Indian Journal of Fundamental and Applied Life Sciences ISSN: 2231– 6345 (Online)
An Open Access, Online International Journal Available at www.cibtech.org/sp.ed/jls/2014/04/jls.htm
2014 Vol. 4 (S4), pp. 1656-1664/Taboli et al.
Research Article

AN EXTENDED MODEL FOR TECHNOLOGY TRANSFER POTENTIALS AT THE INDUSTRIES

Hamid Taboli[1], *Arezo Hamzeie[2] and Mahdiye Sheykhpour[3]
[1]*Payam-e Noor University, I.R. Iran*
[2]*Department of Management, Kerman Branch, Islamic Azad University, Kerman, Iran*
[3]*Department of Management, Kerman Branch, Islamic Azad University, Kerman, Iran*
**Author for Correspondence*

ABSTRACT
Technology contributes to the development of society and economy of the nation through the invention, diffusion, transfer, and application of new knowledge. In the emerging global economy of the 21st century, technology is a key to sustainable economic prosperity. Transfer of technology is the key element for the industrialization, growth, and economic development of the countries. Today Transfer of technology (T-T) is an in evitable path to be followed by many organizations and countries. In any T-T project after coming know the technology, it is very important to the receiver of the technology to determine the appropriate policies and providers of the technology. This paper which has been done in this regard presents a model for determining the appropriate policies and provider of technology, based on the expertise and using statistical methods and multi-criteria decision-making. The knowledge transferring capabilities of the transferor, adaptation and assimilation capabilities of the transferee are important to a large extent on the success of any transfer of technology. The quantitative or mathematical modeling has not been significantly utilized in analyzing the technology transfer process. It is possible that more contribution to the knowledge relating to technology transfer can be made by studying the process of technology transfer using quantitative methods. The main focus of this study is to develop an extended quantitative model. To demonstrate the applicability of the developed model, case studies of technology transfer in automobile industry, electronics industry, and computing industry. It is found that the technology transfer model developed in this study provides a very good fit in all the above transfer situations.

Keywords: *Technology Transfer, Automobile Industry, Extended Model, Industrial Level*

INTRODUCTION
Technology is widely accepted as essential for improving the economy of a nation, in particular, in developing countries where industrial growth has occupied a very important role (Goc, 2002). Evidences from many countries have shown that a country's international competitiveness and capacity to grow in the long term is dependent on its ability to master technology and to manage and generate technological change. Technology can contribute to the development of society and economy of a nation through the invention, diffusion, transfer, and application of new knowledge. The literature on technology management has numerous definitions of technology. In this study, it is considered that technology consists of four basic components, namely, (i) Technoware (Facilities), (ii) Humanware (Abilities), (iii) Inforware (Facts), and (iv) Orgaware (Framework). All the four components of technology are required simultaneously in any transformation operation that involves in the production of goods through the conversion of material inputs into outputs and they are complementary to each another. International transfer of know-how, knowledge and technological expertise is growing and they are increasingly important in the world economy (Minbaeva, 2007). Technology transfer (T-T) suggests the movement of technology from one entity to another, for example, from one organization to another, from a university to an organization, or from one country to another. Narayanan and Lai (2000) suggested that Technology transfer needs to be perceived in terms of achieving three core objectives: (i) the introduction of new techniques by means of investment of new plants; (ii) the improvement of existing techniques, and (iii) the generation of new knowledge. The main objectives of this research are to (i) develop a mathematical

function that evaluates the technological level of a country; (ii) develop a generalized mathematical model for measuring the technology transfer potentials that exist between a transferor and a transferee; (iii) develop a specific dynamic mathematical model incorporating time, technological level and potential technology distance for evaluating technology transfer potentials; (iv) verify the technology transfer model for boundary conditions; (v) derive the technological substitution/change models as special cases of the technology transfer model developed; and (vi) apply the technology transfer model to study the technology transfer pattern in selected countries in certain industries (Pak and Park, 2004).

Literature Review

The definition of technology, general overviews of measurement and indices, methods of determining weights of the factors influencing the technology level, and the technology transfer and various aspects of technology transfer process are presented in this section. Some well-known technological diffusion models and technology transfer models are reviewed in this section.

There are numerous definitions of technology are available in the literature. Some of the definitions have been compiled. Based on the various definitions of technology by researchers, Gold (1981) viewed technology as a transformer, tool, and knowledge. Technology has four components: (i) Object embodied form or "Technoware" (ii) Human embodied form or "Humanware" (iii) Document/Record embodied form or "Inforware" and (iv) Institution embodied form or "Orgaware". This four components classification appears to be more practical because it provides a useful mean to use technology for decision making, especially in manufacturing systems. In this study, the four components definition of technology is considered. All four technology components are complementary to one another, and are required simultaneously for the production of goods and services. Thus, there is a minimum requirement for each of the four components. There may also be a maximum limit for each component, beyond which the production of goods and services would be non-optimal or inefficient.

The international transfer of know-how, knowledge and technological expertise are increasingly important in the world economy (Haque, 1995). Technology transfer (TT) suggests the movement of technology from one entity to another, for example, from one organization to another, from a university to an organization, or from one country to another (Guan *et al.*, 2006). Technology transfer depends to a large extent on the complexity of the technology, the owner's capability of transferring, the acquirer's capability of learning, and the complex interaction between the two parties (Archibugi and Lundvall, 2001). The concepts of technology transfer have been defined in many different ways. However, there is usually agreement that technology transfer requires a profoundly human endeavor (Archibugi and Pietrobelli, 2003). The transfer of technology often requires collaborative activity between two or more individuals or functional units who are separated by structural, cultural, and organizational boundaries. Technology transfer is an interactive process with a great deal of back-and-forth exchange among individuals over an extended period of time. Technology transfer has also been defined as being product-embodied, process-embodied or personnel embodied. It can be a lengthy, complex and dynamic process and its success is influenced by various factors originating from many different sources (Sung and Gibson, 2000). Technology transfer is viewed as an active process, during which technology is carried across the border of two entities. These entities can be countries, industries, companies, or even individuals, depending on the viewpoint of the observer. Technology transfer is the movement of technology from one entity to another, and if the transfer is successful, it results in the proper understanding and effective use of the technology by the receiving entity (Sung, 2009).

Technology transfer process involves seven major elements including transferor (source), transferee (receiver), technology being transferred, transfer mechanism, transferor environment, transferee environment, and greater environment. The entity that possesses the technology is known as the transferor. The entity seeking the technology is the transferee. Technology is the combination of techno ware, human ware, info ware and or aware. A technology transfer mechanism is any specific form of interaction between two or more social entities during which technology is transferred. The transferor environment is the set of conditions such as economic status, its technological status, and policies and commitment towards technology transfer activities, under which the transferor is operating - at the

individual, organizational, industrial or national level. The transferee environment is the economic status, technological status, infrastructure, skills availability, attitude and commitment towards change. These factors determine the absorptive capacity of the transferee. There are greater environments surrounding the transferor and transferee environments such as political relationships between the countries, exchange rates, investment climates, trade negotiations, balance of trade problems, technological levels of the nations, and international competition.

Some of the major mechanisms of technology transfer that can be included under these two categories are as follows: Market Oriented Mechanisms: Purchases of plant, equipment and products; Direct foreign investment; Joint ventures; Technical collaboration; Licensing; Technical services agreements; Engineering and construction agreements; Subcontracting; Turnkey contracts; Product-in-hand contracts; Management contracts; Production sharing; Joint research ventures; and Expert services. Non-Market Oriented Mechanisms: Books, academic journals, business magazines etc; Sales literature; Technical information services; Industrial fairs and exhibitions; Informal personal contacts; Participation in conferences, seminars and workshops; and Training. The technology transfer mechanisms exhibit some limitations or deficiencies (Trunog, 2002) such as failure to recognize adequately the significance of recipient organizations needs failure to address service delivery aspects of the technology and knowledge transfer process, and underestimate the importance of the interactive processes and mechanisms between the supplier and the recipient. Walter (2000) state that there are five basic organizational modes for technology transfer including the international technology market, which is made up of independent buyers and sellers; intra-firm transfer, where organizations do not resort to the market but transfer technology through either an internal venture or a wholly owned subsidiary; agreements or exchanges directed by government, where the counterparts can either be public or private actors; education, training and conferences, where the dissemination of information is made public for common consumption by either a general or specialized audience; and pirating or reverse engineering, where organizations obtain access to technology without resorting to the market but at the expense of the property rights of the owners of the technology.

MATERIALS AND METHODS

The specific objectives of this research is to develop of a mathematical function that determines the technological level of a country; develop a generalized mathematical model for measuring the technology transfer potentials that exist between a transferor and a transferee; develop a specific dynamic mathematical model incorporating time and technological level for evaluating technology transfer potentials; verify the technology transfer model for boundary conditions; derive the technological transfer/change models as a special case of the technology transfer model developed; and apply the technology transfer model to study the technology transfer pattern in selected countries in certain industries. In this section, a mathematical function is developed using the logistic growth pattern to determine the technological level of a country, in a given industry. This is measured by an indicator called "Technology Index". Considering the variables that influence and reflect the performance of that industry, the technology index is computed using the factor loadings obtained by the statistical technique factor analysis. Initially, the concept of technology index and the methodology for measuring the technology index using factor analysis are presented. The normalization of technology index and the development of technology index function are then explained. The available input and output indicators leading to the determinants for measuring the technology index at the industry level are then presented. To develop the technology transfer model, it is hypothesized in this study that the technology assimilation rate of the transferee is proportional to its existing level of assimilation, the level remaining to be achieved in the long run and the function governing the technology transfer rate. The function governing the technology transfer rate is assumed to be the function of relative technological gap, namely potential technological distance, between the transferor and the transferee. A generalized mathematical model for measuring the technology transfer potentials that exist between a transferor and a transferee is developed initially in this study. Then, a specific dynamic technology transfer model is developed incorporating time, technological

level and dynamic potential technological distance. As this study is on developing a quantitative model for measuring the technology transfer potentials that exist between a transferor and a transferee at the industrial level, the variables that influence and reflect the performance of the given industry of various countries under study are identified and collected for the past few years. The raw data collected for various countries for the past few years are then converted into standardized data. The factor analysis is used to determine the factor loadings of the variables for formulating the technology index at the industrial level. The calculated technology index is then normalized to have value between 0 and 1. The past technologies indexes of each country in the given industry are used to develop its technology index function by using the logistic growth pattern. The technology index function developed for each country in the given industry is then used for determining its technology level by way of an index. To show the applicability and validity of the technology transfer model developed in this study, some countries are selected to study their technology transfer pattern in selected industries such as automobile industry, electronics industry, and computing industry. The variables such as Research and Development (R&D) Expenses per economically active population, Output per employee in the manufacturing sector, Value added per employee of the manufacturing sector, Output per employee of the specific industry, and Value added per employee of the specific industry, are considered in this study for developing the technology index function. Here, it is assumed that the national level technology climate variables and the manufacturing scrotal level technology climate variables have direct influence on the growth of the specific industry. The Value added per employee in the specific industry is considered as the technology assimilation parameter indicating the effectiveness of the application of the technological components at the industrial level.

In any Technology Transfer project after knowing the technology, determining the policies and the appropriate provider of T-T (Technology Transfer) is of great importance for the receiver of the technology. When the receiver of the technology decided to transfer a specific technology, he can then discuss the determination of policies and appropriate provider of T-T. In any T-T process there are certain components. According to the receiver's need, the appropriate technology is chosen and then it's transferred from the provider to the receiver following the "policy of mutual technological". In determining the appropriate policies of T-T for the receiver of the technology, the main components of T-T should be taken into account, and the appropriate policies should be determined according to these components.

In addition, since the T-T process is very broad and complex, the expertise of the field can be used according to the T-T component for determining the appropriate policies. Therefore, based on these components a questionnaire was developed in which the important criteria for each component were specified so that the transfer policies could be determined on the basis of these criteria for each component.

The items in the questionnaire have been set in a way that all four components of the T-T process would be covered. In order to determine the appropriate policy, the criteria which optimize the T-T should be known. In order words it should be specified that which features or criteria in the technology, the provider or the receiver of the technology and technologic contribution lead to a more successful T-T. In so doing, the items of the questionnaire have been designed in a sense that the criteria of success for each component (technology, provider of technology, receiver of technology, technologic contribution) be determined and given a source from 1 to 10 by the respondents.

Since this approach was used after choosing the technology, which is a component of T-T, the item on this component was proposed as "the reasons for choosing that specific technology as the appropriate technology". From this we can say that the first question is about investigating the reasons for selecting this technology. The second component of T-T process is the provider of the technology. the second question is about the criteria of choosing the appropriate provider so that by taking it into account we can determine the important criteria and propose a framework upon which the third question, the expert is asked to specify the main provider of the technology. In other words the second question seeks to determine the criteria of the provider of technology and the third one is asked for the option of choosing

the provider. The third component of the T-T process is the receiver. So the fourth question deals with determining the criteria which are necessary for the receiver. The fourth component is the technological contribution for determining whose appropriate conditions, attention has paid to the contract text of T-T. A T-T contract test plays an important role in the appropriate transfer of a technology. Therefore those involved in the business should pay special attention to certain aspects in the T-T contract. The fifth question deals with determining these important aspects (criteria). After specifying the appropriate criteria for each T-T component, statistical methods were employed to determine their respective importance. The procedure of data analysis of criteria through statistical methods is shown in fig. 2 in the section.

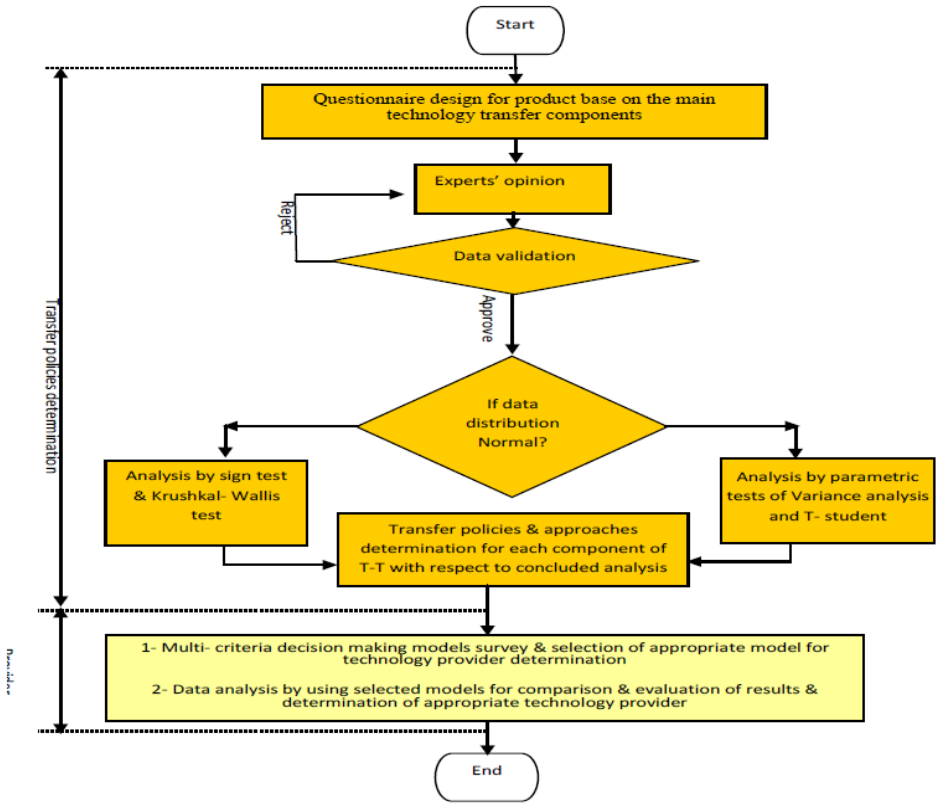

Figure 1: The model for determination of policies & appropriate provider for T-T

Result

A questionnaire with 15 questions was sent to the experts, out of which 13 were received back. As discussed before, the reliability of the data was determined using cronbach a, the value of this coefficient, 0.654, was obtained by SPSS software. Since this value is close to 0.7, the reliability of the data is of a relatively acceptable level. Also as each question dealt with only one component of the T-T, in the following section we analyze the experts' responses on each component. (We have employed statistical methods using SPSS, and Minitab Soft wares). The identified criteria for technology based on the expertise were:

- Using technical knowledge for producing other products.
- Creation strategic industry in the country.
- Appropriate schedule for getting access to technology.
- Acquiring high quality technology.
- Training skilled human force.

In other words, the main reasons for selecting jet Automobile Industry (AI) technology as an appropriate technology are the criteria mentioned above. First we run the normal scores test on the scores given to the

criteria by the experts. Kolmogorov - Smirnov test can be used in this regard. The results of the test revealed that all scores of the criteria are of acceptable normal distributions. Therefore parametric tests could be used. One-way Variance analysis can be used for finding significant difference between the mean of technology criteria. First we test the necessary hypotheses for the Variance analysis. Three conditions must be met for this test: normal distribution of each criterion, homogeneity of the variance criteria, and independence of the data for each criterion. These hypotheses were tested using kolmogorov – Smirnov test, Bartlett's test, and Sign test respectively. Running these tests, we found out that data for technology criteria were confirmed at the significance level of 0.05, and Variance analysis can be used to test whether there is a difference in the mean(s) of the criteria.

Since, $0.8<3.67= f_{0.01,4,58}$ Variance analysis test dose not confirm any difference between means of technology criteria. This analysis showed that there was not a significant difference between means of the technology criteria, Student's T-test can be used for determining the degree of importance of each criterion. We consider a criteria as important criteria if the hypothesis of $\mu>8$ is not rejected for the hypothesis $\mu\leq 8$. The results for the technology criteria show that three criteria of "creation a strategic industry in the country", "acquiring high quality technology and "training skilled human force" are the main reasons for choosing the transfer of jet AI technology. With these result, attention should be taken in training the human force during the transfer process, and also in choosing a technology with an appropriate level of quality. It should be noted that the value of 8 was set according to the values of the mean of scores given by the experts. The identified criteria for the provider of the technology based on the expertise are as follow:

- The quality of the provider's technology
- Training the human force by the provider of the technology
- The political relationship between two countries
- Guarantees
- Providing spare parts by the provider
- Services after selling
- Providing documentation, software, and technical knowledge of design, production and testing
- Providing hardware and special equipment.

We test the normality of the given scores. The results of the normal score test showed that all criteria of the provider of the technology are of an acceptable level of normal distribution. Through running the necessary tests, three hypotheses of normality, data independence, and homogeneity of variances were confirmed. Therefore we could run the Variance analysis test:

Since, $2.06<3.08=f_{0.01,6,77}$ Variance analysis test doesn't confirm any difference between means of the criteria of the provider. This analysis showed that there was not a significant difference between means of criteria's significance.

Student's T-test can be used for determining the degree of importance of each criterion. By running the test we found out that four criteria, "the quality of provider's technology", "providing documentation", "software and technical knowledge of design, production, and testing" and "Providing hardware and special equipment", are the main criteria of the provider of the technology.

The identified criteria for the receiver of the technology based on the expertise are as follow:

- Using experienced and expert human force by the receiver of the technology.
- Having access to the required hardware.
- Having access to the required soft ware.
- Required organizations in the receiver country.
- Necessary bargain at the time of setting the contract by the receiver of the technology.
- Using very high scientific standards by the receiver of the technology.
- Having necessary credits for the project.

We test the normality of the scores given to the criteria by the experts. The results of the test show that all the criteria data of the receiver of the technology have an acceptable normal distribution. Therefore

parametric tests can be used for the analysis of the criteria data. The hypotheses of normality and independence of the data is confirmed. But when running the test of homogeneity of variances we find out that the homogeneity variance is not confirmed. Therefore we use stabilization transformation of variance. Giving different values to λ and interpolation. 2.5 can be used as an appropriate value for the stabilization of variance. In this case we extend the data to the power of 2.5 to make the variances homogeneous.

Since $11.88>3.07=f_{0.01,6,83}$, the Variance analysis test confirms the difference between means of criteria of the receiver of the technology. Paired comparisons of the means, can be used to identify the factor responsible for the difference between the means. In this case, the multivariate test of Duncan is used. Results show two criteria of using experienced and expert human force by the receiver of the technology and having necessary credits for the project are placed into a group and other factors into another group. In other words these two criteria had a larger mean compared to other criteria.

Student's T-test can be used for determining the degree of importance of each criterion. Regarding the results of the test, we can see that two criteria of "using experienced and expert human force" and "having necessary credits for the project" are the main effective factors for the receiver to get satisfactory result from the transfer project of jet AI technology. Other three factors, i.e. hardware, software, and organization are the secondary factors for the receiver's success in this project.

The identified criteria for the technologic contribution based on the expertise are as follow:

- The method of transferring the jet AI technology.
- The percentage of the transferred technology during each year and at the end of the contract.
- License for exporting to the receiver of the technology by the provider.
- Commitment to contribute during and after the project of T-T.
- Training course by the provider of the technology.
- Support for providing parts and subsystems by the provider of the technology.

Through running the necessary tests, three hypotheses of normality, data independence, and homogeneity of variances were confirmed. Since $5.01>3.26= f_{0.01,5,71}$ the Variance analysis test shows a difference between the means of criteria therefore again the multivariate test of Duncan is used. The result of this test shows that the significant difference between the means results from the mean of the criteria "license for exporting to the receiver of the technology by the provider" and other criteria, and due to this criterion is unimportant.

Student's T-test can be used to determine the degree of the important. The results of the above hypothesis testing reveal that two criteria of "the percentage of transferred technology during each year and at the end of the contract" and "license for exporting to the receiver of the technology by the provider" are considered as unimportant and other criteria as important. Due to criterion of "training course" is a important criterion, when a contract, emphasis should be placed by the provider on enforcing a comprehensive training course during the time of transfer, installation conformation, and absorption of the technology in the different administrative stages, support for providing parts and subsystems by the provider of the technology. The criterion of ", method of T-T" has been identified as a important criterion. The study of the characteristics of the transfer project of jet AI technology suggests that only there are three methods of "direct external investment", "joint contribution", and "license contracts" for T-T. Due to the strategic nature of jet AI and it's being not among mass-produced goods, direct investment does not see an appropriate option. Joint contribution is also more appropriate when we are at an acceptable level in a given technology and through joint contribution process we are looking for getting to a higher level of technology. The use of license contracts is in priority. Proceeding through license contract, along with employing scientific and technical staff; importing investment goods and machinery; and contracts of technical and engineering contribution at the first stage, and using inverse engineering at the later stages (if possible) seems the most appropriate method.

Conclusion

Today T-T is an in evitable path to be followed by many organizations and countries. In any T-T project after coming know the technology. It is very important to the receiver of the technology to determine the

appropriate policies and providers of the technology. Incorporating time, technological level and a dynamic potential technological distance for measuring the technology transfer potentials that exist between a transferor and a transferee at the industrial level. This paper which has been done in this regard presents a model for determining the appropriate policies and provider of technology, based on the expertise and using statistical methods and multi-criteria decision-making, jet AI technology was selected as the case study for assessing the proposed model. As developing of the questionnaire was based on the T-T components, the main criteria were identified for each component. Appropriate policies can be determined based on the specification of these criteria for each T-T component. In general success of the T-T project can be attributed to the following factors: the technology being strategic, getting high quality technology, training employee service after selling by the provider, produce of documentation, software and design, product and testing science, providing hardware and special equipment by the provider, using experienced and expert employee by the receiver, having necessary credits for the project, the method of transferring jet AI technology, commitment to contribute during & after the T-T course by the provider, and support spare parts and subsystems by the provider of the technology, forever using multi-criteria decision-making models and expert choice software, a model was developed for identifying the criteria and determining the priority of the providers of the technology. This model was assessed in the complex industry of jet AI production, an industry which is subject to radical changes, and the results were presented in this document.

ACKNWLEDGEMENT
We are grateful to Islamic Azad University, Kerman branch authorities, for their useful collaboration.

REFERENCES

Archibugi D and Lundvall A (2001). *The Globalizing Learning Economy* (Oxford University Press) Oxford.

Archibugi D and Pietrobelli C (2003). The Globalization of Technology and its Implications for Developing Countries: Windows of Opportunity or Further Burden?. *Technological Forecasting and Social Change* **70** 861–883.

Goc ML (2002). Development Techniques for International Technology Transfer. Book Review, Westport, CT: Quorum Books, *Technological Forecasting and Social Change* **70** 923–927.

Gold B (1981). Technological Diffusion in Industry: Research Needs and Shortcomings. *Journal of Industrial Economics* **28**(1) 247-269.

Guan JC, Mok CK, Yam CM, Chin KS and Pun KF (2006). Technology Transfer and Innovation Performance: Evidence from Chinese Firms. *Technological Forecasting and Social Change* **73** 666–678.

Haque I (1995). Trade, Technology and Competitiveness. World Bank, Washington D.C.

Harbison FH, Marvhnic J and Resnick JR (1970). Quantitative Analysis of Modernization and Development', Princeton University, New Jersey.

Hawthorne EP (1971). The Transfer of Technology, Report of OECD Seminar in Istanbul, OECD, Paris.

Minbaeva D (2007). Knowledge Transfer in Multinationals. *Management International Review* **47**(4)567-593.

Narayanan S and Lai YW (2000). Technological Maturity and Development without Research: The Challenge for Malaysian Manufacturing. *Development and Change* **31** 435-457.

Pak Y and Park Y (2004). A Framework of Knowledge Transfer in Cross-Border Joint Ventures: An Empirical Test of the Korean Context. *Management International Review* **44**(4) 435-455.

Sung TK (2009). Technology Transfer in the IT industry: A Korean Perspective. *Technological Forecasting and Social Change* **76** 700–708.

Sung TK and Gibson DV (2000). Knowledge and Technology Transfer: Key Factors and Levels. *Proceedings of 4th International Conference on Technology Policy and Innovation* 4.4.1 – 4.4.9.

Trunog C (2002). A General Unified Mathematical Model of Technology Transfer. International Conference on Quantitative Methods, Sydney, Australia.

Walter J (2000). Technological Adaptation and Learning by Cooperation: A Case Study of a Successful Onshore Technology Transfer in Tierra del Fuego. *Journal of Technology Transfer* **25**(1) 3–22.