

# Identifying Impact Factors in Technology Transfer with the Aim of Technology Localization

L.Tahmooresnejad, M.A.Shafia,R.Salami

**Abstract**—Technology transfer is a common method for companies to acquire new technology and presents both challenges and substantial benefits. In some cases especially in developing countries, the mere possession of technology does not guarantee a competitive advantage if the appropriate infrastructure is not in place. In this paper, we identify the localization factors needed to provide a better understanding of the conditions necessary for localization in order to benefit from future technology developments. Our theoretical and empirical analyses allow us to identify several factors in the technology transfer process that affect localization and provide leverage in enhancing capabilities and absorptive capacity. The impact factors are categorized within different groups of government, firms, institutes and market, and are verified through the empirical survey of a technology transfer experience. Moreover, statistical analysis has allowed a deeper understanding of the importance of each factor and has enabled each group to prioritize their organizational policies to effectively localize their technology.

**Keywords**—Absorption Capacity, Adaptation, Technology Transfer, Technology Localization

## I. INTRODUCTION

COMPANIES, which choose one of the technology transfer methods, must prepare all human resources and facilities to absorb the technology. In the absence of such required infrastructures, the company will not be prepared for future developments and firms will need to exert more effort to develop the technology via technology transfer. This process should provide the sector with technical know-how and know-why by strengthening the scientific and operational skills to adapt the technology to its local context. Hence, technology know-how should be fully transferred to engineers, operators and technicians in order for the firm to develop further innovations [14].

If a company understands all the upgrades needed for a specific technology, it will be able to acquire the basic knowledge necessary to open new markets for their products or expand existing ones. A successful technology transfer is dramatically dependent on the localization process, which promotes scientific and technical knowledge, enhances human skills and develops infrastructures whereby firms reinforce their knowledge basis as well as promote their technological skills.

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Companies should consider the various factors that will help them successfully localize their technology and gain a competitive advantage. If firms consider such factors, they may be able to generate new technologies in the future without the relying on their provider's technicians.

In this paper we have sought to identify the factors in different groups that determine the success or failure of localization. All factors were analyzed with statistical analyses based on the survey of the respondents in localization experience within case study. We use the Farab Company as a case study in order to rank the importance of these localization factors. We chose to study this company's experience in localizing hydropower turbine technology, considering that it is the main water projects contractor in Iran and that it has produced a significant amount of electrical energy for decades.

We developed a questionnaire for people involved in the localization process in our case study and analyzed respondents' answers with statistical tests. Through these tests, we were able to analyze the importance of the localization factors in our case study among the four identified groups and among the factors of each category. The results appeared that how important they are within each group to attract the company concerning on which in firm strategies.

## II. LITERATURE REVIEW

### A. Advantages and Barriers of Localization

The aim of the localization process is to enhance company's knowledge and operational skills in order to stimulate technological growth. There are several advantages for firms that use the technology transfer process to localize technology. Nevertheless, a company's success is strongly related to its ability to overcome obstacles in a competitive world. Some of these advantages and barriers are shown in Table I [11]-[15]-[26]

TABLE I  
ADVANTAGES AND BARRIERS OF LOCALIZATION [11]-[15]-[26]

Advantages	Barriers
-Development of Local Economy	-International Competition
-Creation of New Jobs	-Technical and Technological Advances
-Development of Exports to International Markets	-Constraints of Internal Capacity
-Decrease of Technology Cost	-Limited Skilled Human Resources
-Creation Local Capacities	-Lack of Technology Component Suppliers
-Introduction of New Products	-Intellectual Property Rights
	-Desirability of Using available Technologies

**B. Impact Factors in Technology Localization**

Localization is influenced by several factors distributed among the different levels of firms, government policies, competitors, supply chains and institutes [5]. All aspects require developing the appropriate policies in order to benefit from the factors and reduce negative impacts. Government policies play a key role in promotion of the technological developments to support the localization in commercial and industrial issues. Governments could also implement specific regulations to protect localized products. In this way, special focus should be placed on the company-related factors of establishing appropriate infrastructures and developing strong supply chains [27]. The factors that affect localization are classified in four groups in Fig. 1 [4]-[12]-[20].

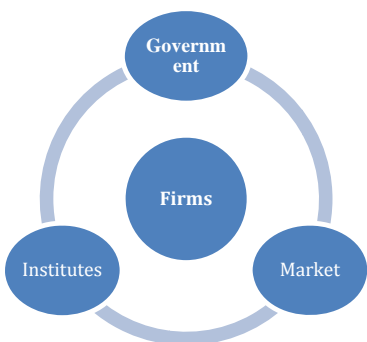


Fig. 1 Impact Factors on Technology Localization [4]-[20]

In this paper, we seek to understand which factors are important in our case study and consequently the importance they play in the localization experience. To achieve this goal, we have identified 27 factors in four groups that are based on the literature review and have ranked them by statistical tests.

**C. Impact Factors in Firm Group**

Companies play an important role in the technology transfer process. Hence, firms must consider factors such as bringing infrastructures and human resources up to par with existing technologies and evaluating the maximum available investments. TableII illustrates the identified factors in this group [19]-[24].

**D. Impact Factors in Government Group**

Government policies can either support or create barriers to technology localization. Sometimes they impose specific demands for new technology that greatly increase the company's chances of success. On the other hand, companies face failure in the market if governments do not implement protective strategies to assist them in accessing the competitive technology market. TableIII declares the four sub-factors in this category [15]-[25]-[3].

**E. Impact Factors in Market Group**

Competition is an important factor in the localization process, since companies' final products will be circulated in the same market as that of their competitors, who already

occupy a substantial share of this market. To overcome the barriers this competition presents, companies should strengthen their supply chain, which is composed of reliable and consistent producers, distributors and many other factors. Table IV points out the significant factors in this group [20]-[23].

TABLE II  
IMPACT FACTORS IN FIRM GROUP [19]-[24]

Impact Factors in Firm Group
<ul style="list-style-type: none"> <li>• Development of Technical Infrastructures</li> <li>• Enhancement of the Human Skills</li> <li>• Analysis of Internal and External Technology Market</li> <li>• Development of R&amp;D Infrastructures</li> <li>• Formal and Informal Communications with the Transferor [9]</li> <li>• Presentation of Technology to Market [12]</li> <li>• Protection of the Localization Process in Organizational Culture [22]</li> <li>• Development of Controls of Transferee on Technology during the Transfer Process [21]</li> <li>• Investments in Technology Developing [6]-[22]</li> <li>• Competitive Capability of the Company</li> <li>• Integration Capability of the Transferred Technology with Existent Technologies [13]</li> <li>• Access to Internal and External Financial Resources</li> <li>• Proportion of the Tacit and Explicit of the Technology Knowledge [16]-[17]- [18]- [21]</li> <li>• The Position of the Company in Lifecycle [8]</li> <li>• The Position of the Transferred Technology in the Lifecycle [7]-[18]</li> </ul>

TABLE II  
IMPACT FACTORS IN GOVERNMENT GROUP [15]-[25]-[3]

Impact Factors in Government Group
<ul style="list-style-type: none"> <li>• Rules and Regulations of the host country</li> <li>• Commercial status of the country</li> <li>• Industrial Status of the country</li> <li>• Political Supports</li> </ul>

TABLE III  
IMPACT FACTORS IN MARKET GROUP [20]-[23]

Impact Factors in Market Group
<ul style="list-style-type: none"> <li>• Competitors</li> <li>• Supply Chains</li> </ul>

**F. Impact Factors in Institutes Group**

Several organizations aid companies in the technology transfer process, helping them to strengthen their capabilities and infrastructures especially on a national level. These organizations provide support through various activities ranging from planning, consulting and enhancing their technical knowledge, and skills through training programs,

workshops and various specialized courses. These institutes are shown in Table V[10].

TABLE IV  
IMPACT FACTORS IN INSTITUTES GROUP [10]

Impact Factors in Institutes Group
<ul style="list-style-type: none"> <li>• Universities and Training Institutions</li> <li>• R&amp;D Labs for Pilot Manufacturing</li> <li>• Engineering and consulting Centers</li> <li>• Technical Workshops</li> <li>• Informative organizations</li> <li>• Supportive Institutes in management, financial and planning</li> </ul>

III. DATA AND METHODOLOGY

We used the Farab Company as the case study for our survey, which is at the forefront of technology localization in hydropower plant equipment. It has operated for large national projects since 1992 by commissioning more than 31 units of hydro power plants with a capacity of 5500 MW. Additionally, 3979.5MW are currently under construction. Over the past few years, national programs have impelled this company to localize their hydropower technologies. Hence, the Farab Company chose to first localize the water turbine, a particular piece of equipment used in electricity production as a primary technology with the aim of localization.

This technology is widely used for electric power generation from moving water, as it is a clean and renewable energy. Since not all engineers are involved in the localization process, we drew our sample population from 100 specialists working directly in localization and top managers of the company. The sample size (n) was calculated with a 95% confidence level and the error range (ε) was between 0.1 and 0.01 with a maximum of p= 0.5 to obtain the largest (n). The sample formula (1) provided 50 numbers for the survey as an objective sample and we received 49 completed questionnaires.

$$n = \frac{N(Z_{\alpha})^2(P)(1-P)}{\epsilon^2(N-1) + (Z_{\alpha})^2(P)(1-P)} \tag{1}$$

A questionnaire with five Likert scale types was used for gathering the data. Respondents were asked about the importance of the localization factors in the technology transfer process. Additionally, interviews were arranged with top managers of the organization and the response rate was 98%.The Friedman test and Wilcoxon signed-rank test are both non-parametric tests, and both were used to understand the relationship between the factors. The null and alternative hypotheses of the Friedman test are mentioned in (2):

$$H_0: \text{There is no difference between the factors} \tag{2}$$

$$H_1: \text{There exists at least one difference between two of the factors}$$

To obtain the precise ranking between the factors, we used the Wilcoxon test to test the differences between the scores of

$$H_0: \bar{R}_i = \bar{R}_j$$

$$H_1: \bar{R}_i \neq \bar{R}_j \quad i \neq j$$

each data pair. Deviation is zero in the null hypothesis and the alternative hypothesis ranks the data based on the deviations. The hypotheses of this test are shown in (3):

(3)

IV. FINDINGS

Analysis results from the Friedman test examine possible differences among the factors. The analysis expresses that since the obtained P-value is less than the significance level of 0.05, the null hypothesis is rejected with a 95% confidence level and it can be claimed that there are differences among the factors. The same results in rejecting the null hypothesis for some of the factors (in some factors the null hypothesis was accepted and they have the same rank) in the Wilcoxon signed-rank test confirm the differences between results and rank them.

Since the p-value is not less than 0.005 between government-market and market-firm, we could not claim significant differences between them. The ranking of the groups regarding the results of Wilcoxon test are shown in the TableVI and Table VII.

TABLE V  
RANKING THE GROUPS OF FACTORS BASED ON FRIEDMAN TEST

Government
Firms

TABLE VI  
WILCOXON SIGNED-RANK TEST FOR THE GROUPS OF FACTORS

Government
Firms

To understand the importance level of the factors within each group, we used the Friedman and Wilcoxon tests for ranking all identified factors. The results for each level are illustrated in Table VIII, TableIX, Table X“to be published” [2] and Table XI.

TABLE VII  
RANKING OF THE GOVERNMENT FACTORS BY FRIEDMAN AND WILCOXON TEST

Commercial status of the country
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Rules and Regulations of the host country	2.19	2
Political Supports	2.07	2
Industrial Status of the country	1.62	3

Informative organizations	3.28	2
Engineering and Consulting Centers	2.65	3
Technical Workshops	2.57	3

TABLE VIII

RANKING OF MARKET FACTORS BY FRIEDMAN AND WILCOXON TEST

Market Factors	Mean Rank by Friedman Test	Ranked by Wilcoxon Test
Supply Chains	13.71	1
Competitors	11.50	2

TABLE IX

RANKING OF FIRM FACTORS BY FRIEDMAN AND WILCOXON TEST "TO BE PUBLISHED" [2]

Firm Factors	Mean Rank by Friedman Test	Ranked by Wilcoxon Test
Development of Technical Infrastructures	11.60	1
Enhancement of the Human Skills	11.50	1
Analysis of Internal and External Technology Market	9.80	2
Development of R&D Infrastructures	9.15	3
Formal and Informal Communications with the Transferor	9.01	3
Presentation of Technology to Market	8.95	4
Protection of the Localization Process in Organizational Culture	8.66	4
Development of Controls of Transferee on Technology during the Transfer Process	8.47	4
Investments in Technology Developing	7.91	4
Competitive Capability of the Company	7.05	4
Integration Capability of the Transferred Technology with Existent Technologies	6.59	5
Access to Internal and External Financial Resources	6.55	5
Proportion of the Tacit and Explicit of the Technology Knowledge	5.85	5
The Position of the Company in Lifecycle	4.90	6
The Position of the Transferred Technology in the Lifecycle	4.00	6

TABLE X

RANKING OF INSTITUTES FACTORS BY FRIEDMAN AND WILCOXON TEST

Factors Institutes	Mean Rank by Friedman Test	Ranked by Wilcoxon Test
R&D Labs for Pilot Manufacturing	4.59	1
Supportive Institutes in management, finances and planning	4.28	1
Universities and Training Institutes	3.63	2

Analysis of the data shows that the commercial status of the country in government factors; supply chains in market; technical infrastructures and human skills in the firm level; and finally R&D labs and supportive institutes on the institute level are the important factors in technology transfer geared towards localization. We also sought to recognize the significant factors in the studied area without considering the groups of firm, government, market and institutes. Our findings concluded that the technical infrastructures and enhancement of human skills, coupled with government policies that protect localized technology stands first among all factors "to be published" [1].

## V. CONCLUSION

Technology transfer, one of the main methods to attain technologies, is suggested particularly for developing countries. It would be useful for companies to reinforce their initial infrastructures during the transfer process. Since companies expect to enhance their capabilities through the acquisition of new technology, different structures within several groups should accompany this process. Moreover, government policies and regulations that protect new technology can either help or hinder firms in achieving their goals. In this research paper, we sought to identify the factors which appear significant in technology transfer and that may lead recipient companies to further developments. Firms are key players in this development process and must be aware of many factors before beginning technology transfer, such as where the technology and the company are in their respective lifecycles.

Furthermore, our research can be used as a guideline for companies that to use new technology for future developments in a way that enables them to develop other technologies through the enhancement of their knowledge and research bases. It should be noted that localized technology may not be able to compete with similar technology in the marketplace in the absence of strong supply chains or government support. We chose the successful company as our case study to analyze the fundamental issues in localization and to validate the importance of the factors in this process. The company we studied made further efforts to localize other equipment in this area under a national program; hence, statistical analysis helps the firm to identify problems in their strategic plan, however ranking factors in the localization process is also important, as this ranking allows the firm to create policies for their strategic plan according to the most important issues.

Independent of the studied case, the identified factors can be applied in all countries and industries, which involve the localization process in future developments. Although the factors were ranked in the selective area, they can be generalized in other companies and especially in government,

market and institute groups; furthermore, the findings can also be implemented in other developing countries, which share similar conditions to those of our case study. Moreover, ranking the factors in a firm provides an appropriate foundation for understanding the important factors in any localization experience.

In conclusion, it should be emphasized that the importance of localization factors may differ depending on the group involved (government, firm, market and institutes) and on the general conditions of a specific country or industry. The general concept of ranking localization factors, however, can be useful independent of the industry or country.

#### REFERENCES

- [1] L., Tahmooresnejad, R., Salami, M.A., Shafia, "Selecting the Appropriate Technology Transfer Method to Reach the Technology Localization", the international conference of Manufacturing Engineering and Engineering Management, London, U.K., 2011, to be published.
- [2] L., Tahmooresnejad, C., Beaudry, M.A., Shafia, "The Localization Process: Eliminating the Gap between Technology Transfer and technology Localization", IEEE International Technology Management Conference, CA USA, 2011, to be published.
- [3] D.J. Bennett, and H. Zhao, "Transferring Manufacturing Technology to China: Supplier Perceptions and Acquirer Expectations", *Journal of Manufacturing Technology Management*, Vol 8, No. 5, 1997, pp. 283-291(9).
- [4] D.J. Bennett, and H. Zhao, "International technology transfer: perceptions and reality of quality and reliability. *Journal of Manufacturing Technology Management*, 15 (5), 2004, pp. 410-415.
- [5] A. Caldera, O. Debande, "Performance of Spanish universities in technology transfer: An empirical analysis", *Research Policy* 39, 2010, PP. 1160-1173
- [6] V. Chiesa, R. Manzini, "Organization for Technology Collaborations: A Managerial Perspective", *R&D Management Journal*, Issue Volume 28, Issue 3, July 1998, pp. 199-212.
- [7] D.H., Cho, P., Yu, "Influential Factors in the Choice of Technology Acquisition Mode: An Empirical Analysis of Small and Medium Size Firms in the Korean Telecommunication Industry", *Technovation Journal*, Vol 20, Issue 12, 2000.
- [8] M., Farhang, "Managing Technology Transfer to China. Conceptual Framework and Operational guidelines", *International Marketing Review*, Volume 14, Number 2, 1997, pp. 92-106(15).
- [9] Gray, C., "Absorptive Capacity, Knowledge Management and Innovation in Entrepreneurial Small Firms", 28th Institute for Small Business and Entrepreneurship (ISBE) National Conference, Blackpool, 2003.
- [10] M., Henkel, M., Kogan, "National science policy and universities: an international perspective". In E. Baker, P. Peterson and B. McGaw (eds), *International Encyclopedia of Education* (3rd edition), Oxford: Elsevier, 2010.
- [11] L. M., Kamp, R. E.H.M., Smits, C.D., Andriess, "Notions on learning applied to wind turbine development in the Netherlands and Denmark", *Energy Policy* 32-14, 2004, pp. 1625-1637.
- [12] V., Kumar, J. S.A., Bhat, "A Successful Technology Transfer Case", Department of Scientific & Industrial Research, Government of India, 2003.
- [13] M., Kondo, "Networking for Technology Acquisition and Transfer" Forum on Management of Technology, Vienna, Austria, 2001.
- [14] A.H.I., Lee, W. M., Wang, T. Y., Lin, "An evaluation framework for technology transfer of new equipment in high technology industry, *Technological Forecasting & Social Change* 77, 2010, pp. 135-150.
- [15] J., Lewis, R., Wisner, "Supporting Localization of wind Technology Manufacturing through Large Utility Tenders in Quebec: Lessons for China", Center of Resource Solutions, the Energy Foundation China Sustainable Energy Program, June 2006.
- [16] R., Li-Hua, "Examining the Appropriateness and Effectiveness of Technology Transfer in China", *Journal of Technology Management in China*, Vol. 1 Iss: 2, 2006, pp. 208 - 223.
- [17] A., Madhok, "Know How, Experience and Competition-Related Considerations in Foreign market Entry: An Exploratory Investigation", *International Business Review*, 5/4, 1996, pp. 339-363.
- [18] C., Marcotte, J., Niosi, "Technology Transfer to China, The Issues of Knowledge and Learning". *The Journal of Technology Transfer*, Volume 25, Number 1, March 2000, pp. 43-57(15).
- [19] Y., Naito, "System Innovation: Technology Transfer", *Enterprise Diagnosis*, Vol. 10, 1998.
- [20] G., Nancy, "Technology and Knowledge Absorption Process in MENA Countries: Stakes and Perspectives Stakes", *Siarheyeva, Taxation and Technology Transfer: Key Issues*", UN, 2005
- [21] D., Rouach, "Technology Transfer and Management", *Technology Transfer and Management. Tech Monitor*, May - June 2003, pp. 21 - 28.
- [22] H., Shahnavaz, "Design for special group: Cultural differences consideration", *ILO Encyclopaedia of Occupational Health and Safety*, fourth edition. 29, 79, 1997.
- [23] S., Tritch, J., Lanzoni, "The Nuclear Renaissance: A Challenging Opportunity", paper presented at the WNA Annual Conference Building the Nuclear Future, Challenges and Opportunities, 7 September 2006.
- [24] S., Wikstrom, R., Norman, "Knowledge and Value: A New Perspective on Corporate Transformation", Routledge Press, London, and HD58.8. W538, 1994.
- [25] I., Rowlands, "Envisaging feed-in tariffs for solar photovoltaic electricity: European lessons for Canada". *Renewable and Sustainable Energy Reviews* 9, 2005, pp. 51-68.
- [26] D. Baily, "A New Growth Record for Canada", *Wind Power Monthly (WPM)*, *Windpower Monthly Magazine* 01 October 2004.
- [27] L. Barclay, "The Continuing Mystique: Multinationals, Technology Transfer and the Development of Indigenous Technological Capabilities in Caribbean Countries", Department of Management Studies, Faculty of Social Sciences, The University of the West Indies Mona, Kingston, Jamaica September 2005.