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Designing a Quality Model of Technology Transfer in the Upstream Iranian Oil Industry

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ABSTRACT

Technology transfer in the oil industry in developing countries faces many obstacles due to cultural, economic, and political barriers. Therefore, besides preparing the existing infrastructure, the technology transfer process should be undertaken with a managerial focus. On the other hand, as far as the more effective transfer of imported technology is concerned, Iran's oil industry faces political constraints related to economic sanctions in addition to cultural and economic constraints. In this study, an attempt was made to identify critical variables affecting technology transfer in the Iranian oil industry by the qualitative method using the content analysis technique. The relevant literature review is in the form of a library study. The technology transfer approach in the Iranian oil industry has been based on classifying and presenting the structure based on previous research. An interview with a group of oil industry experts, sampled by the judgmental and snowball techniques, was conducted to review and answer the research question. Finally, the final qualitative model of the research was designed based on causal factors, intervening context, leader, and outcome.

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1. Introduction

In the coming decades, conventional fuels, specifically oil and gas, will play a major role in the world's energy supply. According to the World Energy Organization, about 65% of the world's energy will be supplied by oil and gas by 2030 (Azadi Tabar, 2021). Accounting for about 13 and 18 percent of the world's total oil and gas reserves, Iran's oil industry is the main axis of economic development. Intelligent use of these valuable reserves can be the most important competitive advantage in the field of international competition. In contrast, advanced technologies are required to extract and convert these resources into high value-added products. Only two-thirds of the available resources can be used, and the worst kind of the use of these resources is to sell them in the raw form or as low-value products (Bagheri et al., 2005).

In Iran, there are many problems and bottlenecks in technology transfer, most of which can be attributed to the lack of a responsible body to direct the flow of technology transfer and development and pay attention to technology as a strategic factor in the industrial development process as revealed by preliminary studies. Consequently, most of our major industries, especially the oil industry, has largely failed to successfully transfer, create, and develop new technologies so that Iran's oil industry is still a buyer and importer of technology from other countries due to the huge reserves of the oil and gas industry, despite its one hundred years of history (Azizi et al., 2007).

A look at the oil industry technology in Iran shows that despite post-Islamic Revolution developments, especially engagement in maintenance, construction, and production and even to a limited scale, in design and engineering, the technological capability of the Iranian oil industry is still related to exploitation yet. Unfortunately, the technology gap is widening due to the investment of other countries and even companies in the field of research and development of new technologies. This can be one of the most important threats against Iran's oil industry. Due to this obvious technology gap, for several decades, the managers of this industry have inevitably been led towards the use of imported technologies in various types of technology transfer projects. However, the lack of emphasis on realizing all stages of a successful transition (DD) (Selection, acquisition, adaptation, acquisition and development) and the lack of necessary mechanisms to achieve this have kept the oil industry as an importer of foreign technologies. A clear indication of this claim is the repeated licensing of similar units, on the other hand, the information gap has led to the fact that in some cases, the imported technologies are not identified and selected properly so that some imported technologies are not compatible with the specific requirements and conditions of Iran. Units based on unproven and outdated foreign technologies are other signs of this information gap (Bagheri et al., 2005).

Technology transfer is an essential process for the widespread use of technology by one or more users. Technology transfer itself comprises several methods and can be considered the main method of technology acquisition and related topics. There is still no comprehensive and acceptable definition of technology. In fact, there are different interpretations of the concept of technology transfer. Some have interpreted technology transfer as the transfer of knowledge, while others have equated it with the transfer of hardware and knowledge implicit in it. Technology transfer is a complex and difficult process through which imported technology is acquired to be used for production and as a basis for the creation of new technology. Accordingly, various definitions have been proposed for technology transfer. In sum, technology transfer is the knowledge required to design and manufacture a product or service provided by an organization or department. Technology may be used in machines, products, or services (Ansari and Zareei, 2009).

A review of the theoretical foundations of research, especially East Asian countries, it can be seen that they have strengthened the technology base of their country by transferring it from other developed countries in their development path to accelerate the solution of the problems of the industrial sector. Then, by creating suitable economic infrastructure, they have sought to strengthen their academic and research centers. As another solution, they intend to acquire scientific and technical knowledge necessary for economic development without using knowledge resulting from research by researchers and scholars around the world. In this case, it will be very difficult and cause irrational waste of forces. In addition, achieving such a solution is not possible when underdeveloped countries are attempting to achieve economic development. If such thinking is accepted globally, the technical progress of all countries in the world, including industrialized countries, will be disrupted (Feghhi Farahmand, 2004). We will examine various methods of technology acquisition below.

2. Literature Review

2.1 Types of Technology Acquisition Methods

Table 1. Types of Technology Acquisition Methods Modified According to Previous Research

Financial support for academic research by joint consortium of industry and university research	Kamala and Swami (1985); Dale (1990); Lopez Martinez et al. (1994); Alp et al. (1970a; 1970b); Things et al. (2000); Ankatraman (2005); Robert and Fukuda (2004); Lichtentalar (2004); Nakamura and Odagiri (2005)
Supporting graduate education of staff in specialized colleges	Wahmy (1993); Alp et al. (1997a; 1997b; 1997c); Poon and McPherson (2005)
Foreign research and development centers	Chonz et al. (2001); Hemmert (2004); Cook and Ceylan (2007)
Consultants	Alp et al. (1997a; 1997b; 1997c); Puk (2001); Nakamura and Odagiri (2005)
Franchise agreements (licensing)	Kling (1980); Rothwell (1992); Chiza and Menzeni (1998); Chiza et al. (2000); Puk (2001); Toshikawa (2003); Granstrand (2004); Lichtentalar (2004); Hemmert (2004); Nakamura and odagiri (2005))
Technical meetings	Alp et al. (1997a; 1997b; 1997c); Chiza and Menzini (1998)
Technical journals	Poon and McPherson (2005); Alp et al. (1997a; 1997b; 1997c)
Participation in trade shows	Poon and McPherson (2005)
Buying existing technology	Narayana (1998); Akarakiri (1998); Jones et al. (2001); Doysters and Hagdom (2000); Cook and Ceylon (2007); Tsai and Wang (2008); Pak (2001); Avoni (2005); Alp et al. (1997a; 1997b; 1997c); Swam and Alred (2003); Granstrand (2004); Hemmert (2004).
Improvement and development of domestic technology	Sen and Robinstein (1990); Rutwell (1992); Alp et al. (1997a; 1997b; 1997c); Krokawa (1997); Narayana (1998); Menzini (1998); Jones et al. (2001); Cook and Ceylon (2007); Rubens and Fukuda (2004); Granstrand (2004); Swam and Alid (2003).

3. Methodology

3.1 Technology Transfer Models

3.1.1 Ted et al. Model

According to this model, the attitude of each organization to the acquisition of technology has two main dimensions: organization features and technology features:

Organization features: Enterprise strategy (leadership, follow-up), compliance with competencies or capabilities (severe, weak), enterprise culture (introverted, extroverted), management ability (low, high).
Technology features: Competitive importance (type of technology, key base, growing, emerging), technology complexity (low, high), coding (low, high) (Najafi, 2008).

3.1.2 Ford Model

This model includes five criteria according to which the company can determine how to achieve technology. These five criteria are the competitive effect of technology, the technology of life cycle, the need to acquire technology, the urgency of access to technology, and the relative ability of the firm in technology (Table 2).

Table 2. Decision Matrix Regarding the Choice of Technology Transfer Method in the Ford Model

Criterion Acquisition method	The relative ability of the firm in technology	The need for rapid access to technology	The need to acquire technology within the organization	Competitive effect of technology	Technology life cycle
Endogenous development	Top		Maximum	Distinctive (vital)	Genesis
Mutual investment				Privileged or basic	The beginning of growth
Outsourcing research				Privileged or basic	The beginning of growth
Buy royalties	Acquisition method		The least	Privileged or basic	Maturity
Buy a technology product	Down	Maximum	Completely unnecessary	Foreign	Time

Source: Taleshian and Shirazi, 2016

3.1.3 Robert and Berry Model

This model examines general methods of accessing technology. Therefore, the user's familiarity with the market and technology are the two main criteria for deciding on the appropriate method of acquiring basic technology. So, the following two scenarios of the above-mentioned and effective criteria in this model are described:

- Existing and well-known technology: Technology that already exists and has been used.

- Existing and well-known market: The market in which the technology applicant is located.
- New but well-known technology: Technology that did not exist before, but there is enough knowledge about it.
- New but well-known market: New technology products have not entered the market, but there is sufficient knowledge of the new market.
- New and unknown technology: Technology did not exist before, and there is no cognition of it.
- New and unknown market: so far, there is no market for technology products and should be created. Alternatively, there was a market, but it was not known.

Table 3 shows the different abovementioned situations.

Table 3. Technology Selection and Transfer Matrix in Model Robert & Berry

	Mutual investment	**Acquisition of education shares**	**Acquisition of education shares**
New and unknown New situation and known base market	Acquisition of joint venture ownership	Acquisition of franchise purchase ownership	Acquisition of education shares
	Acquisition of ownership	Acquisition of franchise purchase ownership	mutual investment

Source: Taleshian and Shirazi, 2016.

3.1.3 Gilbert Model

The model considers the transfer of technology within a system space and tries to obtain the appropriate transfer method by determining the appropriate system (Manteghi and Goodarz Naseri, 2011).

Table 4. How to Choose the Method and System of Technology Transfer

Inactive methods: Purchase of goods (hardware and software) Buy a standard franchize	Collaborative methods: Buy a collection Buy incremental royalties Mutual investment Joint transaction Acquisition / integration	yes	Does the recipient have the desire and ability to meet the technology barrier requirements?
General methods: Disclosure Recruitment Education	Anti-competitive methods: Defense legal activities	no	

Free copy Study course	Key staff entry Simulation Embezzlement Industrial espionage		
		no	yes
		Does the source of the technology have control over how the technology is used according to those requirements?	

Source: Manteghi and Goodarz Naseri (2011).

4. Literature Review

Iran's oil industry can achieve a special position in this industry using new technologies. Unfortunately, due to following in this field and using only the technology of other countries, it has not achieved this position, as it should. According to Derakhshan and Taklif (2015), the results showed that relying on foreign investments in the framework of oil contracts with international oil companies is not and will not be a good solution for technology transfer and development in the upstream part of Iran's oil industry. Unless, first of all, the growth of basic knowledge and operational knowledge related to the country's oil industry has provided suitable grounds for absorbing technology and developing it, and secondly, the active presence of regulatory institutions with the objectives of monitoring, managing, and improving efficiency in the technology market has been able to provide suitable grounds that can be used effectively to attract capacity.

However, according to Areish and Bardai (2013), the findings showed that technology transfer has had a negative and positive impact on the oil and gas industry and some other sectors of the national economy over three periods. During a closed economy, production efficiency and revenue from crude oil sales in the international market declined. The government capital expenditures shown in this study were affected because of reduced production efficiency. Similarly, the findings of this study showed that electricity generation has decreased due to the lack of spare parts and the expansion of existing factories. However, the positive effect was that local engineers and technicians achieved some of the critical positions that foreign immigrants had hitherto dominated. In addition, according to Mabadi (2015) the results showed that the transfer of valuable technology could completely reduce the importance of companies as the only supplier of such vital economic technology to oil-rich developing countries. This may lead to economic and technological competition in this field and again reduce the dependence of developing oil countries on international oil and gas companies and be profitable for such companies.

Also it should be considered that the technology transfer environment and the support of government organizations to private companies have a key role in the successful implementation of the projects (Nouri and Miqani Nejad, 2014). The study's analysis of Al-Hajri (2016) shows the researcher's role, which is considered one of the most effective factors in the success of technology transfer, has not been used in Qatar. As well, some less important scale factors with high availability, such as executive support, compared to other factors where less availability and higher importance scale are only important to change the direction of scale-based factors. This study should be repeated regularly to reflect the current situation with the same issue in mind. Also, Daim and Kocaoglu (2008) discussed about the importance of financial support for university research, industry and university research company consortium, support for staff postgraduate education, specialized colleges, foreign research and development centers, consultants, improvement, and development of internal technology, patent agreements, vendors, suppliers, technical meetings, technical journals, participation in trademark contracts, purchase existing technology, in their study.

The challenge now is if the imported technology is not properly selected and transferred in the right direction, it will cause irreparable damage. The technology transfer process consists of six main stages including selection and learning, adaptation, absorption, application, development, and dissemination. In the context of the successful use of all these steps, commercialization, technology transfer will be provided. Saedi Nia (2014) tries to evaluate the success rate of technology transfer projects in the National Iranian Oil Company (NISCO) and determine the effective technology transfer method based on our priorities and using the Analytic Hierarchy Process (AHP) for the company. In the Article of Elahi et al. (2015), using library resources, while introducing the Iranian oil industry and how to manage technology in it, some requirements and effective factors in technology transfer and plans for the development and commercialization of technology used in the Iranian oil industry and the shortcomings of oil contracts are discussed.

Shen et al. (2011) provide suitable model for selecting the technology of organic light emitting diodes in Taiwan and they declared that the indicators of technological competence, business impacts, technology development potential, risk and types of technology available in the industry are effective. Lee et al. (2010) showed that management and implementation, equipment quality, production technology, service level and cost, and two companies supplying the desired technology are important indicators in the evaluation and selection of modern equipment in technology transfer. According to a poll in Germany and Japan, background and technology level of the company and technology acquisition performance are influencing factors on the technology acquisition performance of high-tech firms (Hemmert, 2004). On the other research by Yu (2000), internal research and development, collaborative research and development, buying technology, intra-organizational, external factors, and technology-related and specific factors are shown as the effective factors.

According to Azadi Tabar et al. (2021) rules and procedures and features of technological transfer are the most important factor in technology transfer in super gas wet and gas wet rock surface.

Due to the great importance of the issue in Iran's oil projects, more attention to strategic planning and improvement of the management and effectiveness of the technology, transfer process will greatly help the transfer of technology as successfully as possible, resulting in the technological growth of this industry (Azizi et al., 2007). An issue that has not been addressed much in domestic and foreign studies is the recognition of the underlying and effective factors in technology transfer. Although it can be accessed briefly and indirectly in related studies, but progress in this area requires accurate and direct evaluation. Therefore, the present study intends to identify the underlying factors of technology transfer in the oil industry. In other words, the main question of the research is what are the important factors underlying technology transfer in the Iranian oil industry.

4.1 Model of Technology Transfer in the Iranian Oil Industry

In Iran there are several methods for technology transfer, among which one may refer to technology transfer through foreign direct investment, joint investment, license contracts, turnkey contracts, import of capital goods and machinery, buy-back contracts, reverse engineering, technical assistance support services contracts, and the recruitment of scientific and technical personnel (Ghazinoori, 2005). However, today, there are some modern methods of technology transfer that can be mentioned: technical training of employees in the advanced industries; the establishment of subsidiary companies and the establishment of research centers in industrialized countries; the establishment of international scientific and technical circles and associations; the establishment of educational centers and high-level research within the country led by academics and advanced research institutes and universities; academic exchange through universities; cooperation of domestic industries with foreign industries; strategic cooperation; registration of inexpensive foreign patents in the country; the acquisition of foreign companies or the purchase of some of their shares; hiring foreign experts and scientists; and the creation of databases (Bandarian, 2005).

5. Methodology

The present study used a qualitative method to review the literature systematically. First, the presented data were collected, and the fuzzy Delphi method was used to analyze and interpret the described information. With the help of the fuzzy Delphi method, it will be possible to integrate different theories from different sources.

The present research was conducted by the qualitative method using qualitative content analysis method. Like any other research, the relevant literature was reviewed by the library method to classify and present the structure based on previous research. The stakeholders' views were considered to provide a suitable model for technology transfer in the oil industry. In other words, managers and experts were asked about the status of standards in the technology transfer system in the oil industry using in-depth interview tools.

In this research, the expressions in question were categorized after collecting data obtained based on keywords of oil industry experts. The concept or key concepts of that phrase were deduced; this step is called "key point coding". In the next step, the resulting analysis codes and those codes that had a common theme were grouped. This common theme is known as "category". After enumerating the categories, the common categories together formed a "theme" with larger and more abstract meanings. The formation of categories and themes eventually led to a key category concerning research questions. This classification can be displayed in the form of a model consisting of simple or multiple relationships.

One hundred twenty nine (129) variables were identified that in the form of factors or preconditions (31 variables), intervention factors (19 variables), bedrock factors (14 variables), strategies (50 variables), and consequences (15 variables) were identified at this stage.

6. Research Findings

6.1 Analysis of Expert Opinions

Results of the first step of the fuzzy Delphi analysis of research dimensions, components, and indicators. In this section, the fuzzy Delphi method was used to validate the identified dimensions, components, and indicators. According to the following coding tables, codes were selected for each of the components and indicators of research for identification and analysis. Finally, the necessary interpretations were made according to the definite values of the non-fuzzy method.

Table 5. Dimensions, Components, and Basic Indicators of Research

Dimensions	Component	Indicator
Causal condition	10	33
Strategic conditions	12	51
Conditions infrastructure	3	15
Interfering condition	8	23
Condition consequence	5	17

Source: Research finding.

The results of the first step of the fuzzy Delphi analysis of research dimensions, components, and indicators.

Table 6. Coding of Dimensions, Components, and Indicators

Code	Indicator	Code	Component	Dimensions
S01	1. The level of advanced technology	C11	1. Technological competence	Causal conditions C1
S02	2. Innovation of technology			
S03	3. The key to technology			
S04	4. The monopoly of technology			
S05	1. Business risk	C12	2. Risk	
S06	2. Technical risk			
S07	1. The amount of investment	C13	3. Financial and economic factors	
S08	2. Operation and maintenance			
S09	1. Compatibility at the native level	C14	4. Institutional factors	
S10	1. Alignment with the company's strategy	C15	5. Business factors	
S11	2. Security of supply			
S12	3. The importance of technology			
S13	1. Advances in technology	C16	6. Level of technology development	
S14	2. Functional results			
S15	3. The degree of uniqueness			
S16	4. Difficulty in accessing technology			
S17	5. Difficulty of learning			
S18	6. Required infrastructure			
S19	7. Functions			
S20	8. Uses			
S21	9. Technology transfer capability			
S22	10. Innovation of technology			
S23	11. Newness of the presented concept			

S24	12. Compared to the best situation in the world			
S25	1. Employment	C17	7. Applications and needs	
S26	2. Barriers to use			
S27	3. Suppliers			
S28	4. The amount of meeting the needs			
S29	5. Profitability			
S30	1. The degree of alignment with goals and programs	C18	8. Strategic importance	
S31	2. Sphere of influence			
S32	3. The extent of the impact on infrastructure development			
S33	1. This factor describes the negotiation process between the recipient and the technology providers	C19	9. Process	
S34	2. Barriers to use	C110	10. Weaknesses, strengths, threats, and opportunities of Iran's oil industry in the face of economic sanctions	
S35	3. Suppliers	C21	1. Assessing the strengths and weaknesses of technological capability	Strategic conditions C2
S36	4. The amount of meeting the needs			
S37	5. Profitability			
S38	1. The degree of alignment with goals and programs			
S39	2. Sphere of influence			
S40	3. The extent of the impact on infrastructure development			
S41	1. This factor describes the negotiation process between the recipient and the technology providers			
S42	2. Main activities (input logistics, production operations, output logistics, marketing and sales, after-sales service)	C22	2. Integrating all company activities	
S43	1. Organization or institution that manages technology transfer (transfer agent)			
S44	2. Official or unofficial carrier through which technology is transmitted (transmission channel)	C23	3. Integrating technology transfer agent	
S45	3. Content and shape of what is being transferred (to be transferred)			

S46	4. Organization or institution that receives the transferred item (transfer recipient)		
S47	2. Main activities (input logistics, production operations, output logistics, marketing and sales, after-sales service)		
S48	1. Change strategies (changes in investment methods and project financing, change in the country's energy diplomacy and take advantage of political and trade relations between friendly countries, changing international discourse, reviewing joint natural gas reservoir management, reviewing consumer markets and future target markets, restructuring the oil industry and downsizing the industry to make it more agile)	C24	4. Choosing the best technology transfer strategy
S49	2. Offensive strategies (Cost reduction, strengthening capable private sector entrepreneurs, active presence in energy trade organizations and treaties, continuation of the joint scientific relationship between industry and universities)		
S50	3. Defensive strategy strategies (strengthening the manufacturing, industry, mining, and agriculture sectors to replace the oil economy, building trust to attract the liquidity of communities guaranteeing above-average profits, paying attention to knowledge forces to create technology and support them appropriately, providing pre-purchase and purchase conditions with long-term contracts)		
S51	4. Diversity strategy strategies (diversity of market geography, variety in transmission routes, variety in the way of financing and technical projects)		
S52	1.Investment participation agreements	C25	5. Proper management of oil contracts
S53	2. Production participation contracts		
S54	3. Service contracts (purely service contracts)		

S55	4. Contracts for purchasing risky services		
S56	5. Mutual service contracts, contract of sale		
S57	1. Partial transfer of technology	C26	6. Managing different methods of technology transfer in the oil industry
S58	2. Semi-complete transfer of technology		
S59	3. Complete technology transfer		
S60	4. Commercial transfer of technology		
S61	1. Interactive mechanism	C27	7. Detailed study of various technology transfer mechanisms in the oil industry
S62	2. Conversion mechanism		
S63	1. Hardware	C28	8. Investigating the transfer factors of technology transfer in the oil industry
S64	2. Software		
S65	3. Capital		
S66	1. Education	C29	9. Managing the technological learning capability of technology transfer in the oil industry
S67	2. Knowledge base		
S68	3. Complexity of technology		
S69	4. Teamwork		
S70	5. Attitude		
S71	6. Capacity		
S72	7. Monitoring		
S73	1. The cost of acquiring equipment	C210	10. Reducing technology transfer costs in the oil industry
S74	2. Maintenance cost		
S75	3. The cost of training and counseling		
S76	4. Personnel costs		
S77	1. Maintenance service training	C211	11. Providing the best methods to improve the level of service in technology transfer
S78	2. Providing a comprehensive operational guide and technology support services		
S79	3. Providing communication and consulting services		
S80	4. Spare parts supply services		
S81	5. Repair services		
S82	1. Compatibility and integration of equipment	C212	12. Selecting the best production technology
S83	2. Preventive maintenance of equipment		
S84	3. Road arrangements and installation of equipment		
S85	4. Experimental use of equipment		
S86	1. Technological position	C31	1. Technical

S87	2. Available resources			
S88	3. Acquisition urgency			
S89	4. Experience in research and development			
S90	5. Manpower for research and development			
S91	6. Hardware and software capacity of existing technology			
S92	1. Appropriate investment risk	C32	2. Factors of the organization	Infrastructure conditions C3
S93	2. Sufficient material resources such as facilities			
S94	3. Machinery			
S95	4. Spare parts, etc.			
S96	5. Adequate transfer of technology to the organization			
S97	6. Active support of management and leadership			
S98	7. Communications between key people of all parties involved			
S99	8. Targeting product exports			
S100	9. Adequate market share			
S101	1. Financial and economic resources	C33	3. Financial and economic resources	
S102	1. An acceptance rate	C41	1. Socio-cultural factors	Interfering conditions C4
S103	2. Perception			
S104	1. Environmental pollution	C42	2. Health and environment	
S105	1. Training of local labor force	C43	3. The nature of technology	
S106	2. Technology map			
S107	3. Technology changes			
S108	1. Political problems of local laws for international investment and technology transfer	C44	4. Rules and procedures	
S109	2. Socio-economic issues			
S110	3. Existence of cultural and social value			
S111	4. Available resources			
S112	1. A key factor that includes the technology provider and recipient environment	C45	5. Environment	
S113	2. Cultural factors			
S114	3. Political and economic			
S115	1. Suppliers	C46	6. Activists	
S116	2. Recipients and organizations			
S117	1. Skills	C47		

S118	2. Financial resources		7. Functions of external institutions	
S119	3. Infrastructure			
S120	4. Technological support and other enterprises			
S121	1. Scientific knowledge	C48	8. Features of technological transfer	
S122	2. Physical technology			
S123	3. Technical design			
S124	4. Tricks			
S125	1. Potential return on investment	C51	1. Improving business effects	Consequence Conditions C5
S126	2. Impact on current market share			
S127	3. New potential market			
S128	1. Availability of technical resources	C52	2. Improving the development potential of technology	
S129	2. Equipment support			
S130	1. Personal productivity	C53	3. Improving the efficiency of technology transfer	
S131	2. Satisfaction and effectiveness of the project			
S132	1. The amount of competitive advantage created	C54	4. Upgrading functional features	
S133	2. Developed technical knowledge level			
S134	3. Created skill level			
S135	1. Stability of equipment	C55	5. Improving the quality of equipment	
S136	2. Equipment safety			
S137	3. Easy to use equipment			
S138	4. Equipment automation			
S139	5. Eco-friendly design			
S140	6. Equipment			
S141	7. Quality of manufactured products			

Source: Research finding.

Table 7. Survey Results in Step 2, the Fuzzy Analysis

Dimensions	Code	L	M	U	Mean	Crisp	Results
Causal conditions	C1	0.758	0.908	0.985	(0.758,0.908,0.985)	0.883	Assent
Strategic conditions	C2	0.828	0.953	0.995	(0.828,0.953,0.995)	0.925	Assent
Infrastructure conditions	C3	0.798	0.933	0.995	(0.798,0.933,0.995)	0.908	Assent
Interfering conditions	C4	0.735	0.895	0.970	(0.735,0.895,0.970)	0.867	Assent
Consequence conditions	C5	0.780	0.923	0.985	(0.780,0.923,0.985)	0.896	Assent

Source: Research finding.

According to the results of the first step of the fuzzy Delphi analysis and de-fuzzy index (Crisp), all dimensions and components were accepted by experts in the first step. Also, according to the results of the first stage, indicators S22 (technology innovation), S90 (human resources for research and development), and S140 (equipment), whose defuzzified values were smaller than 0.7, were excluded, and the indicators whose defuzzified values were greater than 0.7 were accepted by the experts. In line with the changes in this section:
1- The deleted index "technology innovation" (S22) was merged with the index "New concept" (S23) due to its similarity.
2. The deleted index "manpower for research and development" (S90) was also merged with the index of "available resources" (S86) due to similarity.
3. The index of "hardware and software capacity of existing technology" was also divided into two indicators of "hardware capacity of existing technology" and "software capacity of existing technology".
According to the fuzzy Delphi analysis, 5 dimensions, 38 components, and 139 indicators were approved by the experts in the first step.
Given the results of the second step of the fuzzy Delphi and the criterion for setting the crisp de-fuzzing index, no indicators were removed in the second round, signaling the end of the Delphi rounds. In general, one approach to ending the Delphi is to compare the average scores of the first and second step questions. If the difference between the two stages is less than the threshold (0.2), the polling process will stop. Therefore, 139 confirmation indicators were determined as the final indicators of the research model.

6.2 Weighing Dimensions and Components Using Shannon Entropy

The entropy method is one of the multi-criteria decision-making methods for calculating the weight of criteria. This method requires a criterion-option matrix.
The Shannon entropy method is used to calculate the weight of dimensions. The entropy number in each dimension is between zero and one. An increase in Shannon entropy indicates an increase in uncertainty and a decrease in information. The standard deviation is then calculated, which states how much information the relevant dimension provides for decision-making, and the higher the value, the more useful the information. Finally, the normal weight is calculated, which shows how much these dimensions help to make decisions and are prioritized.

Table 8. Dimensional Rank Calculation Using Shannon Entropy

Dimensions	Calculating entropy	Degree of deviation	Normal weight	Rank

Causal conditions	0.9937	0.0063	0.1778	4
Strategic conditions	0.9908	0.0092	0.2587	1
Infrastructure conditions	0.9925	0.0075	0.2115	2
Interfering conditions	0.9947	0.0053	0.1508	5
Consequence conditions	0.9929	0.0071	0.2011	3

Source: Research finding.

According to the results obtained in table 8, the strategic dimension with entropy number 0.9908 has the lowest value among other dimensions and its standard deviation with 0.0092 has the highest value, resulting in the weight of this dimension value 0.2587, which indicates that this dimension has the first priority and is the most important dimension in decision making in the field of technology transfer. Similarly, the dimensions of infrastructure with a weight of 0.2115, consequence with a weight of 0.2011, causal with a weight of 0.1778, and interfering with a weight of 0.1508 are the most important and effective in decision-making.

The Shannon entropy method has also been used to obtain the priority of the components, the results are shown in Table 9.

Table 9. Calculating Component Rankings Using Shannon Entropy

Components	Calculating Entropy	Degree of deviation	Normal weight	Rank
Technological competence	0.983	0.017	0.011	26
Risk	0.999	0.001	0.001	38
Financial and economic factors	0.838	0.162	0.104	2
Institutional factors	0.922	0.078	0.050	6
Business agents	0.833	0.167	0.108	1
Level of technology development	0.990	0.010	0.006	34
Applications and needs	0.989	0.011	0.007	33
Strategic importance	0.997	0.003	0.002	37
Process	0.955	0.045	0.029	14
Weaknesses, strengths, threats, and opportunities of Iran's oil industry in the face of economic sanctions	0.970	0.030	0.019	18
Assess the strengths and weaknesses of technological capability	0.991	0.009	0.006	35

Integrate all company activities	0.975	0.025	0.016	20
integrating	0.988	0.012	0.008	32
Choosing the best technology transfer strategy	0.993	0.007	0.004	36
Proper management of oil contracts	0.984	0.016	0.010	27
Management of various technology transfer methods in the oil industry	0.926	0.074	0.048	7
Detailed study of various technology transfer mechanisms in the oil industry	0.975	0.025	0.016	21
Investigating the transfer factors of technology transfer in the oil industry	0.949	0.051	0.033	12
Managing the technological learning capability of technology transfer in the oil industry	0.976	0.024	0.015	22
Reducing technology transferring costs in the oil industry	0.917	0.083	0.053	3
Providing the best methods to improve the level of service in technology transfer	0.960	0.040	0.026	15
Selecting the best production technology	0.963	0.037	0.024	17
technical	0.988	0.012	0.008	31
Organizational factors	0.945	0.055	0.035	10
Financial and economic resources	0.987	0.013	0.008	30
Socio-cultural factors	0.937	0.063	0.041	8
Health and the environment	0.946	0.054	0.035	11
The nature of technology	0.961	0.039	0.025	16
Rules and procedures	0.976	0.024	0.015	23
Environment	0.938	0.062	0.040	9
Activists	0.952	0.048	0.031	13
Functions of external institutions	0.978	0.022	0.014	24

Features of technological transfer	0.974	0.026	0.017	19
Improve business effects	0.984	0.016	0.010	28
Improving technology development potential	0.987	0.013	0.008	29
Improve technology transfer efficiency	0.981	0.019	0.013	25
Upgrade functional features	0.920	0.080	0.051	5
Upgrade equipment quality	0.919	0.081	0.052	4

Source: Research finding.

According to these results, the business agents' component has the lowest entropy value of 0.833 and the highest standard deviation of 0.167, as a result, the weight of this component is equal to 0.108, which indicates that it has the greatest impact on decision-making in technology transfer in the oil industry. In the second rank is the component of financial and economic factors with a weight of 0.104, which these two components among 38 components each alone have more than 10% of the impact on decision making, while in the third rank the component of reducing technology transferring costs in the oil industry with a normal weight of 0.053 and its impact is reduced to 5% compared to the first two ranks.

In addition, out of 38 components, 10 components have an impact of less than 1%. In the 37th rank, the strategic importance has the normal weight of 0.002 and in the last rank; the risk is with the highest entropy value of 0.999 and the lowest standard deviation. The risk component has the weight of 0.001; therefore, it has the least impact on technology transfer in the Iranian oil industry among all components.

The following figure (Figure 1) is the final qualitative model extracted from the results of expert opinion analysis.

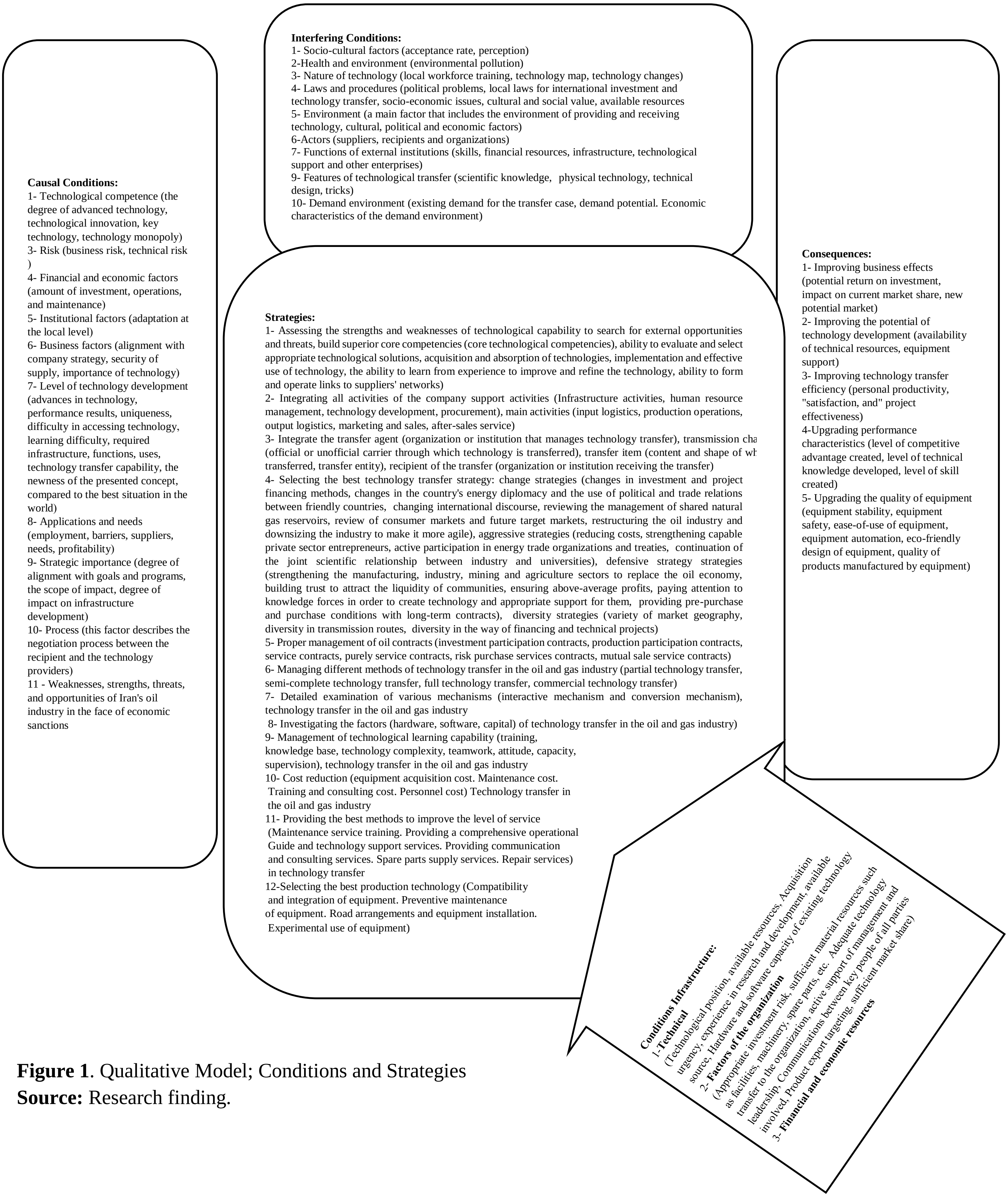

Figure 1. Qualitative Model; Conditions and Strategies
Source: Research finding.

7. Conclusion

The primary goal of the research was to obtain a technology transfer model related to the upstream sector of the oil industry, which could discuss oil contracts in terms of the success rate for technology transfer. Moreover, evaluate their performance in this field and show their strengths and weaknesses to transfer technology in the upstream field of the oil industry. However, in practice, the obtained model is a comprehensive model with variables that can be claimed to be usable in almost all areas of the oil industry, and this model can be used to examine the performance of technology transfer in all areas of the oil industry.

In this part of the research, to review and answer the research question, interviews are conducted with academic experts in the oil industry as well as other knowledgeable experts and thinkers. Academic experts were selected by judgmental and snowball sampling methods.

By analyzing the interviews with experts, Fuzzy Delphi and Shannon Entropy techniques were prepared. 5 dimensions, 38 components, and 139 indicators were approved by experts and were classified as follows.

- Dimensions of causal conditions: Technological competence, risk, financial factors and economy, institutional factors, business factors, level of technology development, applications and needs, strategic importance, process, SWOT of Iran's oil industry in the face of economic sanctions
- Dimensions of strategies: Assessing the strengths and weaknesses of technological capability, integrating all company activities, supporting activities, transferring agent integration, selecting the best technology transfer strategy, properly managing oil contracts, managing various technology transfer methods in the oil and gas industry, detailed study of various technology transfer mechanisms in the oil and gas industry, investigating technology transfer factors in the oil and gas industry, managing technological learning capability of technology transfer in the oil and gas industry, reducing technology transfer costs in the oil and gas industry, choosing the best production technology
- Dimensions of the interventionist conditions: Socio-cultural factors, health, and environment, nature of technology, rules and procedures, environment, actors, functions of external institutions, features of technological transfer, demand environment
- Dimensions of infrastructure conditions: technical, organizational factors, financial and economic resources
- Dimensions of consequences: Improving business effects, improving technology development potential, improving technology transfer efficiency, upgrading performance features, upgrading equipment quality

These results are consistent with some prior studies. Azadi Tabar et al. (2021) showed rules and procedures and features of technological transfer are the most important factor in technology transfer. It is worth to highlight that these factors especially rules and procedures can delay the technology transfer process for years. In another study, Aziz et al. (2007) demonstrated some infrastructure conditions such as technical, organizational factors, financial and economic resources could be effective factors in technology transfer. Therefore, relevant organizations need to remove barriers to solving technology transfer problems. In addition, Yu (2000) evaluated some areas related to technology transfer in the oil and gas industry were professionally. Research evidence showed that since the oil and gas industry need quality models of industrial design, it is necessary to put more accurate quality assessment methods in research priorities. Based on these related studies, quality design models for the oil and gas industry are better able to contribute to more efficient productivity and production.

Finally, the following summary model (Figure 2) is presented that the factors affecting technology transfer are classified into five main dimensions (causal, interfering, infrastructure, strategies and consequences). The following hypotheses can be presented based on the following model and research findings:

H1: Causal factors have a significant impact on technology transfer strategies in the oil industry.

H2: Infrastructure conditions have a significant impact on technology transfer strategies in the oil industry.

H3: Interfering factors have a significant impact on technology transfer strategies in the oil industry.

H4: Technology transfer strategies have a significant impact on the consequences of technology transfer in the oil industry.

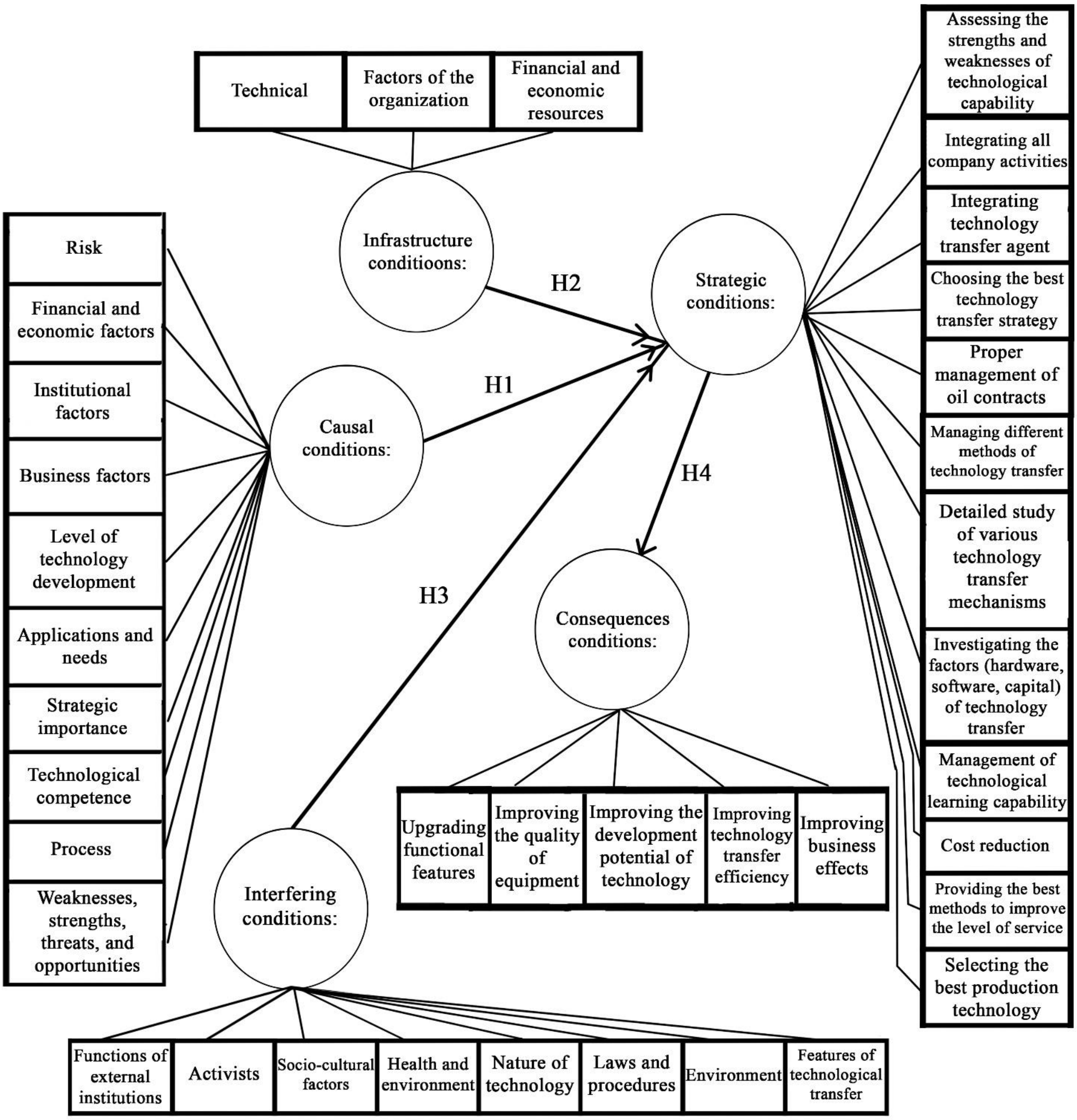

Figure 2. Factors Affecting Technology Transfer
Source: Research finding.

Based on the findings, the following suggestions can be drawn:

1. Providing the necessary bases for technology transfer in different organizational areas, different technology transfer tools, technology localization
2. Identifying, selecting, and evaluating the appropriate technology transfer strategy in the oil industry
3. Utilizing the potential of change strategies (changes in investment and project financing methods, changes in the country's energy diplomacy and the use of political and trade relations between friendly countries, changing

international discourse, reviewing the management of shared natural gas reservoirs, reviewing consumer markets and future target markets, restructuring the oil industry, and downsizing the industry to make it more agile)

4. Properly using offensive strategies (reducing costs, strengthening capable private sector entrepreneurs, actively participating in energy trade organizations and treaties, establishing joint scientific relationships between industry and universities)
5. Using defensive strategies in appropriate conditions (strengthening the manufacturing, industry, mining, and agriculture sectors to replace the oil economy, building trust to attract the liquidity of communities guaranteeing above-average profits, paying attention to knowledge forces to create technology and support them appropriately, providing pre-purchase and purchase conditions with long-term contracts)
6. Utilizing the potential of diversity strategies (diversity of market geography, diversity of transmission routes, and diversity of the way of financing and technical projects)
7. Managing different methods of technology transfer in the oil industry according to the current conditions of the oil industry (partial technology transfer, semi-complete technology transfer, complete technology transfer, and commercial technology transfer)
8. Creating an effective system for selecting and evaluating the best technology transfer mechanisms in the oil industry
9. Creating the necessary infrastructure in the field of hardware, software, and capital for technology transfer in the oil industry
10. Creating effective service structures of technology transfer in the oil industry and in various fields from before technology transfer to after it, including at the service level, comprehensive operational guides, support services, communication and consulting platforms, etc.
11. Considering uncontrollable factors in the process of technology transfer in the oil industry, such as political, economic, cultural, etc.
12. Creating the necessary organizational bases for technology transfer in various financial, organizational, and technical structures
13. Creating effective mechanisms to measure and monitor the effectiveness of technology transfer

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