Original Research

Development of Main Success Factors in Technology Transfer: An Empirical Study of Iranian Oil Industry

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Abstract

Technology transfer helps create innovation and manufacture new products in developing countries, and the identification of major success factors in technology transfer could help obtain competitive advantages. The present study mainly aims to develop the main success factors in technology transfer in the oil industry of Iran. This study is applied research and adopts a descriptive-correlational methodology. The statistical population consisted of 149 oil industry experts at National Iranian Oil Company and its subsidiary companies. The sample size was found to be 107 based on Cochran's formula, and the respondents were selected through random sampling to respond to the validated questionnaires. The main success factors in technology transfer in the oil industry were identified and confirmed by reviewing the literature and implementing exploratory and confirmatory factor analyses. A total of eleven factors were identified, including technology owner characteristics, strategic factors, technology characteristics, political factors, economic factors, management factors, sociocultural factors, human resources, legal factors, infrastructures, and environmental factors, of which technology owner characteristics, strategic factors, technology characteristics, management factors, sociocultural factors, human resources, and environmental factors were the main technology transfer success factors in the oil industry. Correct understanding of the results of the upcoming study can be an effective way to transfer technology in the field of energy in developing countries.

Keywords- Technology transform; Success factors; Exploratory factor analysis; Confirmatory factor analysis; Iranian oil industry

INTRODUCTION

Today, technology transfer is popular among commercial, industrial, non-governmental, governmental, and even academic organizations (Chais et al., 2018). Organizations have a variety of techniques to discover their technological assets to add to their productivity and overall growth, in which the use of technological assets and their advantages in technology transfer are important (Alzubi, 2018). Technology transfer is a possible approach for the growth of industries in developing countries such as Iran. However, success in technology transfer is strongly dependent on the selection of efficient technologies from effective sources. Technology transfer is the process of transferring machinery, skills, knowledge, manufacturing methods, and prototypes between governments, universities, and firms to ensure scientific and industrial advancement so that it would lead to the development of various new products, processes, applications, raw materials, and services (Adeniran et al., 2020). Technology transfer conceptually includes the selection of effective technology, transferring the technology through the selected methods, and receiving suitable feedback from the transferred technology in order to modify its utilization. Technology transfer is a useful management practice to acquire competitive advantages, and the development of relevant theories and the identification of main success factors in technology transfer are major debates in the literature. Hence, numerous studies sought to identify such factors and conceptualize and understand theories and views that could successfully implement technology transfer and describe its practical and empirical dimensions (Agarwal et al., 2021). A review of the technology transfer literature suggests that various techniques and models have been proposed for successful technology transfer (Agwu, 2018). In general, technology transfer models have been developed based on success factors, and a review of earlier works reveals that the contexts of the main technology transfer success factors have not been effectively defined. It can be said that a comprehensive set of technology transfer success factors can rarely be found in earlier works.

Technology development is the most important parameter in the industrial development of oil-dependent developing countries (Alem and Broussard, 2018). Since many developing countries are lagging behind, the transfer of technology from developed countries seems to be necessary for the development of new technologies in the oil industries of developing countries. The effective use of technology is the major factor in oil industry development and economic growth, while an ineffective use of technology may lead to dependence on developed countries (Arefin and Islam, 2019). As a result, the oil industry of Iran requires the successful technology of relevant technologies to develop its activities. Olaya-Escobar et al. (2020) found that technology transfer weaknesses were the main explanation for the inefficiency of operational sectors in the oil industry. Thus, the efficiency and effectiveness of technology transfer should be improved based on internal and oil industry conditions so that competitive advantages would be acquired in the market and industry. Research has shown that more than half of obligations in technology transfer projects are violated by technology transfer agents. Field research has shown that "lack of skilled human resources in technology transfer," "lack of effective contracts," "non-use of research centers," "lack of effective university-industry relationships," "negligence of technology compatibility with country/organization circumstances," "lack of sufficient research budgets in the technology transfer process," "ambiguous technology transfer policies in the country," and "lack of a model for the country's requirements and participation in effective technology transfer" are the main barriers to technology transfer (Olaya-Escobar et al., 2020).

Hence, technology transfer in the oil industry has not been completely successful in recent years, particularly in many developing countries, and industrial equipment has been often purchased rather than technical knowledge transfer (Scuotto et al., 2020). In this respect, the identification of the main technology transfer success factors could be effective in the implementation and evaluation of the technology transfer process in the oil industry. The negligence of such factors is expected not to lead to the waste of time and investment but also weaken the national technologies. Reviewing the literature on the subject and using the opinions of active experts in the field of energy shows that, considering the importance of this issue in developed countries, understanding the factors influencing the transfer of technology in this field is very important. Therefore, in this paper, it has been tried to use a comprehensive and

systematic review of the subject literature, the most important factors affecting the transfer of technology in this industry have been extracted in the first stage and refined and selected using the opinions of experts. Understanding the position of these factors can be the development of all developing and energy-rich countries should have an increasing contribution. Hence, the present work sought to identify factors comprehensively ensuring technology transfer success in the oil industry of Iran.

This study has two contributions to the technology transfer literature. First, the present work evaluates the main technology transfer success factors by integrating various papers in the literature. This provides insights into the main concepts in the technology transfer process, leading to the definition of operational indices. Second, an exploratory model is proposed, measuring the consistency between its theoretical and practical criteria in the oil industry and adding to the body of knowledge in the literature. Therefore, this study can provide deep insights into technology transfer in the oil industry and highlight the requirements that should be considered by managers for successful technology transfer. It should be noted that a focus on solely the technology transfer knowledge/information of experts cannot ensure significant efficiency in the identification of key technology transfer success factors, while the review of relevant works may enable a more comprehensive and accurate set of factors. The present study reviewed the literature and evaluated expert views to extract factors influencing successful technology transfer in the oil industry. Two questions are to be answered: What are the main technology transfer factors in the oil industry? What are the contributions of each factor to technology transfer success in the oil industry?

The structure of this paper is compiled as follows. In the second part, a literature review has been carried out. In the first part, the literature review related to technology transfer has been reviewed, and in the second part of the literature review, the most important influencing factors in technology transfer in the field of energy have been analyzed. In the third part, an overview of the research methodology is presented. In the fourth part, the results have been analyzed. Finally, in the fifth part, the conclusion has been presented.

THEORETICAL FOUNDATIONS AND LITERATURE REVIEW

- *Technology transfer*

Technology transfer refers to the process of transferring machinery, skills, knowledge, manufacturing methods, and prototypes between governments, universities, and firms to ensure scientific and industrial advancement so that new products, processes, applications, raw materials, and services could be developed (Varma, 2019). Takahashi (2005) defined technology transfer as a process between two organizations to acquire, use, develop, and enhance technological knowledge by transferring technology components to implement the process, manufacture products, and distinguish the practice. They also mentioned that successful technology transfer had two prerequisites: (1) the technology transferor should be willing to transfer technology, and (2) the receiver should be able to adopt, adapt, and promote technology. Conceptually, technology transfer includes the selection of effective technology, transferring it using the selected method(s), and obtaining efficient feedback on the transferred technology in order to modify its utilization (Yaming et al., 2018).

A review of earlier works suggests that the process of developing technical capacities in developed and emerging economies is performed through developing economies. This process begins with technology creation in developed countries and includes adaptation, attraction, and negotiation. Entrepreneurs tend to transfer their manufacturing facilities and assembly lines to developing countries rather than exporting their final products. In developing countries, however, technical capacities are developed in a different manner. In such countries, a novel technology is described. Then, technical knowledge and skills are absorbed and adapted to local conditions once local manufacturing has begun (Takahashi, 2005). In general, technology transfer has three different sources:

(1) Free sources: When technology is available, but no technology is officially purchased or there is no interaction between the technology transferor and receiver.

(2) Technology acquisition: When technology is dominant in a field, and the knowledge transferor grants the receiver permission to utilize the technology.
(3) Collaborative innovation: When the technology transferor and receiver collaborate with other partners in technology development projects.

Daim et al. (2018) argued that technology can be transferred directly (equipment, facilities, machines, and parts), indirectly (patents, schemes, and other documents) or in a combined direct-indirect manner, and success in technology transfer could be evaluated based on economic performance, market performance, product performance, technical context, and technology receiver satisfaction. The outcome of technology transfer is dependent on a set of factors, which are classified into external and internal factors, such as infrastructure, market competitiveness, organizational culture, acceptance capacity, technology transfer experience, and management capacities. Shahebrahimi et al. (2022) examined Drivers and Constraints of Success of Transfer of Space Technologies in Iran. Their aim was to determine how advanced technology transfer is operationalized in a developing economy by studying its complexities. SeokKim et al. (2022) examined different technology transfer capabilities and their similarities from two different situations. Carmen Huian et al. (2022) analyzed the technology transfer performance of public research institutions. The results confirmed the positive effect of qualified human resources and business resources (technology transfer offices and spin-offs). Organizational factors were also related to the field of research. Öhman et al. (2022) investigated and analyzed the technology transfer conditions for hydrogen-based steelmaking in Europe. They showed that in order to overcome barriers and create a suitable environment for hydrogen-based steel production, it is important that energy transfer and The industry is aligned, there is a policy framework that supports these transitions, and key players represent all aspects of the transition. Chen et al. (2022) analyzed technology transfer systems and practices of national research institutes in China.

- *Technology transfer models and key success factors*

Several technology transfer models have been proposed since the early 1950s. Gibson and Smilor (1991) described the match model that was introduced during 1945-1950. The match model considers official technology transfer mechanisms to be unnecessary; it is assumed that users contact researchers to utilize a new technology when it is developed and becomes available through technical reports or specialized journals. Gibson and Smilor (1991) also mentioned the diffusion model, which was introduced in the 1960s and 1970s and was later promoted by Rogers (2001). The diffusion model assumes that experts transfer specialized knowledge to potential consumers with the assumption that the new technology is gradually transferred from the expert to the user once effective contact is established. The knowledge utilization model was introduced by Gibson and Smilor (1991) in the late 1980s. It is focused on:

- The key role of interpersonal relationships between technology developers and users, and
- The importance of organizational capacities or barriers in the technology transfer process.

Later, Williams and Gibson (1991) mentioned that the communication model could replace earlier models. It views technology transfer as the process of establishing communication and information flow in which there is a continuous and simultaneous process of idea exchange between the parties. Cohen and Levinthal (1990) believed the key success factors of technology transfer to be:

- Attraction capacity: The ability of the firm to understand, modify, and utilize new knowledge for business purposes.
- Managerial capacities: The activities required to organize a firm to receive, utilize, and discover the received technical knowledge.

- Transfer method: Joint commercial activities, collaboration in research, issuing permissions, and direct foreign investment.

Gibson and Smiloer (1991) proposed a model that evaluated technology transfer from the perspective of technology researchers and users and assumed technological involvement to have three levels, namely (1) technology development, (2) technology acceptance, and (3) technology application. It describes the three involvement levels in the technology transfer process and integrates the activities in earlier models. Solimon (2020) introduced a model to handle the limitations of traditional technology transfer models. It provides reasons for factors influencing technology transfer at four levels, namely (1) knowledge creation and technology invention, (2) sharing, (3) implementation, and (4) commercialization.

Takahashi and Sacomano (2002) developed a conceptual model to describe the theoretical structure of the technology transfer process in the pharmaceutical industry. It defines technology transfer success as the capacity of the receiver in knowledge enhancement or technical performance arising from technology transfer. Choi (2009) modeled technology transfer as a tree aimed at producing innovation (fruits). The tree requires sunlight (plan) and nutrients (training and learning) to grow. Furthermore, expert human resources are required to support the technology transfer process (stem). In general, it can be claimed that the model of Choi (2009) is based on creating new ideas and views human resources to be the key to idea creation. Jagoda et al. (2010) used similar structures to introduce step-by-step models in technology transfer projects. The process of technology transfer was divided into multi-purpose activities, known as steps. There was a control center after each step in which important questions were asked to instantaneously verify the previous step in order to implement critical sensitivity analysis of the model to the final step. A project could issue the permission into the next step, remaining in the step, modification, or discontinuation. In general, several studies introduced transfer models, each of which had a fundamental contribution to technology transfer source development. They identified the factors influencing technology transfer through a variety of approaches, e.g., reviewing the literature, interviews, questionnaires, and qualitative and quantitative analyses.

Pandey et al. (2022) in a study beyond technology transfer to innovation cooperation to advance sustainable development in developing countries. They suggested that "innovation cooperation" is a better framework than "technology transfer" to advance international efforts in the field of Technology is for sustainable development. Such a framework allows for a broader and more comprehensive view of technology-related cooperation between countries. It also emphasizes the need for equitable partnerships rather than donor-recipient relationships and the development of local innovation capabilities that lead to a more effective combination of technologies to help developing countries achieve sustainable development. Palaco et al. (2022) examined the capabilities of international technology transfer intermediaries between emerging and developed countries and provided key success indicators for them. Also, they presented a conceptual framework that can be used to evaluate the performance of an intermediary for a given technology transfer project in which demand arises from emerging country stakeholders. Ravi and Janodia (2022), investigated the factors affecting technology transfer and commercialization of academic research. Their study covers three key aspects: (1) awareness and practice of patents and research commercialization among Indian academics, (2) understanding adaptive strategies for commercialization of research activities, and (3) barriers to university technology transfer to industry.

Riyahi et al. (2020) evaluated governmental, organizational, market, and technology factors and demonstrated that organization-related factors could play a key role in whether the transfer of technology could be successful. Hemmati et al. (2020) showed that knowledge management (KM) had a positive, significant effect on successful technology transfer. Also, KM posed the highest effect on successful technology transfer only through technology capabilities as a key mediating variable. Mohammadrafiei et al. (2019) argued that studies on the effects of technology transfer on performance focused on only the economic aspect of performance and neglected other performance aspects. They indicated that technology transfer had a positive, significant effect on the sustainable performance of small/medium firms. Rezazadeh (2019) suggested that expert consultations were necessary in contracts in order to avoid the

infringement of the rights of the technical knowledge owner and/or receiver. Bakhtiari-Ramezani (2018) suggested that the localization and development of the transferred technology contributed to successful technology transfer, despite various structural, managerial, and sociocultural challenges. Sheykhian et al. (2018) proposed that resource allocation, localization and reforms, cost estimation, information documentation, budget savings and effectiveness, detailed job description, internal training plan, improved rewarding plan, allocated financial resource determination, recruitment, and consensus on the job description were important technology transfer success factors. Sattarzadeh (2017) believed that an ambiguous legal framework, disagreement in the definition of intellectual property standards in, lack of effective supervision, and lack of comprehensive regulations were explanations for the failure of technology transfer. Taghvaei et al. (2017) showed that cost-based factors were the most important factor for technology transfer success. Also, organizational factors, extra-organizational factors, technological factors, and research-and-documentation had the second-, third-, fourth-, and fifth-highest effects on technology transfer success.

Marghalani (1987) suggested that economic factors, human resources, cultural factors, politics, and information infrastructure affected technology transfer. Okoro (1992) argued that cultural, economic, and factors and firm characteristics influenced technology transfer success. Bradley et al. (1995) mentioned innovation productivity, R&D costs relative to employee turnover, and the knowledge level of senior managers, whereas Hussain (1998) only believed cultural aspects to influence technology transfer success. Ming and Xing (1999) suggested that technology lifecycle and technology transfer strategy affected the success of technology transfer. Elsey and Fujiwara (2000) mentioned the importance of technology transfer mentors in technology transfer success. Di Benedetto et al. (2003) adopted a psychological approach and argued that willingness to accept technology, the attitude toward technology acceptance, technology advantages, economic advantage, ease of technology acceptance, and technology adaption influenced technology transfer success. Daghfous (2004) proposed that organizational learning, relevant prior knowledge (of the seller and buyer of knowledge), and project stages played roles in technology transfer. Bennett and Zhao (2004) mentioned the roles of production characteristics, technical risks, market risks, and cooperation risks in technology transfer success. Strandburg (2005) adopted a legal approach and studied only patents and other permissions in technology transfer success.

Pozzali and Viale (2006) adopted a knowledge-oriented approach to technology transfer and argued that implicit knowledge contributed to technology transfer success. Pollard (2006) mentioned technology and innovation transfer intermediaries, attraction capacity, information technology supporters (e.g., government), government-supported institutions, management and innovation practices, and cost structure changes. Stewart and Waroonkun (2007) conducted sequential studies and argued that the transfer medium, learning medium, transferor characteristics, and receiver characteristics affected the technology transfer success. Silva et al. (2022) in a study extracted the basic elements in technology transfer. They were considered a significant collection of articles for bibliometric analysis. Subsequently, based on the relevance of the presented topics and the number of citations by year, they identified key approaches to technology transfer and its elements, including factors, technology, mechanisms, policies, barriers, supporters, models, and effects. Madhusudan-Kuthe et al. (2009) referred to technology transfer speed, quality, and adaptation as the main technology transfer success factors.

Al-Mabrouk and Soar (2009) suggested that the flexible policies of governments, identification and use of high-level competitive suppliers, development of a technology transfer strategy, development of effective and free relationships to share information between transferors and receivers, the measurement of the attitudes toward learning capacities and R&D commercialization, establishment of R&D centers to assess, promote, and develop technology, utilization of consultation services for transferring technology and supporting rapid, efficient execution activities, adaptation of technology transfer to improve social life without compromising local values, beliefs, and traditions, official performance evaluation of suppliers under organizational requirement, and effectiveness and quality evaluation of the selected technologies to be transferred were key technology transfer success factors. Lai and Tsai (2010) reported that management and execution, manufacturing technology, service level, and costs played key roles

in the success of technology transfer. Gottwald et al. (2012) believed general information on the organization, the training and competence of the staff, market requirements, higher education institutions, and general proposals to play key roles in technology transfer. Hirt (2012) suggested that technical and cultural factors and organization had important effects on technology transfer success. Landry and Amara (2012) referred to customer orientation, market separation, value chain and network, income mechanism, and competitive strategy as technology transfer success factors. Elmuti and Abou-Zaid (2013) suggested that internal factors (e.g., organization size and structure), external factors (e.g., general policy and national culture), technology transfer strategies, human resources, and expertise contributed to technology transfer success. Günsel (2015) mentioned the role of implicit and explicit knowledge sharing in technology transfer. Santos et al. (2015) argued that resource management and transfer support, execution contact with supplies/manufacturers, responsibility allocation in the technology transfer team, effective involvement, creative plans, and logistic capacity and resources influenced technology transfer success.

Nguyen and Aoyama (2015) proposed that service quality, management commitment, training, teamwork, sharing, and culture were the determinants of technology transfer success. Kumar et al. (2015) mentioned technological, management, sociocultural, political, and economic factors, value chain, relative advantage in economic conditions, marketing advantage, technical characteristics, supervision concerns, management and strategic subjects, organizational capabilities, relational capabilities, and KM as success factors for technology transfer. Appiah-Adu (2016) referred to technology sophistication as a technology transfer success determinant. Majidpour (2017) mentioned internal factors (organizational level) and external factors (industrial, national, and international levels). Owusu-Manu et al. (2018) viewed knowledge strategy, organizational culture, information technology, and knowledge leadership to be technology transfer success factors. Daim et al. (2018) mentioned user experience and technology characteristics. Chais et al. (2018) suggested that technology transfer process mapping, paperwork reduction, innovative technology centers, technology assessment, experience, local rules, innovation culture, and intellectual and industrial property were success factors in technology transfer. Alzubi et al. (2018) believed organizational culture, information technology, knowledge leadership, knowledge strategy, and knowledge transfer to affect technology transfer success. Lager and Hassan-Beck (2021) proposed that technological equipment, work progress, climate and culture, and organizational knowledge are involved in technology transfer success. A review of the literature suggests that earlier works were not focused on a comprehensive set of essential technology transfer success factors. The assessment of technology transfer factors in earlier works would help collect a more comprehensive set of factors influencing technology transfer, including:

- Technology owner characteristics: They relate to the behavior and technical characteristics, history, and service quality of the technology owner.
- Strategic factors: They include the objectives, policies, development, execution, and assessment of technology transfer.
- Technology characteristics: They relate to technology competitiveness, adaptation, lifecycle, quality, and ease of use.
- Political factors: They relate to macro-policies, political approach, and international relations of the government.
- Management factors: They relate to support and involvement, history, and senior management approach to technology transfer activities.
- Social factors: They include social beliefs, values, and norms to accept and utilize technology.
- Economic factors: They relate to technology cost and technology transfer expenses.
- Legal factors: They include technology transfer tax and legal rules/regulations.
- Human resources: They relate to the characteristics and competence of the technology transfer staff.
- Infrastructures: They include the organizational structure and size of the technology receiver.

- Environmental factors: They relate to the design and output (i.e., manufactured products) of the transferred technology based on environmental requirements.

Table 1 compares these factors to technology transfer success factors in earlier works. As can be seen, the identified eleven factors almost comprehensively covered the literature.

TABLE 1
COMPARISON OF THE PRESENT WORK VERSUS EARLIER WORKS IN TECHNOLOGY TRANSFER SUCCESS FACTORS

Ref.	Technology Owner Characteristics	Strategic Factors	Technology Characteristics	Political Factors	Management Factors	Sociocultural Factors	Economic Factors	Legal Factors	Human Resources	Infrastructures	Environmental Factors
Marghalani (1987)		✓		✓		✓	✓		✓		
Okoro (1992)	✓		✓		✓	✓	✓	✓			
Hong (1994)		✓							✓		
Bradley (1995)					✓		✓				
Hussain (1998)						✓					
Ming and Xing (1999)		✓	✓								
Elsey and Fujiwara (2000)	✓										
Di Benedetto et al. (2003)			✓				✓				
Daghfous (2004)	✓				✓						
Bennett and Zhao (2004)	✓		✓								
Strandburg (2005)	✓										
Pozzali and Viale (2006)		✓									
Pollard (2006)				✓		✓					
Stewart and Waroonkun (2007)	✓	✓			✓	✓					
Madhusudan Kuthe et al. (2009)		✓									
Al-Mabrouk and Soar (2009)		✓		✓	✓	✓					
Lai and Tsai (2009)			✓	✓	✓	✓			✓	✓	
Lee et al. (2010)	✓		✓						✓		✓
Gottwald et al. (2012)						✓			✓		
Hirt (2012)			✓			✓				✓	
Landry and Amara (2012)		✓									
Elmuti and Abu-Zaid (2013)		✓		✓	✓	✓		✓	✓	✓	
Günsel (2015)		✓									
Santos et al. (2015)		✓							✓	✓	
Nguyen and Aoyama (2015)		✓			✓	✓			✓		
Kumar et al. (2015)	✓	✓	✓	✓	✓	✓	✓				
Appiah-Adu et al. (2016)			✓								
Majidpour (2017)			✓	✓	✓					✓	
Owusu-Manu et al. (2018)		✓			✓	✓				✓	
Daim et al. (2018)	✓		✓								
Chais et al. (2018)			✓			✓		✓		✓	
Alzubi (2018)		✓			✓	✓				✓	
Lager and Hassan-Beck (2021)	✓	✓		✓	✓	✓				✓	✓
Present study	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

METHODOLOGY

The present study is applied research and adopts a descriptive-exploratory methodology. It is a survey in terms of data collection and a qualitative work in terms of data analysis.

The statistical population consisted of 149 senior managers and experts at the subsidiary firms of the National Iranian Oil Company. The sample size was obtained to be 107 via Cochran's formula. The respondents were selected using proportionate stratified sampling. To extract technology transfer success factors, a literature review was used. A questionnaire was used to collect data. The questionnaire consisted of a general section and a specialized section; the general section included demographics, as shown in Table 2.

TABLE 2
RESPONDENT DEMOGRAPHICS

Parameter		**Absolute Frequency**	**Relative Frequency (%)**
Gender	Male	101	94.39
	Female	6	5.61
Age	<30	1	0.9
	30-40	24	22.43
	41-50	34	31.78
	>50	48	44.89
Education	Bachelor	34	31.78
	Master	55	51.40
	Ph.D.	18	16.82
Work Experience	<10	20	18.69
	10-15	23	21.50
	16-20	26	24.30
	>20	38	35.51
Total		107	100

The specialized section consisted of 47 items concerning the technology transfer success factors. They were measured based on the five-point Likert scale, with the scores ranging from 1 (very low) to 5 (very high). A total of 126 questionnaires were emailed to the respondents, 107 of which were returned within two months, suggesting a response rate of 84.92%. To reduce the non-response bias, the respondents were informed that their names and organizations were not required for the survey. A procedural approach was adopted. The procedural approach was carried out during the development of the questionnaire, designing a structured questionnaire by reviewing relevant works. Then, the concepts were excluded, with the indices being subjected to an unbalanced combination. The indices were extracted by reviewing earlier works on factors influencing technology transfer. Then, exploratory factor analysis (EFA) was performed in SPSS to find the constructs and types of the factors and validate the questionnaire. Finally, confirmatory factor analysis (CFA) was carried out in R to evaluate the consistency of the theoretical concepts with the empirical environment of the oil industry.

According to Table 4, the Kaiser-Meyer-Olkin (KMO) index was calculated to be 0.690. This implies that the sample size was adequate. Also, the significance level in Bartlett's test was found to be below 0.05, suggesting that the construct variance matrix was not an identity matrix, and latent concepts (factors) could be extracted from the constructs. The EC scale was obtained to be larger than 0.5. This demonstrates that the extracted factors explained the variance of the entire data. The number of eigenvalues larger than 1 was found to be 11, implying that eleven factors could be extracted from the questionnaire indices, and the extracted factors explained nearly 74% of the total variance of the data after the rotation. Table 5 shows the factor loads of the indices along with the corresponding variances. As can be seen, the "technology owner characteristics" factor consisted of seven indices that explained 10.832% of the total variance. They referred to technology owner characteristics that could contribute to technology transfer success. Therefore, this factor was referred to as "technology owner characteristics." The same case holds for the other factors.

TABLE 3
ALLOCATION OF ITEMS TO FACTORS

Factor	Symbol	Items	Ref.
Technology owner characteristics	TOC	7	Okoro (1992); Elsey and Fujiwara (2000); Daghfous (2004); Bennett and Zhao (2004); Strandburg (2005); Stewart and Waroonkun (2007); Lee et al. (2010); Kumar et al. (2015); Daim et al. (2018); Lager and Hassan-Beck (2021)
Strategic factors	SF	7	Marghalani (1987); Hong (1994); Ming and Xing (1999); Pozzali and Viale (2006); Stewart and Waroonkun (2007); Madhusudan Kuthe et al. (2009); Al-Mabrouk and Soar (2009); Landry and Amara (2012); Elmuti and Abu-Zaid (2013); Günsel (2015); Santos et al. (2015); Nguyen and Aoyama (2015); Kumar et al. (2015); Owusu-Manu et al. (2018); Alzubi (2018); Lager and Hassan-Beck (2021)
Technology characteristics	TC	6	Okoro (1992); Ming and Xing (1999); Di Benedetto et al. (2003); Bennett and Zhao (2004); Lai and Tsai (2009); Lee et al. (2010); Hirt (2012; Kumar et al. (2015); Appiah-Adu et al. (2016) Majidpour (2017); Daim et al. (2018); Chais et al. (2018)
Political factors	PF	5	Marghalani (1987); Pollard (2006); Al-Mabrouk and Soar (2009); Lai and Tsai (2009); Elmuti and Abu-Zaid (2013); Kumar et al. (2015); Majidpour (2017); Lager and Hassan-Beck (2021)
Economic factors	ECF	5	Marghalani (1987); Okoro (1992); Bradley (1995); Di Benedetto et al. (2003); Kumar et al. (2015)
Management factors	MF	4	Okoro (1992); Bradley (1995); Daghfous (2004); Stewart and Waroonkun (2007); Al-Mabrouk and Soar (2009); Lai and Tsai (2009); Elmuti and Abu-Zaid (2013); Nguyen and Aoyama (2015); Kumar et al. (2015); Majidpour (2017); Owusu-Manu et al. (2018); Alzubi (2018); Lager and Hassan-Beck (2021)
Sociocultural factors	SCF	4	Marghalani (1987); Okoro (1992); Hussain (1998); Pollard (2006); Stewart and Waroonkun (2007); Al-Mabrouk and Soar (2009); Lai and Tsai (2009); Gottwald et al. (2012); Hirt (2012); Elmuti and Abu-Zaid (2013); Nguyen and Aoyama (2015); Kumar et al. (2015); Owusu-Manu et al. (2018); Chais et al. (2018); Alzubi (2018); Lager and Hassan-Beck (2021)
Human resources	HR	3	Marghalani (1987); Hong (1994); Lai and Tsai (2009); Lee et al. (2010); Gottwald et al. (2012); Elmuti and Abu-Zaid (2013); Santos et al. (2015); Nguyen and Aoyama (2015)
Legal factors	LF	2	Okoro (1992); Elmuti and Abu-Zaid (2013); Chais et al. (2018)
Infrastructure	INF	2	Lai and Tsai (2009); Hirt (2012); Elmuti and Abu-Zaid (2013); Santos et al. (2015); Majidpour (2017); Owusu-Manu et al. (2018); Chais et al. (2018); Alzubi (2018); Lager and Hassan-Beck (2021);
Environmental factors	ENVF	2	Lee et al. (2010); Lager and Hassan-Beck (2021);

FINDINGS

This section provides the EFA and CFA findings. Table 4 reports the EFA results.

TABLE 4
EFA RESULTS

Parameter		Value
KMO		0.690
Bartlett test	χ^2	3216.288
	DOF	1081
	Sig.	0.000
EC		>0.5
Number of factors extracted (eigenvalue>1)		11
Dimensionality reduction and factor extraction		PCA
Rotation		Varimax
Total Variance Explained after Rotation (%)		73.603

TABLE 5
TECHNOLOGY TRANSFER SUCCESS FACTORS

Factor	Index	Load	Variance
TOC	Capabilities and policies	0.827	10.832%
	Technology transfer mentors	0.820	
	Prior relevant knowledge	0.787	
	Credibility and good cooperation	0.803	
	Comprehensive operation manual and support services (e.g., installation, technical support, training, implicit knowledge transfer, and key parts provision)	0.831	
	Level of willingness to transfer technology and control the transferred technology for development	0.856	
	Cultural characteristics	0.813	
SF	Strategic objectives and schemes for technology transfer and development	0.735	9.802%
	Technology transfer roadmap based on the value chain (causes, location, time, and manner of technology transfer)	0.746	
	Development of effective and free relationships and common policies between the technology owner and receiver	0.753	
	Evaluation of the original prototype with the original technology in terms of speed, quality, performance, and reliability	0.722	
	Technology transfer style, including direct investment, joint economic activity, and strategic agreements	0.838	
	Identification and evaluation of technology transferors	0.860	
	Monitoring of the technology transfer process	0.789	
TC	Technology sophistication type	0.750	9.442%
	Up-to-date and competitive technology	0.878	
	Technology lifecycle	0.825	
	Ease of use and maintenance	0.853	
	Technology adaptation	0.833	
	Technology quality, performance, and reliability	0.835	
PF	Cooperation between the government and research institutions on technology transfer	0.773	7.507%
	Political stability and the continuation of sustainable macro-policies (sustainable and allied governments)	0.869	
	Friendly international relations	0.771	
	Security aspects and technology transfer secrecy	0.837	
	Power structures in society	0.768	
EF	Technology price	0.803	7.365%
	Installation costs	0.866	
	Maintenance and accessory costs	0.809	
	Training costs	0.851	
	Technology transfer cost payment conditions	0.653	
MF	History of cooperation with the technology transfer team	0.822	6.519%
	Efficient negotiation team	0.808	
	Senior managers' support and involvement	0.816	
	Utilization of technology transfer consultation services	0.804	
SCF	Reasonable and cultural expectations of technology transfer	0.800	6.129%
	National approach culture at top governmental levels	0.732	
	Individual acceptance (beliefs, values, and norms) to make proper use of technology	0.780	
	Establishment of R&D centers to transfer, evaluate, promote, and develop technology	0.871	
HR	Efficient technical team	0.850	4.961%
	Continuous technology training	0.822	
	Teamwork	0.839	
LF	Legal rules and regulations regarding technology transfer	0.848	3.827%
	Tax regulations	0.857	
INF	Organizational structure	0.87	3.705%
	Organization size	0.855	
ENVF	Environment-based technology design	0.797	3.514%
	Technology-induced pollution rate	0.783	

TABLE 6
FIRST-ORDER CFA

Factor	Index	Load	Z-value	Sig.
TOC	Capabilities and policies	1	-	-
	Technology transfer mentors	1.110	10.133	0.000
	Prior relevant knowledge	1.134	9.337	0.000
	Credibility and good cooperation	0.957	9.462	0.000
	Comprehensive operation manual and support services (e.g., installation, technical support, training, implicit knowledge transfer, and key parts provision)	1.020	9.289	0.000
	Level of willingness to transfer technology and control the transferred technology for development	1.164	10.286	0.000
	Cultural characteristics	1.122	10.664	0.000
SF	Strategic objectives and schemes for technology transfer and development	1	-	-
	Technology transfer roadmap based on the value chain (causes, location, time, and manner of technology transfer)	0.565	7.075	0.000
	Development of effective and free relationships and common policies between the technology owner and receiver	0.942	7.396	0.000
	Evaluation of the original prototype with the original technology in terms of speed, quality, performance, and reliability	0.807	7.554	0.000
	Technology transfer style, including direct investment, joint economic activity, and strategic agreements	1.295	8.427	0.000
	Identification and evaluation of technology transferors	1.187	8.543	0.000
	Monitoring of the technology transfer process	0.999	7.957	0.000
TC	Technology sophistication type	1	-	-
	Up-to-date and competitive technology	1.961	8.311	0.000
	Technology lifecycle	1.603	7.789	0.000
	Ease of use and maintenance	1.723	8.038	0.000
	Technology adaptation	1.626	7.771	0.000
	Technology quality, performance, and reliability	1.437	7.706	0.000
PF	Cooperation between the government and research institutions on technology transfer	1	-	-
	Political stability and the continuation of sustainable macro-policies (sustainable and allied governments)	1.380	7.886	0.000
	Friendly international relations	0.970	6.721	0.000
	Security aspects and technology transfer secrecy	1.453	7.812	0.000
	Power structures in society	0.964	6.904	0.000
EF	Technology price	1	-	-
	Installation costs	1.099	8.534	0.000
	Maintenance and accessory costs	0.920	8.376	0.000
	Training costs	1.028	8.621	0.000
	Technology transfer cost payment conditions	0.487	6.185	0.000
MF	History of cooperation with the technology transfer team	1	-	-
	Efficient negotiation team	0.842	7.888	0.000
	Senior managers' support and involvement	0.876	8.231	0.000
	Utilization of technology transfer consultation services	0.822	8.112	0.000
SCF	Reasonable and cultural expectations of technology transfer	1	-	-
	National approach culture at top governmental levels	0.935	6.734	0.000
	Individual acceptance (beliefs, values, and norms) to make proper use of technology	0.955	7.293	0.000
	Establishment of R&D centers to transfer, evaluate, promote, and develop technology	1.222	8.856	0.000
HR	Efficient technical team	1	-	-
	Continuous training of technology	1.154	7.183	0.000
	Teamwork	1.301	7.452	0.000
LF	Legal rules and regulations regarding technology transfer	1	-	-
	Tax regulations	1.492	2.792	0.005
INF	Organizational structure	1	-	-
	Organization size	1.129	1.614	0.107
ENVF	Environment-based technology design	1	-	-
	Technology-induced pollution rate	0.957	4.478	0.000

The loads of the technology transfer success factors were obtained to be larger than the empirical value of 0.6. This indicates that the indices effectively explained the factors. To evaluate the validity of the findings, CFA was carried out based on maximum likelihood estimation (MLE), measuring the load significance of each index in explaining the factors and the load significance of each factor in explaining technology transfer success, as shown in Table 6. In CFA, an index is assumed to be the reference with a fixed load of 1, measuring the significance of the remaining indices relative to the reference. Therefore, one of the indices of each factor would not be tested and interpreted in CFA. According to Table 6, all the indices except for the organization size, significantly explained the corresponding factors. Hence, the "organization size" index seems to be an ineffective index in the measurement of the "infrastructures" factors. To evaluate the significance of the technology transfer success factors, a second-order factor analysis (between the factors and technology transfer) was carried out, as shown in Table 7.

TABLE 7
SECOND-ORDER EFA

Concept	Factor	Load	Standardized Load	Z-value	Sig.
Technology transfer	TOC	-	0.512	-	-
	SF	0.758	0.400	2.480	0.013
	TC	0.442	0.315	2.109	0.035
	PF	0.257	0.162	1.197	0.231
	EF	0.570	0.273	1.879	0.060
	MF	0.773	0.339	2.197	0.028
	SCF	0.562	0.336	2.186	0.029
	HR	0.668	0.368	2.272	0.023
	LF	0.557	0.368	1.920	0.055
	INF	0.351	0.234	1.316	0.188
	ENVF	1.337	0.656	2.875	0.004

According to Table 7, political factors (p-value=0.231), economic factors (p-value=0.060), legal factors (p-value=0.055), and infrastructures (p-value=0.188) had no significant effect on technology transfer. The success of technology transfer in the oil industry is dependent on only technology owner characteristics, strategic factors, technology characteristics, management factors, sociocultural factors, human resources, and environmental factors. Figure 1 graphs the model of the technology transfer success factors.

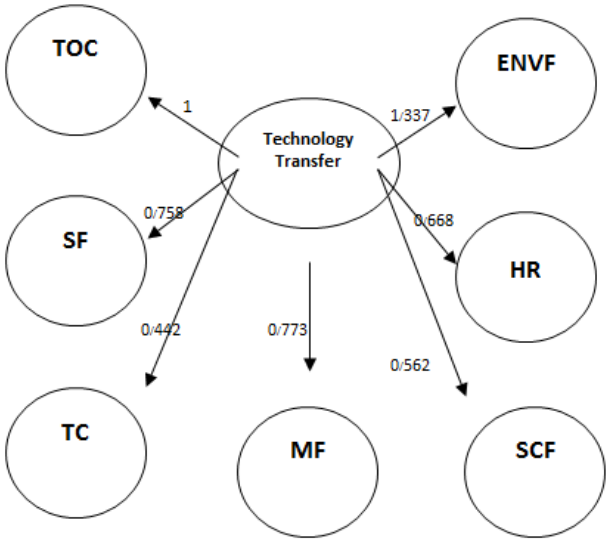

FIG 1
MODEL OF TECHNOLOGY TRANSFER SUCCESS FACTORS

Based on the standardized loads, the importance of the factors in technology transfer in the oil industry can be inferred to be in the order of environmental factors>technology owner characteristics>strategic factors>human resources>management factors>sociocultural factors>technology characteristics.

CONCLUSION

A total of eleven technology transfer success factors were identified, seven of which were verified to be important in the oil industry of Iran. This is consistent with Okoro (1992), Ming and Xing (1999), Bennett and Zhao (2004), Stewart and Waroonkun (2007), Lai and Tsai (2009), Kumar et al. (2015), Majidpour (2017), Owusu-Manu et al. (2018), Alzubi (2018). It was found that technology owner characteristics were a major determinant of technology transfer success in the Iranian oil industry. It can be assumed to be a decision-making criterion for technology receivers since the control policies of technology owners could be an important factor in technology transfer development (Santos et al., 2015). The decision-making criterion of technology receivers is based on culture, technology transfer mentors, knowledge, prior experience, and the support services of technology owners (Bennett and Zhao, 2004). Günsel (2015) suggested that the reputation of the technology owner should be evaluated prior to negotiations. In other words, the ability of the owner to successfully transfer technology and satisfy the receiver could be an important criterion to choose a transferor.

Strategic factors are a backbone component of technology transfer. Strategic planning and a technology transfer roadmap further assure managers of technology transfer activities (Chais et al., 2018). In other words, a technology transfer roadmap serves as an intelligent instrument that helps managers attain their goals in the technology transfer process and measure their decisions. Technology characteristics are an essential technology transfer success factor. Lai and Tsai (2009) claimed that technology characteristics were the first factor that determined whether the technology receiver would be satisfied or dissatisfied. In other words, once the receiver utilizes the transferred technology, the managers of the company seek to improve the speed, quality, and efficiency of production. They also hope to compete for a reasonable time to achieve a later technology (Kumar et al., 2015). Also, managers expect technological processes and activities to facilitate technology utilization, maintenance, and adaptation (Appiah-Adu et al., 2016). Management factors were found to be essential in technology transfer. Indeed, senior managers' support and intervention emphasize the importance of activities and projects; thus, the necessary financial resources are allocated to particular activities. Owusu-Manu et al. (2018) suggested that successful managers consult professional consultants before signing technology transfer agreements and use an efficient, expert negotiation team. Concerning technology transfer agreements, managers believe that implicit knowledge is better than explicit knowledge and, as a result, believe in experience and expert consultations (Nguyen and Aoyama, 2015). Sociocultural factors were demonstrated to be important in technology transfer. The adaptation of technology to the beliefs, values, and norms of the organization facilitates the technology transfer process. In other words, the cultural characteristics of the receiver should be evaluated based on predefined cultural expectations before technology transfer.

The culture of the receiver society is important enough to influence governmental policies (Hirt, 2012). In developing countries, governments make decisions through a reasonable and scientific approach as the main culture of technology transfer (Owusu-Manu et al., 2018; Alzubi, 2018). Human resources are a crucial factor in the success of technology transfer. Teamwork, multi-expert teams, and specialized technical training, e.g., "more efficient and effective use of technology" and "repair and maintenance," play a key role in technology transfer success (Nguyen and Aoyama, 2015). Environmental factors are also an essential success factor in technology transfer. Due to global competition, companies should adapt their processes and products to environmental requirements. Hence, technologies of lower pollution and more eco-friendly design are in priority (Lee et al., 2010). On the other hand, political factors, economic factors, legal factors, and infrastructures were found to be insignificant in technology transfer success. It should be mentioned that the present study sought to identify the most important technology transfer success factors in the oil industry of Iran, and factors of low significance are not necessarily unimportant. In

oil-dependent countries, however, economic, political, and legal factors are not barriers to technology transfer as they are considered by authorities due to the economic properties of the country, while the other factors could be subject to managerial decision-making. In sum, technology transfer is a complicated process and involves several parameters. The identification of the key success factors can facilitate the technology transfer process and provide a roadmap to implement and assess technology transfer. To successfully transfer technology in the oil industry, it is suggested that:

- The technology owner be chosen by reviewing their characteristics;
- A strategic technology transfer scheme be developed based on measurable indices;
- A transfer technology agenda be requested from the owner;
- The transfer of up-to-date and knowledge-based technologies be promoted rather than outdated ones;
- A human resource training and empowerment agreement be signed along with technology transfer agreements;
- Organizations focus on the owners of eco-friendly technologies with environmental values and behavior.

Our current research has several limitations. Data was collected from a small sample size. When answering the questionnaire, the bias of the respondent cannot be ruled out. In order to extract more meaningful data for analysis, it is necessary to conduct a large-scale study including a larger sample size with the size and structure of companies, geographical extent, different management systems.

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