European Journal of Training and Development

Differentiating knowledge transfer and technology transfer: What should an organizational manager need to know?

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Received 30 April 2018
Revised 21 August 2018
25 August 2018
29 August 2018
Accepted 6 September 2018

Abstract

Purpose – The purpose of this paper is to examine the conceptualization of knowledge transfer and technology transfer to seek answers to the question: Why should an organizational manager need to know the difference between knowledge transfer (KT) and technology transfer (TT)?

Design/methodology/approach – An extensive literature review method was used to identify and analyze relevant international publications. The literature sources are categorized as follows: literature on KT only, literature on TT only and literature on comparative analysis on KT and TT. The conceptualization of KT and TT is based on signaling theory.

Findings – The authors identified differences between KT and TT based on six dimensions, namely knowledge versus technology characteristics, usage of KT and TT in national development, sender versus receiver, intra-firm versus inter-firm transfer, foreign direct investment (FDI) and workers' mobility.

Research limitations/implications – This is a conceptual analysis that should contribute to the existing literature by comprehensively reviewing the processes of KT and TT based on selected research conducted worldwide as well as suggest practical guidelines to organizational managers in managing KT and TT.

Originality/value – This review could shed new insights for future researchers to validate and examine the identified differences between KT and TT so that managers could make use of the findings to manage KT and TT successfully in their organizations.

Keywords Knowledge transfer, Tacit knowledge, Signaling theory, Innovation, Technology transfer, Explicit knowledge

Paper type Conceptual paper

Introduction

The field of knowledge transfer (KT) and technology transfer (TT) is unique because of its multidisciplinary nature (Audretsch *et al.*, 2016). KT and TT have been used in the fields of communication, rural and industrial development and management. Many scholars are in agreement with the view that KT and TT are among the ingredients in innovation (Wagner, 1994; Cohen and Levinthal, 2000; Schulz, 2003; Nezu, 2007; Ikeda and Marshall, 2016). Business institutions in the knowledge-driven environment are constantly affected by the pressure of competition and innovation in this globalized era, rendering KT and TT vital to the success of an enterprise.

European Journal of Training and Development
Vol. 42 No. 9, 2018
pp. 611-628

2046-9012
DOI 10.1108/EJTD-04-2018-0042

Argote and Ingram (2000, p. 151) define KT as "the process through which one unit (e.g. group, department, or division) is affected by the experience of another". It also refers to a dyadic exchange between individuals, groups or organizations, in which a recipient can understand, learn and apply knowledge transmitted from a source (Abdul Hamid and Salim, 2011; Ismail, 2015; Hill *et al.*, 2016). Based on these definitions, we surmise that KT requires three important elements to make it possible:

(1) factions involved, *namely*, informant and recipient;

(2) knowledge to be transferred; and

(3) the medium or context where the informant and recipient reside.

TT, on the other hand, is defined as the process of transferring or disseminating technology from its origin to a wider distribution, to more people and places. It occurs along various axes: among universities, from universities to businesses, from large businesses to smaller ones, from governments to businesses, across borders, both formally and informally and both openly and surreptitiously (Debackere *et al.*, 2014; Osabutey and Jin, 2016). Often it occurs by planned effort to share skills, knowledge, tools, methods of manufacturing and facilities among governments or universities and other institutions to ensure that scientific and technological developments are accessible to a wider range of users who can then further develop and exploit the technology for new products, applications, services (Davenport, 2013).

Research gap

In view of the critical need for both KT and TT to take place, it is important to differentiate between the two concepts to avoid confusion and their inaccurate use in managing knowledge by organizations. However, studies on KT and TT are mostly focused separately on either KT (Hsu, 2012; Asmussen *et al.*, 2013; Ismail *et al.*, 2016; Wehn and Montalvo, 2018) or TT (Abdul Wahab *et al.*, 2012; Gilsing *et al.* 2011; Dubickisa and Gaile-Sarkanea, (2015). Sometimes the terms are even used interchangeably (Sadoi, 2011; Štrach and Everett, 2006; Kidanemariam, 2014). However, there are not many studies that examine the differences between the two constructs.

Dagenais *et al.* (2016) used KT to examine the prevention of psychological and musculoskeletal problems among 911 emergency call center agents. Their findings indicated that the evaluation of KT programs was likely to have had a positive impact on the behavior of the call center personnel. This suggests that KT relates to the learning process in the organization. However, the study did not include the TT dimension of knowledge management in assessing the problems faced by the call center agents.

Davenport (2013) specifically examined KT and TT among professionals working at university offices in the UK, but the researcher did not include KT and TT in business organizations. Gopalakrishnan and Santoro's (2004) study in the USA on industrial firms-universities collaboration provided comprehensive comparisons between KT and TT based on inter-organizational predictors using McKinsey's 7S-framework (strategy, structure, systems, shared values, skills, style and staff). The study, however, was limited to only five organizational factors; it excluded skills and staff, two employee-related factors that were very close to the responsibilities of managers. The researchers also asserted that KT is more of an inclusive construct directed towards understanding the 'why' for change. In contrast, TT is a narrower and more targeted construct that usually embodies certain tools for changing the institutional and production environment. However, it is still unclear what

specifically differentiates the two constructs as the focus of their study was limited to the influence of organizational factors on KT and TT.

Gilbert and Cordey-Hayes's (1996) framework analysis conceptualizes KT as a vehicle for technological change/innovation that relates to evidence of changed behaviors and attitudes (core routines of organization). The paper describes the application of knowledge (instrumental and developmental knowledge) in the KT process based on empirical data. However, there is no clear conceptualization of TT in the article. In addition, as KT and TT are multi-faceted concepts, studies on them are very much dependent on innovation theory (Davenport, 2013), communication and innovation theories (Wagner, 1994; Rogers, 2003); and knowledge-based view and organizational models (Daghfous, 2004; Abdul Wahab *et al.*, 2012). We conclude, therefore, that there has been limited KT and TT research using signaling theory to support the analysis of these constructs. Hence, there is a substantial knowledge gap on what differentiates KT from TT.

The objective of this paper is to clarify the discussion on KT and TT by examining the differences between these two constructs with regard to their conceptualization and usage. We conducted a thorough search via online databases and search engines (e.g. EBSCO Publishing, ProQuest, Elsevier, Emerald, JSTOR and Wiley). Keywords such as knowledge transfer, technology transfer, tacit knowledge, explicit knowledge and innovation were used in literature search. The articles collected were on:

- KT or TT separately;
- the usage of KT and TT interchangeably; and
- on limited documents comparing KT and TT in relation to the dissemination of innovation, influence of organizational factors, employee mobility and development in general.

Finally, we used the content analysis technique of 78 articles to differentiate KT from TT, covering knowledge versus technology characteristics, their usage in the development stages of selected countries, the processes and practices of KT and TT involving the role of foreign direct investment (FDI) and workers' mobility in domestic and international transfer.

This article looks at underlying assumptions associated with KT and TT in their general use that goes beyond their function as required resources, be they tangible or intangible, external to merely organizational boundary that affects transferability. Essentially, this article provides an insight for mapping guidelines to be deployed by managers involved in the transfer process. The use of signaling theory in the analysis further enriches the application of the theory in knowledge management. Specifically, it answers our research question:

RQ1. Why should an organizational manager need to know the differences between knowledge transfer and technology transfer?'

The next section of this article continues with a discussion on signaling theory underpinning KT and TT and a comparison of the differences between KT and TT. We then present the recommendations for practice, future research and conclusion.

Signaling theory

We conceptualize KT and TT within the framework of signaling theory (Spence, 2002; Connelly *et al.*, 2011) that examines communication between individuals or parties. Signaling theory is fundamentally concerned with reducing information asymmetry between two parties (Spence, 2002), the provider and receiver of knowledge. Typically, one

party, the sender, must choose whether and how to communicate (or signal) that information, and the other party, the receiver, must choose how to interpret the signal.

Management scholars have applied signaling theory to help explain the influence of information asymmetry in a wide array of research contexts including KT and TT. Information asymmetry refers to different levels of knowledge and technology accessed and possessed by two parties, and to have an equilibrium between the two, knowledge or technology needs to flow or transfer from the higher to the lower level party through the processes of KT and TT. Among the principles of asymmetric information are:

- Sender A knows her quality but Receiver B does not;
- A has an unobservable quality (very knowledgeable, for instance, in medical health or digital technology) which should be disseminated to others;
- A benefits from an interaction with B; and
- B benefits from an interaction with A, and in this case, the level of knowledge transferred is high.

Signals (the knowledge or technology) may be honest and purposeful, conveying information which enhances the competence of the receiver (Jeitschko *et al.*, 2016).

Stiglitz (2000) highlights two broad types of information where asymmetry is particularly important, namely information about quality and information about intent. In the first case, information asymmetry is important when one party is not fully aware of the characteristics of another party. In the second case, information asymmetry also is important when one party is concerned about another party's behavior or behavioral intentions.

Differences between KT and TT

In the following section, we discuss the differences between KT and TT based on general development and organizational contexts.

Knowledge versus technology characteristics

The characteristics of information (knowledge and technology) influence the firm's KT and TT processes. Key characteristics of knowledge and technology include:

- transferability, whether the information is tacit or explicit, complex versus simple (Simonin, 1999);
- capacity for aggregation, whether the recipient of the information can add new knowledge to their existing knowledge (Cohen and Levinthal, 2000); and
- appropriability, whether the owner of the information is capable of receiving a return equal to the value created by the resource (Teece, 1977).

KT and TT seem to be similar in terms of the capacity for aggregation and appropriability. However, KT and TT differ in relation to transferability. Knowledge seems to be less transferable compared to technology as it is more tacit, inarticulable, amorphous, subjective and includes more elements of human judgment, thus making it less codifiable (Gopalakrishnan and Santoro, 2004). Knowledge is also more intangible, more theoretical and conceptual-based. Accordingly, the characteristics of tacit knowledge make it less sharable compared to technology. In contrast, technology is more explicit; most of the time, it is presented in the forms of tools and equipment, and thus, it is more measurable (Goffin and Koners, 2011; Davenport, 2013).

Another construct relevant to tacit knowledge is embrained knowledge, which is dependent on one's conceptual skills and cognitive abilities. We could consider this to be practical, high-level knowledge, where objectives are met through perpetual recognition and revamping. Tacit knowledge may also be subconscious, but is action-oriented and comprises contextual practices. Acquired through socialization, it is about how individuals interact in and interpret their environment. An example of tacit knowledge is cultural intelligence (Ismail, 2015). On the other hand, explicit knowledge, also known as encoded knowledge, is conveyed via signs and symbols (e.g. books, manuals, databases, software) and decontextualized into codes of practice. In addition, for knowledge to be used, it must, in the first place, be presented in a way that is concise and simple to understand (Dagenais *et al.*, 2016). Knowledge can be presented on paper and electronic formats (Sinden and MacDermid, 2014).

According to Barney *et al.* (2001), valuable technologies are often difficult to imitate or transfer. This is because of the substantial costs of technology transfer and also costs declining with the age of the technology. As indicated earlier, technologies are presented in the form of tools and inventions (defined as an idea and innovation turned into a viable product), and inventions are registered as intellectual property (IP) that are patented to avoid piracy and illegal duplication. The patent is aimed at protecting a particular type of invention, usually one that is used for a specific commercial purpose (Lemley and Feldman, 2016). Technology is, hence, geared towards practicality; it involves psychomotor skills and is trial-and-error oriented. Thus, we can say that both KT and TT have the capacity of aggregation, that is, adding and improvising new knowledge and technology, respectively. Also, KT and TT are both expected to have the appropriability in returns equal to the value created by the resource. However, they differ in terms of tacitness and explicitness of the knowledge they embody (Davenport, 2013; Günsel, 2015) that determine the nature of transferability.

Usage of KT and TT in national development

A brief historical usage of KT and TT in several countries is worth highlighting here to discern the differences between the two. This brief country analysis looks at the evolution of the constructs and their applications in specific countries over the years and highlights findings that are thought to be important for managers to know. It is believed that KT and TT are related to the country's level of development as many scholars confirm that the two transfers have a strong impact on the country's capacity to innovate (Davenport, 2013; Ikeda and Marshall, 2016). Japan is representative of developed countries, Malaysia and South Korea represent fast developing/industrializing nations, and Kazakhstan represents the emerging economies in the Central Asia.

KT and TT have been used interchangeably in Japan (Isobe *et al.*, 1998; Sadoi, 2011). Japan was considered a prime mover in the emerging economic region (EER) markets of Asia after the Second Word War (1939-1945). In the initial phases of development, much of the R&D undertaken in Japan was absorptive capacity, that is, Japanese firms were able to acquire, assimilate and exploit information regarding technological inventions and products. Hence, organizational managers aimed at integrating foreign technologies to achieve indigenous technological development.

The TT that took place from the West to Japan throughout the Meiji period could be categorized as follows:

- overseas factories founded through direct investment by suppliers;
- businesses established by migrants from the supplier country;

- joint ventures;
- management contracts with suppliers;
- turnkey contracts where suppliers guaranteed the transfer of technology when they constructed factories;
- employment of engineers and skilled workers provided by suppliers or by businesses owned by receivers;
- purchase contracts for machinery and know-how;
- TT as an integral part of the machinery imported by the recipient;
- patent license agreements;
- production of imitations or reverse engineering; and
- in-house development of a technology (Kidanemariam, 2014).

The countries from where the technologies came were Britain, the USA, France, Germany and The Netherlands.

In Japan, 'transfer of knowledge and technology' is an important topic, especially after the publication of the best-selling book by Nonaka and Takeuchi (1995) titled 'The Knowledge Creating Company'. This book looks at the success of Japanese firms achieved through employees creating and distributing especially tacit knowledge in and out of companies. Also, Japan capitalizes on the research tradition of 'monotsukuri' (or manufacturing). Fujimoto (2007) summarizes under monotsukuri all value-creating activities associated with the production of goods, including 'transfer and distribution' activities. In addition, Hirose and Hitomi (2016), for instance, describe the Mazda-way of building and distributing efficient motors which, in a way, implies the importance of 'transferring' specific knowledge and skills such as automotive technology to consumers on a wide scale. This brief scenario shows KT and TT have been interchangeably used in Japan, albeit with more emphasis on KT.

Before Malaysia embarked on industrialization in the 1970s, TT was used more widely than KT in the country. TT was especially applied in the agricultural sector to denote the flow of technology from the country's research centers such as Rubber Research Institute of Malaysia (RRIM), Malaysian Agricultural Research and Development Institute (MARDI) and public universities such as the University of Agriculture (Mohd Yassin *et al.*, 1984; Ismail, 1990). The major goal of TT then was for the development of commodities such as rubber, paddy, oil palm and other agricultural produce, where relevant technologies were disseminated through various agricultural development departments throughout the country. Similarly, at the international level, TT involved dissemination of technology and new innovation from research centers such as the International Rice Research Institute (IRRI) located in the Philippines that was mandated to transfer high yielding varieties of paddy and other paddy-related technologies to farmers in rice-producing countries worldwide.

In Korea, modern technology development and/or technology transfer began only in the early 1960s (Kidanemariam, 2014), about a century later than Japan. As in Japan, old industrial equipment and facilities from developed countries were imported to Korea on a turnkey basis through foreign aid or loan programs. In the early 1960s, Korea's production technology was characterized by simple manufacturing with unskilled or semi-skilled labor. To achieve the goal of TT, Korea's science and technology policy received strong government support and was adjusted to conform to national development goals and strategies. Today, Korea has become an exporter of technology in high-tech fields, such as electronics, information technology, communication and automotive goods.

Similarly, the concept of TT emerged and was used before KT in Kazakhstan, a central Asian country (Smirnova, 2014). TT was used in legislative documentation although its definition seemed to be blurred. The first detailed explanation of the concept and its importance might be attributed to scholars from the Institute of Economics of the Ministry of Education and Science of the Republic of Kazakhstan and in 'Strategy Kazakhstan, from 2000 to 2030' (Kenzheguzin *et al.*, 2005; Smirnova, 2014).

The above discussion shows that TT was used much earlier and more intensively in the countries' development as TT was considered as vehicle to innovation. The conceptualization of KT came later as it was assumed to be embodied within technology. In addition, KT became more sophisticated and differentiated from TT, with the notion of knowledge as being both tacit and explicit in nature as noted by Nonaka and Takeuchi (1995) and advanced by other scholars such as Goffin and Koners (2011).

Sender versus receiver

During KT and TT, the sender is an individual (e.g. scientist, expatriate or consultant), group or organization that is seen as resourceful, valuable, influential, talented or which has distinguished himself/itself from others (Wagner, 1994). If we relate it to an organizational setting, then the sender is highly needed to close the gap in daily work processes and to bring new ways of doing work to the organization. The sender carries knowledge regarding industrial products, services, customer needs, technology and trends, each of which constitutes an important source of innovation (Lin *et al.*, 2005). Therefore, the characteristics of a sender play an important role in enhancing knowledge and technology transfer.

Similarly, the receiver or user might also consist of individuals, groups and organizations that will benefit from the transfer (Lin *et al.*, 2005). During the transfer processes, the sender disseminates new knowledge and technology through a particular medium, either formally (e.g. forum, workshop) or informally (e.g. daily interaction basis) to the organization's members. In this case, we consider the individual employee in an organization as the smallest unit or acting as the organization's representative to receive whatever knowledge and technology is transmitted before it can be distributed to other members in the organization. Therefore, we suggest that the roles of individual employees and the organization's environment as receivers are important in supporting the transfers.

In this context and based on signaling theory, KT refers to parties who: (1) give out signals; (2) assign meaning to the signals (Liu *et al.*, 2014). Aside from local employees, individuals involved in KT process also include foreign personnel such as expatriates and consultants. Hence, KT takes place where an employee of a firm becomes knowledge sender, while others (inside or outside the organization) act as knowledge receiver and vice versa (Hsu, 2012).

Young and Lan (1997), in contrast, refer to technology senders as technology owners representing an organization, and sometimes they are called technology middlemen or technology vendors. The technology receiver on the other hand, might be a private enterprise, state-owned enterprise or the firm's local personnel. Hence, TT frequently involves foreign affiliates, which includes cross-border mergers and acquisitions as well as joint venture firms. TT depends on the technological level of the foreign investor or affiliate, on its ability to bridge the technological gap or correct the information asymmetry between technology supplier and receiver (Young and Lan, 1997). Therefore, the main difference in relation to sender versus receiver in TT and KT is that the sender and receiver for KT are mainly employees in the organization, while those in TT are the owners of the technology, which are normally (but not always) the organization or firm itself because technology ownership goes to an institution, not an individual.

Intrafirm versus interfirm

Both KT and TT can take place within the organization (intrafirm) and between organizations (interfirm); this can happen domestically and internationally. Intrafirm KT involves two directions: inward and outward flows (Lai *et al.*, 2016). Inward flows, or inflows, refer to knowledge acquired by a focal unit, from peer units within the same corporation; and outward flows, or outflows, refer to the knowledge disseminated to peer units by the focal unit (Gupta and Govindarajan, 1991). As such, an organizational unit is often both a knowledge source and a knowledge receiver (Gupta and Govindarajan, 1991; Harzing and Noorderhaven, 2006). At the intrafirm level, transfer is possible at three distinctive levels: a) individual, b) group or team and c) division or department. Within an organization, therefore, it is said that the flow of information is more through KT as it involves a wider circle of knowledge instead of technology. Within an organization, however, TT takes place through the employment of foreign personnel and technologists for technology commercialization who are tasked with patenting, licensing or sale of products and training.

KT between organizations is often materialized through consultancy, research collaboration, staff secondment, KT partnership or joint ventures (Ado *et al.*, 2017) and strategic alliances (Mowery *et al.*, 1996; Simonin, 1999). The way personnel from organizations interact for mutual learning affects how knowledge is transferred. Other mechanisms of KT are customer–supplier relationships (Albino *et al.*, 1998), research and development (R&D) relationships (Faems *et al.*, 2007), franchisor/franchisee systems, voluntary and cooperative partnership (Burkink, 2002). Most of the time, knowledge regarding marketing and production feasibility is in great demand by recipients and business partners.

Unlike KT, TT often occurs through technology transfer offices (Boh *et al.*, 2016), science parks and technology incubators (Diez-Vial and Montoro-Sanchez, 2016), venture capital industry initiatives (Colombo *et al.*, 2016), subsidies and financing mechanisms (Audretsch *et al.*, 2016) and multinational corporation activities (Yoon and Han, 2017). For instance, in Malaysia, TT takes place through the Malaysian Technical Development Corporation (MTDC), a technology incubator of a public university that has links with the industry to exploit research results for commercialization. In Mexico, patents are of increasing interest in the transfer of technology from the university to firms, benefiting from the university's technology transfer office and the technology park (Calderón-Martínez and García-Quevedo, 2013).

Hence, TT is any process by which one organization or firm gains access to another's technical information and successfully learns and absorbs it into the production function of the former. To conclude, TT largely involves the movement of commercial technologies across countries (involving firms that have technology offices), as well as within countries, both intra- and inter-firms. While KT is a hidden process, TT is materialized through various means that may involve tangible and intangible knowledge, which is also transferred through TT offices, science parks and technology incubators and other learning approaches such as consultancy, research collaboration, staff secondment, joint ventures and strategic alliances. KT also takes place through forums, conferences, workshops, on-the-job training as well as industrial training of students.

Foreign direct investment (FDI)

Foreign direct investment (FDI) has been found to create many externalities in the economies of developing countries in the form of benefits available through transfers of general knowledge, specific technologies in production and distribution, industrial

upgrading, work experience for the labor force, the establishment of finance-related networks and telecommunications services. There is a relationship between FDI for expenses in infrastructure, KT and TT in many developing countries (Acharya and Keller, 2009; Osano and Koine, 2016). International KT and TT are more impactful compared to domestic transfers, particularly in high technology industries, because of the magnitude of knowledge and technology involved. This is associated with the FDI received by the recipient country. More recently, countries such as Mexico, Brazil, India and China view FDI by firms from technologically advanced countries as a vehicle of TT. Likewise, developing countries such as Malaysia, Thailand, Singapore, South Korea and Taiwan treat FDI from multinational corporations (MNCs) as a major means of technology development (Wang and Chien, 2007; Nezu, 2007; Sadoi, 2011). Zhang (2001) refers to FDI as long-term participation by a country in another country, and that it usually involves participation in management, joint-venture, transfer of technology and mobility of expertise. Bodman and Le's (2013) study further found that, apart from human capital being necessary for the direct general enhancement of the technological level itself, it is also essential for the recipient firm to have the ability to learn from foreign technological sources.

FDI brings in new technologies. Consequently, TT incurs more cost than KT. The cost of transfer, which can be defined to include both transmission and absorption costs, may therefore be considerable when the technology is complex, sophisticated, and the recipient firm may have inadequate capability to absorb the technology (Teece, 1977). The cost of communication, or information transfer, is a fundamental factor influencing the world-wide diffusion of technology (Nezu, 2007), and it is frequently dependent on FDI. Hence, TT is more closely associated with FDI, measured in monetary value than KT.

Workers' mobility

Workers' mobility refers to the presence of international personnel in an organization or MNC that normally comes with the inflow of FDI. KT is known to involve higher mobility of workers because knowledge resides in people's minds (Song *et al.*, 2003). While the major mode of TT operation is through technology transfer centers and R&D Institutes, KT depends on workers' mobility. According to Argote and Ingram (2000), the strength of moving people as a KT mechanism complements the speed and magnitude of moving tools or TT based on the framework of knowledge reservoirs that comprise people, tasks and tools. People are able to transfer tacit and explicit knowledge when they move and adapt their knowledge to the contexts of the recipient environment (Argote and Ingram, 2000). Hence, it could be implied that the higher the number of foreign personnel in a local firm, the higher is the expected level of KT, which eventually leads to a higher degree of TT.

Kidanemariam (2014) refers to workers' mobility as human capital transfer that normally involves professionals or expatriates (if they involve cross-border movement). It also refers to an international movement of people associated with nationals studying or working abroad for a specified duration. This group of individuals, upon their return, apply their accumulated knowledge, experience and technological skills through knowledge transfer initiatives with local employees. In addition, surveys among Indian and Chinese PhD holders in the USA revealed that more than half of the scientists and technologists went home because of many reasons among which was the desire to perform role as knowledge innovators in their respective countries (Saxenian, 2005; Wadhwa, 2009). Kunasegaran *et al.* (2016), who call these individuals professional returnees, find that they have important roles in both KT and TT, but more so in the former.

The summary of some dimensions differentiating KT and TT discussed above is shown in Table I.

Dimension	Knowledge transfer (KT)	Technology transfer (TT)
1. Knowledge versus technology characteristics	Knowledge is more tacit and less explicit Knowledge resides mostly in people's minds Less tangible than technology Amorphous or less structure Difficult to measure quantitatively Patents less relevant Less intellectual property rights (IPR) involved	Technology is more explicit/ physically visible and stored in database, software, document More tangible with physical structures Precise or specific in nature Can be measured quantitatively Patents are frequently involved The presence of IPR, an incentive and for protection in technology commercialization
2. Usage of KT and TT in country's development	Known and used later than TT in county's development (such as Japan, Malaysia, Korea and Kazakhtan) With the advancement of the typology of knowledge in terms of 'tacit and explicit characteristics', KT becomes significant	Known and applied earlier than KT (in the selected countries) as the countries equate knowledge and technology for innovation and economic development TT becomes prominent when the country is technologically advanced
3. Sender versus receiver	Sender: Foreign personnel Local personnel Consultant Receiver: Local personnel Foreign personnel Organizational peer	Sender: Foreign investor and personnel Technology owner/scientist Technology middleman/vendor Consultant Receiver: Local personnel Technology middleman/vendor Consultant/scientist
4. Intra-firm versus inter-firm	Involves departments, divisions, firms Mechanisms are mainly through consultancy, research collaboration, staff secondment, KT partnership and industrial training of students Through forums, conferences, workshops, on-the-job training	Joint ventures between firms Merger and acquisition firms Licensing Exporting/importing or sale/purchase of machinery goods Spinoff companies (commercializing technology) Collaboration Venture capital industry initiatives to research institute and industrial firm Technology incubators, R&D centers, science parks
5. Foreign direct investment (FDI)	FDI viewed by investors from technologically advanced countries as a vehicle of KT Knowledge that consists of technology will transfer faster than knowledge without technology	FDI viewed by investors from technologically advanced countries as a vehicle of TT Transmission and absorption costs of technology are higher than for KT FDI brings in relevant technologies
6. Workers' mobility	Workers' mobility leads to KT through expatriates and host country nationals and vice versa Through higher education and training of personnel abroad/ in industrialized nations Strength of moving people as a KT mechanism complements the speed and magnitude of TT	International transfer from HQ to subsidiary of MNC TT is positively associated with the level of FDI TT is accompanied by worker's mobility because people are capable of adapting tools and tasks to new contexts

Table I.
Summary of dimensions differentiating knowledge transfer and technology transfer

Implications for future research

As this article is limited to a literature review analysis of KT and TT, future research is necessary to find and validate empirical evidence on the differences identified. Such evidences can come from multi-perspective approaches and frameworks. First, the use of in-depth interviews to key personnel responsible for specific tasks in the commercialization of technology such as basic and applied R&D, technology trial at the incubator center, licensing and the IPR development, with a consideration what leads to different levels of KT and TT. This is significant because the key personnel could articulate various expressions in relation to the truth, practicality and significance of the tacit and explicit knowledge in the transfer process. The key personnel may come from different sectoral contexts of a country such as engineering, agriculture, health, pharmacy and food manufacturing that have different background in handling various soft and hard technologies.

Second, there is a need to study the speed at which fast industrializing countries such as South Korea, Taiwan and Singapore as well as China receive and absorp technologies from their partnering counterparts abroad. For this purpose, a comparative country analysis is appropriate by incorporating various HRD dimensions such as T&D of skilled workers, retraining program of returning scientists/tecnologists and other mobile workers, leadership and mentoring initiatives involving senior and young employees in KT and TT. Also to be included are FDI indicators such as the magnitudes and the country sources, the proportion of FDI allocated for HRD initiatives in a specific sector. Research on country development analysis should proceed, for instance, in terms of temporal aspect of relationship between firms that come from two countries, whether this relationship influences the speed and level of KT and TT differently. Take for an example the long historical relationship between Malaysia and two deceloped countries of Britain and Japan of which a comparative analysis on the two relationships may be instrumental to explain the transfer process.

Third, future research capturing the specific influence of personal and organizational factors on KT and TT could provide additional insights on the dynamics of the transfer process from the current global perspective of KT and TT that depend heavily on digital means in communication and knowledge management. From the perspective of sender versus receiver, therefore, it is very pertinent to differentiate personal factors based on who are the receivers and senders whether they are scientists, technologists or consultants as their competence in the usage of digital technologies varies depending on job contexts.

Fourth, it is noted that employees, as senders and receivers, have a tendency to remember interrupted tasks resulting from barriers better than they do remember those that have been completed. In addition, an organization learns to cope with stickiness (Szulanski, 2000) or difficulty by drawing on the lessons from previous experience with transfers. Thus, it is suggested to study predictors of stickiness to KT and TT, as it is expected that factors that affect an opportunity to transfer knowledge and technology are more likely to predict difficulty during the initiation phase, whereas factors that affect the execution of the transfer are more likely to predict difficulty during subsequent implementation phases (Szulanski, 2000). As the initiation to execution phases of KT and TT take a long duration, a cross-sectional survey involving a diachronic analysis should be the suggested approach because longitudinal archival data may be non-existent in an organization or in two organizations that the transfer occurs.

Fifth, by concentrating on factors that relate to KT and TT, with special insight on types of institutions involve such as firm and university research centre or other knowledge-driven organizations, could expand upon our findings. Moving forward, future researchers could examine a number of HRD and managerial-related issues such as cultural and leadership compatibility between institutions that are known to focus on KT and TT

differently. This is so required as according to Gopalakrishnan and Santoro (2004), structure of organization (mechanistic versus bionic), shared vision and support systems, which are all dependent on leadership, instrumental to KT and TT.

Finally, it is recommended to study the roles of higher education in science, technology, engineering and mathematics (STEM) as well as the academic and professional network developed during post-graduate studies abroad among the graduates and returnees in their homeland. This is a promising area for future research to embark on as the individuals involved are considered 'mobile wokers' who have the accumulated knowledge and experience related to specific technological specialization that should be transfered and made to good use by peers in the host country.

Recommendations for practice

Managers should use the insights on differences between KT and TT in managing relevant human resource practices in their organizations so that planned activities are suited to the respective goals of KT and TT. The practical implications of this article to organizational managers are as follows:

- From the perspective human resource development and training, organizational managers should plan and execute training activities differently for KT and TT based on the nature and characteristics of knowledge versus technology. This implies that: i) differentiation should take in the form of the contents of subject-matter to be delivered to training participants that arises from the characteristics of 'tacit and explicit' nature as well as the tangibility issue as TT involves more tools and physical dimension of knowledge compared to KT; ii) consequently, the sites for training for KT program may be different from TT as the latter requires tools and equipment that could only be found in laboratory, science park and technology incubator centre; iii) the trainer recommended to be involved in TT would be technology specialist and scientist, as well as subject-matter specialist or consultant who are responsible for activities in the chain of technology commercialization such as patenting, IPR and licensing. On the other hand for training in KT, it would be possible to involve a trainer who is a generalist and not necessarily very competent about the specific technology; iv) TT requires higher levels of learning and thinking and may involve psychomotor and hands-on skills as both involve more explicit and encoded knowledge than tacit knowledge. Therefore, elements of analysis, evaluation, creation and recreation should be emphasized in training and knowledge acquisition programs; v) TT involves precision technology that is fast changing over time. Hence, more periodic problems-based as well as commercial-based training programs should be designed for employees who plan for R&D activities; vi) managers in R&D institutions therefore, should plan strategic short and long-term training programs about TT processes because of the fast-changing nature of technology, as according to Gopalakrishnan and Santoro (2004), this is necessary to suit with the change-oriented or organic culture of organization; and vii) managers should be aware that employees who are involved in KT and TT should also be knowledgeable not only with research intricacies in knowledge and technology development but should also be skillful in commercialization practices such as patenting, IPR negotiation, licensing and inter-organization collaboration.
- Many organizational managers are currently in the age groups of middle-level (35 to 45 years) or even younger (the millennials). KT and TT do vary in their existence in some countries based on their evolution and development. This has implication

when a firm wants to start a KT or TT network with another firm abroad, the manager of the former should study the background details of KT and TT of the partnering firm against the latter. This implies the younger managers should equip their knowledge in relation to countries' KT and TT development, as they may lack certain knowledge and experience compared to the senior managers.

- As there is a co-existence of senders and receivers of knowledge and technology among employees, it is crucial for organizational managers to use clear definition of performance assessment indices that is context-specific, measureable and attainable for the respective functions of KT and TT. Even though there may have some overlapped activities in relations to the functions as senders and receivers, types of knowledge and technology, involvement within or outside organization and the costs involve that are associated with FDI, the final outcomes of KT and TT would be the differentiated knowledge and technology gained that are specific to the functions of a receiving organization. This assessment has been found as one of the predictors of career aspiration of employees in R&D institutions (Ismail and Ramly, 2011).
- It is evident that knowledge that consists of technology will transfer faster than knowledge without technology, as well as there is a positive relationship between FDI and TT. Therefore, organizational managers should formulate and create global strategic plan to bring in investors with an anticipated magnitude of FDI. Managers should establish global network with potential investors and collaborators such as MNCs, R&D institutions and universities. At the domestic level, managers should negotiate with companies and entrepreneurs as the role of TT is not only for product commercialization but also for students' industrial training and job creation. Essentially, it is said that managers also create and facilitate pathways for the transfer of innovations to wider commercial partners.
- Workers' mobility is a form of human capital investment (Vithana *et al.*, 2018). This is further supported by Argote and Ingram (2000) that the strength of moving people as a KT mechanism complements the speed and volume of moving technologies. Other than about technologies, mobile workers also have rich experience in work culture (Ismail *et al.*, 2016). A practical implication to managers is that they should capitalize on the accumulated knowledge of these professionals in KT and TT training program as trainers, consultants and subject-matter specialists and more so for mentoring initiative as a mentor-cum-leader in a specific technology dissemination and commercialization.

Conclusion

From the above analysis, it is concluded that differentiating KT and TT is not a straightforward process as both constructs are inter-related and complement each other. Nevertheless, our analysis of the constructs shows that KT and TT can be differentiated based on the characteristics and conceptualization of knowledge and technology, and the resulting concepts of KT and TT based on processes, as well as the contexts that involve individuals as senders and receives. The analysis also concludes that the way to differentiate KT and TT is to examine intra- and inter-organizations that go beyond the country's borders, which then inevitably includes FDI and mobility of human resources as knowledge keepers and owners. The advancement of taxonomy of knowledge in the form of

tacit-versus-explicit dimensions leads to a significant and challenging differentiation between KT and TT.

It is further concluded that in the earlier stages of development of many countries, there is no clear differentiation between KT and TT, and the two concepts are often used interchangeably. Furthermore, in the earlier days, much of the knowledge and technology had been transferred informally by migration, imitation, reverse engineering, import and purchase of capital goods. In recent years, the transfers have become more formalized and accelerated through various ways such as FDI of MNC from developed to developing countries, cross-border interorganizational collaboration, university-firm linkage, merger and acquisition, joint venture and organizational alliance, higher education and advanced technology training programs, import and export of goods and government policies on R&D. The establishment of technology transfer centers, science parks and technology incubators is also instrumental in facilitating the transfer process, especially TT. Finally, workers' mobility or the movement of professionals from one country to another helps to bring foreign expertise to the receiving country. This is especially important in this globalized era as the movement of skilled workers as a KT mechanism expedites the strength of moving technologies (or TT) within and between organizations.

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