International Journal of Industrial Engineering & Production Research (2010) pp. 177-185

March 2010, Volume 20, Number4

International Journal of Industrial Engineering & Production Research

Journal Website: http://IJIEPR.iust.ac.ir/

ISSN: 2008-4889

Introducing a Project Management Framework for Transfer of Technologies

Mohammad Ali Shafia* **& Arnoosh Shakeri**

M.A. Shafia, *is with the Department of Industrial Engineering, Iran University of Science & Technology IUST, Tehran, Iran*
A. Shakeri, *is a PhD student at the same Department Tehran, Iran*

KEYWORDS

Technology Transfer (TT)
Project Management (PM)
Technology Absorption Indices
PM Framework

ABSTRACT

This paper aims at emphasizing the importance of establishing a Project Management (PM) system in Technology Transfer (TT) processes and developing a conceptual framework for it. TT is an important process in Technology Management affairs for all enterprises. Most of the time, lack of a particular concentration on technical, commercial and legal aspects of TT process, leads to mismanagement of other aspects of transferring project, like Time and Project Integration. This situation may lead to failure and loss of many opportunities in transfer process. To overcome this problem, inputs, outputs and activities of a typical TT processes are identified and based on these components, a conceptual framework for managing this project & prevent the loss is developed using Project Management models and methodologies.

1. Introduction

1-1. Opening Talk

Technology Transfer or TT is known as one of the most appropriate and fastest method for countries & firms to speed up their industrial development process, through absorbing the capabilities brought up by the others and conveyed to them. At least three influential key components directly involved in each TT affair [1]:

1. Owner or technology seller, which is sometimes called Transferor and is prepared to convey her capabilities or share with others,
2. Recipient, purchaser known as Technology Transferee, and
3. Linkages which are the transfer channels.

A fair & fruitful TT contract should lead to a win-win outcome for both transferor & transferee. Based on the intention of the two bodies, there are two approaches to the TT process, owner view & recipient one. Transferring intentions & conveying stages are different for these two approaches. The present paper looks at the transaction between them from the recipient point of view.

Each TT process has the unique characteristics and containing activities which have specific results, so it can be considered as a project. The paper is intending to construct a conceptual framework for aiming the recipient of technology in transferring program by depicting the critical elements in the transfer process, and overcome the possible present weaknesses, using project management concepts as a mean to raise the assurance level of TT.

2. Background and Related Published Literature on Different Aspects of Technology Transfer

2-1. Definitions

There are two major methods to get hand on a technology, producing it somehow or purchase it from an owner. Second method is generally known as Technology Transfer [2]. TT is a process that permits the flow of technology from a source to a recipient [1]. The source in this case is the owner or holder of the knowledge and expertise, while the recipient is the

* **Corresponding author. Mohammad Ali Shafia**
Email: *Shakeri@iust.ac.ir*
Paper first received July. 21. 2009 ,and in revised form March. 03, 2010.

beneficiary of such possessing. TT can be expected to happen in different levels [1]: International, Regional, Cross-industry or Cross-sector, Inter -firm.

2-2. Channels of Technology Transfer

Many direct or indirect channels are used to transfer a technology from a body to another, namely licensing, franchise, joint-venture, turn-key, Foreign Direct Investment or FDI, technical consortium, reverse-engineering, training, conferences, etc. each of which has its own characteristics and is more appropriate for the specific conditions [3].

2-3. Technology Transfer Models

There are several TT models describing appropriate transfer channels, based on the technology and other specifications. Chiesa and Manzini have introduced a managerial perspective for mutual technologic collaborations [4]. Robert and Berry placed several transfer methods in nine cells of a matrix based on the market situation and technology situation [5]. A model for selecting appropriate transferring method based on factors like firm's level, necessity of technology and technology lifecycle is provided by Ford [1]. Eventually, Gilbert has divided transferring methods into four categories of: passive or non-active, collaborative, competitive & general methods [6].

2-4. Technology Transfer Stages

TT Stages can be different from owner to recipient's point of view. It can be summarized from the recipient's point of view as the followings. The sequence of events is also illustrated in fig. 1 [1, 7]:

- Needs Analysis and Feasibility Study
- Selection of Appropriate Technology
  - Technology Identification Stage
  - Technology Assessment Stage
- Selection of Appropriate Transfer Channel
- Negotiation and Contracting
- Technology Acquisition
- Technology Adoption
- Technology Development

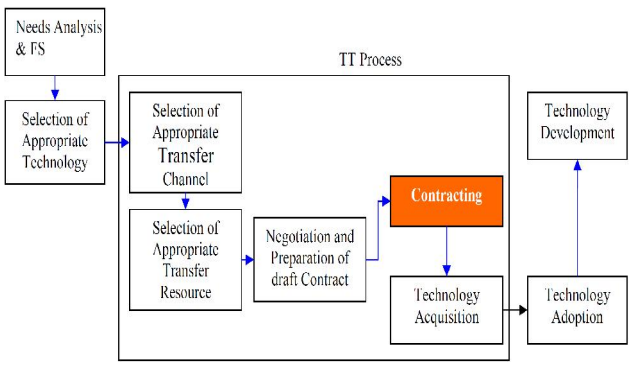

Fig. 1. Typical stages of a TT Process

2-5. Technology Transfer Aspects

Generally, each TT negotiation includes three major aspects of technical, legal & commercial issues which are deeply interrelated and their effects on each other should be considered in depth.

- Technical Aspect: Encompasses issues like Title, Contents, Scope, License & Method, Licensed Products, Development, Manufacture, Process, Preparation, Application Technical Assistance, etc.
- Legal Aspect: Deals with issues like Territory, Delivery of Information, Governing Regulations, Responsibilities and Obligations, Confidentiality, Intellectual Property Rights and Infringement of all Liabilities, Disclaimer, Breaches, Term, Post-Termination Rights, Amendment, Applicable Law and Dispute Resolution, Notice, Counterparts etc.
- Commercial Aspect: Covers issues like Purchasing condition, commercializing Licensed Products, License Fee, Royalties, Payments, and Reports, Method of Payment, Handling of Proceeds and so on.

3. Literature Review on Project Management

3-1. Definitions

As defined by PMI[1], a project is a temporary endeavor undertaken to create a unique product, service, or result [8].Word temporary in this definition emphasizes that, every project has a definite beginning and a definite end. Project management is the application of knowledge, skills, tools and techniques to project activities to meet project requirements.

3-2. Project Management Methodologies, Models and Standards

From past to the twenty-first century, world nations recognized the benefits and importance of project management, so worldwide standards for project management were established [9]. There are several models and methodologies in respect to the project management affairs. The most well known standard one is PMI's PMBOK[2], others are IPMA[3]'s ICB[4], OGC[5]'s PRINCE II, APM[6]'s BOK, Kerzner Model, ISO 10006, SEI's CMM[7] set, etc. Each of these models has concentrated on some of important areas to be considered in every project. In a holistic view, one can consider a framework to manage a project safely through management activities, inputs, outputs, constraints and mechanisms for each project [10]. Fig. 2 illustrates related issues in each of these components.

[1] *Project Management Institute (PMI)*
[2] *Project Management Body of knowledge (PMBOK)*
[3] *International project Management Association (IPMA)*
[4] *International Competency Baseline (ICB)*
[5] *Office of Government Commerce (OGC)*
[6] *Association for project Management (APM)*
[7] *Capability Maturity Model (CMM)*

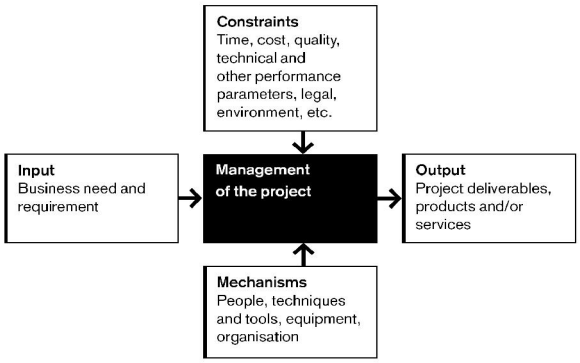

Fig. 2. Project Management Components [10]

By summarizing important areas which have been mentioned in different project management methodologies and standards-like those mentioned above- most common-agreed project management aspects and areas for a project can be visualize as [8, 9, 10 and 13]:

- Project Strategy
- Project Governance & Leadership
- Project Scope Management
- System Approach and Integration Management
- Project Time, Cost and Quality Management
- Project Resource Management
- Project Risk Management
- Project Communication, Information & Configuration Systems
- Project Commercial and Legal Management
- Etc.

Project Management models and methodologies, can provide a range of influencing factors on a TT processes and can safeguard the success of the process. On the contrary, neglecting this opportunity may lead to a poor TT procedure.

4. A Big Gap: Lack of an Integrative View

4-1. A Problem

TT in its customary form of implementation has provided benefits for both transferor and transferee so far. But if the probable negative impacts of TT are considered, it would be revealed that transferee will gain less than her fair share of expected benefits. It is obvious that most dissatisfied transferee is the one, who has acquired a technology with a poor or improper transfer strategy [2]. The literature on transfer of technology to developing countries, has documented many examples of the ineffective acquisition of technology and dissatisfied technology recipients [11]. Possible reasons for this dissatisfaction may lie on many issues as [12]:

- Low local technological capacity for TT -i.e. entrepreneurial, technical, managerial, intellectual, socio-political, cultural and physical aspects.
- Poor infrastructures in local area at technology recipient,
- Lack of local technology absorptive capabilities,
- Disintegration of technical, legal and commercial aspects of transfer,
- Poor quality of working relationships,
- Inefficient decision making mechanisms,
- Lack of enough field studies,
- Lack of negotiating competencies and etc.

Based on the abovementioned reasoning, after the termination of the transfer process, the recipient frequently encounters a variety of problems. Kiguudu [11] had found that in the majority of TT cases, little or no effort is spent on the development of proper ties and adequate constructive relationships between the members of both parties.

4-2. Factors Affecting Success of Technology Transfer Process

Several researchers have used the concepts of technological competence and economic performance to measure the success of TT from the recipient's point of view [12]. As a result, they have determined different sets of variable combinations to reveal the success factors of TT project, depending on the measure of the success. Local technological capacity, government assistance procedures and mechanisms of TT are amongst the most important influencing factors. It seems that less attention has been paid to the last factor -i.e. mechanisms of TT- amongst these influencing factors, in comparison to the others. This problem is more vital in "negotiation and contracting" stages as essential mechanisms in transferring process includes negotiations, contracts and exchange of related documents and information. The experience of the 3rd world countries in transferring technologies from the developed countries like purchasing Automotives, Machine Tool Manufacturing Technology or Electricity Generating Systems shown more pronounced effects in male functioning of the technology received [3]. These problems were raised from some tacit aspects of transferring project like as the lack of integration or poor planning for transfer lifecycle. It was evident that in majorities of TT negotiation affairs -which one of the writers were involved in- sellers usually were not interested even to talk on issues like Design Criteria & Planning Procedures. Due to this situation after investigating several approaches in a research program which its results have been published before [14], some evidences revealed that one can eliminate or remove this weakness by using project management approaches as a way to break through this conveying barrier, which is presented hereinafter.

5. Construct the Solution: A Conceptual Framework

5-1. Design and Approach of the Solution: TT as a Project

Each TT contract has a unique set of characteristics and embodying activities which have

the specific results [1], so it can be considered as a project which can be controlled to make sure of the safe implementation process and yield the most expected results. Fig. 3, schemes TT in a project form demonstration.

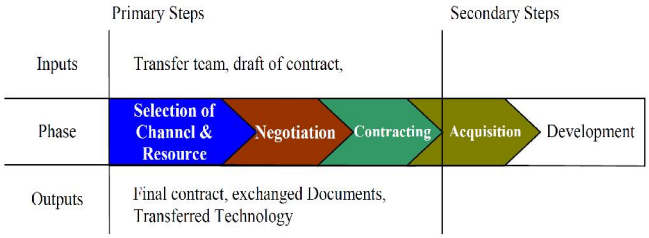

Fig. 3. A natural sequence of a TT project

Based on the diagnosis of the reasons for ineffectiveness of the TT projects, as it can be seen in the figure 4, core and the most influential phase of the TT project is "negotiation and contracting" phase. Regarding the project-oriented aspects of TT, it seems that utilization of a project-oriented approach to the transfer process can overcome weaknesses of this process and improve the success probability rate.
Fig. 4 illustrates related issues which must be considered in a TT project to make sure of the greater possibility of success.

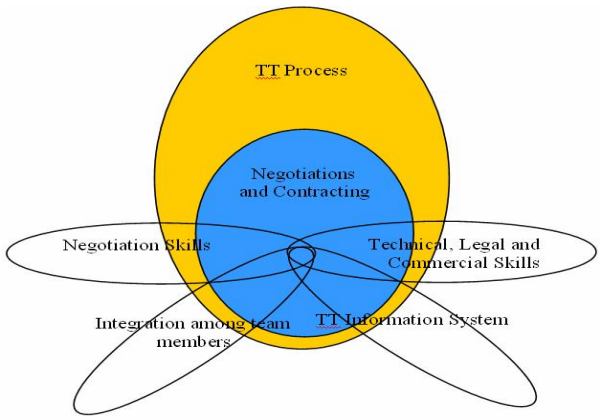

Fig. 4. Aspects of influential issues on a TT project

5-2. Applicability of PM Models

To draw a brighter picture of the case, the important areas of project management have been mentioned below with a deeper insight. At the first step of the model construction, it was important to get an acceptable confidence that selected project management models will be applicable to the intended TT project. For this purpose, five project management models and methodologies have been investigated including PMBOK, ICB, APMBOK, ISO 10006 and PRINCE II. PMBOK describes that the knowledge and practices described in it are applicable to majority of projects most of the time, and there is widespread consensus about their value and usefulness [8]. The ICB also contains basic terms, tasks, practices, skills, functions, management processes, methods, techniques and tools that are commonly used in project management [13]. Three others mentioned models also propose common approaches to the management of projects. For more confidence, one can take advantages of the results from a national research on project management models for designing a project management methodology for Iranian Petrochemical Projects. Based on this research, all abovementioned models have similar basis and use similar concepts and their differences are in their entrance to the body of project management knowledge and their approaches to the project management processes and activities [14]. Therefore, using these models for the purpose of this investigation is defensible. Through searching into details of these project management models, it is found that there are several similar knowledge and experience areas common in them. So, it is decided to use their most common issues to construct an appropriate framework for TT projects which is the intention of this paper. As it can be seen from the table 1, reference PM model for each proposed solution is specified. Besides, related tools or sub-processes are mentioned in the detailed explanations of each solution in section 5.3.

5-3. Proposed Framework

We have constructed the proposed TT project management framework based on some managerial or systematic basis. By investigating project management models, some issues which have more importance from the technology transfer point of view were selected. Authors' approach in selecting these factors was a problem solving method, i.e. based on several problems encountered through a set of technology transfer programs which discussed earlier; it is tried to find some proper tools or techniques to overcome those shortcomings. Table 1, shows the most evident problems and then proposed solution in this regard from PM point of view.

Tab. 1. Most noticed problems in TT projects and proposed solutions

No.	Problem	Proposed Solution, from PM view	Reference PM Model
1	Disintegration of technical, legal and commercial aspects of transfer process	System Approach & Integration Management	PMBOK, ISO10006, APMBOK, Prince II
2	Lack of negotiating competencies	Transfer Lifecycle Management	PMBOK, ISO10006, APMBOK, ICB
3	Poor quality of working relationships	Relationship and Communication Management	PMBOK, ISO10006, APMBOK, ICB
4	Lack of local technology absorptive tools and capabilities	Documentation Management, Project KM	PMBOK, APMBOK, ICB, Prince II
5	Inefficient decision making mechanisms, Lack of enough field studies	Human Resource Management	PMBOK, ISO10006, APMBOK, ICB

In the following, based on detailed investigation of the project management models, most applicable areas with their direct meaningful effect on a TT project are illustrated:

1. System Approach and Integration Management.

In a TT project, one will deal with at least 3 major aspects of say technical, legal and commercial. Nature of these aspects, indicate the requirement of having a tight relationship amongst them. Integration can bring together different activities, attempts, documents and results, as well as coordinating them to reach the transfer project objectives. The integration effort involves making trade-offs among competing objectives and alternatives. The available experiences of the authors on the real TT projects show that in a TT project, effective integration requires appropriate personality in TT team members, adequate technical, legal and commercial knowledge as well as managerial skills. For this purpose, these mechanisms for establishing integration in a TT project are seen as prerequisites of the success (*ref.:* ISO 10006, *Section 4, QM in Projects;* PMBOK, *Chapter 4, Project Integration Management;* APMBOK, *Section 4.6, Configuration Management,* PRINCE II, *Section 19, Configuration Management):*

- *TT Information System or TTIS:* the TTIS is an automated system containing all information required in a TT project. This information can be supportive issues or generated information as the project progresses. TTIS can be used to support generation of a project prism, facilitate feedback as the document is refined, control changes to the transfer project, and specify the approved documents -like as body or exhibits of contract. This system can be designed at MIS[8] or DSS[9] level, that the second one is superior with no doubt. Using this system, transfer project team can have access to their required information and document whenever and wherever they need. This feature can be of great assistance to the TT project and help more effectively during the negotiation and contracting phase. Some types of encompassing information are technical awareness related to the interested technology, legal articles, substitute materials or machines, price information, economic ratios, exchange rates, etc.
- *Transfer Configuration Management and Change Traceability:* During the time period of a transfer project, many changes might take place. Change control is necessary because transfer projects seldom run exactly according to their plan and foreseen situations. This control can be accomplished through a transfer configuration system. This system should be able to identify all required changes or those have occurred. In addition, all alternations must be documented in this system. Configuration system provides the mechanism for the transfer project team to consistently communicate all changes together. Probable changes in a TT project may include those in time periods, in project team members, in legal items, in commercial rates, or change in contract articles, etc.
- *TT Prism:* The author's understandings of project prism mean a document which provides the transfer project manager with the authority to apply organizational resources to project activities. Besides needy information related to the transfer of technology -like as business needs, legal requirements, scope and boundaries, milestones, summary budget, assumptions and constraints, etc.- are also put together in this document.
- *TT WBS:* WBS or Work Breakdown Structure actually is a mean to determine the scope of a project. In a TT project, defining WBS will help team to have maximum dominance on the transfer process and also will prevent scope creeps.

2. Transfer Lifecycle Management.

This lifecycle is the sequence of phases through which a TT project will pass to enhance its objectives from the conception stage to its completion. These phases can be named as needs analysis and feasibility study, selection of appropriate technology, technology identification, technology assessment, selection of appropriate channel, negotiation & contracting, and technology acquisition. The specifications and requirements of these phases are different with each other, thus for yielding a better result in this area, this mechanism in a TT project is proposed (*ref.:* PMBOK, *Chapter 10, Project Communication Management;* ISO 10006, *section 7.6, Communication Related Processes;* APMBOK, *Section 7.0, Communication; ICB, Section 1.18, Communication):*

- *Phase-based Human Resource Allocation:* The number and expertise of team members in different stages are distinctive for the success of the TT i.e. one needs some technical experts and commercial experts at the technology selection phase, but for negotiating, she needs legal experts as well, and in some cases, a psychologist may also be added to the team too. So, each TT project needs a phase-based plan to specify required expertise -and also number of requirements- for each phase of a TT project.
- *Risk-based Scenario Making:* Having several substitutional scenarios is a key to success in any risky processes. Specially in a technology transfer negotiation, which is full of ambiguities and tricks, predicting partner's actions and planning of proper reactions for all steps of TT lifecycle, is an important ability for negotiation team.

[8] *Management Information System (MIS)*
[9] *Decision Support System (DSS)*

3. Relationship and Communication Management.
One of the most important skills required in a transfer project is communication skill, which is not sufficient and utmost by itself. Because of different characteristics of people and probability of change in the TT team, TT manager needs to establish a common and agreed approach for the relationships and negotiations during the transfer lifecycle, particularly in negotiation phase. Based on several experiences of transferred technologies, regarding this requirement, the authors propose these mechanisms in a TT project (*ref.:* PMBOK, *Chapter 9, Project HRM;* ISO 10006, *section 6.2, Personnel Related Processes;* APMBOK, *Section 7.4, Negotiation; ICB, Section 2.11, Negotiation):*

- *Relationship and Negotiation Procedure:* Different people have different relationship approaches. It is important for the TT team to be informed of critical features or characteristics of technology holder. In addition, a harmonic and specified relationship and negotiation approach must be defined in advance for the transfer team members. This will help them to take the proper behavior and reaction in different situations. A relationship and negotiation procedure can provide the TT team a guide to response properly to these requirements. Based on a scenario building approach, a plan for recovering disasters in relationships or negotiations may be included in this procedure.
- *Emergency Help Desk:* As mentioned before, sometimes -especially at negotiation phase- TT team may need special and emergency assistance in concept of relationships or negotiations, i.e. they may require the assistance of a special psychologist for refreshing team members or providing them with new tricks in negotiations. In other cases, a special political relation may be required. Emergency help desk is a pool of relationship tools and contacts to help transfer team as they require.

4. Documentation Management.
Documents have an in-ignorable role in TT. It includes both technical and managerial ones. In many TT projects, concentration on technical documents, leads to a poor attention to the non-technical ones -i.e. transfer goals and objectives, negotiating registered in minutes of meetings, mutually-agreed issues, history of transfer activities, peoples involved to the project, etc. The followings is proposed for in a TT project (*ref.:* PMBOK, *all Chapters, Lessons Learned;* APMBOK, *Section 6.5, Project Evaluation Review;* ICB, *Section 1.17 Information & Documentation;* PRINCE II, *Section 5.8, Setting up Project Files):*

- *Knowledge Management System:* This mechanism can also be called as *Lesson Learned and Event Registration System*. In spite of the unique aspects of each TT project, experienced achieved in each project, may be valuable and useful for next transfer cases. Based on this, it will be beneficial to register and record these important events. In addition, in case of any changes in transfer team which is most probable in developing countries, through registering the important events, one can prevent any possible failure or even the disaster and loose of vital information.

5. Human Resource Management.
Based on the field experience in some TT projects, lack of obvious and clear plan for transfer team, may lead to serious problems in their outcomes. As an example, ambiguity in team members' roles and responsibilities, make decisions unreliable and time consuming (*ref.:* PMBOK, *Chapter 10, Project Communication Management;* ISO 10006, *section 7.6, Communication Related Processes;* APMBOK, *Section 7.0, Communication; ICB, Section 1.18, Communication):*

- *Job Qualifications, Authorities and Responsibilities System or JQAR:* For the better accomplishment of transfer project issues, it is necessary to define qualifications, responsibilities and authorities for each team member. All team activities will be coordinated by a TT project manager who must be aware of all issues related to the transfer project. Roles and responsibilities of other transfer team must be clarified and communicated accordingly as well.
- *Transfer Project Organization:* Organization of transfer team must be clarified as soon as possible. Transfer project manager should be identified and assigned as early in the project as it is feasible. The project manager should always be assigned prior to the start of TT planning. Project manager might be changed if required in different phases of the transfer.

Authors have found these five mentioned issues as most important managerial aspects which can be considered in a TT project management case to help their success probability. Fig. 5 exhibits abovementioned areas as a conceptual framework.

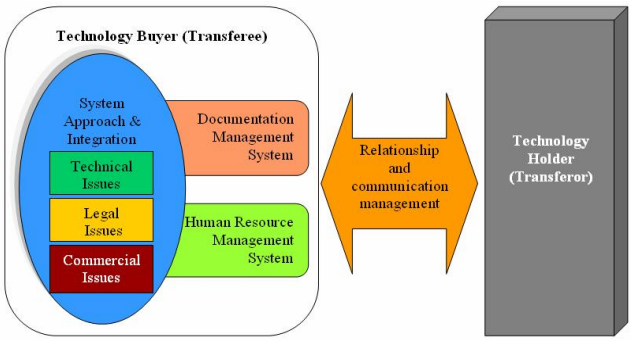

Fig. 5. Conceptual PM Framework for TT project

It would be mentioned that like as each project, the TT project also has its own characteristics which may differ from one to another. For example, type of

technology, contract type, payment system; economical issues, etc. are not the same in all TT projects. So this framework must be customized for each individual project and changed to the specific procedures, tools and techniques.

6. Validation of the Proposed Framework

6-1. Criteria for Measurement of Success in a TT Project

The primary intention of designing a project management system for TT projects is to increase the degree of conveying materialization of TT project for technology recipient. So, it is important to have some supporting figures which confirm that after incorporating these arrangements, TT would yield better results and brings a higher level of confidence and reliability. It means that one need to reveal that looking at a TT program as a project, can improve success of transfer achievements and satisfaction of recipient of technology.

To do that, a special questionnaire on technology transfer aspects was devised & distributed amongst a certain numbers of technology transfer experts - actually 15 experts- in national agencies who have been dealing with the TT affairs, to provide appropriate metrics for measurement of success in TT projects. In the primary questionnaire, TT expert were requested to introduce their idea on 20 questions regarding some proposed TT aspects in a Likert scale or propose some new factors.

Then information gathered in the first round refined, classified and distributed again amongst them to get confidence about necessity and adequacy of the indices, using Delphi method. Finally based on the gathered information, a set of absorption indices defined which is summarized in Table 2.

Tab. 2. Technology Absorption Indices

Index No.	Individual Project Indices
1	Development of Technical & Local Skills
2	Ease & speed of technology absorption and its leverage
3	Firm's mastery the technology
4	Degree of firm's satisfaction
5	Economic performance of the firm
6	Reduced Expenditures

It should be mentioned that, these indices concentrate on the measurement of success in TT processes not on final results, since final results of a TT program are influenced by several environmental factors. Holding several technical meetings with TT experts revealed that proposed indices can be calculated as follows:

1- Development of Technical & Local Skills: this index is includes the following factors:
   a. Ability of conveying absorbed technology to the other sites
   b. Creation of value added and tacit technology

This index will be measured by financial benefits obtained in the transfer period or after that as a percentage of prices of the main TT contract.

2- Rapidity in absorbing and leveraging technology: this index is equal to the time duration by months, after which the firm is able to practice the transferred technology by her own.

3- Firm's mastery the technology: this index can be calculated by number of refers to the technology transferor for solving problems occurred after transfer of technology in a six months or so period.

4- Degree of firm's satisfaction: this index is measured by a satisfaction questionnaire which will be filled in by firm's technology managers after six months or so of transfer period. In that, several issues like quality of TT documents, quality of transferred technology, market share growth, technological skills improvement, etc. will be responded. Mean of the filled questionnaires' scores will be considered as the degree of firm's satisfaction.

5- Economic performance of the firm: this index is encompasses the following factors:
   a. Growth in market share
   b. Net annual profit for the first year
   This index will be measured by multiplying two said factors.

6- Reduced expenditures: main expenditures associated with each TT project can be seen as below:
   a. Repair & maintenance expenditures
   b. Cost of technology application:
   This index is used to measure the amount of cash flows assigned to the application affairs such as repair & maintenance expenditures, administration costs, training expenditures, document costs, start up costs, etc. This index is to be measured as a percentage of the total contract price.

6-2. Findings and Implications, Using Paired t-Test and P-Value

This paper argues that a supporting data of institutions is essential if one claims that a transferred technology is absorbed effectively. Therefore three pairs of similar industrial technology transfer contracts are evaluated for their relationship to the absorption of technology after using supporting tools introduced in the previous part of paper. Because of the unique attribute of each project, it was not possible to measure one specific project, before and after using proposed tools, so maximum attempts devoted to select a set of secondary project which are most similar to the primary ones, in respect of their types, volume, activities, required resources, time boundaries, etc. These three pairs of projects are compared in respect of the model, providing relevant data available on technology absorption, before and after applying the proposed framework. Table 3, contains data based on the technology absorption indices introduced earlier.

Tab. 3. Technology Absorption Indices, before & after using TTPM framework

Technology Absorption Indices	TT Project 1		TT Project 2		TT Project 3	
	before	after	before	after	before	after
Development of Tech. & Local Skills	4.4%	7.2%	6.5%	8.3%	3.8%	6.1%
Rapidity in leveraging technology	11	8.5	16	12.5	7.2	5.5
Firm's mastery the technology	3	2	6	4	3	1
Degree of firm's satisfaction	67%	81%	55%	83%	65%	85%
Economic performance of the firm	27%	48%	48%	63%	23%	54%
Reduced Expenditures	33%	27%	35%	21%	28%	17%

A review of the data indicates broad support for the propositions developed in the paper, and for the overall thesis linking technology transfer to the efficiency of technology absorption. By the way, for confidence, using a statistical Paired-t test can prove this claim. For this aim, we should define our hypothesis as Equation (1):

$$\begin{cases} H_0 : \mu_1 = \mu_2 & \text{i.e. there is no significant difference in indices before and after use.} \\ H_1 : \mu_1 \neq \mu_2 & \text{i.e. a significant difference is exist} \end{cases} \quad (1)$$

For each index, 't' value has been calculated based on its formula, in which μ_i is the index mean of sample projects, $\bar{d}$ is the mean of d_i, the differences between index values before and after using proposed method, S_d is the standard deviation of sample, 'n' is the sample size and 't' is the Student-t quantile with n-1 degrees of freedom:

$$t = \frac{\bar{d}}{\sqrt{s^2 / n}} \quad (2)$$

Resulted calculations are shown in table 4.

Tab. 4. Paired-t test results for Absorption Indices

Technology Absorption Indices							
before	after	d_i	$\bar{d}$	$(d_i - \bar{d})^2$	S_d	t	P Value
Development of Technical & Local Skills							
4.4%	7.2%	2.8%	2.3%	0.002%	0.005	7.97	0.015
6.5%	8.3%	1.8%		0.003%			
3.8%	6.1%	2.3%		0.000%			
Rapidity in leveraging technology							
11	8.5	-2.50	-2.57	0.004	0.902	-4.93	0.039
16	12.5	-3.50		0.871			
7.2	5.5	-1.70		0.751			
Firm's mastery the technology							
3	2	-1.00	-1.67	0.444	0.577	-5.00	
6	4	-2.00		0.111			0.037
3	1	-2.00		0.111			
Degree of firm's satisfaction							
67%	81%	14%	20.67%	0.444%	0.070	5.09	0.036
55%	83%	28%		0.538%			
65%	85%	20%		0.004%			
Economic performance of the firm							
27%	48%	21%	22.33%	0.018%	0.081	4.79	0.041
48%	63%	15%		0.538%			
23%	54%	31%		0.751%			
Reduced Expenditures							
33%	27%	-6%	-	0.188%	0.040	-4.43	0.047
35%	21%	-14%	10.33%	0.134%			
28%	17%	-11%		0.004%			

By choosing 95% Confidence Interval or $\alpha = 0.05$, with a two-sided type I error with using a two-tailed 't' table,'t' score is $t_{0.05,2} = 4.3027$.

As it can be seen in table 4, for each index, $|t_i| \geq t_{0.05,2}$; so the null hypothesis H_0 is rejected and it means that there is a significant difference between TT indices, after using our propose solutions from PM points of view, i.e. using TTPM framework has significant affect on better absorption of technology in TT projects. Some results which do not support this idea may be occurred because of other environmental uncontrolled factors.

As another way to confirm our results, a P-value test, which draws t-values to [0,1] interval, has been used which its results have been inserted in the last column of table 4. As it is obvious, in all indices, $P-Value \leq \alpha$, so the null hypothesis H_0 is rejected again using this test.

7. Conclusions

As mentioned in the first part of the paper, there are many cases which indicate that, recipient of a technology in a TT process, is not satisfied finally or technology has been transferred in a poor and unreliable form. Based on investigating related works and also the real experiences of real TT projects, it is found that many of these problems and weaknesses may be overcome using tools and techniques related to the project management.

By this finding, a survey on project management models has been conducted & more appropriate models to indicate the success of the TT projects were selected. Then a conceptual framework is proposed, by incorporating project management tools and techniques in important TT areas. Founded on this conceptual framework, TT team should pay more attention to some subjects like system approach and integration management, transfer lifecycle management, relationship and communication management, documentation management and human resource management. This model is a conceptual one & obviously must be customized for each TT project, since each transfer project has its specific characteristics.

8. Research Limitations

To confirm that the proposed framework can improve performance of TT projects, it is better to do the competition of a specific TT project before and after using this framework, but actually it was not possible, since they are unique and won't be duplicated. So it was required to use the framework for a pair of similar TT projects and this leads to some deviations in results. By the way, shortage of very similar projects was another limitation for the second plan. Furthermore, in the literature there was scarce body of proper criteria for evaluating appropriateness of TT processes not just results.

9. Acknowledgements

The authors are acknowledge the support given by Mr.Tavakoloi & Mr.Khanjani of the Specialized Research & Development Society of Iranian Industries & Mines, as well as, Mr.Ale Ebrahim of the R&D Fund of Industry & Mines which are working closely with academic institutions and backing up those studies who can open up the new windows of opportunities to the cause of technology development in the society. The access to a range of data embedded in technologies transferred cases which was facilitated by these organizations is well appreciated. Furthermore, we acknowledge assistances given by national Petrochemical Industries Development Management Company and Project Management Research and Development Center for their supporting data on effects of using project management concepts in their technological projects. Moreover we should give our special thanks to Ms.Nayeri who supported us with his efforts on statistical calculations on samples of the proposed model.

References

[1] Khalil, T.M., *Management of Technology: The Key to Competitiveness and Wealth Creation*, p. 343, McGraw Hill, 2000.

[2] Sharif, N., *Management of Technology Transfer and Development*, Bangalore, India, UN ESCAP, 1983.

[3] Shafia, M.A., et all., *Web Based Fuzzy Expert System for TT Method Selection*, 15th International IAMOT conference, 2005.

[4] Chiesa, V., Mazini, R., *Organizing for Technology Collaborations: A managerial Perspective*, UK, R&D Management, 1998.

[5] Robert, E., berry, C., *Entering New Business: Selecting Strategies for Success*, Sloan Management Review, 1985.

[6] Gilbert, A., Lee, *Negotiating Technology Acquisition: Getting the Tools you Need to Succeed*, Working Paper, Nanyang Technology University, 1999.

[7] Radosevic, S., *International TT & Catch up in Economic Development*, Massachusetts, USA, Edward Elgar Publishing Limited, 1999.

[8] Project Management Institute, *A Guide to the Project Management Body of Knowledge (PMBOK)*, 3rd ed., an American national standard, ANSI, 2008.

[9] Kerzner, Harold, '*Project Management: A System Approach to Planning*, Scheduling and Controling', 9th ed., John Wiley & Sons, Inc., 2008.

[10] Association for Project Management, Project Management Body of Knowledge, 4th ed., UK, 2000.

[11] Kiggudu, M.N., *Managing Operations in Developing Countries*, West Hartford, Kumarian Press, 1989.

[12] Movahedi, B., *Identifying the key factors influencing the Mode of International TT in Iranian Manufacturing Industry*, Business School, Carleton University, Ottawa, Ontario, CA, 2003.

[13] International Project Management Association (IPMA), "ICB-IPMA Competence Baseline", Version 3.0, 2006.

[14] *Petrochemical Industries Development Management Company (PIDMCo.)*, Petrochemical Projects Management Maturity Model, PMRDC publication, Tehran, Iran, 2006.