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New Technology Assessment: A Case Study of Iran's Petrochemical Industry

Maryam Ebrahimi[1], Abbas Mogbel Baerz[2], Seyed Hamid Kodada Hoseini[3], Adel Azar[4]

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Abstract

Job creation, income generation, and natural resources conservation, all are pillars of sustainable development for industries using new technologies. Despite the importance of new technologies, developing countries face many limitations, such as economic and political problems, which make the development and transfer of technologies more difficult. In this study, we focus on development of new technologies in Iran's petrochemical industry, including nanotechnologies, biotechnologies, and membranes. Solutions are proposed to improve the current unsatisfactory status. For that matter, taking into account experts' viewpoints, a new technology tree is suggested for Iran's petrochemical industry. The literature on technology assessment and prioritization is reviewed, and then primary indicators are proposed based on ability, attractiveness, and patent features. Forty industry experts are surveyed and the results are analyzed using face validity, reliability test, and factor analysis, by which the current status of new technologies is assessed.

Keywords: Nanotechnology; Biotechnology; Membrane; Ability; Attractiveness.

1.PhD Student, Faculty of Management and Economics, Tarbiat Modares University. mar.ebrahimi@gmail.com
2.Assistant Professor, Faculty of Management and Economics, Tarbiat Modares University. moghbela@modares.ac.ir
3. Professor, Faculty of Management and Economics, Tarbiat Modares University. khodadad@modares.ac.ir
4. Professor, Faculty of Management and Economics, Tarbiat Modares University. azara@modares.ac.ir

1. Introduction

Proper industrialization under appropriate conditions in developing countries is equivalent to creating technology foundations for economic development. Although endogenous innovation is an important feature of knowledge-based societies, developing countries still resort to technology transfer due to the lack of knowledge and expertise in technology [1]. Moreover, most developing countries were unsuccessful in proper technology transfer as a result of not fully understanding various aspects of imported technologies and selecting inappropriate or outdated technologies.

A closer look at Iran's technology transfer projects, particularly in the oil sector, shows that the thorough process of technology transfer has been disregarded. Possessing about 13 to 18 percent of global oil and gas reserves, Iran's oil industry is the main focus of country's economic development. However, technological capabilities of Iran's oil industry never satisfy the needs of this industry, despite having one-century-old background [1, p.75].

Poor technology transfer and localization, in addition to imposing extravagant costs for buying technology, have reduced the industry to a mere importer of foreign technology. Iran's petrochemical industry (IPI), as a subset of the oil industry, has encountered similar challenges.

In order to promote the production of petrochemical products in Iran and satisfy the need for "oil-free economy" to hold a worthy position in the world, IPI should assess and prioritize technologies, especially new technologies such as nanotechnologies, biotechnologies, and membranes. Furthermore, sustainable development is based on three main components of economy, society, and environment. Using these technologies will result in economic, social, environmental benefits, including value added for petrochemical industry product chain, job creation, income generation, natural resources conservation, green technologies and renewable materials creation.

In this study, the literature on the subjects such as technology assessment and prioritization is reviewed and a new technology tree is suggested for IPI based on experts' viewpoints. Primary indicators of technology assessment are proposed based on ability, attractiveness, and patent features. For that matter, 40 industry experts have been surveyed and the current status of the new technologies industry is assessed through face validity, reliability tests, and factor analysis. The results of assessment lead to a guideline to make decision and formulate strategies for new technologies development in the industry.

2. New Technologies in IPI

In this section, three main categories of new technologies used in IPI are discussed: nanotechnology, biotechnology and membrane.

Nanotechnology: Nowadays, nanotechnology, which is an important tool to empower petrochemical processes and products, has drawn greater attention of governments and leading companies in including petrochemical industries. Numerous applications of nanotechnology in the petrochemical industry have been commercialized, such as:

1) Polymer clay-reinforced nanocomposites and carbon nanotubes used in the automotive industry and sport devices.
2) Nanocatalysts in ammonia production.
3) Zeolite membranes used for sweetening natural gas.
4) Anti-Corrosion, stainless coatings, thermal insulation, etc.

Biotechnology: Findings and knowledge of experts in biotechnology has increased using biotechnology in various industries such as healthcare, agriculture, and petrochemical. Today, both developed and developing countries have considered biotechnology applications in petrochemical and chemical industries as their high level priorities and a great deal of money has been budgeted in this field (like British petroleum (BP), Shell, etc). Due to its high-volume production and large added value; oil, gas and especially petrochemical industries in Iran have the potential to employ biotechnology. Products currently commercially available or about to be available can be mentioned as follows:

1) Use of raw materials and agricultural wastes as a precursor of polymer industries,
2) Use of renewable material to produce fuels and replacing fossil fuels with alternative biofuels (and thus using fossil hydrocarbons to produce materials with high added value),

3) Use of starch products to produce nontoxic, biodegradable and skin-friendly detergents,
4) Clean up the environment from water, soil and air contaminants.

Membranes: In recent years, membranes and membrane separation techniques have grown from laboratory scales to industrial processes. Membranes are used for producing drinking water from seawater through reverse osmosis, cleaning up output fluid of the industry, recycling valuable components by electrodialysis, separating macromolecular solutions in the pharmaceutical and food industries by ultra filtration, removing Urea and other toxins from the blood system by dialysis, separating gas to produce nitrogen, natural gas sweetening, etc.

3. New Technologies Tree in IPI

Before suggesting new technologies tree in IPI, it is necessary to define technology for the present research. In general, there are various definitions about technology: referring to the technology triangle, technology is described as the integration of people, knowledge, tools and systems in order to improve people's lives [2], [3]. Khalil (2000) defines technology as hardware, software, brain-ware and know-how. He describes technology as all the knowledge, products, processes, methods and systems employed in the creation of goods or in the provision of services [4]. Vernet and Arasti (1999) divide technology into four components: 1) technoware i.e. machines, tools and equipments, 2) humanware i.e. human skills and experiences, 3) infoware i.e. information, standards and procedures, and 4) orgaware i.e. business infrastructure and managerial systems [5].

In this study, technology is defined as all the main knowledge, products, processes and methods employed in the creation of goods or in the provision of services according to viewpoints of experts involved in the industry. Based on this definition, the new technologies tree in IPI will be as follows:

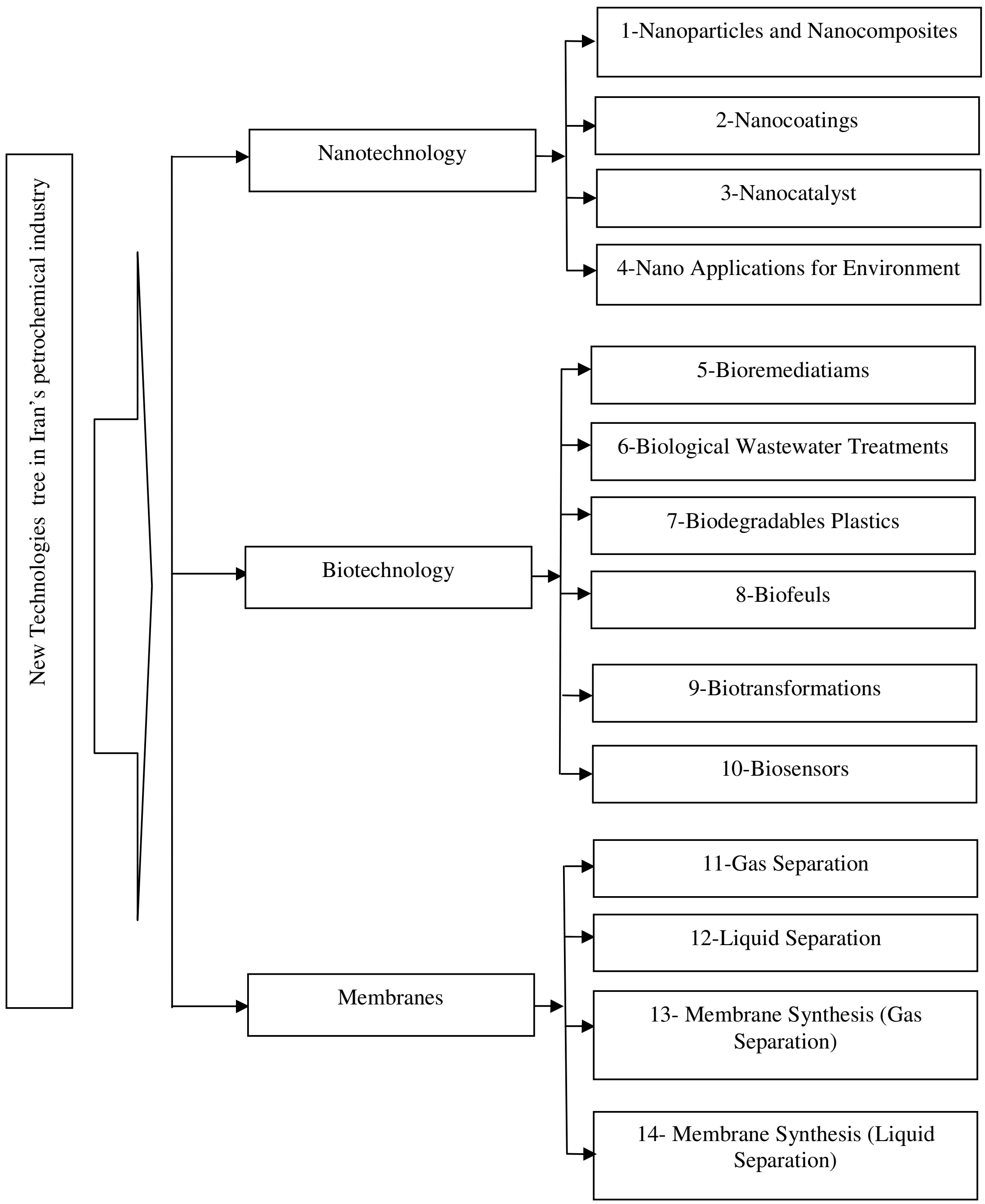

Fig. 1 Technology Tree for New Technologies of IPI

4. Technology Assessment

The process of technology assessment aims to collect information on the current and future state of technology development, in order to evaluate the importance of each technology in the competitive arena and the strength of the organization in each technology [6]. Three major functions of the technology assessment are: 1) to identify what technologies are truly needed and when they are needed, 2) to implement a technology prioritization /planning process, and 3) to provide (R&D) investment recommendations based on continuing existing projects and executing new projects [7]. Technology assessment can be studied in three different levels: 1) organization, 2) division or industry, and 3) country.

There are different methods to assess and identify national technology priorities. One of the most practical methods that is widely used in several countries, e.g. United States, France and recently in Iran, is the method of critical technologies, which presents the matrix of feasibility-attractiveness whereby technologies are prioritized based on feasibility and attractiveness features [8], [9].

The attractiveness of the technology is determined by its socio- economic potential benefits, as well as scientific and technological opportunities it could provide. The feasibility feature of the technology is identified in terms of research and technology potential, and the social awareness to effectively utilize the new technology [9, p. 837].

In this study, primary indicators for IPI ability in each technology (ability feature) and attractiveness of IPI technologies (attractiveness feature) are presented through indicators extracted from several researches and patents as shown in table 1.

5. Technological Capability (TC) Models

The feasibility or ability feature of the technology can be identified by TC, especially in developing countries. Studies in developing countries started in 1960s, as the focus was on unsuccessful technology transfer from developed countries. In this period, TC of a country was defined as the capability of its companies in effective management of international technology transfer. From the late 1970s to 1980s, the focus was on acquisition and adaptation of imported technology [10]. TC of a company can be defined as a set of functional abilities that are reflected in its performance through various activities ultimately aimed to develop difficult-to-copy organizational abilities [11]. In a broader view, TC is the national capability, which helps in the acquisition, adaptation, modification and innovation of the imported technology and involves technological change [12]. So, TC was interpreted not only as the ability to transfer technology internationally, but also as the ability to become an expert in applying transferred technology, effectively. TC also refers to the management of knowledge creation and diffusion [13].

One of the prerequisites for technology development in an organization, industry or country is planning for technology development. Determining technology priorities by critical technology method is a requirement for technology strategy formulation [14]. In addition, an assessment of current condition is the first logical step in the development of an effective technology management program. When an organization decides to invest its resources only in the critical areas, it should first assess its current condition via technology audit [15].

There are different models and techniques to assess the TC, each of which have been developed for a specific reason. Models of TC assessment can be divided into the below categories:

1) Models which assess TC at the country level: There are five different models to measure TC at the country level, which are used to compare national technological status of different countries. These models are: the United Nations Development Program (UNDP) Technology Achievement Index (TAI) [16], the World Economic Forum (WEF) Technology Index [17], ArCo indicator of TC [18], [19], the United Nations Industrial Development Organization (UNIDO) Industrial Development Scoreboard [20], and finally the Science and Technology Capacity Index developed by the RAND Corporation and associated partners [21].
2) Models which assess TC at the country level and lower like division: there are seven models to measure TC, which are used to compare current status with desired status. These models are described by UNIDO (1968) [22], Lall (1992) [23], Sharif (1993) [24], Ramanathan (1993) [25], Dore (1984) [26], Bell (1984) [27], Fransman (1984) [28]. They focus mainly on acquisition

ability in the sense of the ability to explore technology based on country situation, operative ability in the sense of the capability to acquire skills for new technology and ability to employ the technology in the current situation, adaptive ability in the sense of adapting the suitable technology with special changing status of production over the time, innovative ability in the sense of minor innovations at the beginning and major innovations at the end, and finally supportive/marketing ability in the sense of transferring technology to others.

3) Models which assess TC in manufacturing companies: these models determine activities in manufacturing companies and identify TC in each stage of performing activities. The value chain concept, developed by Porter (1985) [29] becomes a useful tool for identifying activities performed by the company. Panda and Ramanathan (1995) [30] extended Porter's value chain concept by broadly categorizing the value addition activities performed by a company into primary value-adding activities and support value-adding activities. Activities that result in long-term competitive advantage are called primary value-adding activities; activities that support the primary value-adding activities are called support value-adding activities. Abeysinghe and Paul (2005) [31] identified the major activities of primary value-adding for a telecommunications service provider as: design and engineering, creation, marketing and selling, and providing services. TCs in each stage determine how well the company can perform these activities.

4) Models which assess TC in R&D organizations: according to the different and specific nature of the employees, culture, financial resources and ideas of R&D organizations, compared to that of the manufacturing companies, some models have been proposed, which assess TC in R&D organizations like innovative capability audits models [32].

5) Models which assess TC in technology management: these models like models developed by Lin (1997) [33] and Garcia-Arreola (1996) [34] can be used in either R&D organizations or manufacturing companies. In these models, all technology management activities in all organizations are identified. The performance of these

activities indicates TC of the organization.

6) Models made by patents indicators at the organization, industry and country: There are different kinds of patent indicators that make TC calculation possible. They are the basis of comparing current status at the level under study with the desired status or comparing several cases at the same level.

6. Patent Indicators

Patent is a contract between an inventor and the government, whereby in return for full public disclosure of an invention, the government grants the inventor the right to exclude others for a limited time from making, using and selling the invention. In 1965, Frederic Scherer drew economists' attention to the importance of patent data as output indicators of industrial innovation in industry [35].

The patent databases offer valuable information for technological strategy planning. Patent analysis techniques are widely adopted in planning the company's technological innovation strategies. There are a set of identified indicators which have been found useful to plan the technological strategies of a company [36], [37], [38], [39], [40].

We selected two following indicators that are approved by TCs models:

1) Number of declared patents, i.e. the number of inventions, which received register No. from international databases. Thus, distribution across each technology, research and development activity of industry and investment in each technology area of the industry are determined.
2) Patent growth, i.e. the change in the number of patents from one time period to another, increasing of which indicates emphasis on technologies.

7. Primary Indicators of Technological Ability and Attractiveness

Since IPI contains different manufacturing companies and R&D centers, all of the TC models can be used to evaluate technological ability in each technology. A list of indicators used for assessing "technological ability" and "technological attractiveness" are given in Table1.

Table 1 Assessing Technological Ability and Attractiveness

Assessment indicators for Technological Ability in Different Areas of Technology:
Access to the required expert human resources in technology (run fundamental and practical research and develop technology) [8], [9], [23], [24], [41], Australia CSIRO cited by [42]
Access to required experience, knowledge and information in the technology [9], [22], [25], [41], Australia CSIRO cited by [42]
Level of education in related fields [8], [16], [17], [18], [19], [21]
Access to required resources in the technology (R&D, operation and development) [8], [9], [22], [23], [24], [41], Australia CSIRO cited by [42]
Potential to advance in the fundamental knowledge and technology through relationship with scientific communities [8], [23], [41]
No. of declared patents of technology in petrochemical industry [16], [17], [18], [19], [21], [41]
The capacity of financing from various resources [8], [41], Australia CSIRO cited by [42]
Commercializing research results in technology field in international market [8], [16], [17]
Supporting by policy making and intellectual property rights legislation [8], [41]
Competitiveness between upstream and downstream industries [8], Garcia-Arreola (1996) sourced in [34]
Upstream and downstream industries requests of research results [8], Garcia-Arreola (1996) sourced in [34]
Potential growth of small and medium sized business in industry [8], Garcia-Arreola (1996) sourced in [34]
Assessment indicators for technological attractiveness in different areas of technology:
Ease of access to the required resources in the technology (R&D, operation, development) [9], Australia CSIRO cited by [42], (Abele 2006 and Pfeiffer 1991 cited by [43]
Span of applications achieved by researches in technology [8], Abele 2006 and Pfeiffer 1991 cited by [43]
Probability of a synergic effect of research in the field of technology with other research areas [8], Australia CSIRO cited by [42], Abele 2006 and Pfeiffer 1991 cited by [43]
The time required to acquire technology and proficiency gain in using it [9], Abele 2006 and Pfeiffer 1991 cited by [43]
The comparative position of the new technology vis – a – vis the competitive technologies [9], [41]
Position of technology in its own life-cycle [41]
Technology ability to make competitive advantage in production and export [9]
The technology effect on quality improvement and customer satisfaction [9]
Technology influence on job creation [8]
GDP increased by technology [8]
Export volume increased by technology [8], Australia CSIRO cited by [42]

Productivity improved by technology [8], Australia CSIRO cited by [42], Abele 2006 and Pfeiffer 1991 cited by [43]
Market volume influenced by technology [8], [41], Australia CSIRO cited by [42]
The effect of technology on involvement in international cooperation [8]
Technology influence on providing the social requirements [8], Australia CSIRO cited by [42]
Technology impact on material effectiveness [8]
Technology impact on energy effectiveness[8]
Environment – friendly effect [8], Australia CSIRO cited by [42]
Technology importance for human health [8], Australia CSIRO cited by [42]
Technology importance for the safety of the society [8], [9]
Strategic importance of technology for Iran internationally [8], Australia CSIRO cited by [42]
Public perception of technological outcomes and their use by general public [8], [9], [41], Australia CSIRO cited by [42]
Coordination with government financial budget allocations for technology development [9]
Coordination with national technological priorities [9]
Patent growth rate in the technology [36]

8 Methodology

In the present study, the valid technological ability and attractiveness indicators adopted in the current conditions of IPI are identified, and then the current conditions of the various technologies are determined.

8.1. Sampling Method

The population in this study is researchers and technology specialists in subsidiary companies in the petrochemical industry. Data is collected from the entire population. Due to the lack of researchers and technology experts, the sample size is forty experts from the petrochemical industry subsidiaries. The experts participating in this research must have the following characteristics:

1) They must have more than five year research experience in the IPI,

2) They must have at least a Masters Degrees.

We used structured questionnaires to define the indicators and the current conditions of the technologies with the help of forty researchers. We also used experts' viewpoints because there is no specific data or databases available related to defined indicators.

8.1.1. The Minimum Sample Size

There are two categories of general recommendations in terms of minimum sample size in factor analysis. One category says that the absolute number of cases (N) is important, while the other says that the subject-to-variable ratio (p) is important [44],[45],[46]. Costello and Osborne (2005) surveyed two years of PsychINFO articles that reported principal components or exploratory factor analysis and they showed the minimum sample size or STV ratio used in practical studies as Table 2.

Table 2 STV Ratio Used in Studies [47]

STV Ratio	% of Studies	Cumulative %
2:1 or less	14.7%	14.7%
2:1 - 5:1	25.8%	40.5%
5:1 - 10:1	22.7%	63.2%
10:1 - 20:1	15.4%	78.6%
20:1 - 100:1	18.4%	97.0%
100:1 or more	3.0%	100.0%

In the present study, STV ratio is in the range of 2:1 to 5:1 which is justified according to the above table.

8.2. Statistical Tools Used

Using Statistical Package for Social Sciences (SPSS), the following tools were administered in this study 1) reliability test, and 2) factor analysis.

8.2.1. Validity Test

Validity refers to whether a study is able to scientifically answer the questions it is ntended to answer. Besides conducting a literature review to ensure that all the content is included, face validity is used to measure the construct. It is a visual inspection of the test by expert reviewers. Face validity should be good enough to withstand scrutiny and helps researchers to find potential flaws before they waste a lot of time and money. We have sent questionnaires to the experts, asking them to offer an opinion on whether the test looks valid and good. Then after receiving their viewpoints, we have modified the indicators.

8.2.2. Reliability Test

An examination is made from the reliability of the data to check whether random error causing inconsistency and in turn lower reliability is at a manageable level or not. It is clear, from table 3 and 4, that values of coefficient alpha (cronbach's alpha) have been obtained. Table 3 shows the minimum value of coefficient alpha obtained from "determination of technological ability indicators in IPI" questionnaire with fourteen questions is 0.816. This shows that the data has satisfactory internal consistency reliability. Table 4 shows the minimum value of coefficient alpha obtained from "determination of technological attractiveness indicators in IPI" questionnaire with twenty six questions is 0.876. This shows that the data has satisfactory internal consistency reliability.

Table 3 Reliability Statistics for Technological Ability

Cronbach's Alpha	N of Items
0.816	14

Table 4 Reliability Statistics for Technological Attractiveness

Cronbach's Alpha	N of Items
0.876	26

8.2.3. Factor Analysis Results

Factor analysis has become an important statistical instrument for investigating in modern science and an adequate tool to investigate the principles of interaction of components and their integration into a system. We reduce the complexity of technology assessment by dividing it in to various indicators. But the structure of the system of technology management is not only a set of its elements, so with the help of factor analysis, we study the system of technology assessment from a higher level. It also facilitates data collection and makes the researchers answer the questionnaires, which are surveyed to analyze IPI conditions in the identified technologies of technology tree.

In the principal components analysis (PCA), rotation is defined as "a procedure, in which the eigenvectors (factors) are rotated in an attempt to achieve a simple structure" [48]. SPSS offers five rotation methods: varimax, direct oblimin, quartimax, equamax, and promax, in that order. Three of those are orthogonal (varimax, quartimax, & equimax), and two are oblique (direct oblimin & promax). Varimax, which was developed by Kaiser (1958), is indubitably the most popular rotation method by far. It is the best way to achieve orthogonal simple structure [49]. Varimax simplifies the interpretation, because after a varimax rotation, each original variable tends to be associated with one (or a small number) of factors, and each factor represents only a small number of variables. In addition, the factors can often be interpreted from the opposition of few variables with positive loadings to few variables with negative loadings [50].

For factor analysis of the "determination of technological ability indicators in IPI " questionnaire, two variables were excluded: 1) access to the required resources in the technology (R&D, operation and development) and 3) potential growth of small and medium sized business in industry. Moreover, for factor analysis of the "determination of technological attractiveness indicators in IPI" questionnaire, seven variables were excluded: 1) position of the technology in its own life-cycle, 2) Strategic importance of technology for Iran internationally, 3) technology impact on material effectiveness, 4) probability of a synergic effect of research in the field of technology with other research areas, 5) the time required to acquire technology and proficiency gain in using it, 6) technology importance for the safety of the society, 7) public perception of technological outcomes and their use by general public.

Consequently, the results of factor analysis of the "determination of technological ability indicators in IPI" questionnaire and "determination of technological attractiveness indicators in IPI" are as followings:

1) The number of the valid cases for 11 variables of technological ability is 39, so the ratio of the valid cases to variables is 3.54. In addition, the number of the valid cases for 19 variables of technological attractiveness is 39, so the ratio of the valid cases to variables is 2.05.
2) Determinants are higher than zero.
3) In correlation matrix, it can be seen that there are several sets of correlations above 0.30, and there are no correlation coefficients above 0.80.
4) KMOs are satisfactory according to (KMO>0.5).
5) Significances in the bartlett's test of sphericity are (0.000), which is lower than (0.05) and indicate that factor analysis is appropriate.
6) Chi-squares in the bartlett's test of

sphericity are large value and indicate that factor analysis is appropriate.

7) In anti image correlation, all of the amounts of MSAs are higher than 0.5 (MSA>0.5).

8) In communalities matrix, all of extractions are higher than 0.5.

9) Percent of variance explained by total components of technological ability is 74.466 (C1 = 23.847, C2 = 23.115, C3 = 16.892, C4 = 10.611). In addition, percent of variance explained by total components of technological attractiveness is 70.961 (C1 = 17.774, C2 = 16.770, C3 = 14.586, C4 = 12.061, C5 = 9.771).

The final results for technological ability are shown in Table 5 and Figure 2.

Table 5. Rotated Component Matrix for Technological Ability (higher than 0.5)

	Component			
	1	**2**	**3**	**4**
Var1	0.852			
Var2	0.656			
Var3	0.889			
Var5			0.569	
Var6		0.897		
Var7		0.949		
Var8		0.870		
Var9			0.838	
Var10				0.629
Var11				0.654
Var12			0.605	
Var13	0.705			

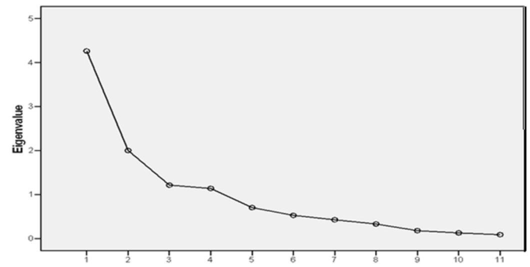

Fig. 2 Scree Plot of Technological Ability Factors

The final results for technological attractiveness are shown in Table 6 and Figure 3.

Table 6. Rotated Component Matrix for Technological Attractiveness (higher than 0.5)

	Component				
	1	**2**	**3**	**4**	**5**
Var 1	0.670				
Var2			0.693		
Var5					0.825
Var7	0.591				
Var8	0.648				
Var9		0.639			
Var10			0.684		
Var11		0.775			
Var12		0.698			
Var13		0.737			
Var14		0.662			
Var15	0.583				
Var17	0.790				
Var18					0.572
Var19	0.653				
Var23			0.798		
Var24					0.601
Var25				0.818	
Var26				0.892	

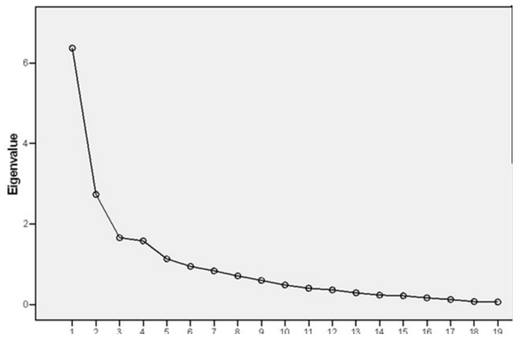

Fig. 3 Scree Plot of Technological Attractiveness Factors

1. IPI Technologies Assessment

According to the analysis shown in Figs. 4a-4e, nanoparticles and nanocomposites (No.1) are technologies in which IPI has a relative ability.

Based on results shown in Figs. 5a-5f, nanparticles and nanocomposites (No.1), nanocoatings (No.2), and nanocatalysts (No.3) are relatively attractive. In other words, IPI has better conditions in nanotechnology area than other new technology areas. This type of technology is also more attractive.

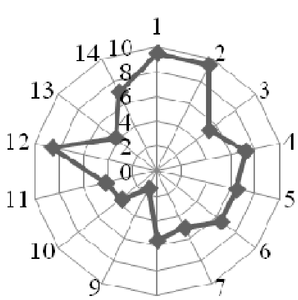

Fig. 4a Access to Commercializable Knowledge

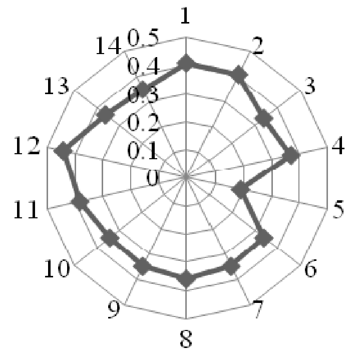

Fig. 4b Comparative Position of Patents Declaration in IPI against the Entire Patents Declaration in the International Patent Databases

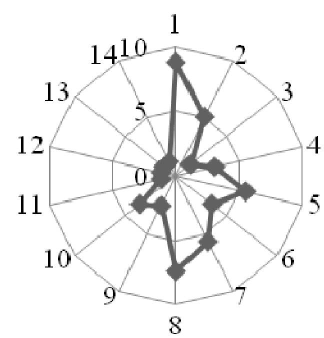

Fig. 4c Capability of Penetration in Global Market

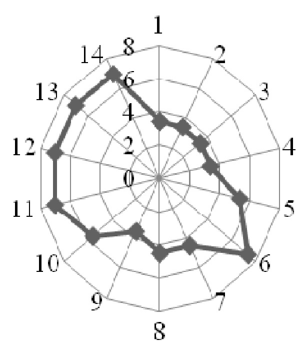

Fig. 4d Government Support in Policymaking

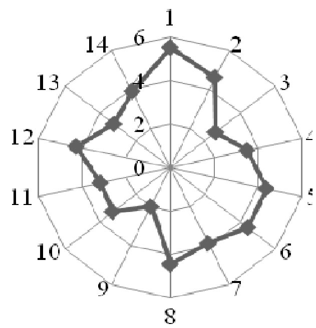

Fig. 4e The Ability of IPI in the Field of Technology.

The ability analysis also came to the following conclusions:

1) The level of access to commercializable knowledge in nanoparticles and nanocomposites (no.1), nanocoatings (no.2) and liquid separations (no.12) is higher than other technologies.
2) IPI does not have an appropriate performance in patenting of new technologies in international databases and therefore does not have a suitable comparative position.
3) The penetration in global market in nanoparticles and nanocomposites (no.1) and biofuels (no. 8) is higher than other new technologies.
4) The government support status in policy making is better in biological wastewater treatments (no.6) and membrane technologies (Nos. 11 to 14) than other new technologies.

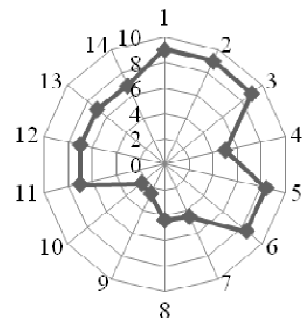

Fig. 5a Impact of Technology on Improving Customer and Social Welfare.

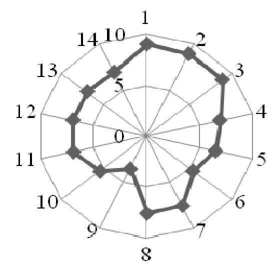

Fig. 5b Impact of Technology on Developing Local, Regional, and Global Markets.

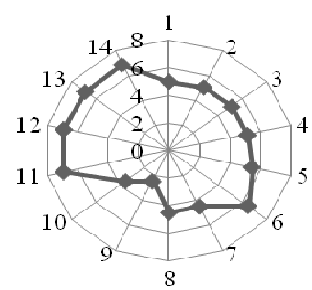

Fig. 5c Compliance with the Allocated Budget in Research, Technology and Production.

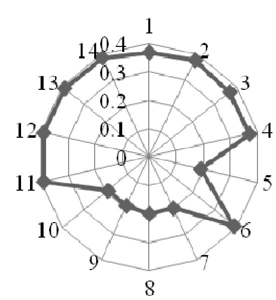

Fig. 5d The growth Rate of Patents in IPI in the International Databases.

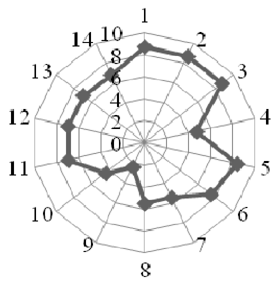

Fig. 5e. Technology Appropriateness in Comparison with National Technological Priorities and Competitive Technologies.

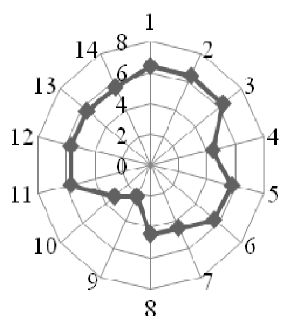

Figure 5f. The Attractiveness of Technology in IPI

The attractiveness analysis also came to the following conclusion:

1) Nanoparticles and nanocomposites (no.1), nanocoatings (no.2), nanocatalysts (no.3), bioremediatiams (no.5) and biological wastewater treatments (no. 6) technologies are more attractive from the aspect of improvement in customer and society welfare.
2) Nanoparticles and nanocomposites (no.1), nanocoatings (no.2), nanocatalysts (no.3) are highly attractive from the aspect of the effect on developing local, regional and international markets.
3) Regarding the compliance with the allocated budget in research, technology and production, all membrane technologies have a better position than nano and bio technologies (Nos. 11 to 14).
4) IPI has not improved in new technologies patents.
5) About the appropriateness of technology in comparison with technological national priorities and competitive technologies, nanoparticles and nanocomposites (no.1), nanocoatings (no.2), nanocatalysts (no.3) have more attractiveness.

9 Conclusion

Based on the research results, nanoparticles and nanocomposites are the only critical technologies in IPI. This category plays a significant role in obtaining the long term technological goals of the industry. The industry should protect their position in these kinds of technologies at all costs. In addition, the industry should harmonize domestic technological changes with global advances on the subject, and even aim to initiate major breakthrough.

Causes and factors related to technology deficiency should be realized and appropriate plans should be developed to increase industry's technological ability in nanocoatings, nanocatalyst, bioremediatiams, biological wastewater treatments, gas separation, liquid separation, membrane synthesis (gas separation), membrane synthesis (liquid separation). Policies should target simultaneous exploitation of other countries' abilities and maximum use of existing capabilities within industry. Future plans in industry should consider technologies with low risk and high profitability.

For the remaining technologies: nano applications for environment, biodegradables plastics, biofeuls, biotransformations, and biosensors; industry should encourage to stay abreast of latest development and maintain their expertise, without the need for government's allocation of large financial resources for research and development.

To improve the status of technology in IPI, the petrochemical industry chain should be reviewed. Feed supply, product selection, project execution and commissioning, production and storage, packaging, transporting and delivering products to customers, marketing and maintenance of the market should be improved. For example, about the feed supply, hydrocarbon resources are not supplied for the petrochemical industry and are exported. While according to the major policies in the field of energy, it should be considered that the ultimate goal of exporting is obtaining the maximum added value of the exported products, which needs evaluation of the feasibility of providing necessary raw material for petrochemical products.

To select a product, local, regional and global markets investigation is necessary. In project execution and commissioning step, necessary research should be done and experiences should be documented and protected. Operational problems in production and maintenance should be reduced to increase the productivity of the operation.

Packaging systems development, modification and facilitation of the distribution networks, reduction of the cost of packaging, shipping and delivery should be done. Paying attention to marketing and market maintenance is important in petrochemical industry chain, in which few people are working, especially internationally.

To improve technologies in the petrochemical industry, required infrastructure should be upgraded. In this regard, a data base of know-how knowledge and license holders and features of each license in terms of cost, technology, participation opportunity, technology development opportunity, and legal considerations should be identified. Documentation and use of the experimental knowledge of the operational technical experts is one of the ways for localization and development of technologies.

Modifying the communication among research bodies of petrochemical field leads to optimum use of resources and research facilities. Creation of the petrochemical technology parks increases the communication among industry, research institutions, and universities. Modifying the communication within the industry makes the industry have more research cooperations, more large scale manufacturing implementations, and commercialization of technologies. This helps IPI to acquire technical knowledge, improve some other set of quality standards, ensure the products' quality, and transfer knowledge and experience of foreign design engineers and researchers to Iranian counterparts.

Modifying human resources management and changing the structure of organizations are important for technology development. Reducing organizational constraints, adequate salary, providing appropriate hardware and software facilities for research and motivation for researchers are necessary.

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ارزیابی وضعیت فناوری‌های نوین: مطالعه موردی صنعت پتروشیمی ایران

مریم ابراهیمی[۱]، عباس مقبل با عرض[۲]، سید حمید خدادادحسینی[۳]، عادل آذر[۴]

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ایجاد اشتغال، درآمدزایی و حفظ منابع طبیعی، همگی ارکان توسعه پایدار برای صنایعی است که فناوری‌های نوین را استفاده می‌کنند. با وجود اهمیت فناوری‌های نوین، کشورهای در حال توسعه با محدودیت‌های بسیاری مانند مشکلات سیاسی و اقتصادی مواجه‌اند که توسعه یا انتقال فناوری منجمله فناوری‌های نوین را مشکل‌تر می‌کند. در این مطالعه، ما بر توسعه فناوری های نوین در صنعت پتروشیمی ایران تمرکز می‌کنیم که شامل فناوری‌های نانو، بایو و غشاء می‌باشد. همچنین، راه حل‌هایی را به منظور بهبود وضعیت نامطلوب فعلی فناوری‌های نوین در این صنعت پیشنهاد می‌کنیم. بدین منظور، درخت فناوری‌های نوین صنعت پتروشیمی ایران براساس نظرات خبرگان صنعت، ارائه می‌شود. از طریق مرور ادبیات نظری در خصوص موضوع‌های ارزیابی فناوری و اولویت‌بندی فناوری، شاخص‌های اولیه ارزیابی فناوری براساس ویژگی‌های توانایی، جذابیت و ثبت اختراع مشخص می‌شود. گردآوری داده‌ها از طریق نظرسنجی از چهل نفر از خبرگان صنعت و تحلیل وضعیت فناوری‌های نوین صنعت بواسطه روایی صوری، آزمون‌های اعتبار و تحلیل عاملی انجام می‌شود.

واژگان کلیدی: نانو فناوری، زیست فناوری، غشاء، توانایی، جذابیت.

۱. دانشجوی دکتری، دانکشده مدیریت و اقتصاد، دانشگاه تربیت مدرس. mar.ebrahimi@gmail.com
۲. استادیار، دانشکده مدیریت و اقتصاد، دانشگاه تربیت مدرس. moghbela@modares.ac.ir
۳. دانشیار، دانشکده مدیریت و اقتصاد، دانشگاه تربیت مدرس. khodadad@modares.ac.ir
٤. استاد، دانشکده مدیریت و اقتصاد، دانشگاه تربیت مدرس. azara@modares.ac.ir