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Identification of influencing factors on the informal advanced technology transfer using a qualitative approach in the industry LNG

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Abstract

The advanced technology transfer become importance because of the various countries and company's requirement to technology transfer in recent years and is paid attention by many academics so that many companies aim to transfer advanced technology to increase their productivity and on the other hand to tackle their technologic weak and faults. The identification of influencing factors on the advanced technology transfer is very important highly. The aim of current research is to identify the factors influencing on advanced technology transfer. For achieving to this goal, several studies have been done and the gap is identified. For identification of factors influencing on the advanced technology transfer the content analysis and Delphi is used the using content analysis the factors are extracted. Then they are screened using Delphi. Finally, 18 influencing factors are identified.

Keywords: Advanced technology, transfer-informal, transfer-qualitative, Delphi methodology

1. Introduction

Technology transfer always can be done formally and some conditions cause that technology transfer should be done informally. It is the focus of our research the identification of technology

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transfer model informally due to uncertainty in macro level is considered as a requirement and for this research current research is conducted in order to identify such models.

Technology transfer is an active process in which technology is transferred between two entities. The entities can be two companies, organizations or countries. Technology transfer is an objective oriented intentional interaction among two or more social entities in which the technology knowledge resource is fixed or can be increased during transferring one or more technology components (Delshad et al. 2024). Thus transfer or acquisition of technology is considered as a process based objective interaction among two or more entities that its goal is to increase technology or knowledge. Despite the fact that technology transfer is discussed very serious but the literature provides some research or focus on special aspects of technology transfer or acquisition and few of them provide a comprehensive framework and refer to major parameters in designing and implementation of a knowledge and technology transfer activity (Batistela et al, 2015; Ashoka & Keihani. 2020).

In context of global and variable market competition, tracking the external technologies as key activity for enterprises are considered. So far researchers indicate that international technology transfer have positive effects on the enterprises innovation including external direct investment, strategic union, research and development cooperation, developing and licensing (Iraj et al. 2024; Salahi et al. 2023).

While many countries tries in the frontier of innovation and creativity but developing countries hope to adopt the advanced countries technological advancement and heritage from them. So the developing countries can enhance their technological competitiveness based on current knowledge from advanced countries (Noh et al, 2019; Mahdavimanshadi et al. 2024).

Apart from technology transfer among countries, it is true about organizations and among the various organizations, because of competition pressure, geographical disperse and reduction of lifecycle of products the organizations are asked to combine their internal and external knowledge in the process of development and research in order to gain to benefits from interaction among research and development activities internally or externally. Among strategies that can be adopted by enterprises in order to reinforce their internal research and development activities with external knowledge participation in markets for technologies are attracted by researchers and managers (Ardito et al, 2017; Mehrani et al. 2019; Akhlaghpour et al. 2023).

Technology transfer is considered as active process during which the technology is transferred between 2 distinct entities. Technology transfer is not done always formally and the formal channels are not always used some informal ways can be used for it. Reasons for using from informal channels can include blockage of formal channels or difficulty in technology transfer through formal channels that require the seeking technology entity to use from informal ways. The example for blockage of formal paths can be economic sanction against a country or company. It can be seen in current situation of our country.

Due to current situation of our country it is required that technology acquisition to be rethought because of cruel sanction and blockages. Informal path can be replaced by formal path in current

conditions. Thus we can say that formal technology acquisition can be considered in this situation.

In current research based on above items we aim to identify the influencing factors on advanced technology transfer. The current methodology is qualitative. In the researcher tries to answer the question what are the influencing factors on advanced technology transfer?

Major goal:

Designing informal advance technology transfer model in process industry (LNG industry)

Major question:

How is Designing informal advanced technology transfer model in process industry (LNG industry?

Minor questions

1- What are the elements of informal technology transfer model?
2- What is the characteristic of informal technology transfer model?
3- What are the elements of technology transfer model for process industry?
4- Which informal methods are most needed for process industry?

In this paper we aim to provide a new model for technology transfer through informal channels and informal way that exclusively can be applicable in process industry. Due to few researches about this field and ignorance of technology transfer informally the research try to bridge research gaps.

2. Literature review

In this section it is tried to review the most similar researches with current research in the field of technology transfer during the last years. Batistela et al. (2016) aim to provide a strong theory base that contribute to identify cirtical factors for transferring and acquisition of knowledge and technology, khan et al. (2017) tries to identify technology transfer barriers based on existed literature. Ardito et al. (2017) explore the relationship between the way of research and development activities organization and continuous technology acquisition. Novix et al(2017) tries to solve the innovation system problems in Latvia. Authors choose the model of technology transfer, knowledge and innovation as a bridge between market and knowledge. Helikovich (2017) analyze the major factors on evolution of transfer and acquisition technology models and its comparison. Aim of mikonen et al. (2017) is to answer to following questions. How software engineering research with high quality can be executed in cooperative situation swiftly? How the timely trade feedback for continuous improvement of volunteer solution can be achieved?

Gonzales (2018) provide a systematic review about manufacturing technology in cooperation of industry and university. Shaffer et al (2018) study the interaction between formal and informal channels of transfer and acquisition for technology and knowledge between industry and university. Fartash et al (2018) aim to analyze the relationship between organization performance, organization innovation and technology acquisition. Noh et al. (2019) aim to explore to use from international technology acquisitions strategies among developing countries.

Guerero and Orbano (2019) aim to improve perception about policy, managerial and theory concepts of technology transfer effectiveness about entrepreneurship innovation.
Aim of pinto et al (2019) is to analyze relationship between innovation, transfer and acquisitions of technology and knowledge and management of green supply chain. Howang et al (2019) focus on perspective of multiple participators, relationship of transfer and acquisition of technology and a multi criteria decision making model including analytical network process and Dematel. Dasilva et al (2019) aim to descriptive and analyze technology acquisition process. Link et al (2019) provide a experimental evidence about factors determining 3 kinds of informal technology transfer by university members. Ositalo and lavika (2021) explore the technology transfer in construction industry. Liu and Meng(2021) consider production based on technology transfer.
Sotopo et al. (2022) develop the model of performance efficiency measurement model in order to accelerate technology trade in universities. Hafiz et al. (2023) explore the attractive capacity on effectiveness of technology transfer through organizational innovation. Mohammad Nasir et al (2023) examine technology transfer for construction of local floating bridge. Ashar et al. (2023) aim to technology and knowledge through publications, patents and standards and explore the hydrogen technological innovation system.

3. Methodology

Current research is survey from data collection method and is applicable from the goal view since results can be used in the various organization. Research is qualitative. For data collection 2 methods of library and survey is used, data collection tools include following items;

1- Interview with experts for determination of primary factors and variables of advance technology transfer
2- Delphi questionnaire for screening factors from interview and determination of new variables

Validity of above tools is explore by content validity and is confirmed by 10 experts. For reliability of questionnaire Cronbach alpha method can be used
Population include following items

1- Experts
2- Experienced managers
3- Engineering units of experience experts
4- Knowledge based companies that are active in this field

Among experts, some professors that are intellectual in the field of technology transfer are prioritized. Experienced managers are persons who are active in the field of process industry like oil and gas and petrochemical. Knowledge based companies in the researches are ones that their register time is passed by one year and are active in the field of process industry. The engineering units include experts in the field of process industry that are active minimum 5 years. Sampling method is availability. In other word the sampling random method is not used

and the experts that are ready to answer interview questions are selected as sample. Analysis is used by 2 content analysis and Delphi that Delphi complete content analysis method and can be led to delete and screen extracted factors from content analysis.

4. Finding analysis

In this section the first stage of reach identifying influencing factors on advanced technology transfer is proposed. In this section that is qualitative step of work the interview with experts is used since there is less background about technology transfer and whenever the background is weak and the literature review is not a good way to achieve a model, so the experts' opinion should be used. The interview text is provided firstly and then extraction context is determined as factors.

Table 1. Factors extraction using experts opinions

NO	Extracted context	**Interview text**
1	Using from globalization capacity	As you know LNG technology is owned by few companies like shell, Phillips and linde that some of them like shell want give technology unless they participate in a project. Technology customers of phillips company also should give rigorous commitment for not closure of technical details and they should use from EPC participators of phillips for doing their project. Iran because of several sanctions can not be put in the framework of technology owners expectation thus transfer of technology is difficult. Of Couse no tendency of other countries owning LNG equipment in order to enter new competitor to LNG market and latent lobbies for not helping to iran can be thoughtful. Totally I think if the capacity of international and global relationships are increased the better condition for technology transfer in LNG can be expected
2	Dispatching human force to abroad	Dispatching young and motivated forces to advance countries in order to experience about the various fields of industry and using from their knowledge and experience can be contribute to improve the current condition of industry
3	Inside organization motivation increasing	Inside organizational motivation increasing for all personnel of oil ministry with increasing wages and enhancement of welfare level can recover the lost motivation of work for forces highly
4	Valuation on youth for scientific development	Due to presence of active forces and experience engineers in oil ministry unfortunately since of wrong policies of past government , the young forces are not valued yet and most of managerial tenures are occupied by aged persons and no youth is not selected as manager. By replacing aged managers with young ones their talent can be prospered
5	Export approach adoption	The most important application of LNG industry is for export that there is no thought for its export in iran. Of course due to the fact that export by pipeline is

NO	Extracted context	Interview text
		more reasonable the value of export gas should be calculated Unfortunately, almost in our country the novel phenomenon is not treated appropriately and is resisted. Although it seems there is no surplus gas for exports and there is no usage inside country but Islamic republic of iran as first or second gas storage and by accessing to free see should achieve to gas technology since swap can export Turkmenistan gas of course if it has gas surplus can export its gas too
6	Using from efficient managers	Unfortunately, in gas industry we have not had efficient managers and one of the reason of not transferring technology is this fact. In my idea approaching to young and efficient managers and experienced one can contribute to improve technology transfer process in LNG industry
7	Using from startups and university capacities	For achieving to technology a technical committee in this field in oil ministry should be created to help universities and startups in this field of course as you know LNG iran project is created already and currently is active but it is not certain whether there is a plan for creation of native e technology in iran or not
8	Conference and meetings	In my idea conference and meeting can be useful in achievement of informal technology since the meeting usually can be influencing in technology transfer indirectly
9	International Exhibitions and presence in them	International exhibitions in the industry field indicate that some total plans about industrial products can be achieved and the 40 years background of international exhibitions indicate that although such exhibitions wont led to technology acquisition but can pave way. Of course it should be noted that exhibitions can not be effective inside country and it Is better to internalize presence in international exhibitions
10	Publications and books	Publications like articles and books can be effective like exhibitions and conferences both using and its publication by experts is effective in technology transfer
11	Internship terms inside and outside country	Internship terms that is done in many fields is effective in technology transfer and Is categorized in the field of educational activities. Of course internship terms both inside and outside country can be executable and is different with dispatching force to abroad. In inside internship internal forces under technology owned companies perform their internship activity
12	Purchasing and importing	The subject that should not be ignored in informal technology transfer is to purchase and import equipment in process industry. Due to complexities of such industry, using from manufacturing equipment can be useful in this industry and

NO	Extracted context	Interview text
	equipment	thus one of the method for achieving to technology is to import equipment. Of course in sanction conditions the work is difficult and it is hoped that by removal of sanctions the path can become open
13	Visiting from similar production centers	Visiting from production centers and familiarity with the way of process products can be a step toward informal technology transfer since natural technology owner is not aware from this goal. Of course the main note is that the relationship with country that is visited should be so that the country allow to visit or shape and nature of relationships should be so that accomplishment of such visit to be possible.
14	Requiring external companies to train internal forces	Often in international contracts there is a possibility that an investor company is able to train internal forces. Of course it is fact that it can not be accomplished and many companies that own technology withdraw from this. But there are some cases that level of cooperation is so high that external company provide the education to internal forces.
15	Sharing production information with Consensus	In some cases there is possibility for sharing production especially whenever international important agreements is contracted among multiple countries that production information to be available for all members. this is one of the most important method of technology transfer in process industry. of course we cannot say that is an informal approach but can have informal nature.
16	Employing persons in technology owned companies	One of the methods of informal technology transfer is to employ own persons in process technology owned companies but this is different with internship and have the nature of employment. In fact, internal force in this companies are employed and act in the terms of contract and then transfer gained information to country. The main note is that knowledge and job level of employed person should be so high that can attraction information and then transfer it.
17	Offering study opportunities with scholarship to experts	I spoke about dispatching forces and internship and employment but one of the methods that should not be ignored is to offer scholarship in universities of technology owned countries and education through universities not industry. In fact in countries in which there is a good relationship between industry and university we can use from university instead of industry as the resource of technology. Therefore one of the main approach is scholarship
18	International cooperation with technology owned countries	2 side International cooperation with technology owned countries is a good method in this method production information sharing can not be done but information is transfer from top to down meaning technology owned company to technology demanded country. Its difference with information sharing is that in information sharing all parties are benefited same but in this method just one party is benefited and information is downloaded

As we observe in table 1 based on interview with experts 18 factors are extracted. they are provided in table 2.

Table 2. Contexts from experts

Notations	**Extracted contexts**
C1	Using from globalization capacity
C2	Dispatching forces to abroad
C3	Inside organizational motivation
C4	Valuation to young forces for scientific development
C5	Export approach adoption
C6	Using from efficient managers
C7	Using from start ups and universities capacities
C8	Exhibitions and conferences
C9	International exhibitions and presence in them
C10	Publications of articles and books
C11	Internship terms inside and outside country
C12	Equipment import and purchasing
C13	Visiting from similar production centers
C14	Requiring external companies to education internal forces
C15	Sharing production information with consensus
C16	Employing persons in technology owned companies
C17	Offering studies opportunities with scholarship to experts
C18	International cooperation with technology owned countries

In table 2 factors beside their notations is provided. But the main note is that above factors can be revised. In order to revisiting factors Delphi technique is used. Delphi technique can confirm extracted factors or delete additional factors. The steps of Delphi test is provided.

In this section screening and revising factors comprising model are provided. Criteria for deletion of factors in Delphi technique is that in 3 stages experts consensus on each factors to be confirmed.

Table 3. Delphi technique step one

Factors	A	B	C	D	E	F	G	H	I	J	average
Using from globalization capacity	10	6	6	3	3	5	1	5	4	2	4.5
Dispatching forces to abroad	10	3	5	3	2	1	9	2	10	5	5
Inside organizational motivation	9	3	10	2	10	6	4	2	2	5	5.3
Valuation to young forces for scientific development	9	1	9	6	7	8	9	7	9	7	7.2
Export approach adoption	8	8	3	8	4	7	5	2	10	9	6.4
Using from efficient managers	10	3	10	2	2	3	10	4	7	5	5.6
Using from start ups and universities capacities	6	3	2	3	10	3	10	3	6	5	5.1
exhibition and conferences	4	6	2	8	7	1	9	8	7	10	6.2
International exhibitions and presence in them	1	1	9	6	9	4	9	7	9	10	6.5
Publications of articles and books	7	2	4	4	6	2	4	6	8	6	4.9
Internship terms inside and outside country	6	5	9	2	7	1	8	8	2	2	5
Equipment import and purchasing	8	9	9	3	8	7	10	4	9	9	7.6
Visiting from similar production centers	5	4	6	9	10	3	3	5	7	6	5.8
Requiring external companies to education internal forces	7	1	4	3	3	9	3	10	3	4	4.7
Sharing production information with consensus	7	1	9	8	1	1	5	10	5	2	4.9
Employing persons in technology	10	1	6	5	1	2	5	4	9	7	5

Factors	A	B	C	D	E	F	G	H	I	J	average
owned companies											
Offering studies opportunities with scholarship to experts	7	7	8	2	5	7	8	2	5	6	5.7
International cooperation with technology owned countries	9	2	4	6	8	1	2	3	10	6	5.1

As we see in above table 18 extracted factors is determined as object and is scored from each expert and finally average is calculated. This work in step 2 of Delphi technique is repeated.

Table 4. Step 2 of Delphi test

factors	A	B	C	D	E	F	G	H	I	J	average
Using from globalization capacity	10	5	4	1	3	5	1	5	3	1	3.8
Dispatching forces to abroad	9	2	5	1	1	1	9	1	9	4	4.2
Inside organizational motivation	7	2	9	2	8	5	3	1	1	5	4.3
Valuation to young forces for scientific development	7	1	7	5	5	8	8	6	7	5	5.9
Export approach adoption	6	7	2	8	3	5	5	1	10	9	5.6
Using from efficient managers	8	1	10	2	1	3	9	2	5	5	4.6
Using from start ups and universities capacities	5	3	1	1	8	1	10	1	5	4	3.9
exhibitions and conferences	4	4	2	8	5	1	8	6	5	8	5.1
International exhibitions and presence in them	1	1	8	5	8	4	9	5	7	9	5.7
Publications of articles and books	6	1	2	2	4	1	4	6	6	4	3.6
Internship terms inside and outside country	5	5	9	2	7	1	7	6	0	1	4.3
Equipment import and purchasing	8	8	9	1	8	5	10	3	7	7	6.6
Visiting from similar production centers	3	4	4	8	8	1	3	4	7	6	4.8
Requiring external companies to education internal forces	5	1	3	1	1	7	2	8	3	2	3.3
Sharing production information with consensus	5	1	9	8	1	1	4	9	5	2	4.5
Employing persons in technology owned companies	10	1	4	4	1	1	4	3	9	5	4.2
Offering studies opportunities with scholarship to	7	7	6	1	3	5	6	1	4	5	4.5

factors	A	B	C	D	E	F	G	H	I	J	average
experts											
International cooperation with technology owned countries	7	1	4	4	6	1	2	1	8	4	3.8

After step 2 of Delphi technique, average for each factor is calculated that in table 5 variation between then is indicated.

Table 5. Calculation of variation between step 1 and 2 averages

Factors	Step one average	Step two average	variation
Using from globalization capacity	4.5	3.8	0.7
Dispatching forces to abroad	5	4.2	0.8
Inside organizational motivation	5.3	4.3	1
Valuation to young forces for scientific development	7.2	5.9	1.3
Export approach adoption	6.4	5.6	0.8
Using from efficient managers	5.6	4.6	1
Using from startups and universities capacities	5.1	3.9	1.2
Exhibitions and conferences	6.2	5.1	1.1
International exhibitions and presence in them	6.5	5.7	0.8
Publications of articles and books	4.9	3.6	1.3
Internship terms inside and outside country	5	4.3	0.7
Equipment import and purchasing	7.6	6.6	1
Visiting from similar production centers	5.8	4.8	1
Requiring external companies to education internal forces	4.7	3.3	1.4
Sharing production information with consensus	4.9	4.5	0.4
Employing persons in technology owned companies	5	4.2	0.8
Offering studies opportunities with scholarship to experts	5.7	4.5	1.2

Factors	Step one average	Step two average	variation
International cooperation with technology owned countries	5.1	3.8	1.3

In table 5 average variation for 2 steps is calculated. As we see factors like visiting from similar production, requiring external companies to educate internal forces, offering study opportunities with scholarship to experts and international cooperation with technology owned companies are exceeded from threshold of 0.9 and therefore we say that during 2 steps of Delphi technique researcher consensus about such factors is not gained and thus the factors should be sent to third step in order to more revising. But factors like sharing production information with consensus and employing persons in technology owned companies is less the threshold value and such factors can be considered as finally factors after 2 steps of Delphi technique.

Table 6. Step 3 of Delphi test

Factors	A	B	C	D	E	F	G	H	I	J	average
Increasing Organizational inside motivation	6	2	8	1	8	5	1	1	1	5	3.8
Valuation on young forces for scientific development	5	1	5	5	5	8	6	6	6	3	5
Using from efficient managers	6	1	9	1	1	2	7	2	4	4	3.7
Using from startups and university capacity	3	2	1	1	6	1	10	1	5	4	3.4
Conferences and meetings	4	3	2	6	4	1	6	4	4	8	4.2
Publication of articles and books	4	1	2	1	4	1	4	6	6	3	3.2
Purchasing and importing equipment	7	8	7	1	8	4	10	1	7	6	5.9
Visiting similar production centers	1	3	3	8	8	1	2	3	6	4	3.9
Requiring external companies to education internal forces	4	1	3	1	1	7	1	8	1	1	2.8
Offering study opportunism with scholarship to experts	7	7	6	1	3	3	4	1	3	5	4
International cooperation with technology owned countries	6	1	4	4	5	1	2	1	8	2	3.4

Table 7. Comparison average for step 2 and step 3

Factors	Step 2 average	Step 3 average	variation
Increasing Organizational inside motivation	4.3	3.8	0.5
Valuation on young forces for scientific development	5.9	5	0.9
Using from efficient managers	4.6	3.7	0.9
Using from startups and university capacity	3.9	3.4	0.5
Conferences and meetings	5.1	4.2	0.9
Publication of articles and books	3.6	3.2	0.4
Purchasing and importing equipment	6.6	5.9	0.7
Visiting similar production centers	4.8	3.9	0.9
Requiring external companies to education internal forces	3.3	2.8	0.5
Offering study opportunism with scholarship to experts	4.5	4	0.5
International cooperation with technology owned countries	3.8	3.4	0.4

As we observe the comparison of average for step 2 and step 3 shows that none of factors violated threshold of 0.9 and all of factors are confirmed in revising of third step and can be considered in final model final model is as following:

Table 8. Final factors

Notation s	Final factors
C1	Using from globalization capacity
C2	Dispatching forces to abroad
C3	Inside organizational motivation
C4	Valuation to young forces for scientific development
C5	Export approach adoption
C6	Using from efficient managers
C7	Using from startups and universities capacities
C8	exhibitions and conferences
C9	International exhibitions and presence in them
C10	Publications of articles and books

Notation s	Final factors
C11	Internship terms inside and outside country
C12	Equipment import and purchasing
C13	Visiting from similar production centers
C14	Requiring external companies to education internal forces
C15	Sharing production information with consensus
C16	Employing persons in technology owned companies
C17	Offering studies opportunities with scholarship to experts
C18	International cooperation with technology owned countries

Therefore after 3 steps of Delphi techniques none of extracted factors are acceptable and all of them are considered as final factors from interview.

5. Conclusion

The final aim of current research is to identify influencing factors in informal technology transfer that the factors were extracted by content analysis and Delphi. Based on identified factors in content analysis and Delphi we can say that most important characteristics of informal technology transfer model is as following

- More internal and external interaction
- Knowledge sharing
- Active role of human resource
- Scientific and technological development

Due to the fact that in next steps of research we witness continuous and confirmation of extracted factors in content analysis step we can say that elements of technology transfer model elements for process industry can be aligned with primary comprising elements and there is no difference between informal technology acquisition model and process industry technology acquisition model. Totally we can say that elements of process industry technology acquisition model that including model characteristics is as following

- Knowledge publication
- Hardware purchasing
- Developing internal and international cooperation
- Development of capable human resources
- Adoption of software and hardware approach
- Knowledge publication per se including following properties
- Conferences and meetings

- International exhibition and presence in them
- Publication of articles and books
- Internship terms inside and outside company
- Visiting from similar production centers
- Sharing production information with consensus
- Offering study opportunities with scholarship to experts
- Above items are categorized under knowledge sharing while other elements interfere on it

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