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Evaluation of Key Factors Influencing Technological Innovation Management in the Petrochemical Industry with a Focus on Chemical Companies

Hamid Doulabi[a], Abbas Khamseh[b]*, and Taghi Torabi[c]

[a] *Ph.D. Candidate, Department of Technology Management, Faculty of Management and Economics, Science and Research Branch, Islamic Azad University, Tehran, Iran, Email: hamid.doulabi@srbiau.ac.ir*

[b] *Associate Professor, Department of Industrial Management, Karaj Branch, Islamic Azad University, Karaj, Iran, Email: abbas.khamseh@kiau.ac.ir*

[c] *Associate Professor, Department of Economics, Faculty of Management and Economics, Science and Research Branch, Islamic Azad University, Tehran, Iran, Email: t-torabi@srbiau.ac.ir*

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ABSTRACT

Special attention to the relative advantages of the economy is the best way toward the country's economic development. The chemical sector has significant grounds and scope for technological innovation and development given the country's considerable natural oil and gas resources, high diversity of products, technology, and market. Nowadays, the country's political and economic status has created opportunities for chemicals, but existing policies have merely increased scientific research papers, providing only a few opportunities for practical technological innovations (patents). Understanding the factors influencing firms during technology innovations is the first step in the policies for this sector. Therefore, this study seeks to analyze factors influencing the management of technological innovations in the chemical industries to provide solutions. Hence, confirmatory factor analysis and structural equations are used to examine the factors. Then, the relative importance of each factor is determined using the fuzzy BWM method. According to the results, R&D ability, R&D efforts, and sustainable profitability ranked the highest, while low-risk chemical synthesis, less chemical waste, and science and technology diplomacy ranked the lowest.

1. Introduction

With its vast oil and gas resources, Iran was at the forefront of gas reserves and the world's fourth-largest oil reserves by the end of 2018 (EIA, 2019). The oil and gas industry has recently faced several challenges. For

*Corresponding Author

example, the production cost of one barrel of oil has risen by 60% over the past 10 years (Tidey, 2015), and oil prices have dropped by almost 70% since their peak in 2014 (Decker et al., 2016). International factors (e.g., the devaluation of the RMB in China and sanctions on Iran (Sebastian, 2015), as well as shale oil extraction, have led to greater volatility in oil prices and increased instability in this industry.

Petrochemical materials derived from the oil and gas industries are the most valuable chains of these resources (Sedghiani Baghche et al., 2016). The importance of the petrochemical industry and its relative advantages for the country is undeniable. Moving from upstream to downstream and the contribution of technology will intensify the factors of production, investment, the employment increase rate, and the profit margin for productive activities (Sedghiani Baghche et al., 2016). There is also a demand for global imports of petrochemicals that have a massive global market and a massive global demand of $877 billion, while the country’s share of global demand for this market is negligible (GCC, 2014).

So far, Iran’s petrochemical industry model has followed the pattern of resource exploitation in a project-oriented approach rather than the development-oriented one (Islamic Parliament Research Center of Iran, 2015). This industry has not been considered the engine of development in the country, while the developed countries have developed technology based on technology development and sale. In this way, their income is equivalent to or greater than what countries are rich in oil resources. Figure 1 shows an appropriate correspondence in this regard. Accordingly, this study aims to gain insight into the factors that make the chemical industry more capable in terms of technological innovations. Consequently, this research benefits from the following central question: What are the factors affecting technological innovation in the chemical industry?

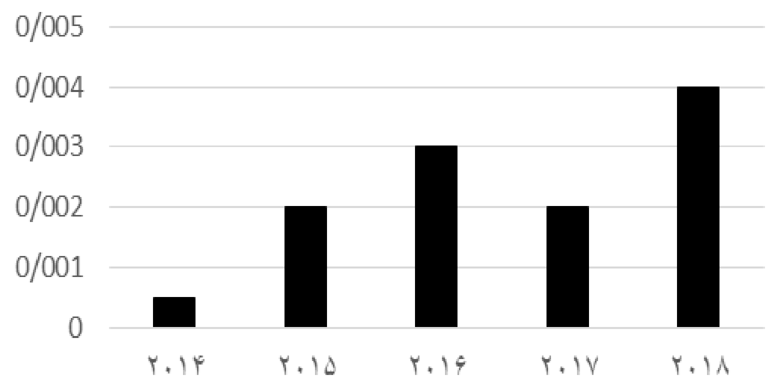

Figure 1: The ratio of Iranian WIPO chemical patents and chemical ISI articles of Iran (WIPO and Web of Science)

According to paragraph A of the General Energy Policy of 2025 Outlook and Section 5 of the General National Production Policies, Iranian Work and Capital Support, and paragraphs 13 and 15 of the General Resistance Economics policies that promoted technology, the completion of the value chain in the industry and increased exports of petrochemical products could be considered primary objectives; one could also conclude that the current and future needs of the petrochemical industry and the technology and innovation of this industry are supposed to be increasingly emphasized.

Formerly conducted studies have shown that research on the analysis of influential factors in the management of technological innovation in chemical industries has failed to focus on the innovation part. Further, prioritizing the factors affecting technological innovation management in this industry is another prerogative of the applied method.

2. Materials and methods

The present paper pays particular attention to the research literature in the field of innovation management practices. Tide et al. believed that innovation is trying to make things better than what has already been present.

Technological innovation is a form of innovation that occurs in the technical systems of an organization and is directly related to the organization's work.

In 2001, Nassimbeni showed that the propensity of small units to export was strictly associated with their ability to innovate the products and develop valid inter-organizational relations, while it was less related to the technological profile (manufacturing, quality control, management, design, communication, handling, and storage technologies) of the company. Moreover, in 2003, Swamidass investigated modeling the adoption rates of manufacturing technology innovations by small US manufacturers. He found that small plants were slower than larger plants to adopt manufacturing innovations. His findings showed that manufacturing innovations are in greater need of government assistance programs. However, small plants were progressing in catching up with larger plants in computerized technology use. In another research, Koellinger (2008) analyzed the relationship between the use of Internet-based technologies, different types of innovation, and performance at the firm level and found that all studied types of innovation, including Internet-enabled and non-Internet-enabled product or process innovations, were positively associated with turnover and employment growth.

Gracht et al. (2010) examined two main future organizational development trends for corporate foresight and innovation management. Hence, companies in traditional industries with conventional business models and long product life cycles will follow a different development path from companies in dynamic industries with innovative business models and short product life cycles. Hecksher et al. (2012) conducted a study to propose a way to manage the research, development, and innovation of the Brazilian Electricity Services Company. The innovative method involved reforming the organizational structure of research and development (R&D) activities, the systematic model for innovation education, and the operating model that systematized the processes of reflection with partners to make innovation proposals. However, Nagano et al. (2014) proposed an integrated model for innovation management in three dimensions: organizational factors, innovation process, and resources in developing Brazilian products. Palmqvist and Unevik (2015) identified the critical factors in the Swedish innovation management system to manage organizational structure: innovation strategy, culture innovation, estimation and management of innovation performance, collaboration and communication, resource management, endless innovation, and reversible process. Salerno et al. (2015) found by outlining the processes of innovation that there was no particular innovation process suitable for all types of innovation projects.

Hamidi and Benabdeljlil (2015) studied the relationship between management innovation and technological innovations (process and product) among Moroccan companies. Researchers believed that most companies driving technological innovation were more likely to have managerial innovations. Silva et al. (2016) introduced the demands of the customers, the market need, the communications network, the organizational environment, employee participation, and leadership style as factors affecting innovation development in small and medium-sized enterprises based on Brazilian technology. However, Lancker et al. (2016) sought to identify critical and influential factors in managing the development processes of biotechnology innovation. They proposed a set of management principles of innovative processes in the bio-economy classified into three groups: relevant shareholder groups in the development of innovation, strategy and network management, and organizational characteristics.

Lager (2016) studied the methods and tools used in the process industry to manage innovation and technology better. To this end, the methods and tools used in the process industry were examined to improve effectiveness, such as the technology map, research and development strategies, and the balance of technology. Aarikka-stenroos (2017) presented a comprehensive picture of innovation management in massive networks with various actors throughout the entire innovation process. Two fundamental and gradual innovation processes of an empirical conceptualization of seven critical managerial activities were analyzed, including motivation, resource provision, target setting and reforms, consolidation, reinforcement, coordination, control, and empowerment throughout the innovation process. However, Kralisch et al. (2017) followed the successful transfer of ideas to sustainable innovations using innovation management in the pharmaceutical and chemical industries. Finally, they proposed a step-by-step approach defining the criteria for operational management, financial management, environmental performance, and social performance with the assessment of sustainability and multi-criteria decision analysis. In another research, Bellegard and Prates (2017) tried to assess the main factors determining the necessary skills in the process of technology innovation, including the strategic plan of technology, intellectual property management, technology forecasting and monitoring, and the management of research and development projects, some of which were internal and some external. Hassani et al. (2017) indicated the importance of innovation and technology and the measurable effects of both in oil and petrochemical industries.

Leonidou et al. (2018) provided a more comprehensive and deeper understanding of the interaction between entrepreneurs and the various stakeholders to enhance innovation management and entrepreneurship development. However, Niewöhnera et al. (2019) referred to digitalization as an essential driver of innovation with a significant influence on innovation management. Their analyses identified the essential design fields for agile holistic innovation management in SMEs. However, Solaimani et al. (2019) proposed the Lean philosophy, integrating a firm's "hard" and "soft" processes, as a promising way to enhance firm innovativeness. The findings of their study suggested five Lean principles specific to the innovation management context, including coaching leadership, learning culture, employee appreciation, learning routines, and collaborative networks. Odea and Ayavoo (2020) examined the hypothesis that knowledge management practices are directly and indirectly associated with the firm's innovation. Their study indicated that knowledge generation, storage, and application had significant and positive effects on firm innovation, and knowledge application had the most significant impact. Ahmed et al. (2020) examined the hypothesis that product and process innovations complement each other to improve innovation speed and quality.

Moreover, in the case of innovative products, manufacturing performance was introduced as a key to enhancing marketing performance and the firm competitive capabilities. Hidalgo and Herrera (2020) conducted a study to develop an innovation management model to analyze the co-creation process in companies in ICT services. In this context, customers, partners, and suppliers played a vital role, which was not the case with universities. Usai et al. (2021) argued that considering innovation the result of creativity and constant R&D efforts, the most frequently-used digital technologies had significantly low impacts on firms' innovation performance. By contrast, excessive use of digital technologies might even deplete the long-run innovation capabilities of firms.

As presented in Table 1, the variables affecting technological innovation and the model used in each case can be summarized based on the abovementioned studies.

Table 1: The variables and model used in technological innovation

Reference	Concentration	Model	Dimensions
Lee and Om (1994)	Offering the conceptual model of technological innovation management	Hellerigel's model	People, task, technology, structure, and strategy
Altmann and Engberg (2015)	Assessing human resources management for technology innovations	Gopalakrishan and Dumpanpour models	Product capabilities, technological capabilities, human resources management, resources, incentives, and innovation
Li et al. (2017)	The overall process of formation of innovation elements in the technology innovation process	Collecting and review	environmental, structural, operational, mechanism, material, dynamic, process, and human-machine relationship dimensions
Seo and Chae (2016)	Practical ways of designing innovation management	Multi-factor simulation using NetLogo	Market, performance, and variety
Mir et al. (2016)	Relationships between the standard systems of UNE166002 innovation management	Standard innovation management systems (SMIS)	Innovation performance, innovation capacity, and business performance
Walrave and Raven (2016)	Development of a dynamic system model in technological innovation systems	Dynamic system based on "innovative engines"	Technology and science pressure engine, entrepreneurship engine, manufacturing system engine, market engine, and loop resistance structure
Prange and Schlegelmilch (2017)	Presentation of a structure in order to better formulate the innovation strategy	Innovation cube	Change effect, strategy effect, and market effect
Kralisch et al. (2017)	Successful transfer of ideas to sustainable innovation using innovation management	Stage and gate and multi-criteria decision analysis method	Operational management, financial management, environmental performance, and social performance aspects

Reference	Concentration	Model	Dimensions
Choi et al. (2015)	Provide a comprehensive model for technological innovation	Dynamic system	R & D investment, technological innovations, and financial performance
Khamseh and Sadeghi (2018)	Development of innovation management model in petrochemical companies	Conceptual	Economic, organizational, regulatory-supervision, technological, marketing, systematical
Hashem (2016)	Evaluation of dimensions and indicators of innovation management in business	Chiesa model and statistical analysis based on the analytic hierarchy process (AHP) model	Innovation strategy, management systems, project management, innovation culture, product innovation, commerce and business, and process innovation
Sedghiani Baghcheh et al. (2016)	Proposing a model for the commercialization of created know-how knowledge in research centers	Conceptual	Ability to manage unity and building integrity and planning, business empowerment and branding, technological capabilities, risk management capability procurement, potential risk management in project management
Fazeli (2016)	Identification and evaluation of effective indicators on innovation management dimensions in Iran Khodro	Verhaeghe and Kfir model and ranking based on the AHP model	Technology transfer, Innovation resources, networking, leadership, technology acquisition, innovation implementation, market focus, development proposal, idea and innovation production, systems and tools
Tohidi et al. (2015)	Evaluation of systems engineering processes on innovation capabilities in Iranian aerospace industries	TOPSIS multi-criteria decision-making techniques	Systems engineering design, architectural design and codification, comparative studies, and requirements management
Talebi (2016)	Innovation management performance assessment at Iran's new energies organization (SANA)	Joe Tidd model and ranking based on the AHP model	Processes, external communications, learning, organizational environment, and strategies
Ghasemi Aghababa et al. (2015)	Presentation of the business model of technological innovation management at the Iran National Gas Company	Conceptual	Acquisition, leverage, and protection

This research is applied regarding its objectives and a descriptive survey from the information collection perspective. First, 34 influencing indicators in technological innovation management were identified in petrochemical industries to achieve the study objectives. Then, the final questionnaire was designed based on the extensive library studies, including domestic and foreign valid papers and publications, and field studies using semi-structured interviews with 20 experts from CEO or senior managers of knowledge-based chemical production companies in type 1 in the field of advanced materials and equipment based on chemical technologies. The reliability of the questionnaire was confirmed by Cronbach's alpha, while the same experts verified its validity. Then, Smart PLS software was used to perform confirmatory factor analysis, classifying four factors of firm, industry, national, and international into 26 indicators to confirm or reject the analysis variables of the research. The fuzzy best-worst method was also used to prioritize factors. The pairwise comparisons were adjusted to the same 20 chemical industry experts at this stage according to the previous stage's extracted indices. The experts were supposed to express their preferences in the pairwise comparisons using the verbal variables listed in Table 2. Then, pairwise comparisons were combined using the geometric mean method. Figure 2 shows the research executive model, and Figure 3 represents the selective model for research and the approach through which the factors influencing technological innovation management in chemical industries were categorized. The extracted indicators were categorized according to their nature and experts' opinions.

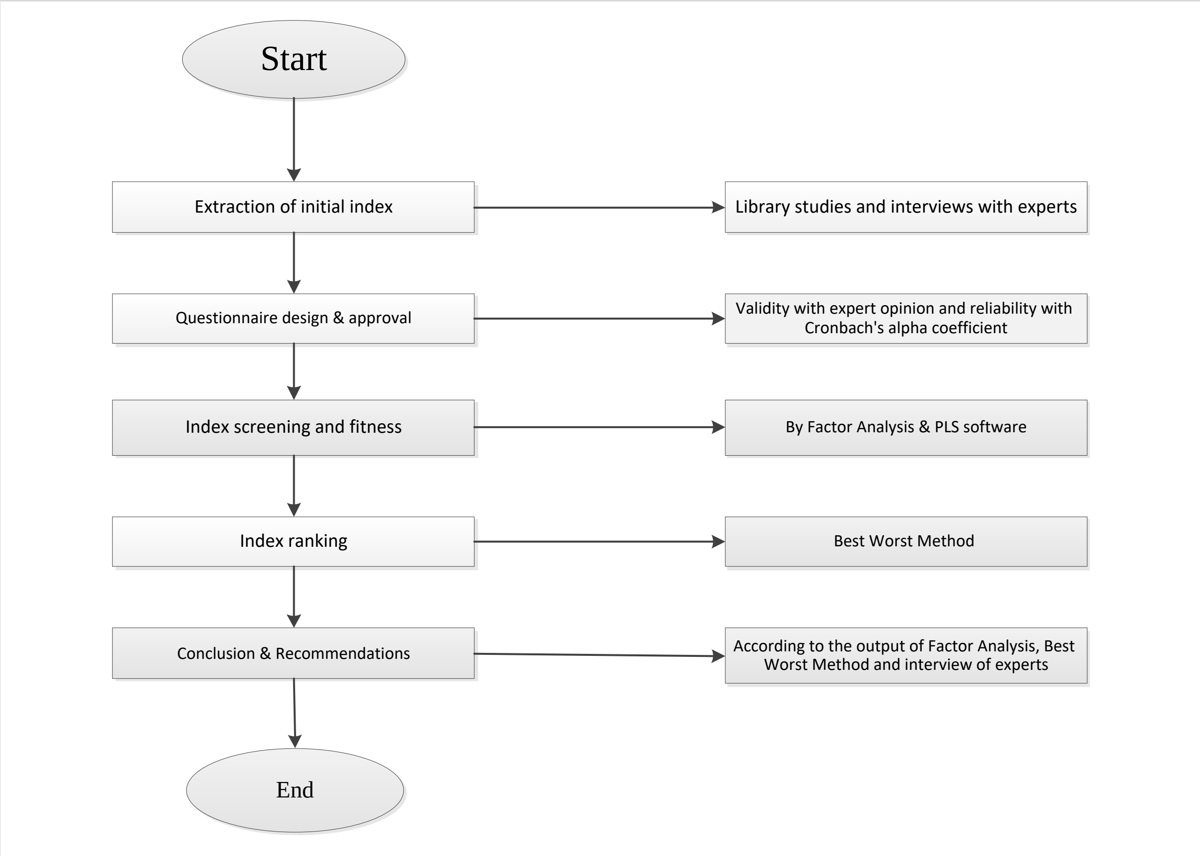

Figure 2: The research executive model

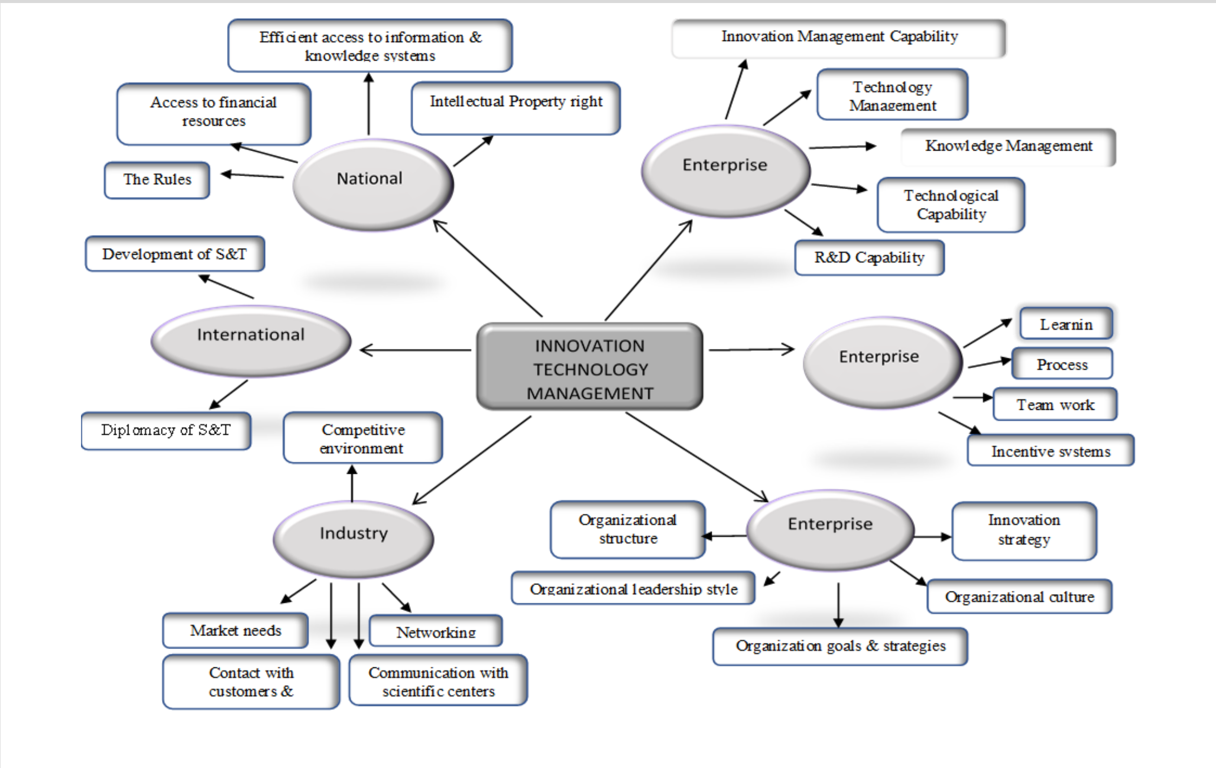

Figure 3: The conceptual model

3. Results

To identify the key factors influencing petrochemical technology innovation, 34 leading indicators were filtered by the experts. Then, the research model was analyzed using Smart Pls software for validation purposes. All the questions with a factor load less than 0.7 were excluded from the research model, and indices with a factor load of ～0.7 and other variable index variables were included in the model (Hair et al., 2006).

According to Figure 4, eight indicators of the model were eliminated to enhance the homogeneity of the research model. The results of all the tests of reflection measuring models and structural and general models are presented in Table 2. Finally, Figure 6 shows the structural model in the estimation of path coefficients, and Figure 7 shows the structural model in a meaningful state of the path coefficients; the final model of the research with 4 factors was confirmed in the form of 26 indicators, according to Table 3.

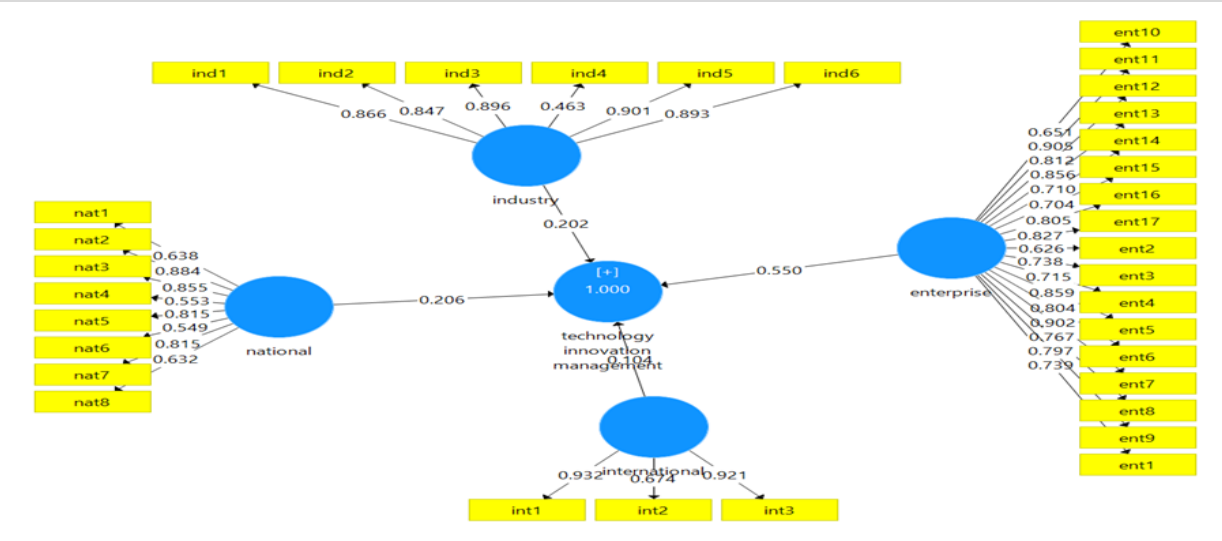

Figure 4: The initial measurement model with factor load coefficients

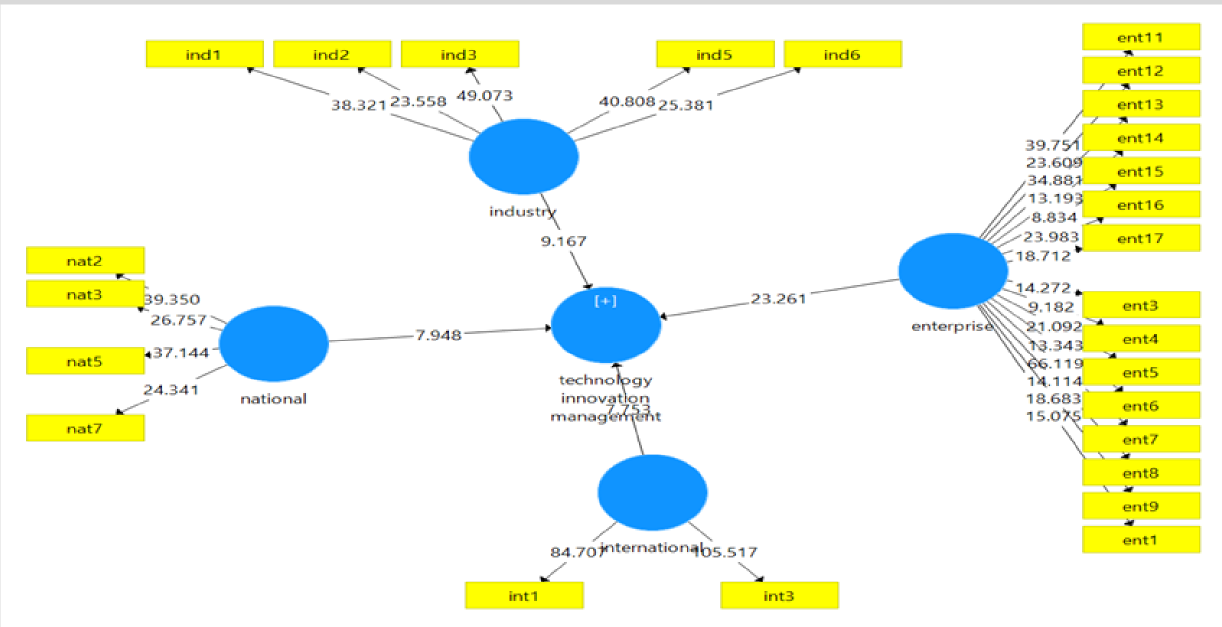

Figure 5: The post-fit research measurement model along with Z-meaningful coefficients

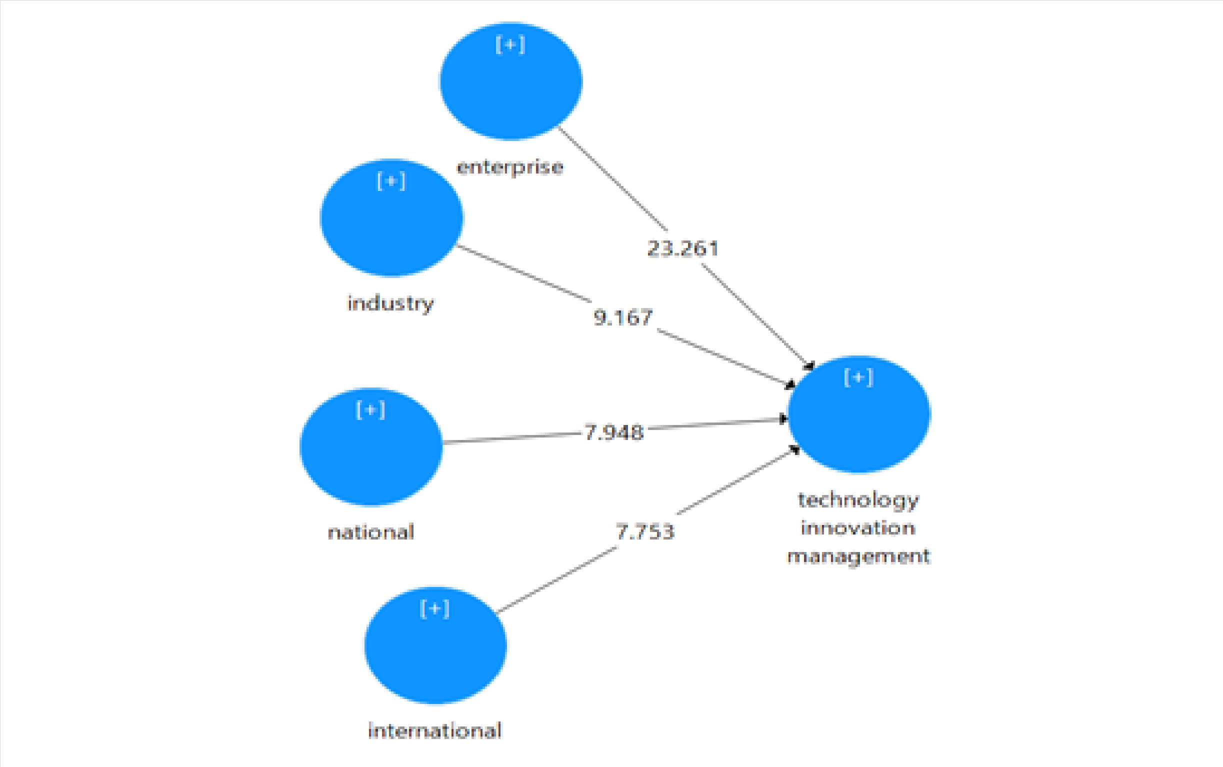

Figure 6: The structural model in the prediction of path coefficients (standard)

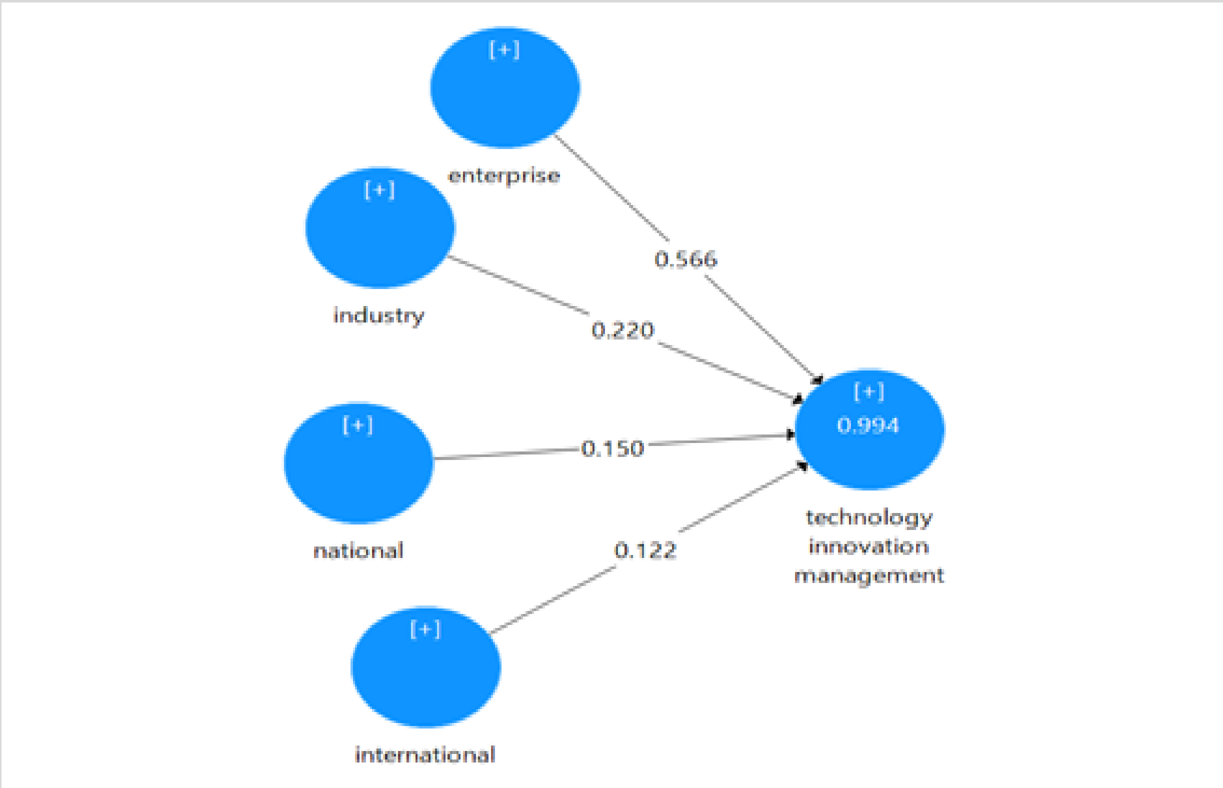

Figure 7: The structural model in the mode of the significance of path coefficients (non-standard)

Table 2: The results of the model fitness test

Type of test	Inclusion criterion	Test result
Significance coefficient	t-value for all relationships between independent and dependent variables is supposed to be larger than 1.97.	Confirmed for all research relationships
Coefficient of determination of R^2	Determination coefficient 0.67: strong 0.33: medium 0.19: weak	According to the value of 0.994, the model's strong criterion is verified.
Q^2 prediction relation	Q^2 prediction value 0.02: weak 0.15: medium 0.35: strong	With a value of 0.272, the moderate upward power prediction model is confirmed.
GOF	0.02: weak 0.15: medium 0.35: strong	A GOF of 0.875, an appropriate fit for the general model, is verified.

Table 3: Research factors

Criteria	Sub-criteria	Criteria	Sub-criteria
Enterprise (C1)	Knowledge management	Industry (C2)	Communication with scientific centers
	Technology management		
	Technological capability		Contact with customers and suppliers
	Innovation management capability		
	R&D capability		Networking
	Innovation strategy		Market needs
	Organizational goals and strategies		Competitive environment
	Organizational leadership style	National (C3)	Access to financial resources
	Organizational structure		Intellectual Property right
	Organizational culture (innovation)		The rules
	Teamwork		Efficient access to information and knowledge systems
	Creativity	International (C4)	Development of science and technology
	Incentive systems		
	Learning		Diplomacy of S&T

4. Research findings related to question 2

The fuzzy best-worst method was used to answer this question.

Guo and Zhao (2017) first presented this method, whose algorithm resembles the best–worst definitive method. The use of fuzzy numbers results in greater accuracy and better results in calculations due to the verbal ambiguity of respondents. This method is suitable because it requires fewer comparative data and provides more reliable answers. The steps in this method are as follows:

Step 1: The research criteria, including 26 indicators in 4 factors, were extracted for evaluation.

Step 2: Generally, this step identifies the most (best) and the least (worst) essential indicators. The most (best) and least (worst) essential indicators of the present study were identified using the opinions of the selected experts. The main criteria and the associated sub-criteria of each criterion were identified and presented in Table 4.

Table4: The best and the worst sub-criteria

Criteria	The best sub-criteria	The worst sub-criteria
	Enterprise	International
Ent	Innovation management capability	Organizational leadership style
Ind	Market needs	Networking
Nat	Intellectual Property right	The rules
Int	Development of S&T	Diplomacy of S&T

Step 3. Best-to-others (BO) and others-to-worst (OW) pairwise comparisons were conducted in this step. In this study, a pairwise comparison questionnaire was designed and made available to the same 20 experts. According to the fuzzy approach used in the present research, verbal phrases and fuzzy numbers were used in Table 5. The degree of prioritization was determined in pairwise comparisons according to the spectrum of the experts' ideas and opinions.

After the provision of answers by the experts, pairwise comparisons were combined using the geometric mean method, according to Tables 6 and 7.

Table 5: The verbal phrases and relevant fuzzy numbers (Chou et al., 2012)

Codes	Priorities	The fuzzy equivalent of priorities		
		Low	Medium	High
1	Equally important	1	1	1
2	Equally and relatively more important	1	2	3
3	Relatively more important	2	3	4
4	Relatively and moderately more important	3	4	5
5	Moderately important	4	5	6
6	Moderately and highly important	5	6	7
7	Highly important	6	7	8
8	Highly and absolutely important	7	8	9
9	Absolutely important	8	9	10

Table 6: Comparison of the pairwise (the best criterion with other criteria) main criteria

BO	C1	C2	C3	C4
C1	(1,1,1)	(3.226,4.356,5.426)	(1.547,2.216,2.797)	(6.176,7.213,8.238)

Table 7: Comparison of the pairwise (other criteria with the worst criterion) main criteria

OW	C1	C2	C3	C4
C4	(6.176,7.213,8.238)	(1.231,1.551,1.798)	(2.235,3.294,4.264)	(1,1,1)

Step 4: In this step, the weight of the criteria is calculated. To do this, the nonlinear optimization model forms the problem using Equation 7. However, Guo and Zhao (2017) proposed turning the model into a linear one in models with three or more criteria. Therefore, the linear model of the fuzzy BWM method was solved by the Lingo 17 software, and the criteria weights were then presented. Then, the criteria weights were calculated in Table 8 by solving the model in Lingo 17 software. The rankings and specific orders are shown in Figure 7.

For example, the linear optimization model should be as follows for the main criteria.

Min = z;
L1 – 3.226 × u2 <= z × u2; l1 – 3.226 × u2 >= –z × u2;
L1 – 1.547 × u3 <= z × u3; l1 – 1.547 × u3 >= –z × u3;
L1 – 6.176 × u4 <= z × u4; l1 – 6.176 × u4 >= –z × u4;
M1 – 4.356 × m2 <= z × m2; m1 – 4.356 × m2 >= –z × m2;
M1 – 2.216 × m3 <= z × m3; m1 – 2.216 × m3 >= –z × m3;
M1 – 7.213 × m4 <= z × m4; m1 – 7.213 × m4 >= –z × m4;
M1 – 7.213 × m4 <= z × m4; m1 – 7.213 × m4 >= – z × m4;U1 – 2.797 × l3 <= z × l3; u1 – 2.797 × l3 >= –z × l3;
U1 – 8.238 × l4 <= z × l4; u1 – 8.238 × l4 >= –z × l4;
L2 – 1.231 × u4 <= z × u4; l2 – 1.231 × u4 >= –z × u4;
L3 – 2.235 × u4 <= z × u4; l3 – 2.235 × u4 >= –z × u4;
M2 – 1.551 × m4 <= z × m4; m2 – 1.551 × m4 >= –z × m4;
M3 – 3.294 × m4 <= z × m4; m3 – 3.294 × m4 >= – z × m4;
U2 – 1.798 × l4 <= z × l4; u2 – 1.798 × l4 >= –z × l4;
u3 – 4.264 × l4 <= z × l4; u3 – 4.264 × l4 >= –z × l4;
0.167 × l1 + 0.668 × m1 + 0.167 × u1 + 0.167 × l2 + 0.668 × m2 + 0.167 × u2 + 0.167 × l3 + 0.668 × m3 + 0.167 × u3 + 0.167 × l4 + 0.668 × m4 + 0.167 × u4 = 1;

Table 8: The weight and the final rating of the main criteria

Criteria	Fuzzy weight	Crisp weight	Rank
Ent	(0.517, 0.541, 0.619)	0.550	1
Ind	(0.111, 0.119, 0.152)	0.123	3
Nat	(0.208, 0.239, 0.314)	0.246	2
Int	(0.077, 0.077, 0.086)	0.079	4

Similarly, the linear optimization model was formed and solved by the software for other indicators, whose final weights and ranks were obtained and provided in Figures 8–12.

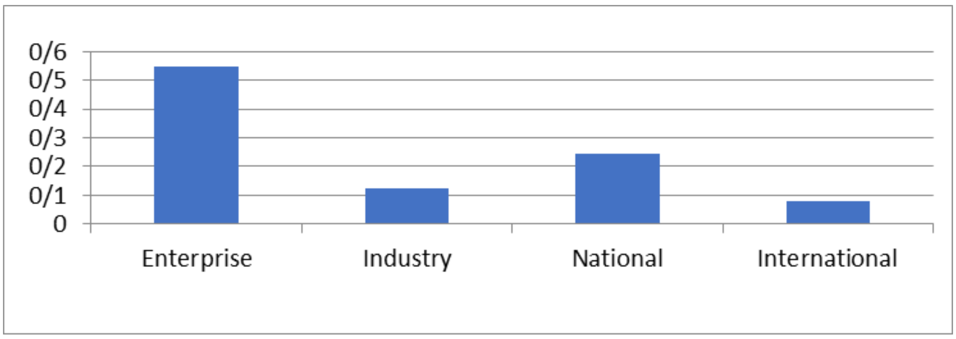

Figure 8: The weight and the final rating of the main criteria

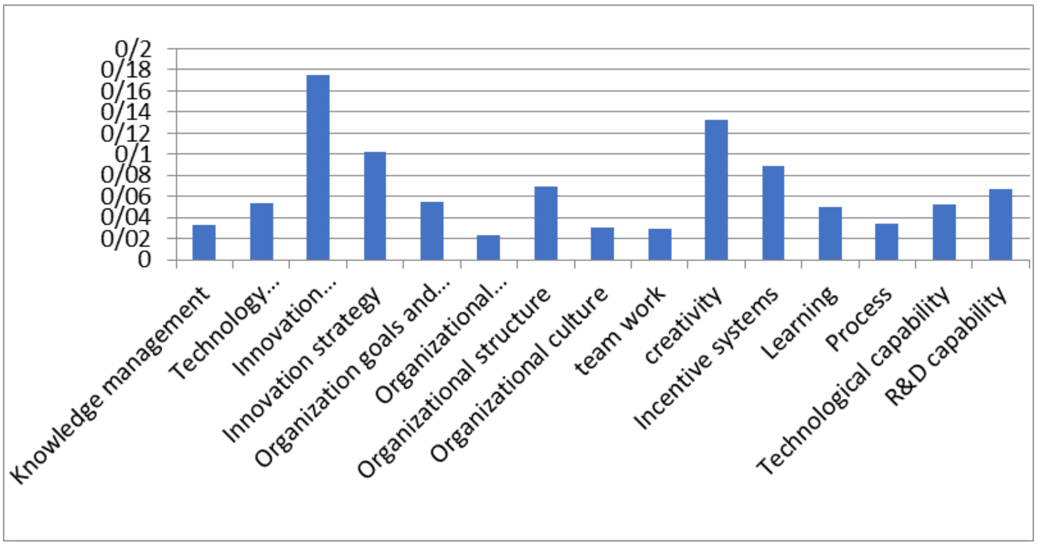

Figure 9: The weight and rank of the enterprise index

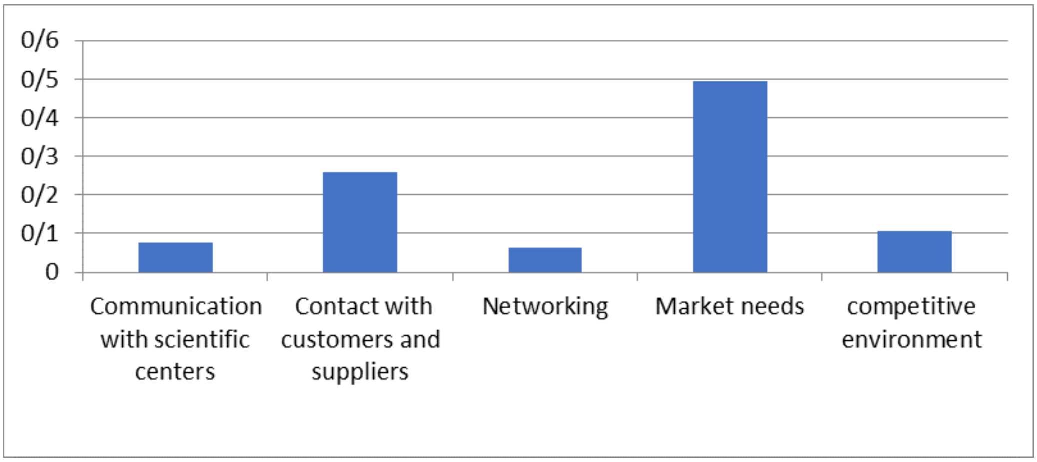

Figure 10: The weight and rank of the industry index

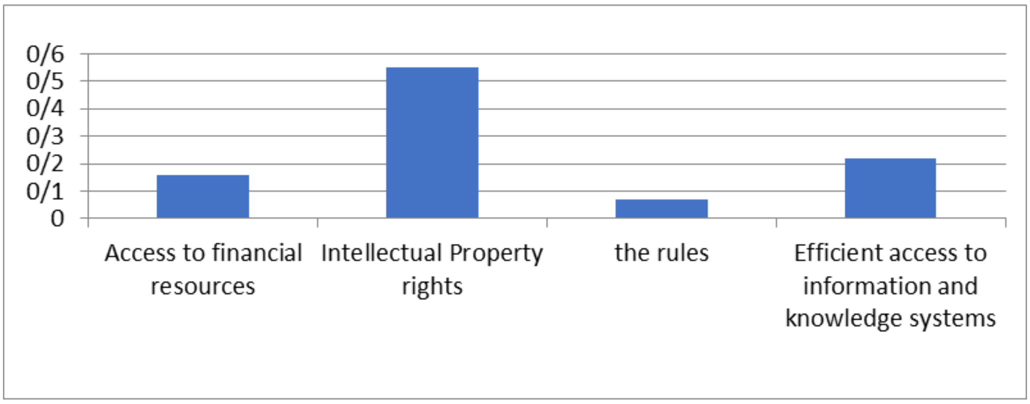

Figure 11: The weight and rank of the national index

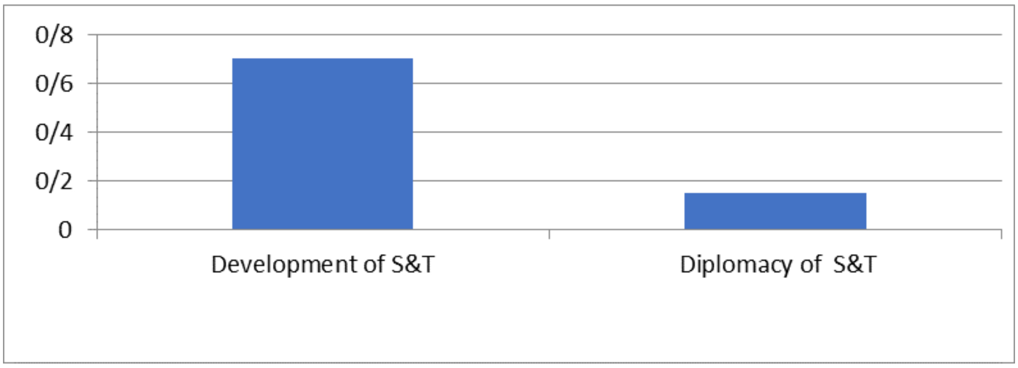

Figure 12: The weight and rank of the international index

The fuzzy weight was directly obtained from the solution of the model in the Lingo software. Then, these fuzzy weights were converted to actual weights by the relation $R(\tilde{a}_i) = \frac{l_i+4m_i+u_i}{6}$. Accordingly, the second rank was occupied by the national standard, and the third and fourth ranks were allocated to industry and international standards.

Intellectual property rights, market needs, and the development of science and technology had the highest ranks (best) among indicators of innovation management capability. On the other hand, the lowest (worst) values were related to the organization's leadership style, national laws (science and technology), networking and diplomacy, and science and technology addressed to agents of firm, national, industrial, and international affairs, respectively.

5. Discussion and conclusions

Iran's political and economic circumstances have led to opportunities and threats to the national chemical industries. However, current policies and incentives have only triggered scientific research papers with no focus on technology innovation (product patent or process). The first step in considering supportive policies for advancements in chemical technology is to comprehend the factors influencing the attempts made by innovative businesses. Nevertheless, studies show a lack of attention to this crucial area in Iran's chemical industries. Accordingly, this study tried to recognize and prioritize the influential key factors of technological innovation management in the chemical industry while providing solutions to fill the existing gap. According to studies, the fuzzy BWM method prioritized the factors affecting technological innovation management in this industry. Another innovation is the design of approaches and strategic plans along with the arrangement of a related model to this issue.

In the first section, the experts' opinions and the statistical population were selected as the influential factors in this field by reviewing the literature, considering the subject, and summarizing the relevant studies. Then, the research model was enhanced using structural equations and Smart Pls software, according to which 4 factors were categorized into 26 indicators. According to the final results of the research in structural equations, firm, industry, national and international factors contributed significantly to the management of technological innovation in this industry. In the second part, given a large number of research criteria, the fuzzy BWM method was used to prioritize the factors and indicators affecting the management of technological innovation in the chemical industry to overcome the uncertainties of the problems and resolve those uncertainties in decision-making. The research findings in the second part illustrated the capability index of the firm with the highest scores in the first place and the index of science and technology diplomacy from the international factors with the lowest scores.

To improve this index, we suggested that companies develop their research and development capabilities through inside improvement, which comprises the selection of proficient personnel; suitable training; providing, equipping, and updating laboratory equipment and materials; and continuous monitoring of technological advancement and the progress of markets. External development includes cooperation with units of companies (competitors, customers, and suppliers), universities, and research centers (e.g., Iran Chemical Development Research Institute, Iranian Research

Institute for Chemical Chemistry and Chemical Engineering, and Scientific and Industrial Research Organization) in the form of educational acquisition; investigation in research and development; contract in research and development; joint research and development; consortium and alliance; and continuous efforts of personnel through giving feedback for performance assessment systems with appropriate motivational incentives.

Another important argument is the sustainable profitability index of technology innovations. The weakness of government laws and policies concerning healthy competition, indiscriminate entry of imports from official and informal exchanges, and noncompliance with intellectual property rights have cooled the essential motivation of the private sector from entering this field. Accordingly, governments are supposed to address this problem through policy-making to provide opportunities and inspiration by stimulating demand and defense. Some measures taken by the government in the domestic market within a defined period include financial support for research and development activities, granting low-interest facilities, guaranteed purchases, non-entry of similar domestic goods, and helping commercialization and dissemination of technology innovation.

However, another critical point that should be taken into consideration by companies operating in the industry is the last place of the international benchmark. As illustrated, the international limitations and prospects had the least impact on the management of technological innovation in the chemical industry compared to other factors. On the other hand, science and technology diplomacy gained the lowest score, indicating that it did not affect technological innovations significantly in the chemical industry. Therefore, this index was regarded to be the last indicator .

Different results obtained in the present study were consistent with the results of previous related works. However, in a few cases, there was a difference in the results of the reviewed studies based on the conditions of chemical production companies and different research methods. Considering the government's position on the development of petrochemical industries and the establishment of the Downstream Industries Development Office as the custodian of this sector, no referring authority or center currently offers information services to the chemical industry of Iran. It is suggested that specialized technology management and innovation units should monitor and predict the future of technology in this sector while informing the chemical industry, academic context, and research centers effectively to prevent similar and impractical activities.

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