CT8

confirm	0.795	The potential of technology in the progress and improvement of the organization	CT9
confirm	0.736	Up-to-date technologies based on life cycle	CT10
confirm	0.674	Exclusivity of available technologies compared to competitors	CT11
confirm	0.712	Equipment technology level and the difficulty of reverse engineering	CT13
confirm	0.705	Technological infrastructure maintenance and repairs	CT19
confirm	0.701	Ability to use existing equipment	CH2
confirm	0.691	Ability to repair general production units and equipment	CH5
confirm	0.688	The ability of research and development to improve production lines and products	CH7
confirm	0.681	Leadership of the organization in creating motivation in the field of technology management	CH11
confirm	0.681	The value of technology-oriented professionals in the organization	CH17
confirm	0.681	The ability to use the technology of production lines/organizational processes	CH19
confirm	0.677	Creating systemic thinking of organization managers	CH23
confirm	0.663	Having knowledge about the production and operation of existing equipment	CI1
confirm	0.663	Having knowledge of repairs, maintenance and calibration of production lines of units	CI2
confirm	0.649	Having knowledge of research and development and changes in production lines and improving the quality and quantity of current products	CI5
confirm	0.615	Ability to innovate and create changes in the current license to increase capacity and improve product quality	CI7
confirm	0.604	Completeness of information and having ERP	CI11
confirm	0.594	Creation of technology development engineering information system	CI16
confirm	0.587	Maturity of the organization in the field of technologies and organizational process maturity	CO2

confirm	0.587	Maturity of the knowledge management process	CO4
confirm	0.583	Maturity of the change management process in the field of technology	CO5
confirm	0.566	Access, quality and costs of research and development	CO6
confirm	0.576	The level of knowledge of the organization about the required technologies	CO8
confirm	0.545	Technology management deployment and technology gap assessment	CO17

-Determining the intensity of the impact of technology components:

Continuing, considering the large number of identified factors and the complexity of the relationships between them, a more accurate assessment of the factors of the Pars Petrochemical Company's technology atlas model and their mutual impact is done using the combined DEMATEL-ANP method. The mentioned combined approach is a very suitable approach for identifying causal and correlation relationships between various indices, which has been used in many studies (Rao, 2018). Therefore, in this section of the study, by using the DEMATEL method, the interaction between the factors is quantified and the dependency between them is determined, and finally, the complete comparison matrix of pairwise comparisons of DEMATEL is used to form the complete relationship matrix of technology dimensions. Then, in the final stage, the final weights of the technology components and sub-components are determined using the ANP technique. Therefore, after calculating the matrices of the degree of interaction and relationship of each sub-criterion with other sub-criteria, the final results of the intensity of the impact of hardware, humanware, infoware, and orgware sub-criteria were obtained as follows.

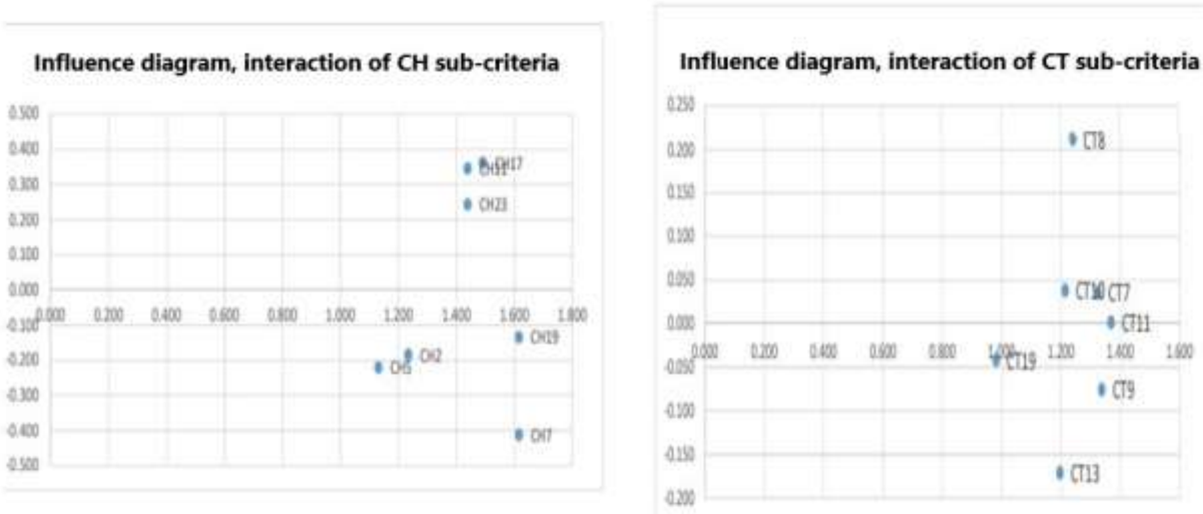

Fig 2: Intensity of impact under Hardware (CT) and Humanware (HC)

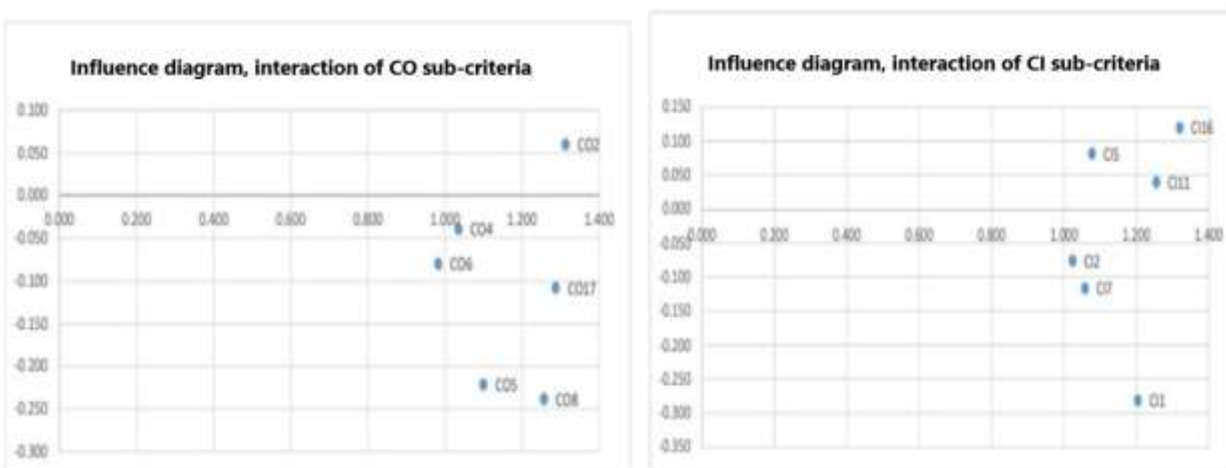

Fig 3: Intensity of impact under Infoware (CI) and Orgware (CO)

- Determining the Complete Relationship of THIO Technology Atlas Dimensions

Due to the complex interactions among the factors of the technology atlas model, relying on the aforementioned method, the complete relationship matrix of THIO is calculated based on the average of the complete relationship matrix of factors (Li et al., 2020). Therefore, after categorizing the arrays related to the sub-criteria of each criterion and calculating the average to form the complete relationship matrix, the following results are obtained:

Table 3: Categorization of the array of sub-criteria of each component and the average for forming

Code	criteria	R	J	R/J	R-J
CT	Techno Ware	0.35293	0.363	0.716	0.010
CH	Human Ware	0.43956	0.370	0.890	0.070
CI	Info Ware	0.39452	0.393	9.780	0.002
CO	Orga Ware	0.37696	0.438	0.815	0.061

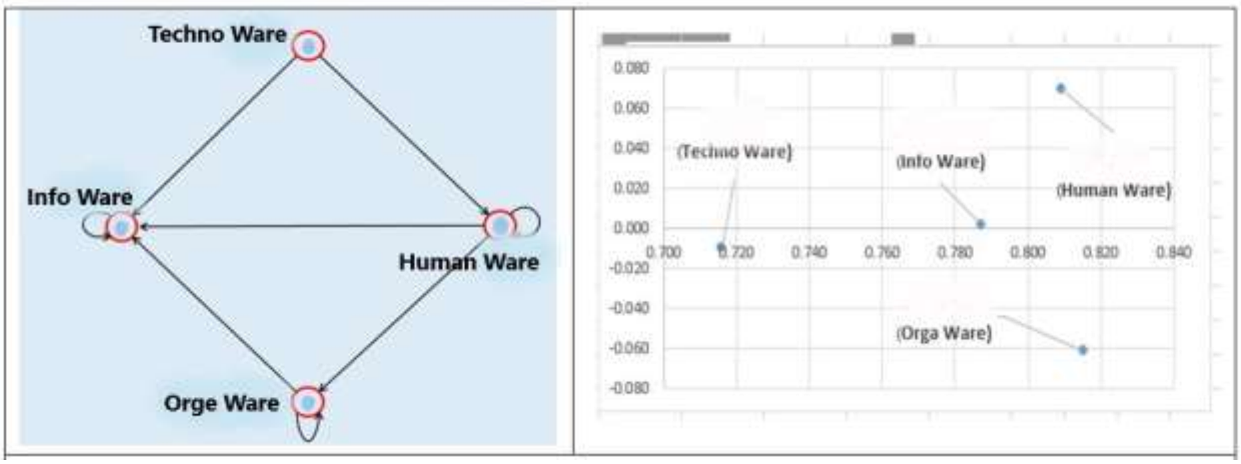

Fig 4: The impact intensity of technology evaluation criteria and the causal relationships between them

-Weights of Technology Dimensions:

At this stage, using the ANP method, by calculating the sub-criteria matrix, the normalized matrix, and the transposed matrix, and forming the unnormalized super matrix (W); the complete relationship matrix T_D of sub-criteria is calculated, through which the final weights of the criteria are obtained. These weights are presented in Table 4 below.

Table 4: Final weights of the four technology dimensions in Pars Petrochemical Company

Code	Dimensions of Pars petrochemical technology	Weights	Present
CT	Techno Ware	0.237	24 %
CH	Human Ware	0.304	30 %
CI	Info Ware	0.215	22 %
CO	Orga Ware	0.242	24 %

Now, based on the obtained results, we can draw a radar chart for these coefficients to compare the four technology components. The radar chart also clearly shows in which technology components this industrial unit is stronger and in which it is weaker. The provided spider chart is a very useful tool for comparing the performance of different business units based on multiple criteria. In this chart, each axis represents one of the technology components (hardware, humanware, infoware, and orgware), and each industrial unit (in this case, we have one industrial unit) is represented by a polygon. The distance of each point from the center of the chart indicates the contribution of that technology component to the respective industrial unit.

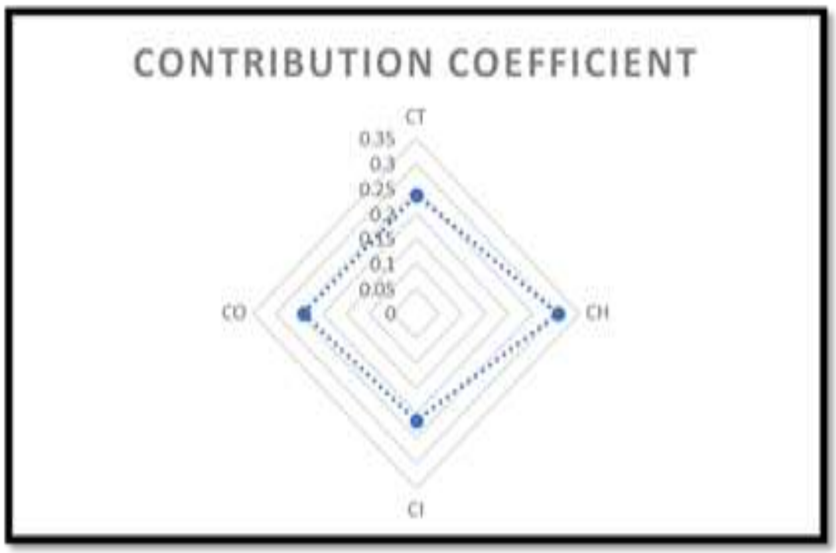

Fig 5. spider chart of the 4 main dimensions of technology in Pars Petrochemical

-Calculation of Technology Contribution Coefficient (TCC):

Further analysis of the intensity of the contribution of technology components was conducted using the Analytic Hierarchy Process (AHP) method and the Expert Choice software. Based on the formula for the Technology Contribution Coefficient (TCC) presented in the following equation (Retnowati & Mayasari, 2016), the component with the highest intensity value (weight) will have a high impact and potential for increasing the TCC. This index shows us to what extent an organization uses technology in its processes and what level of technological advancement it has reached. The results of the assessment of the intensity of the contribution of technology components are shown in Table 5, where the final value of the TCC is 0.489, indicating a moderate numerical value for this coefficient, as suggested by (Anggariawan et al., 2019). Here again, the largest share in the total value of technology classification belongs to the humanware/technology assets aspect.

$$TCC = T^{\beta t} \times H^{\beta h} \times I^{\beta i} \times O^{\beta o}$$

Where:
TCC: Technology Contribution Coefficient T: technoware component contribution value
H: humanware component contribution value I: infoware component contribution value
O: orgaware component contribution value

Table 5. Technology Component Contribution Intensity

-	CT	CH	CI	CO
Pars Petrochemical	0.3201	0.5136	0.2984	0.4169

-Discussion and Conclusion:

Given the importance of Iran's petrochemical industry as a major contributor to the country's economic growth and development, and its promising future due to access to feedstock, a skilled workforce, and suitable regional markets, maintaining its international and regional competitive advantages is of paramount importance. Therefore, identifying the needs as well as the strengths and weaknesses of the technologies used becomes increasingly important. This action helps to identify technological capabilities while increasing the coordination between the various components of technology and organizational processes and ultimately making optimal decisions for investment and technology upgrade.

Therefore, in this research, by examining the four dimensions of the THIO technology atlas model in Pars Petrochemical Company, the various dimensions of hardware, software, infoware, and orgware were analyzed using the fuzzy DEMATEL technique to identify the relationships and influences between criteria, the fuzzy ANP model to determine prioritization and importance coefficients, and finally, using the AHP method and Expert Choice software to calculate the technology contribution coefficient. The results of this study showed that the humanware dimension was the technology driver of the company, followed by the orgware, hardware, and finally, the infoware dimensions. Therefore, it can be said that the role of technology in gaining a competitive advantage for the organization and improving resilience and passive defense in this company depends on the commitment of senior management to retain human experts with knowledge, skills, creativity, and experience; managerial actions, communication, and improvement of organizational arrangements; upgrading equipment, tools, machinery, and appropriate physical infrastructure; and finally, improving production methods, guidelines, data, and process relationships. The final calculated value for the Technology Contribution Coefficient (TCC), which was **0.489**, indicates that the petrochemical company is in the medium category of technology classification, in which the humanware dimension plays the most important role.

Comparing the results of this research with previous studies, it can be observed that there is a good overlap in some of the existing findings. The results of this study are consistent with the findings of Khamseh and Siktekkin (2009). Both studies emphasize the importance of recognizing the level of technological capabilities of firms and show that a lack of awareness of these capabilities can prevent the achievement of a competitive advantage. The present research is also in line with the study of Habibzadeh et al. (2015) regarding the role of leadership performance in technological learning. Both studies show that strong leadership and effective training programs (humanware dimension) play a key role in improving the technological level of organizations. The obtained results are consistent with the study of Bitman (2005) on the importance of the THIO model in analyzing and managing the research and development project portfolio. Both studies show that this model can be used as a powerful tool for evaluating and improving the technological performance of organizations. Another overlap can also be seen in the study of (Marlyana et al., 2018) which, by developing the THIO technology assessment model to THIOCMP, also examined three new components (networking, software management, and partnership) alongside the four main components of the THIO model and emphasized the important role of all these components that can contribute to increasing technological capabilities and competitiveness of industries.

Therefore, the use of technology and its improvement and development can greatly facilitate communication with stakeholders and marketing products. Technology also strengthens innovation and creativity in human resources by providing access to a vast amount of information about target markets and potential products. This enables the petrochemical industry to be at a higher level with greater competitiveness and readiness to adopt technology.

Now, based on the research findings, the following suggestions are presented:

 Human Resource Development and Retention:

- Design a compensation system and development programs to retain specialized personnel in the field of technology.
- Expand technology management to lower organizational levels through participation calls to improve production, reduce costs, and manage energy.

 Education and Awareness:

- Conduct training courses for senior managers and department heads in the field of technology management for sustainable development, increased efficiency, safety, and reduced environmental impacts.

 Strategic Planning and Organizational Oversight:

- Evaluate the organization's technological strengths and weaknesses and develop a roadmap for selecting and utilizing technologies suitable for business needs.
- Prioritize technology management activities, prepare a schedule, and report on progress.

 Energy Management and Information Systems:

- Develop an energy management cycle guideline.
- Create and implement advanced information systems such as ERP and technology development engineering information systems.

 Technology Planning and Evaluation:

- Develop a comprehensive program for establishing technology management and conducting continuous evaluations in related processes.
- Implement technology management audits to identify and address gaps in the four dimensions of the atlas model (hardware, humanware, infoware, orgware).

- Develop a system for evaluating the organization's technology level, technological vision and strategies, and documenting major technological changes.
- Monitor emerging technologies to increase the competitiveness of products and technological resilience.

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