DESIGNING A DECISION MAKING MODEL FOR SELECTING TECHNOLOGY TRANSFER PROJECTS

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Abstract - In this paper, first, a conceptual framework has been developed and while truly recognizing different aspects of the technology transfer process, it is trying to introduce a decision-making methodology in the choice of projects. Then by choosing effective variables in technology transfer process, a Multiple Criteria Decision-Making (MCDM) model has been designed, so that the choice of appropriate technology transfer projects based on a clear criterion, would be possible. Also, in order to improve the efficiency of the designed MCDM model, possible distribution of some effective qualitative variables such as technology life cycle, technology level, the possibility of technology adoption, etc. have been observed. In this way, most of the ambiguities, which are the results of using qualitative variables in decision-making issues, in the area of technology management would become clear. In addition, the risk analysis (RA) as well as the decision-making process related to technology assessment (TA) would be possible. In this research, various examples of the previous experiences of the Iranian companies in the area of technology management have been dealt with, and by designing nearly a realistic model, the main reasons for the failure of some foreign investment projects in Iran from the point of view of technology management are discussed. At the end, while generally introdueing the designed model, this research elaborates on some suggestions for the better performance of foreign investments in the area of advanced technologies in Iran.

Keywords - Technology Transfer, Decision Making, Fuzzy Logic, Multi-Criteria.

THE ROLE OF TECHNOLOGY IN DEVELOPMENT:

Due to the very effective role of technology in the progress and economic development of different countries, nowadays it is considered as one of the most effective short-cuts for compensating technical and economic disadvantages in the developing countries. Therefore, it is believed that technology would create appropriate potentials and capabilities for the preparation of economic development programs in these countries.

Technology is not just limited to the manufacturing of hardware or methods, rather it has a multi-dimensional nature. Decision-makers have been experiencing too many problems for choosing the appropriate technology transfer projects, which could meet the needs of different economic sectors of a country and/or prepare the essential introductory tools for adapting and localizing the imported technologies. This issue has, often, faced the decision-makers with different, and even, contradictory demands, which are based on multiple attributes.

As a result of insufficient information and proper details regarding the different aspects of a technology transfer project, the whole decision-making process and the technology selection could be affected. This may also happen because of the lack of an authentic and a clear method in the analysis of the above-mentioned information or, perhaps, by not paying enough attention to a wider spectrum of decision-making process. In these circumstances, national wealth could be wasted and the decision-makers would make inappropriate biased decisions based on their personal and regional scopes. Therefore, in order to limit the undesired outcomes and side-effects of the personal decision-makings, based on personal tastes and preferences, a comprehensive and systemic decision-making model must be adapted. This model, while presenting a documentary approach, sheds light on the ambiguities that are the results of lack of necessary information in the process of decision-making in the choice of technology transfer projects.

Reviewing the history of economic changes in the developed countries indicates that technology plays an essential role in the economic development of these communities. This economic development is due to the onset of new technologies of production; therefore, production and export of industrial goods form a large portion of these countries' products.

In other words, due to the limited potentialities of the agricultural sector and traditional production in creating job opportunities, and also, due to the unlimited potentialities of the industrial sectors, especially in the field of High-Tech, industrial development approach has been introduced as an inevitable solution to many of the countries througout the world [1].

KINDS OF TECHNOLOGIES

There are different methods for the classification of different technologies. United Nations Industrial Development Organization (UNIDO), according to the level of complexity, classifies different technologies in a wide range of skill-oriented to knowledge-based technologies [2]. In some other classifications, the level of complexity of different production stages are considered. However, according to the national viewpoints towards the technologies, and also according to their importance, they are divided into vital, strategic or conventional ones.

It seems quite natural that, in the classification of technologies, emphasizing on the related processes and avoiding, as far as possible, the product approaches, would give us more clear outcomes. Looking at technology from the viewpoint of R&D expenditure and patent purchasing, it could be regarded as another appropriate method for appreciating the differences between traditional and modern/advanced technologies. Table 1 is an illustration of this approach.

Table 1: Branches in different technologies, cost for research, development and licensing (% of sale)

Group 1	Group 2	Group 3	Group 4
Aeronautics	Basic organic	Inorganic chemicals	Textiles, clothing.
	chemicals		Footwear
Instrumental Electronics computer components	Secondary chemicals	Iron metallurgy	Foodstuffs
Instrumentation	Intermediate chemicals	Non-ferrous materials Railways	Paper
Pharmaceutical	Motor vehicles	Petroleum	Wood
Artificial and synthetic fiber plastics Frozen and freeze-dried foods	Appliances Non-electrical machinery Electrotechnical rubber Electrochemical products		Building materials

Source: [3]

TECHNOLOGY DYNAMICS

Whenever scientific and technical innovations could lead to a relative superiority in one of the production technology components, and consequently, the productivity grows up, we can say this innovation could lead to a technology development as well.

If a country enjoys appropriate national technology atmosphere, and if a new innovation is applied in a specific area, then this ability is quickly diffused in other production centers, so that it could lead to the elevation of technology in a national level. The most important requirements in this regard include:

1. possibility of communication and exchange of information among experts.
2. preparedness of the manufacturing organizations for the acceptance of technical innovations.
3. enjoying a level of public consumption criterion that could identify qualified goods.

If these requirements are fulfilled, then the technology environment will be an uniformed one, which is highly dynamic against innovations. Therefore, due to the use of better and advanced technologies, the manufacturing costs will be reduced and the competition powers will be highly increased.

As a result, we must not be surprised that in the recent decades mass production flexible corporations, with various productions, have gradually replaced factories throughout the world. In addition, the production lines have been divided into multi-functional and multi-purpose cells, due to the fact that flexibility and dynamism in such a high rate of innovation are not compatible with great sizes and measurements.

In these situations under which technology always faces fundamental changes, some basic questions are posed here. What is the main reason behind these changes? To which destination do these changes lead the world? And above all, what is/are our responsibiliti(es) regarding these changes? Perhaps some important reasons for technology changes could be cited as follows:

1. passage of time and termination of useful life of technology components, is nowadays typically short, due to the necessity of compatibility with the rapid changes.
2. technical innovations for elevating the productivity of manufacturing technology.
3. different innovation rates in technology components; some technology components are prematurely faced with their end-lives.
4. shift of client's demands and expectations, which would lead to the substitution of more appropriate technologies.

All the above-mentioned factors help the new technologies replace the older ones. It has been experienced that generation and, then, diffusion of an innovation in a national or international level are subjected to 'S' curves.

Therefore, it can be said that one of the most important factors for measuring the useful life of a specific technology is the time in which more appropriate technologies are generated and introduced into the industry. It is so crucial a fact that industrial leaders can view them as appropriate tools for their purposes.

In Figure 1, taken from [4] a general image of the above-mentioned process is illustrated.

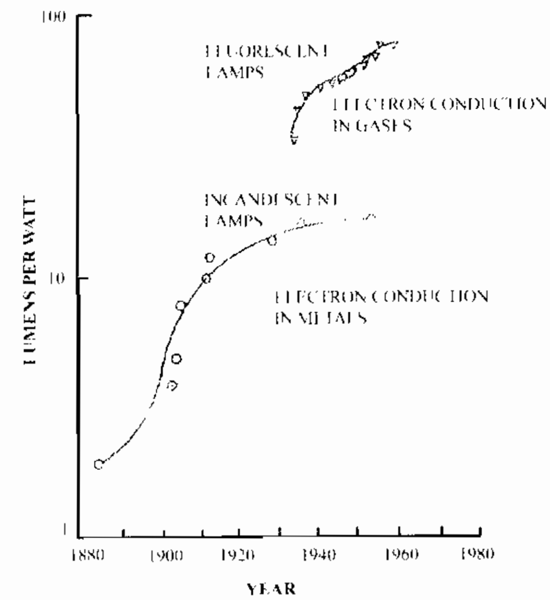

Figure 1: Technology S curve for progress in lamp technology

DIFFERENT LEVELS OF TECHNOLOGY

Technology is considered as a mediator between science and industry. Research and scientific sectors prepare proper backgrounds for generation of new ideas, while the industrial sectors need practical and assured applications in production cycle. Therefore, direct contact between scientific sectors (universities) and manufacturing sectors (industries), due to their natures, can not lead to a proper and permanent cooperation between them.

In such a situation, another sector is needed to act as a mediator between the above-mentioned sectors. The establishment of this sector could lead to the absorption of scientific innovations and after practicing necessary engineering improvements on them, their outcomes can be diffused through industry.

As technology approaches industry, economical aspects of the activity gain more importance and its theoretical aspects lose their importance. On the other hand, when technology approaches to research and scientific activities, theoretical aspects overshadow other aspects of the activities and time urgencies become less significant. Table 2 shows this issue.

Table 2: Different levels of technology

No.	Human Res	Field	Example	Level
1	Research	Science	Study radiation in materials	Basic research
2	Research & Eng.	Science	Use of special conductor in new lamps	Applied research
3	Research & Eng.	Science & Tech.	Developing Designing software and tables	Research and development
4	Eng.	Tech.	General and detailed maps for constructing factories	Design engineering
5	Eng.	Tech. & Industry	General contractor	Construction
6	Eng. & Management	Industry	Supplier	Maintenance and repair
7	Management	Industry	Lamp producing factory	Production line
8	Merchant	Economy	Electrical lamp	Product
9	Politician	Economy & Society	Light	Necessity

TECHNOLOGY TRANSFER

Cotinuously increasing the importance of new technologies in quality; improving and creating higher value added productions as well as a highly time consuming process of changing the research and theoretical ideas into assured economic approaches, all suggest that the only practical way of compensating the technical retardation of a country, or an economic corporation, is to use other nations' successful experiences. When the experience or technology is transferred, and the recipients can finally manage to improve those technologies, then we can say that 'real technology transfer' has occurred. In other words, technology transfer is a process through which some other individuals, for the same or different purposes, use a specific technology [5].

Technology transfer includes several main stages: discovering, evaluating, adoption and development of the technology [6]. Therefore, in technology transfer, it is necessary to correctly understand the technology, and according to the operational policies of the recipient party, an appropriate method be adopted [7].

Technology transfer is a very vital and necessary process. At the same time, it is a difficult process, facing many problems while in practice. Among these problems are lack of preparedness of the technical experts of the two parties as well as resistance of the related organizations, laws and regulations. These problems will not be solved unless a comprehensive effort is initiated. Generally speaking, in technology transfer the role of experienced people who act as contact persons (in both giver and recipient parties) is crucial [8].

Technology transfer constitutes part of the process of innovation transfer form research sectors into industrial sectors. In the process of technology transfer, activities of the research and industrial sectors are coordinated. This issue has been explained in a very simple way in Figure 2.

Step 1	Step 2	Step 3
Technology development by federal agency	Technology transfer by both parties	Technology utilization by outside partner

Figure 2: Technology transfer steps

As Figure 3 indicates, technology transfer is a process through which the technology recipient (client/customer), successfully obtains necessary hardware and, at the same time, achieves a favorable level of software proficiency, technical skills and knowledge related to the received technology from the supplier (seller).

Therefore, paying the necessary expenses, the recipient party is introduced to far better methods in production or providing the necessary services.

Accordingly, in every technology transfer process, the following components are detectable as shown in Figure 3.

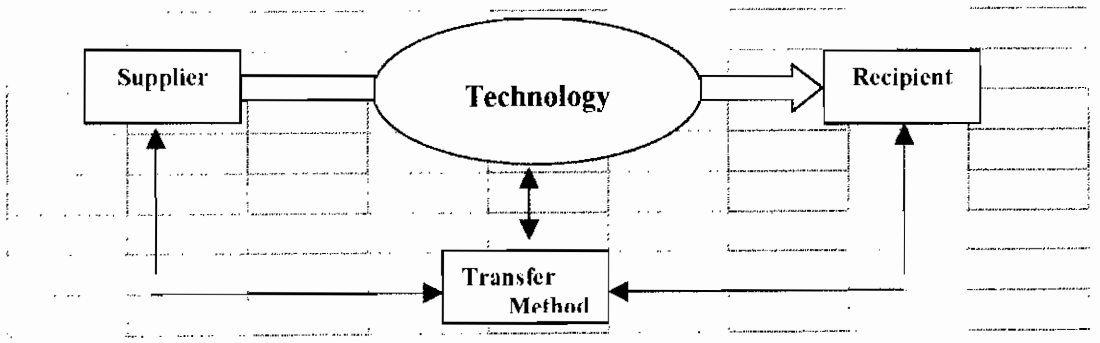

Figure 3: Basic components of technology transfer

1. Technology supplier (transfer of/seller)
2. Technology recipient (recipient/customer)
3. Transferred technology
4. Technology transfer method

In the process of technology transfer, providing machinery and their necessary facilities constitutes the main part of the investments, especially in large conventional industries. This process has a tangible trend and access to hardware, through it, is far easier.

This leniency is made clear when we realize that software components including experts and skillful personnel, technical production methods and technology structures are all intangible concepts. Hence, we may never be assured of their fulfillment and their being translated into action. Unfortunately, as it has been widely experienced, due to the unawareness of technology recipients about the software aspects of the technology transfer, technology is not transferred to the recipient party in a correct manner. Therefore, such countries can not manage to develop their currently used technologies and are even unable to appropriately use the received technologies [9].

In order to understand the process of technology transfer and its position in the national technology system, it is necessary to obtain correct understanding of the prevalent governing spirit in decision making policies. This issue is illustrated in Figure 4.

As Figure 4 indicates, the proper technologies for each country are clarified to its national technology programming system. In this clarification, the following issues must be observed:

1. It must be in parallel with macro-development programming.
2. Although technology programming system is a system subjected to national program of development, the above mentioned programs are the axes for major national programs of development.
3. Technologies needed by every economic sector are determined according to the priorities of those sectors. In the next phase, the appropriate approaches for meeting those needs are clarified.
4. Although every economic sector endeavors to adopt a professional and sectional view to fulfill its technological needs, in technology transfer this adoption is based on national and infra-sectional concerns.

According to what has already been mentioned by the experts and researchers active in the area of technology transfer, we must adopt a comprehensive view towards the decision-making policies and their prevalent atmosphere. And, it is hoped that our previous discussions, have been able to prepare the background for the configuration of the above mentioned view point [9].

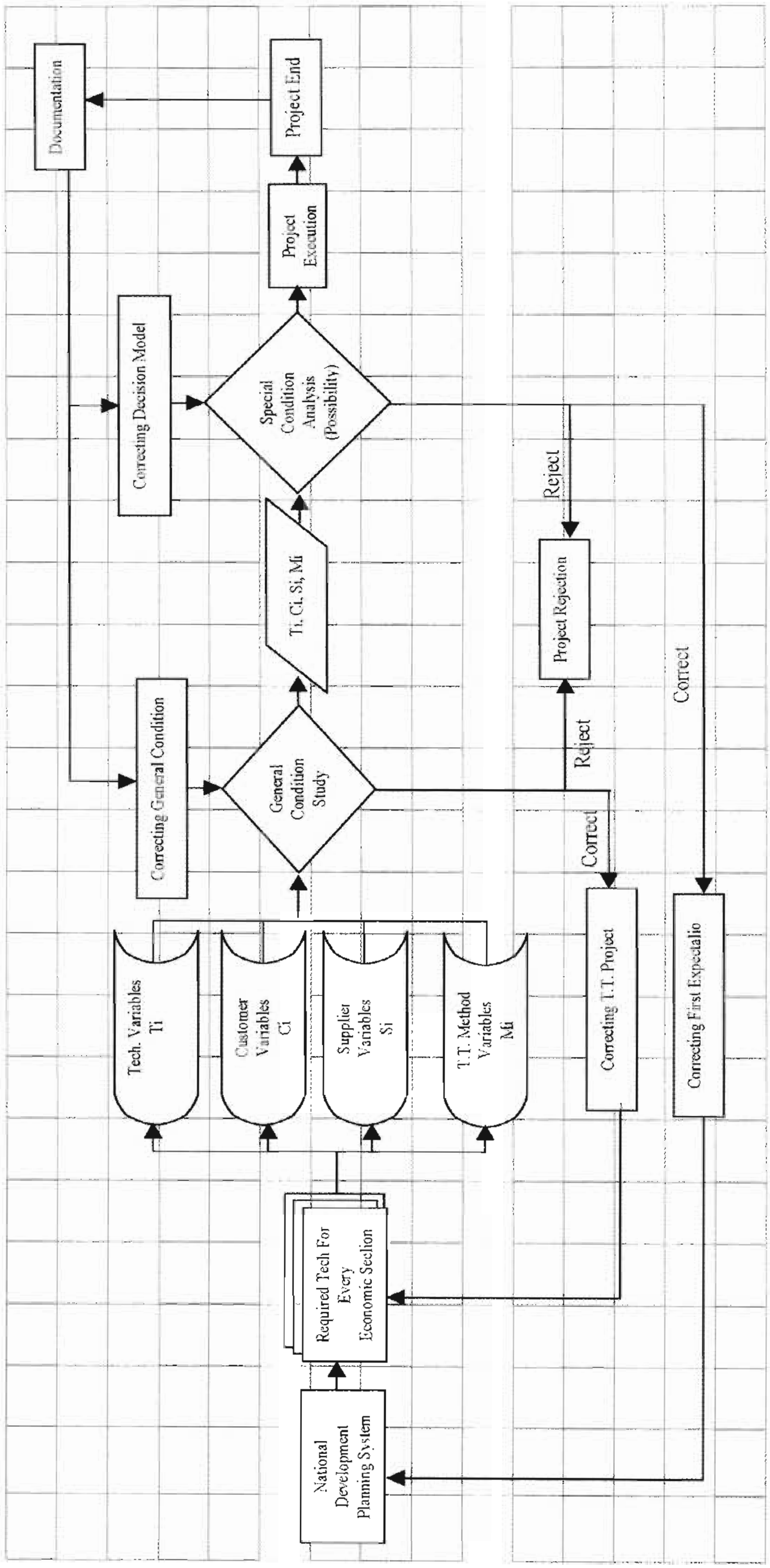

Figure 4: Process of providing required technology

DECISION-MAKING IN SELECTING TECHNOLOGY TRANSFER PROJECT

Technology transfer project includes several coordinated activities through which the technology client receives its necessary technologies from the technology supplier. In other words, in every technology transfer project, the characteristics of four major principles of technology transfer process must be clarified. In addition, in order to provide a specific technology, several different approaches must be available.

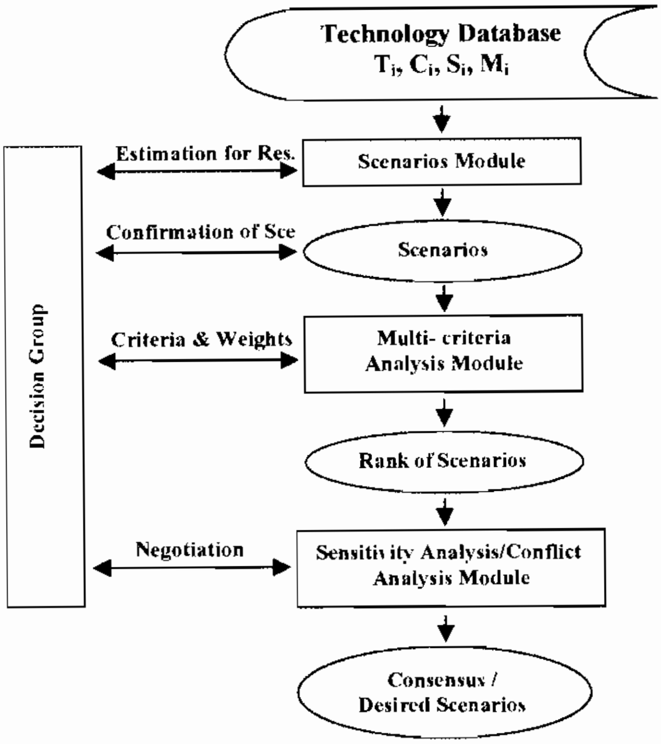

Figure 5: Main structure of selecting model in T.T. projects
Source: [10]

Figure 5 illustrates major elements of a decision-making model in the choice of technology transfer projects. As this Figure shows, in every selecting model, different scenarios must be suggested. Then, scenarios are arranged through multiple criteria discussion-making model and according to the priorities of the decision-makers. After the final process of analysis, the appropriate scenario/solution is adopted.

Reconsidering Figure 5, the important status of the choice of the technology transfer project model is fully realized. These models are important, because they are considered as bottlenecks for technology transfer programming.

Selecting models have got a very strategic status in the technology transfer processes. In addition, the interactive quality of these models is of vital importance. In other words, it is necessary that through the process of selective decision-making, the opinions of decision-makers be practical on the function and optimization of the model in an effective manner.

Basically, in these models, three general variables are observed in the formulation of a process:

1. quantitative variables such as cost or profit
2. critical variables such as maximum admitted cost or minimum expected profit
3. qualitative variables, such as technology life or its strategic importance

Quantitative variables, including decimal or integer ones, as well as critical variables, such as 0 and 1 do not lead to insoluble problems. Generally speaking, it is the role of qualitative models that create the main problems. This is so important a problem that changing qualitative variables into quantitative ones is considered as being the main reason for inefficiency of crisp selective models [11].

It seems possible that the efficiency of selective models could be increased to a great extent by fuzzification of the important qualitative variables [12]. In addition, it is possible that by observing some qualitative measures in projects, such as considering the qualitative priorities in the objective function of the model, the problem of changing qualitative variables into quantitative ones will be reduced to a great extent.

Therefore, remembering that one of the most important reasons for the failure of technology transfer project is the lack of realistic view points towards feasibility of the project, using possibility distribution of qualitative variables could lead to a higher reliability coefficiency [13].

Another critical issue in changing qualitative variables into quantitative ones, is the interactive relationship among qualitative parameters, For instance, a project which is considered to be strategic. may have direct relationship with the costs of the project. and indirect relationship with its time. This issue, due to the high flexibility of fuzzy relations, provides more appropriate grounds for the designer and decision-maker to change qualitative variables into quantitative ones [14].

Anyhow, it must be confined that selective fuzzy models, which enjoy multiple decision-making techniques, are considered to be a very new subject that requires research activity. Therefore, due to the interactive quality of selective models and their important role in the choice of projects, it seems that producers of the selective models have to use the following three basic components simultaneously:

1. a mathematical model
2. an appropriate software
3. a team of decision-making managers

CONCLUSIONS

Although planning an intelligent decision-making system is vital and inevitable for the choice of technology transfer project in every country, it must be amditted that it is not the whole solution to the problem.

The most important outcome of the present study, after an extended effort for planning an intelligent model, is reviewing the history of several important technology transfer projects in Iran.

During a two-year period of comprehensive program, nearly 140 technology transfer projects, specially advanced technologies, have been analyzed and studied carefully. These studies have been based on: interviewing heads of Iranian/foreign negotiating delegates; reviewing the documents of the cooperation between both parties and tracking the outcomes of the negotiations as well as assessing the success of the projects.

The above-mentioned experiences have been analyzed in collaboration with a team of active consultants in the area of technology transfer. According to these analyses, the main factors for the failure of technology transfer projects, especially in the area of advanced technologies usually accomplished by enormous investments, could be summarized as follows:

REASONS OF FAILURE/INCOMPLETE SUCCESS OF TECHNOLOGY TRANSFER PROJECTS IN IRAN

A. Deficiencies of Iranian parties:

1. Iranian parties' lack of awareness on the nature of the technology transfer process and its success factors
2. Inability of Iranian experts in appropriately training the technical observation/Maltose of the Iranian institutes who receive the technology
3. Irregular and untimely payment of the expenses of technology transfer projects
4. Incomplete technical and economic chains of the transferred technologies to Iran
5. Inability of technical information systems in Iran to diffuse and develop the transferred technologies
6. Absence of efficient technical and economic organizations, such as industrial manufacturing groups, in order to facilitate the process of technology transfer
7. Inability of national programs of technology development in establishing the necessary coordinated procedures for objective development of the technologies domestically
8. Absence of an identified authority for policy-making, programming and supervising the development of the country's technology
9. Scarcity of engineering services and companies receiving the technology as well as technical laboratories in different technical areas

B. Problems concerning the type of technology:

1. Incompatibility of the imported technologies with the existing domestic technologies
2. Selecting technologies that are at the end of their useful life
3. Selecting technologies that are contrastive to the economic life of some existing manufacturing technologies

C. Problems concerning the technology transfer methods:

1. Adoption of inefficient and expensive approaches, such as turnkey purchase, for technology transfer
2. Ambiguity of the principles of technology transfer prices in every project
3. Breaking off technical relations after inauguration of the project, especially in the area of technical knowledge (know-how & know-why)

4. Lack of definitions for the common objects in technology transfer projects to develop technology for both Iranian and foreign parties
5. Incompatibility of the technology transfer methods with the type of technologies and their levels of complexity
6. Existence of so many ambiguities for both parties at the time of technical negotiation and lack of a standard method for negotiation among the countries

D. Problems concerning the foreign party

1. Lack of foreign party's real intention to establish long-term Techno-Economic cooperation through mutual relationships
2. Exertion of some unjust political discriminations by the foreign parties, especialy in the field of advanced technologies
3. Unfamiliarity of the foreign parties with the technical-economic realities of the Iranian parties
4. Unawareness of the foreign party about the employment norms and the governing human relationships in Iran's industrial and manufacturing centers
5. Unawareness of the foreign parties of the existing, and sometimes ambiguous, regulations concerning the foreign investments in Iran

Considering the above-mentioned issues, it can be concluded that should these misunderstandings be cleared, the foreign investment projects in Iran, especially in the area of technology transfer, can successfully be conducted. Therefore, it is suggested that by developing scientific cooperations among the individuals/research centers, active in the area of technology management in Iran and their main commercial partners, an international effort for clarifying the ambiguities governing the atmosphere of the negotiations must be initiated. Undoubtedly, such an initiation could be an effective method, the developing countries could use in their technology transfer activities.

Anyhow, it must always be remembered that in the global community, individual happiness is just a mirage, and happiness is the outcome of the efforts of all individual human beings on the earth.

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