

# Research on Effectiveness of Technology Transfer from a Knowledge Based perspective

## Abstract

Many SMEs in newly industrialized countries with limited technological infrastructure and R&D resources can still compete successfully at the international level. Those SMEs typically depend on technologies that are transferred from foreign partners of developed Western countries. Even though the topic of technology transfer has long been studied, the main stream studies focus on the hardware aspects, the soft –knowledge- facet of technology transfer is still a matter of concern. This study bridges a gap in the extant literature by examining interrelationships between knowledge sharing and the effectiveness of technology transfer from developed countries to SMEs in developing countries. In studying the data from 33 Turkish SMEs, and using the partial least squares structural equation modelling (PLS-SEM), we find that explicit knowledge sharing forms the fundament of technology transfer. Also the findings address a significant deficiency regarding tacit knowledge sharing.

## 1. Introduction

Since 1990s firms have had to confront more and more highly complex and turbulent environments. Management of technology offers ongoing challenges to firms, due to the increasing cost and complexity of products and services against a background of global competition, IT-based innovation networks, accelerating industrial change, and of a shortening technology life cycle (TLC). In view of the fact that worldwide changes and progress are generally attributed to the development or introduction of new technologies and more than 50% of the new products and process are outsourced, the topic of technology transfer has become an important theme for both practitioners and academicians (Inzelt and Hilton, 1998; Kim and Kim, 2000; Lin and Berg, 2001; Lehner and Maier, 2000). Technology, the basic theme of this transfer process, is widely accepted as essential for improving the economy and wealth in changing competitive landscape. Evidences across many countries and firms, have illustrated that there is an increasing appreciation in which the long term the ability to master technology and to manage and generate technological change is a determinant for competitiveness and capacity to grow (Guan et al. 2005). Accordingly, effective acquisition and utilization of new technology from an outside source can contribute significantly to the firm success (Palviaa et al. 2002: 719). Recent studies (e.g., Henry et al., 2009; Salahaldeen, 1995; Lee et al., 2012) have demonstrated the importance of foreign research and development (R&D) to domestic productivity growth. One aspect of globalization concerns the increased transfer of technology among countries and firms especially from developed countries to the developing ones (Jones and Ruffin, 2008). Many SMEs in newly industrialized countries with limited knowledge infrastructure and R&D resources can still compete successfully at the international level (Asakawa and Westney, 2013). Those SMEs usually depend on technologies that are transferred from foreign partners in developed countries (Lin, 2003). Hence, the topic of technology transfer has become an important theme for both practitioners and academics. Technology transfer is the flow of technology from one place to another, for example, from one organization to another, from a university to an organization, or from a country to another. It has been described as being product-embodied, process-embodied or personnel-embodied (Guan et al., 2005). While the hardware aspect of the technology is emphasized in the main stream perspective in which technology transfer is considered to be a one-way process from the donor to the recipient; the software part is underlined on modern view; and technology transfer turns out to be a two-way communication process (Buratti and Penco, 2001) based on knowledge sharing on a mutual exchange (Amessea and Cohendet, 2001; Dahl and Pedersen, 2004). Knowledge sharing is a mechanism installed to encourage the sharing of expertise throughout an organization. (Fong and Lo, 2005). To a greater extent firms are utilizing interdisciplinary organizational structures in which employees share knowledge and expertise within and between units, groups and hierarchical levels and other firms with the intention of dealing with complex tasks (Krogh, 2002). Even the extant literature abounds of many different approaches concerning the knowledge sharing process such as tool based (Scarborough, Swan and Preston, 1999; Swan, Newell, Scarborough, and Hislop, 1999), incentive based (Bartol and Srivastava, 2002; Bock and Kim, 2002; Liebowitz and Chen, 2001) or articulation based (Lee, 2001; Nonaka and Takeuchi, 1995); our study focused on the articulation based on the assumption that a technology transfer is closely related to the articulation level of the given knowledge in terms of tacit and explicit. The theory of KM suggests that tacit knowledge is not easily replicable and transferable (Nonaka and Takeuchi, 1995). The level of tacit knowledge determines the extent to which organizations will be competitive in a turbulent market, and it composes the unique technologies of the firm (Ng et al., 2012). Johannessen et al. (2001) suggested that even technology has long been considered the transfer of explicit knowledge; without tacit knowledge, the background technology would never be adapted fully. Accordingly, this study aimed to provide new insight into the theory of KM by addressing a knowledge sharing schema among partners to achieve technology transfer. Furthermore, Çavuşgil et al. (2003) claimed that most KM research is limited to

knowledge transfer at the individual level. This study aimed to explore the effects of knowledge sharing – between donor companies of developed Western countries and recipient SMEs of newly industrializing countries- on the effectiveness of technology transfer.

The remainder of the paper is organized as follows. Section 2 provides a review of the relevant literature to establish a clear theoretical ground and describes the specific hypotheses for the research model. Section 4 presents the empirical results to test the assumptions. Section 5 concludes the paper.

## **2. Literature Review and Hypothesis Development**

### **2.1 Technology and Technology Transfer**

We are presently in a transitional period, as disruptive technologies compete for markets in developing countries and top-down and bottom-up communications initiatives try to exploit these technologies to bridge the 'digital divide' (Talyarkhan et al., 2004). To understand this technology and innovation based competition we should first identify what the technology is. Technology is the integration of any tool or technique, any product or process, any physical equipment or method of doing or making, by which the human being potential is broadened. In this delineation technology is considered to be hardware or a physical product (Buratti and Penco, 2001). On the other hand technology can be described as technical knowledge or "know-how" that is put into use for improving an organization's ability to provide products and services or to accomplish a specific goal (Rogers et al., 2001). As technical knowledge differs extensively in the extent of physical embodiment, a specific technology can be a machine, a process, software code, a handbook, blueprints, documents, operating procedures, an electrical or mechanical constituent or assembly, a patent, a technique, or even a person. (Palviaa et al. 2002). Technology is an essential factor in the industrialization process, particularly for developing countries (Salahaldeen, 1995).

Considering the fact that high cost of producing new technologies and recognizing the fact that more than 50% of the new products and process are outsourced, has long been a comprehensively studied area for a variety of disciplines including economics and management (Inzelt and Hilton, 1998). Technology transfer in its most general sense is any process that aims at transferring technological know-how from a donor firm to a recipient (Khalil, 2000; Buratti and Penco, 2001). Technology transfer is a complex process which requires clear definitions from the outset, to ensure that both the seller and purchaser of technology clearly understand its implications, and try to maximize the benefits for both parties. (Salahaldeen, 1995). Technology transfer is a trade off process that enables a recipient firm to access or imitate complete technological capabilities of the donor one (Kotabe et al., 2002). In other words technology transfer is the movement of technology via some communication channels from one individual or organization or a country to another (Rogers et al., 2001). Technology transfer and therefore information takes on even greater importance for productivity growth in developing countries, which as a group undertake little domestic R&D and therefore have few domestic sources of new technology (Henry et al., 2009). Over the years, there has been an increasing interest in the process of technology transfer from the industrialized to the developing countries (Salahaldeen, 1995). Indeed firms are interested in such partnership relationships and strategic alliances if it returns a favour. In other words firms trade information tend to favour partners that promise the most useful knowledge in return. Clearly, a firm is much more interested in establishing relationships with another firm that is at the forefront of technological development. (Dahl and Pedersen, 2004). Effective acquirement and employment of new technology from a partner can contribute significantly to firm innovativeness and success (Palviaa et al. 2002:719).

### **2.2. Technology Transfer and Knowledge Sharing**

From the main stream model, technology transfer was defined as technology moving from one well-defined economic unit to another well-defined one (Amessea and Cohendet, 2001). In this view, in which technology was thought as a hardware or a physical product, technology transfer was a one-way course of action from donor firm to recipient one in which a benefiting firm gains the new technology from the donor through the condition of contracts, patents, license agreements, etc., (Buratti and Penco, 2001).

The new circumstances of the knowledge based economy introduce a central change in the way technology transfer is envisioned. Although, the main stream technology transfer model focused on a well-defined technology flowing from one well-defined unit such as a firm department, lab, firm or country to another, the knowledge based perspective proposes a completely novel technology transfer model (Amessea and Cohendet, 2001). Faster technological development, shorter product life-cycles, and more intense global competition, the blurring of the line between the production and the use of knowledge, and the blurring between intra- and inter-organizational transfer results with a strong need for speed in development and speed to market. These recent conditions constitute a strong invitation to redefine the basics of technology transfer (Santoro and Gopalakrishnan, 2000: 299). In this competitive landscape, in which the economic value of technology as a strategic asset arises from the combination of general and specific knowledge; the

effectiveness of technology transfer becomes more and more dependent on the specific knowledge-communication or knowledge sharing process (Amessea and Cohendet, 2001; Buratti and Penco, 2001; Rogers et al., 2001).

Knowledge is one kind of scarce resource, it belongs to intangible asset of the knowledge main body, but this kind of property does not have the loss, namely, when a person provides the knowledge to another person, the providers will not therefore cause their own knowledge to reduce (Leng, 2009). Knowledge is a firm's most important resource for the reason that it embodies intangible assets, routines, and creative processes that are hard to copy (eg. Renzl, 2006; Panteli and Sockalingam, 2005). Smith et al. (2005) stated that the ability of an organization's members to combine, transfer and share knowledge determines the success of new product development process. Furthermore, as Argote et al. (2000) highlight the ability to share knowledge among the departments and hierarchical levels contributes considerably to the firm performance. Performance can be enhanced, when people share information, best practices, lessons learned, experiences, insights. Individuals share knowledge via more or less intense interaction.

Knowledge sharing is a mechanism installed to encourage the sharing of expertise throughout an organization. Knowledge begins with the individual, with new brilliant ideas or fruitful experience. It then comes to the central activity of making personal knowledge available by sharing it with others. This takes place continuously and among professionals of the same and/or different disciplines (Fong and Lo, 2005). To a greater extent firms are utilizing interdisciplinary organizational structures in which employees share knowledge and expertise within and between units, groups and hierarchical levels with the intention of dealing with complex tasks (Krogh, 2002). In literature there is a variety different approach concerning the knowledge sharing process. (Hsu, 2006) such as tool based (Scarborough, Swan and Preston, 1999; Swan, Newell, Scarborough, and Hislop, 1999), incentive based (Bartol and Srivastava, 2002; Bock and Kim, 2002; Liebowitz and Chen, 2001) or articulation based (Lee, 2001; Nonaka and Takeuchi, 1995). Indeed articulation level is an important dimension of knowledge especially considering the fact that knowledge and technology transfer is closely related to the articulability degree of the given knowledge. Accordingly there are many studies concerning the properties of knowledge related to articulation (see e.g., Nonaka and Takeuchi, 1995) and their effect on knowledge sharing. Zander and Kogut [1995, see Renzl, 2006] state that knowledge that can be articulated and codified can be documented, transferred and communicated more easily than non-codifiable knowledge. According to the articulability, knowledge is classified into two types as tacit and explicit by Polanyi (1966 p.135-146).

Explicit knowledge: is the type of knowledge, which is much easier to articulate, capture, codify, document, shape and imitate (Bhatt, 2001:70). Explicit knowledge is closer to information -the system-bound side of knowledge- (Beijerse, 2000:164). It is transmittable through formal, systematic language and information technologies and may adopt the form of computer programs, patents, diagrams (Perez and Pablos, 2003:83). Because of its ease in expression, explicit knowledge is more easily imitated (Bloodgood and. Salisbury, 2000:58).

Tacit knowledge: is the knowledge type which is hard to document, transfer, codify, articulate, replicate and imitate. It is embodied in the background of the organization. It takes form in human mind, behavior, perception and mental processes. It is related to the people-bound side of knowledge (Beijerse, 2000: 164). Tacit knowledge is contingent on firm's own history and its unique circumstances; it is acquired and transferred by experience (Choi and Lee, 2003: 406; Bhatt, 2001: 70). Moreover tacit knowledge sharing discussed in this study is important in the area of business ethics, because an unwillingness to share knowledge that may hurt an organization's survival is seen as being seriously unethical (Lin, 2007).

Accordingly our first hypothesis is offered

H1: Tacit knowledge sharing is closely related to the effectiveness of technology transfer.

H2: Explicit knowledge sharing is closely related to the effectiveness of technology transfer

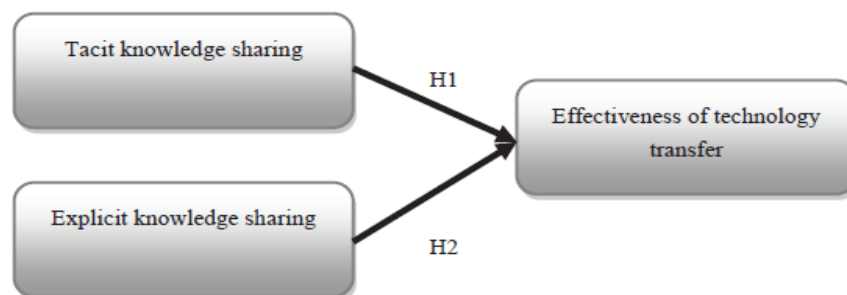


Fig 1. Proposed Model.

### **3. Research Design**

#### **3.1 Research Instrument and Sampling**

*This study focused on testing the relationships between knowledge sharing activities and the effectiveness of technology transfer in Turkish SMEs engaged in technology transfer partnerships with West European and US firms. Based on a comprehensive literature review of the BM literature in general and empirical studies on SMEs in particular, the question items were identified and translated by using the parallel-translation method, i.e. the items were first translated into Turkish by one translator and then retranslated into English by another translator to ensure consistency of their meaning in English and Turkish. The two translators then worked jointly to reconcile the identified disparities.*

*The questionnaire was refined and administrated to the initial sample consisting of 146 SMEs located in Istanbul. The firms were selected from the reports of European Business Network that have technology transfer relationships with Western firms. Indeed European Business Network had provided consultancy and training support for technology transfer to over 50.000 SMEs but only 146 of them were reported to build such transfer relationships.*

*The managers of the selected SMEs were initially contacted by telephone and the aim of the study was explained to them. Out of the 146 firms contacted, 47 agreed to participate in the study. To avoid single-source bias, at least two respondents at middle management level and/or top management level participated in the survey from each firm. The selection was based on the assumption that these individuals were knowledgeable about the technology transfer processes taking place in their respective organizations. All respondents were informed that the data would remain anonymous and would not be linked to them individually, to their company, or to the company products. Out of the 47 firms that agreed to participate, 33 firms completed the survey in full. An overall adjusted response rate of 23 percent was achieved, with 105 completed questionnaires returned.*

#### **3.2 Measures**

*This study adopted multi-item scales from prior studies for the measurement of the constructs. Each construct was measured using 5-point Likert scales ranging from “strongly disagree” (1) to “strongly agree” (5). For measuring tacit and explicit knowledge sharing, the knowledge sharing question items were adopted and modified from the study of Lee (2001). Four questions for explicit knowledge sharing and three for tacit knowledge sharing were asked. The technology transfer question items were modified from Lin and Berg’s (2001) scale to measure the effectiveness of technology transfer. Consistent with their study, five questions were asked concerning technical effectiveness, effectiveness compared to other projects, competitors, expectations, and overall satisfaction from the transfer process.*

#### **3.3. Measure Validity and Results**

*We used the partial least squares (PLS-Graph 3.0, Chin, 2001) approach to path modeling to estimate the measurement and structural parameters in our structural equation model (SEM) (Chin, 1998).*

*To assess the psychometric properties of the measurement instruments, we estimated a null model with no structural relationships. We evaluated reliability by means of cronbach alpha ( $\alpha$ ), composite scale reliability (CR) and average variance extracted (AVE). According to the findings, all reliability estimates—Cronbach’s Alpha ( $\alpha$ ), average variance extracted (AVE), and composite reliabilities (CR)— are well-beyond the threshold levels (Nunnally, 1978; Fornella and Larcker, 1981). Table 2 shows the correlation among all three variables that provide further evidence of discriminant validity. Besides, to fully satisfy the requirements for discriminant validity, AVE for each construct should be greater than the squared correlation between constructs (Fornell and Larcker, 1981). Such results suggest that the items share more common variance with their respective constructs than any variance the construct shares with other constructs (Howell and Aviolo, 1993). In the model, none of the inter-correlations of the constructs exceed the square root of the AVE of the constructs (see Table 2). In addition, we evaluated convergent validity by inspecting the standardized loadings of the measures on their respective constructs and found that all measures exhibit standardized loadings that exceed .60.*

Table 1. Correlations and Descriptive Statistics

No	Mean	Standard Deviation	Variables	1	2	3
1	5.15	1.40	EKS	<b>.88</b>		
2	4.98	1.48	TKS	.70**	<b>.92</b>	
3	5.47	1.37	TT	.38**	.35**	<b>.8</b>
						<b>1</b>
			CR	.93	.94	.9
			AVE	.78	.84	.6
			$\alpha$	.91	.90	.8

\*  $p < .05$ , \*\*  $p < .01$ .

Note<sub>1</sub>. Diagonals show the square root of AVEs.

Note<sub>2</sub>. EKS = Explicit Knowledge Sharing, TKS = Tacit Knowledge Sharing, TT = Technology Transfer, CR = Composite Reliability, AVE = Average Variance Extracted,  $\alpha$  = Cronbach's Alpha

Table 2 shows our results. For the knowledge sharing technology transfer relationship, the findings show that it is only the explicit knowledge sharing that positively affects the effectiveness of technology transfer ( $\beta = .27$ ,  $p < .05$ ), partially supporting H1. Moreover the results demonstrate that knowledge sharing mechanism – tacit and explicit knowledge sharing- as a whole explains 16% of variance ( $R^2 = .16$ ) in the effectiveness of technology transfer.

Table 2. The Results

Paths	Betas ( $\beta$ )	Hypotheses	Results
EKS → TT	.27*	H1	Supported
TKS → TT	.17	H2	Not Supported
<b>Endogenous Constructs</b>		<b>R<sup>2</sup></b>	
Technology Transfer		.16	

Note. EKS = Explicit Knowledge Sharing, TKS = Tacit Knowledge Sharing, TT = Technology Transfer

\* $p < .05$ , \*\*  $p < .01$

#### 4. Results and Discussion

Globalization, as the growing disappearance of the national boundaries for monetary, product and labour markets, forces SMEs, in general, and SMEs of new industrialized countries, in particular, to play in the same league of companies as the developed ones. Many SMEs in newly industrialized countries with limited knowledge infrastructure and R&D resources can still compete at the international level successfully by establishing technology alliances with other firms, both large and small. Even though the issue of technology transfer has long been a comprehensively studied area; most of the literature is grounded and empirical studies are completed on large firms rather than SMEs. But as well as large firms SMEs are very important for today's dynamic economy. Accordingly, enhancing the literature on technology transfer with SMEs is imperative for both scholars and practitioners. In this study, the relationships between knowledge sharing activities and the effectiveness of technology transfer are tested in SMEs of a developing country, enhancing technology transfer literature by focusing the soft "knowledge" part of technology Turkey. This study has two main contributions. First, the findings of the study demonstrated that knowledge sharing and technology transfer scales which are developed in Western countries, are appropriate for an emerging economy and eastern country; Turkey. Measures demonstrated high validity and reliability, and model results were similar with the empirical studies completed in developed and western countries.

Second, this study investigated the contingencies of knowledge sharing on the effectiveness of technology transfer within the context of partnerships and other types of collaboration relationships. The results confirm a statistically significant positive relationship between explicit knowledge sharing and effectiveness of technology transfer. In other words, formal transfer and communication of technical information and know-how in the form of computer programs, patents, blueprints, and diagrams between units, groups, and hierarchical levels play a critical role in accessing, replicating, and implementing the technologies under transfer. This finding implies that managers of companies involved in technology transfer should work together to ensure that all relevant documentation and information is prepared in the appropriate formats and made available to the working teams.

To our surprise, we found no empirical support for a direct relationship between tacit knowledge sharing and

*technology transfer. This finding, paired with the confirmed strong influence of explicit knowledge sharing on the effectiveness of technology transfer, contradicts previous studies that have claimed that explicit knowledge-sharing systems and activities do not add value because they involve only quantitative knowledge components. This inconsistency could be attributed to the organizational structure of SMEs, which is typically informal and flat. Vital knowledge is often stored in the minds of a few key employees, which enables them alone to acquire and transfer tacit knowledge. Hence, the inclusion of these key employees in the working teams is vital for the success of tacit knowledge sharing.*

*In addition, SMEs often lack formalized systems and methods for knowledge storing and processing. Hence, it could be argued that SMEs involved in technology transfer partnerships might benefit more, in relative terms, from access to well organized systems for transfer and storage of explicit knowledge than from tacit knowledge sharing because of their intrinsic deficiency of organizational capabilities. This interpretation appears even stronger when applied to SMEs in developing countries.*

*The findings of this study cannot be taken as definite evidence because several limitations to the study results deserve commentary. First, this study is conducted on small and medium sized firms. Second, these results reported here emerge from a local area; results may differ for SMEs located on different areas that are operating in different cultural, environmental and political conditions. Third, there was not an industrial separation while evaluating data; results may differ for different industries. Despite these limitations, this study provides important implications from theoretical and practical perspectives. This study indicates that explicit knowledge sharing is an important component of technology transfer; formulating an effective technology transfer relationship takes its roots from an explicit knowledge sharing mechanisms (e.g. technical information exchange, technical support) It also demonstrates a significant deficiency in tacit knowledge sharing between the donor firms of developed countries and recipients of that technical information exchange has an important effect on explicit knowledge sharing while open sharing channels and mutual trust are positively related to tacit knowledge sharing. Finally the results highlights the importance of explicit knowledge sharing for the effectiveness of technology transfer.*

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