Defining the Concepts of Technology and Technology Transfer: A Literature Analysis

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Defining the Concepts of Technology and Technology Transfer: A Literature Analysis

Sazali Abdul Wahab
National Defence University of Malaysia, Kuala Lumpur 57000, Malaysia
Tel: 60-39-051-3060 E-mail: saw@upnm.edu.my

Raduan Che Rose
National Defence University of Malaysia, Kuala Lumpur 57000, Malaysia
E-mail: raduan@upnm.edu.my

Suzana Idayu Wati Osman
Felda Global Ventures Holdings

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Abstract

The primary objective of this paper is to contribute to the existing literature by comprehensively reviewing the development, definitions and concepts of technology and technology transfer based on a literature review conducted on these wide research areas. This review covers various definitions and dimensions of both technology and technology transfer from the early technology concept i.e. from the development of Solow's (1957) growth model up to Maskus's (2003) definition and concept of technology and technology transfer. While the term 'technology' itself is difficult to interpret, observe or evaluate, as argued by many scholars, this review attempts to provide in-depth discussion and enhance understanding on these concepts from various perspectives, research background and disciplines. This review could shed some dynamic ideas for future researchers to further identify, conceptualize and understand the underlying theories and perspectives which strongly influence the previous, current and future concept of technology transfer.

Keywords: Definitions, Concept, Technology, Technology transfer, Malaysia

1. Introduction

The dynamic nature of technology has contributed to the existence of various definitions and concepts of technology by the previous studies which are related to technology transfer. The discussion on the concept of technology is crucial in getting a clear understanding of the nature of technology and examining what the technology consists of. Past studies have shown that defining the concept of technology is not easy (Reddy and Zhoa, 1990); therefore technology has been defined from different perspectives. Existing studies on technology transfer and international technology transfer have attracted researchers from cross-section of disciplines including organizational management, political science, economics, sociology, anthropology, marketing and recently management of technology (Cusumano and Elenkov, 1994; Zhoa and Reisman, 1992). The term 'technology' is inherently abstract concept which is difficult to interpret, observe and evaluate (Blomstrom and Kokko, 1998). Regardless of the extensive research done on this subject, many of the literatures are fragmented along different specialties and generally there is no commonly accepted paradigm (Reddy and Zhoa, 1990). Lan and Young (1996) stress that the technology definition is varied according to authors and context of disciplines. Because of this the concepts, variables and measures relevant to the study are different from one study to another (Kumar et. al, 1999). Therefore, the main objective of this paper is to contribute to the existing literature by comprehensively reviewing the development, definitions and concepts of technology and technology transfer.

2. The Definition and Concept of Technology

Past researchers have viewed and defined the term 'technology' from many perspectives and this has influenced the research design and results, negotiations around a transfer and government policies in general (Reddy and Zhoa, 1990).

Thus, the term technology has been given various definitions by previous literatures. According to Kumar et. al (1999) technology consists of two primary components: 1) a physical component which comprises of items such as products, tooling, equipments, blueprints, techniques, and processes; and 2) the informational component which consists of know-how in management, marketing, production, quality control, reliability, skilled labor and functional areas. The earlier definition by Sahal (1981) views technology as 'configuration', observing that the transfer object (the technology) relies on a subjectively determined but specifiable set of processes and products. The current studies on the technology transfer have connected technology directly with knowledge and more attention is given to the process of research and development (Dunning, 1994). By scrutinizing the technology definition, there are two basic components that can be identified: 1) 'knowledge' or technique; and 2) 'doing things'. Technology is always connected with obtaining certain result, resolving certain problems, completing certain tasks using particular skills, employing knowledge and exploiting assets (Lan and Young, 1996). The concept of technology does not only relate to the technology that embodies in the product but it is also associated with the knowledge or information of it use, application and the process in developing the product (Lovell, 1998; Bozeman, 2000).

The early concept of technology as information holds that the technology is generally applicable and easy to reproduce and reuse (Arrow, 1962). However, Reddy and Zhoa (1990) contend that the early concept of technology contradicts with a strand of literatures on international technology transfer which holds that "technology is conceived as firm-specific information concerning the characteristics and performance properties of the production process and product design". They further argue that the production process or operation technology is embodied in the equipment or the means to produce a defined product. On the other hand, the product design or product technology is that which is manifested in the finished product. Pavitt (1985) suggests that technology is mainly differentiated knowledge about specific application, tacit, often uncodified and largely cumulative within firms. Thus, based on this argument, technology is regarded as the firm's 'intangible assets' or 'firm-specific' which forms the basis of a firm's competitiveness and will generally release under special condition (Dunning, 1981). Tihanyi and Roath (2002) propose that technology can include information that is not easily reproducible and transferable. Based on this argument technology is seen as "tacit knowledge (Polanyi, 1967) or firm-specific, secrets or knowledge known by one organization" (Nonaka, 1994).

Technology as the intangible assets of the firm is rooted in the firms routines and is not easy to transfer due to the gradual learning process and higher cost associated with transferring tacit knowledge (Rodasevic,1999). Valuable technological knowledge which is the intangible assets of the firm is never easily transferred from one firm to another because the technological learning process is needed to assimilate and internalized the transferred technology (Lin, 2003). Rosenberg and Frischtak (1985) also consider technology as firm-specific information concerning the characteristics and performance properties of production processes and product designs; therefore technology is tacit and cumulative in nature. Burgelman et al. (1996) refer technology as the theoretical and practical knowledge, skills, and artifacts that can be used to develop products and services as well as their production and delivery systems. Technology is also embodied in people, materials, cognitive and physical processes, facilities, machines and tools (Lin, 2003). Based on Sahal's (1981) concept, Bozeman (2000) argues that technology and knowledge are inseparable simply because when a technological product is transferred or diffused, the knowledge upon which its composition is based is also diffused. The physical entity cannot be put to use without the existence of knowledge base which is inherent and not ancillary.

MacKenzie and Wajcman (1985) define technology as the integration of the physical objects or artifacts, the process of making the objects and the meaning associated with the physical objects. These elements are not distinctive and separable factors but form a 'seamless web' that constitutes technology (Woolgar, 1987). In defining the term technology, all the three elements must be understood as being inter-connected to each other and a change in one element will affect the other two elements. The latest definition given by Mascus (2003) has broadened the concept of technology where technology is defined as 'the information necessary to achieve a certain production outcome from a particular means of combining or processing selected inputs which include production processes, intra-firm organizational structures, management techniques, and means of finance, marketing methods or any of its combination'. Other scholars such as Tepstra and David (1985) suggest that technology as a cultural system concerned with the relationships between humans and their environment. From the systems perspective Afriyie (1988) defines technology as encompassing: 1) the basic knowledge sub-system; 2) the technical support system (software); and 3) the capital-embodied technology (hardware). This perspective views that technology recognizes the need to identify the different elements of a particular country's technology that are complementary and mutually reinforcing. The previous studies done by the researchers have offered various definitions and concepts of technology from different disciplines, contexts and perspectives. Table 1 below shows a list of definitions and concepts of technology (in a chronological order) which was gathered from the previous literatures.

Insert Table 1 Here

Apart from understanding the concept of technology, the classification of technology is also crucial in explaining the various kinds of technologies that embody in the product, production processes and human capital of the firm. Reddy and Zhoa (1990) in their extensive review of technology transfer literature have constructed taxonomies of technology from the previous literatures. The early taxonomy of technology was developed by Mansfield (1975) who used "embodied" and "disembodied" technology classification. The classification was later further extended by Madeuf (1984) to include capital embodied, human embodied and disembodied technology. Hall and Johnson (1970) suggest the use of "product-embodied", "process-embodied" and "person-embodied" technology classification rather than the classification based on "general", "system-specific", and "company specific" technology. General technology includes technical information which is common to companies in the same activity. System specific technology corresponds to knowledge and know-how develops for solving particular industrial problems. Company specific technology covers the corporate skills and capabilities from general activity and experience of each individual firm. Robock (1980) and Chudson (1971) have constructed technology taxonomy by separating product designs, production techniques and managerial functions. Madeuf (1984) suggests a distinction between "alienated' technology and "socialized" technology. Alienated technology includes information which is not free such as secret know-how. Conversely, "socialized technology" does not imply any specific transaction.

3. Defining the Concept of Technology Transfer

The definitions and concepts of technology transfer have been discussed in many different ways based on the disciplines of research and according to the purposes of the research (Bozeman, 2000). Gibson and Smilor, (1991) view technology transfer is often a chaotic, disorderly process involving groups and individuals who may hold different views about the value and potential use of the technology. According to them technology often has no definitive meaning or value. Researchers, developers, and users are likely to have different perceptions about the technology. A review of literature on technology transfer reveals that technology transfer is a complex, difficult process even when it occurs across different functions within a single product division of a single company (Zaltman et al., 1973; Kidder, 1981; Smith and Alexander, 1988). Technology transfer is commonly acknowledged to be a complex process that needs time to evolve (Agmon and von Glinow, 1981).

Nevertheless, the economic theories for example Solow's (1957) growth model, have often treated technology as given that is embodied in products or processes; where technologies that resemble blueprint, machines, or materials are easily replicated and transferred (Lin, 2003). The literatures on technology transfer and international technology transfer are extensive and varied in perspective from various disciplines which include political science, economics, sociology, public policy, marketing and management of technology (Kumar et al., 1999). The issues that have been investigated, among other, are technology transfer process, appropriateness of technology, cooperation and conflict between transfer countries, the success of technology transfer, and the social and economic benefits of technology transfer for both suppliers and recipient countries (Katz, 1985; Lall, 1982).

Past literatures have referred technology transfer as the transmission of know-how to suit local conditions, with effective absorption and diffusion both within and across countries (Chung, 2001; Kanyak, 1985). Other early researchers for example Baranson (1970) defines technology transfer as transmission of know-how (knowledge) which enable the recipient enterprise to manufacture a particular product or provide a specific service. As compared to the sale of machinery and equipment, the transfer of technology requires a sustained relationship between two enterprises over a period of time to enable the receiving enterprise to produce the product with the desired level of quality standards and cost efficiency (Reddy and Zhoa, 1990). This is consistent with the earlier argument by Chesnais (1986) who argues that technology transfer does not only transfer the technical know-how (knowledge) required to produce the product to the recipient but also the capacity to master, develop and later produce autonomously the technology underlying the products. In the context of developing countries, Hoffman and Girvan (1990) argue that technology transfer needs to be perceived in terms of achieving three core objectives: 1) the introduction of new techniques by means of investment of new plants; (2) the improvement of existing techniques and (3) the generation of new knowledge.

Since the term "technology transfer" provides many dimensions, it has often been used to describe the process by which ideas and concepts are moved from the laboratory to marketplace (Phillips, 2002; Williams & Gibson, 1990), the transfer and knowledge and concept from developed to less technologically developed countries (Derakhshani, 1983; Putranto et al., 2003) and the transfer of inventive activities to secondary users (Van Gigch, 1978). Autio and Laamanen (1995) suggest a broader definition by proposing that technology transfer involves an intentional, goal-oriented interaction between two or more social entities, during which the pool of technological knowledge remains stable or increases through the transfer of one or more components of technology. Levin (1996) considers

technology transfer as the application of scientific principles to solve practical problems. From the social science perspective Levin (1993) defines technology transfer as a socio-technical process implying the transfer of cultural skills accompanying the movement of machinery, equipment and tools. This definition includes the transfer of the physical movement of artifacts and the embedded cultural skills. Majority of the previous studies have defined technology transfer as the transmission or movement of knowledge as a process. It involves the process how an organization or a country transfers scientific or technological achievements, new uses for technology, designs, and the technical knowledge that can be used in production (Chun 2007). Technology can also be transferred from one place to another or from a university to an enterprise (Solo and Rogers, 1972). The process that involves does not only concern about the transmission of knowledge but it is also relate to a learning process where technological knowledge is continually accumulated into human resources that are engaged in production activities. A successful technology transfer will eventually lead to a deeper and wider accumulation of knowledge (Shiowattana, 1991).

The technology transfer concept is not only concern about the transfer of technological knowledge or information but also the technology recipient's capability to learn and absorb technology into the production function (Maskus, 2003). Das (1987) argues that technology transfer can be of two types: 1) production of new product (product or embodied technology transfer); and 2) more efficient production of existing products (process or disembodied technology transfer). Hall and Johnson (1970) define technology transfer as technology system in terms of whether it is embodied in people (person-embodied), things (product-embodied) or processes (process-embodied). Farhang (1997) suggests that transfer of technologies in cases of manufacturing processes requires not only the transfer of technological knowledge in the form of process sheets, blueprints, products, and materials specification but also the transfer of know-how of high-calibre engineering and technical personnel.

In their extensive review on technology transfer literature from various disciplines, Zhoa and Reisman (1992) view that economists often define technology transfer on the basis of the properties of generic knowledge where the main focus is on variables that relate to production and design (Arrow, 1969; Dosi, 1988). For the sociologist, they tend to link technology transfer to innovation and view technology as 'a design for instrumental action that reduces the uncertainty of cause–effect relationships involved in achieving a desired outcome' (Rogers, 1962; Rogers and Shoemaker, 1971). The anthropologists tend to broadly view technology transfer within the context of cultural change and how technology affects changes. Zhoa and Reisman (1992) identify that bulk of the technology transfer literatures have also been contributed by the management researchers. They argue that business disciplines tend to concentrate on issues such as stages of technology transfer, design and related stages and sales (Teese, 1976; Lake 1979). On the other hand, the management researchers tend to focus on intra-sector transfer and relationships between technology transfer and strategy (Rabino, 1989; Chiesa and Manzini, 1996; Laamanen and Autio, 1996; Lambe and Spekman, 1997). Most of the literatures on management have shifted their focus to alliances among enterprises and how alliances are crucial to the development of technology transfer (Zhoa and Reisman, 1992). Table 2 below shows a list of technology transfer's definitions and concepts which was gathered from various literatures on technology transfer.

Insert Table 2 Here

4. Technology Transfer and Knowledge Transfer

Based on the above definitions and concepts gathered from various literatures, the area of technology transfer is wide and dynamic. The numbers of literatures on the subject are voluminous, extensive and varied in perspectives (Kumar et al., 1999; Zhoa and Reisman, 1992). A review of literature reveals that past studies have made little attempt to explain the difference between knowledge transfer and technology transfer. Many of the studies do not draw a clear line between knowledge and technology transfer because most of the studies have regularly applied the term interchangeably in both technology transfer and knowledge transfer literatures; where majority have treated knowledge transfer and technology transfer as having similar meaning. Based on various definitions from different disciplines of research and background, majority of the researchers have affirmed that technology transfer is closely associated with the transfer of information, know-how, technical knowledge which is embodied in the products, processes and managements. This is obviously because of the critical element of knowledge that underlies technology transfer (Hall and Johnson, 1970; Kanyak, 1985; Shiowattana, 1987; Das, 1987; Williams and Gibson, 1990; Hayden, 1992; Gibson and Rogers, 1994). Other definitions of technology transfer, for example Grosse (1996) makes direct reference to knowledge as elements underlying technology transfer of product technology, process technology and management technology.

There are many researchers who have attempted to explain, directly or indirectly, the relationship between technology transfer and knowledge transfer and some even tried to draw distinction between the two concepts. Kogut and Zander (1992,1993), in their study on knowledge transfer within the multinationals (MNCs), use both terms interchangeably to establish a close association between technology transfer and knowledge transfer when suggesting that technology

transfer within MNCs can be explained by the attributes of knowledge such as tacitness, codifiability and teachability. Sinani and Meyer (2004), when studying the spillovers of technology transfer from FDI in Estonia, make no distinction between technology transfer and knowledge transfer. Sung and Gibson (2000), in their study on levels and keys factor in knowledge and technology transfer, connote technology and knowledge transfer to have similar meaning. They suggest that knowledge and technology transfer as the movement of knowledge and technology through some channels from one individual or organization to another. Past studies have suggested that technology and knowledge are inseparable. For example Sahal (1981, 1982) argues that technology as 'configuration', observing that the transfer object, the technology must rely on a subjectively determined but specifiable set of processes and products. It is no longer sufficient to simply focus on the product because it is not only the product that is being transferred but the knowledge of its use and application which are embedded in the products.

Bozeman (2000), in his study on technology transfer and public policy, states that the approach by Sahal (1981, 1982) has resolved a major analytical problem in distinguishing the technology and knowledge transfer. Both technology and knowledge transfer are inseparable because when a technological product is transferred or diffused the knowledge upon which its composition is based is also transferred (Bozeman, 2000). A recent study by Li-Hua (2006) on the effectiveness of technology transfer in China indicates that the technology will not occur without knowledge transfer as knowledge is the key to control technology. Simonin (1999b), in the study of transfer of marketing know-how in strategic alliance, suggests that study on knowledge transfer turn almost invariably to technology transfer when empirical investigation is in order. Studies have shown that the tendency of the current studies have connected technology directly with knowledge (Dunning, 1994). In the context of technology transfer through FDI, Kogut and Zander (1993) have explicitly indicated foreign direct investment is the transfer of knowledge, which embodies a firm's advantage, underlies technology, production, marketing or other activities. Although technology transfer and knowledge transfer has been regularly used interchangeably in many literatures since they are highly interactive, however, they serve different purposes. Gopalakrishnan and Santoro (2004) distinguish technology transfer and knowledge transfer in term of their purposes when they argue that knowledge transfer focuses on a broader and have more inclusive construct which is directed more towards the "why" for change, whereas technology transfer focuses on a narrow and more targeted construct that usually embodies certain tools for changing the environment. Even though there are distinctions between their purposes, majority of researchers agree that knowledge is the critical element that underlies technology transfer.

5. Conclusion

Based on the above discussion, both technology and technology transfer concepts encompass many different interpretations and views depending on the organizations' objectives, research background, researchers, developers, users, research areas and disciplines and underlying perspective (theories). Therefore, various parties are likely to hold different views and perceptions on these two concepts. This review could shed some dynamic ideas for future researchers to further identify, conceptualize and understand the underlying theories and perspectives which strongly influence the previous, current, and future concept of technology transfer. Such understanding is necessary to enable the interested parties (such as private sectors, government departments, academics, researchers and students) to relate with the practical and empirical aspects of various relevant theories which explain technology transfer concept. The simple explanation is that different perspectives/theories underlying technology transfer will have different theoretical arguments and insights, research problems, constructs, variables, and measurements.

References

Afriyie, K. (1988). A Technology Transfer Methodology for Developing Joint Production Strategies in Varying Systems, In F. J. Contractor and P. Lorange (Eds.). *Cooperative Strategies in International Business*, 81-95.

Agmon, T., & von Glinow, M. (1991). *Technology Transfer in International Business,* Oxford: Oxford Universities Press.

Arrow, K. (1969). Classificatory Notes on the Production and Transmission of Technological Knowledge. *American Economic Review*, 244–250.

Arrow K. J. (1962). *Economic Welfare and the Allocation of Resources for Invention, in: R. R. Nelson, The Rate and Direction of Inventive Activity*. Princeton University Press, New Jersey.

Autio, E., & Laamanen, T. (1995). Measurement and Evaluation of Technology Transfer: Review of Technology Transfer Mechanisms and Indicators. *International Journal of Technology Transfer Management*, 10(6), p. 643-664.

Baronson, J. (1970). Technology Transfer through the International Firms. *American Economic Review Papers and Proceedings*, 435-440.

Blomstrom, M., & Kokko, A. (1998). Multinational Corporations and Spillovers. *Journal of Economic Surveys,* 12(3), 247-77. http://dx.doi.org/10.1111/1467-6419.00056

Bozeman, B. (2000). Technology Transfer and Public Policy: A Review of Research and Theory. *Research Policy*, 29, 627-655. http://dx.doi.org/10.1016/S0048-7333(99)00093-1

Burgelman, R. A., Maidique, M. A., & Wheelwright, S. C. (1996). *Strategic Management of Technology and Innovation*. (2nd ed.). Chicago: I. L, Irwin.

Cameron, E. H. (1960). *Samuel Slater: Father of American Manufacturers*, Portland, MA: The Bond Wheelwright Company.

Caves, R. E. (1974). Multinational Firms, Competition and Productivity in Host-Country Markets. *Economica*, 41, 176-193. http://dx.doi.org/10.2307/2553765

Chesnais, F. (1986). Science, Technology and Competitiveness. *OECD STI Review,* 1.

Chiesa, V., & Manzini, R. (1996). Managing Knowledge Transfer within Multinational Firms. *International Journal of Technology Management*, 12(4), 462–476.

Chudson, W. A (1971). The international transfer of commercial technology to developing countries. *UNITAR Research Reports* No. 13 New York.

Chun, C. L. (2007). Modeling the Technology Transfer to Taiwan from China. *International Research Journal of Finance and Economics*, 7, 48-66.

Chung, W. (2001). Identifying Technology Transfer in Foreign Direct Investment: Influence of Industry Conditions and Investing Firm Motives. *Journal of International Business Studies*, 32 (2), 211-229. http://dx.doi.org/10.1057/palgrave.jibs.8490949

Cusumano, M. A., & Elenkov, D. (1994). Linking international technology transfer with strategy and management: a literary commentary. *Research Policy*, 23(2), 195–215. http://dx.doi.org/10.1016/0048-7333(94)90053-1

Das, S. (1987). Externalities and Technology Transfer through Multinational Corporations. *Journal of International Economics*, 22, 171-182. http://dx.doi.org/10.1016/0022-1996(87)90028-6

Daghfous, A. (2004). An Empirical Investigation of the Roles of Prior Knowledge and Learning Activities in Technology Transfer. *Technovation*, 24, 939-953. http://dx.doi.org/10.1016/S0166-4972(03)00059-2

Derakhshani, S. (1983). Factors affecting success in international transfers of technology — A synthesis, and a test of a new contingency model. *Developing Economies* 21 (1983), 27–45.

Dosi, G. (1988). The Nature of the Innovation Process. In: Dosi, G. et al. (Eds.). *Technical Change and Economic Theory*. London: Pinter Publishers.

Dunning, J. H. (1994). Multinational Enterprises and the Global of Innovatory Capacity. *Research Policy*, 23, 67-88. http://dx.doi.org/10.1016/0048-7333(94)90027-2

Dunning, J. H. (1981). Alternative Channels and Modes of International Resource Transmission, in T. Sagafi-Nejad, Perlmutter, H., & Moxon, R. (Eds.). *Controlling International Technology Transfer: Issues, Perspectives and Implications*. New York: Permagon.

Ernst, D., & Kim, L. (2002). Global Production Network, Knowledge Diffusion, and Local Capability Formation. *Research Policy,* 31, 1417-1429. http://dx.doi.org/10.1016/S0048-7333(02)00072-0

Farhang, M. (1997). Managing technology transfer to China: conceptual framework and operational guidelines. *International Marketing Review*, 14(2), 92 - 106. http://dx.doi.org/10.1108/02651339710170195

Foster, G. (1962). *Traditional Cultures and the Impact of Technological Change*. New York: Harper Publishing.

Galbraith, J. K. (1972). *The New Industrial State*. London, UK: Andre Deutsch.

Gibson, D. V., & Rogers, E. M. (1994). *R&D Collaboration on Trial: The Microelectronics and Computer Technology Corporation.* Harvard Business Press.

Gibson, D. V., & Smilor, W. (1991). Key Variables in Technology Transfer: A field – Study Based on Empirical Analysis. *Journal of Engineering and Technology Management*, 8, 287-312. http://dx.doi.org/10.1016/0923-4748(91)90015-J

Gopalakrishnan, S., & Santoro, M. D. (2004). Distinguishing Between Knowledge Transfer and Technology Transfer Activities: The Role of Key Organizational Factors. *IEEE Transaction on Engineering Management,* 51(1), 57-69. http://dx.doi.org/10.1109/TEM.2003.822461

Goulet, D. (1989). *The Uncertain Promise: Value Conflicts in Technology Transfer*. New York: New Horizons Press.

Grosse, R. (1996). International Technology Transfer in Services. *Journal of International Business Studies*, 27(4), 781-800. http://dx.doi.org/10.1057/palgrave.jibs.8490153

Hall, G. R., & Johnson, R. E. (1970). *The Technology Factors in International Trade.* New York: Colombia University Press.

Hawkins, R., & T. Gladwin. (1981). *Conflicts in the international transfer of technology: a US home country view*. In Sagafi-Nejad et al.

Hawthorne, E. P. (1971). *The Transfer of Technology*. Paris: OEDC.

Hayden, F. G. (1992). *Corporate Networks, A US Case Study*. Rotterdam: Erasmus University, Conference on the Dynamics of the Firm.

Hoffman, K., & Girvan, N. (1990). *Managing International Technology Transfer: A Strategic Approach for Developing*, IDRC.

Jeannet, J. P., & Liander, B. (1978). Some patterns in the transfer of technology within multinational corporations. *J. Int. Business Stud,* 3, 108–118. http://dx.doi.org/10.1057/palgrave.jibs.8490672

Jones, R. (1970). *The Technology Factors in International Trade*. New York: Universities Bureau of Economics Research.

Katz, J. M. (1984). *Echnological innovation, industrial organization and comparative advantages of Latin American metalworking industries*. London: Macmillan.

Kanyak, E. (1985). *Transfer of Technology from Developed Countries: Some Insights from Turkey*. CT: Quarum Books.

Kidder, T. (1981). *The Soul of a Machine*, Massachusetts: Little Brown.

Kogut, B., & Zander, U. (1993). Knowledge of the Firm and the Evolutionary Theory of the Multinational Corporation. *Journal of International Business Studies*, 24 (4), 625-646. http://dx.doi.org/10.1057/palgrave.jibs.8490248

Kogut, B., & Zander, U. (1992). Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology. *Organization Science*, 3(3), 383-97. http://dx.doi.org/10.1287/orsc.3.3.383

Kumar, V., Kumar, U., & Persaud, A. (1999). Building Technological Capability through Importing Technology: The Case of Indonesian Manufacturing Industry. *Journal of Technology Transfer*, 24, 81-96. http://dx.doi.org/10.1023/A:1007728921126

Laamanen, T., & Autio, E. (1996). Dominant Dynamic Complementarities and Technology-Motivated Acquisitions of New Technology-based Firms. *International Journal of Technology Management,* 12 (7–8), 769–786.

Lambe, C. J., & Spekman, R. E. (1997). Alliances, External Technology Acquisition, and Discontinuous Technological Change. *Journal of Product Innovation Management,* 14 (2), 102–116. http://dx.doi.org/10.1016/S0737-6782(96)00077-X

Lake, A. (1979). Technology Creation and Technology Transfer by Multinational Firms. *Research in International Business and Finance*, 1 (2), 137–177.

Lall, S. (1982). *Technological learning in the Third World: Some implications of technology exports*. London: Frances Pinter.

Lan, P., & Young, S. (1996). International Technology Transfer Examined at Technology Component Level: A Case Study in China. *Technovation,* 16 (6), 277-286. http://dx.doi.org/10.1016/0166-4972(96)00005-3

Levin, M. (1996). Technology Transfer in Organizational Development: An Investigation into the Relationship between Technology Transfer and Organizational Change. *International Journal of Technology Management*, 2 (3), 297-308.

Levin, M. (1993). Technology Transfer as a Learning and Development Process: An Analysis of Norwegian Programmes on Technology Transfer. *Technovation*, 13 (8), 497-518. http://dx.doi.org/10.1016/0166-4972(93)90065-4

Li-Hua, R. (2006). Examining the Appropriateness and Effectiveness of Technology Transfer in China. *Journal of Technology Transfer in China*, 1 (2), 208-223. http://dx.doi.org/10.1108/17468770610670992

Lin, W. B. (2003). Technology Transfer as Technological Learning: A Source of Competitive Advantage for Firms with limited R & D Resources. *R & D Management*, 33 (3), 327-341. http://dx.doi.org/10.1111/1467-9310.00301.

Lovell, S. A. (1998). *Technology Transfer: Testing a Theoretical Model of the Human, Machine, Mission, Management and Medium Components*. Unpublished Msc. thesis. Cranfield: College of Aeronautics, Cranfield University.

Mansfield, E. (1975). International Technology Transfer: Forms, Resource Requirement and Policies. *American Economic Review*, 65, 372-376.

MacKenzie, D., & Wajcman, J. (1985). *The Social Shaping of Technology: How the Refrigerator Got Its Hum*, Milton Keynes: Open University Press.

Madeuf, B. (1984). International technology transfers and international technology payments: definitions, measurements and firms' behaviour. *Research Policy,*13(3).

Maskus, K. E. (2003). *Encouraging International Technology Transfer.* UNCTAD/ICTSD Capacity Building Project. On Intellectual Property Rights and Sustainable Development.

Merrill, R. (1968). The Role of Technology in Cultural Evolution. *Social Biology*, 19 (3), 246–256.

Methe, D.T. (1991). *Technology Competition in Global Industries*. New York: Quarum Books.

Natarajan, & Tan, J. M. (1992). *The Impact of MNC Investments in Malaysia, Singapore and Thailand*. Singapore: Institute of Southeast Asian Studies,.

Nonaka, I. (1994). A Dynamic Theory of Organizational Knowledge Creation. *Organization Science*, 5, 14–37. http://dx.doi.org/10.1287/orsc.5.1.14

Pacey, A. (1983). *The Culture of Technology*. Oxford: Blackwell.

Pavitt, K. (1985). Patent Statistics as Indicators of Innovative Activities: Possibilities and Problems. *Scientometrics*, 7, 77–99. http://dx.doi.org/10.1007/BF02020142

Phillips, R. (2002). Technology Business Incubators: How Effective Is Technology Transfer Mechanisms? *Technology in Society,* 24 (3), 299-316. http://dx.doi.org/10.1016/S0160-791X(02)00010-6

Polanyi, M. (1967). *The Tacit Dimension*. NY: Anchor, Garden City.

Putranto, K., Stewart, D., & Moore, G. (2003). International Technology Transfer of Technology and Distribution of Technology Capabilities: The Case of Railway Development in Indonesia. *Technology in Society*, 25 (1), 42-53. http://dx.doi.org/10.1016/S0160-791X(02)00035-0

Rabino, S. (1989). High Technology Firms and Factors Influencing Transfer of R & D Facilities. *Journal of Business Research.* 18 (3), 297–312.

Radosevic, S. (1999). *International Technology Transfer and Catch-up in Economic Development*. Nothampton, MA: Edward Edgar Publishing.

Reddy, N. M., & Zhao, L. (1990). International Technology Transfer: A Review. *Research Policy*, 19, 285-307. http://dx.doi.org/10.1016/0048-7333(90)90015-X

Reisman, A. (2006). Transfer of Technologies: A Cross-disciplinary Taxonomy. *The International Journal of Management Science*, 33, 189-202.

Robock, S. H. (1980). *The International Technology Transfer Process*. Washington D.C: National Academy of Sciences.

Roessner, J. D. (1993). What Companies Want From the Federal Labs. *Issues in Science and Technology*, 10 (1), 37-42.

Rogers, E. M. (1962). Diffusion of Innovations. New York: The Free Press of Glencoe.

Rogers, E. M., & Shoemaker, F. F. (1971). *Communication of Innovations. A Cross Cultural Approach*. New York: Free Press.

Rosenberg, N., & Frischtak. C. (1985). *International Technology Transfer: Concepts, Measures and Comparisons*. New York: Praeger.

Sahal, D. (1982). *The Transfer and Utilization of Technical Knowledge*. Lexington: Lexington Publishing.

Sahal, D. (1981). Alternative Conceptions of Technology. *Research Policy,* 10, 2-24. http://dx.doi.org/10.1016/0048-7333(81)90008-1

Sazali, A.W., & Raduan, C. R. (2011). *The Inter Firm Technology Transfer in Malaysia – A Holistic Approach*. Saarbrucken: VDM Verlag Publishing.

Sazali A. W., & Raduan C. R. (2011). *The Handbook of Inter Firm Technology Transfer – An Integrated Knowledge-Based View and Organizational Learning Perspective.* Germany*:* LAP LAMBERT Academic Publishing.

Sinani, E., & Meyer, K. E. (2004). Spillovers of Technology Transfer from FDI: The Case of Estonia. *Journal of Comparative Economics*, 32, 445-466. http://dx.doi.org/10.1016/j.jce.2004.03.002

Simonin B. L. (1999b). Transfer of marketing know-how in international strategic alliances: an empirical investigation of the role and antecedents of knowledge ambiguity. *Journal of International Business Studies*, 30(3), 463–90. http://dx.doi.org/10.1057/palgrave.jibs.8490079

Sherman, G. (1981) *Technology Transfer Innovation and International Competitiveness*, New York: John Wiley & Sons.

Shiowattana, P. (1991). *Transfer of Japanese Technology and Management to the ASEAN Countries*. Tokyo: University of Tokyo Press.

Smith, D. K., & Alexander, B. C. (1988). *Fumbling the Future: How Xerox Invented, the Ignored, the First Personal Computer*. New York: William morrow.

Solo, R. A., & Rogers, E. M. (1972). *Inducing Technological Change for Economic Growth and Development*. East Lansing: Michigan State University Press.

Solow, R. M. (1957). Technical Change and the Aggregate Production Function. *Review of Economics Statistics*, 39 (3), 312-320. http://dx.doi.org/10.2307/1926047

Strassman, W. P. (1968). *Technological Change and Economic Development: The Manufacturing Process of Mexico and Puerto Rico*. Ithaca: Cornell University Press.

Sung, T. K., & Gibson, D. V. (2000). Knowledge and Technology Transfer: Key Factors and Levels. *Proceeding of 4th International Conference on Technology Policy and Innovation*.

Szulanski, G. (1996). Exploring Internal Stickiness: Impediments to the Transfer of Best Practice within the Firm, *Strategic Management Journal*, 17, 27–43.

Techakanont, K., & Terdudonthan, T. (2004), Evolution of Inter-firm Technology Transfer and Technological Capability Formation of Local Parts Firms in the Thai Automobile Industry. *Journal of Technology Innovation,* 12 (2), 151-183. http://dx.doi.org/10.1080/19761597.2004.9668602

Teece, D. (1986). Transaction Cost Economics and the Multinational Enterprise: An Assessment. *Journal of Economic Behavior and Organization*, 7, 21-46. http://dx.doi.org/10.1016/0167-2681(86)90020-X

Teece, D. (1977). Time Cost Trade-off: Elasticity Estimates and Determinants for International Technology Transfer Projects. *Management Science*, 23 (8), 830-841. http://dx.doi.org/10.1287/mnsc.23.8.830

Teese, D. (1976). *The Multinational and the Resource Cost of International Technology Transfer.* Ballinger: Cambridge, MA.

Tepstra, V., & David, K. (1985). *The Cultural Environment of International Business*, Cincinnati,, OH: Southwestern Publishing Co.

Tihanyi, L., & Roath, A. S. (2002). Technology Transfer and Institutional Development in Central and Eastern Europe. *Journal of World Business*, 37, 188-198. http://dx.doi.org/10.1016/S1090-9516(02)00077-9

Van Gigch, J. P. (1978). *Applied General Systems Theory*. New York, NY: Harper and Row.

William, F., & Gibson, D. V. (1990). *Technology Transfer: A Communication Perspective*. Sage: Beverly Hills, CA.

Woolgar, S. (1987). Reconstruction Man and Machine: A Note on Sociological Critiques of Cognitivism. Cambridge, MA: MIT press.

Zaltman, G., Dundan, R., & Holbeck, J. (1973). *Innovation and Organizations*, New York: Wiley.

Zhao, L. M., & Reisman, A. (1992). Towards Meta Research on Technology Transfer. *IEEE Transaction on Engineering Management*, 39 (1), 13-21. http://dx.doi.org/10.1109/17.119659

Table 1. Various Definitions of Technology from Previous Literatures

Year	Scholars	Definitions
1968	Merrill	Technology connotes the practical arts, bodies of skills, knowledge and procedures for making, using, and doing useful things.
1968	Strassman	The tools, a stock-pile of utensils, but to a kind of tool-using behavior, a set of methods for making specific goods.
1970	Jones	The way in which the resources inputs are converted into commodities.
1971	Hawthorne	The application of science to solve well-defined problems.
1972	Galbraith	The systematic application of knowledge to practical tasks.
1976	Teese	A set of knowledge or experience related to the production of a product or the implementation of a process.
1981	Hawkins and Gladwin	The specialized knowledge pertaining to the production of the goods and services in organized economic activity, including the knowledge and skills required to manage a set of interrelated technical processes.
1983	Pacey	The application of scientific and other organized knowledge to practical tasks by ordered systems that involve people and organizations, living things, and machines.
1987	Woolgar	An integration process of physical objects, the process of making the objects and the meaning associated with the physical objects. These elements are not distinctive and separable factors, but form a seamless web that constitutes technology
1989	Goulet	The application of science because of their special relationship.
1991	Methe	A process where its origins and destination are connected and its dynamic nature is highlighted.
1992	OECD	A structure or a network due to various feedback loops between it and other sub-systems within a society, and to its obviously non-linear development projections
1992	Natarajan and Tan	The knowledge or expertise that is required in the production or assembly of a given good. Technology therefore embodied in the related machinery and utilized by a firm.
1996	Levin	Technology is not really a ‘thing’; it is better characterized as an approach. It is the application of scientific principles to solve practical problems. Technology has been described as having three facets: material artifacts (things), the use of artifacts to pursue a goal, and the knowledge to use these artifacts.
1996	Burgelman et al.	The theoretical and practical knowledge, skills, and artifacts that can be used to develop products and services as well as their production and delivery systems. Technology is embodied in people, materials, cognitive and physical processes, facilities, machines and tools.
1998	Lovell	Technologies are separated into ‘product technologies’ (associated with the physical and engineering aspects of equipment) and ‘process technologies’ (associated with the processed by which problems are solved).
2002	Tihanyi and Roath	Information such as a patent, know-how or trade secrets. Conversely it can be modified as equipment, component assemblies/parts or as a final product. Production techniques/processes, which require necessary skills to apply different methods of production, represent a combination of tangible and intangible technology. Technology can also include information that is not easily reproducible or transferable.
2003	Maskus	The information necessary to achieve a certain production outcome from a particular means of combining or processing selected inputs which include production processes, intra-firm organizational structures, management techniques, and means of finance, marketing method or any of its combination. Technology may be codified in formulas, blueprints, drawings, and patent applications or uncodified in the sense of requiring implicit know-how on the part of personnel.
2006	Reisman	The development and application of tools, machines, materials and processes that help in solving human problems.

Source: Sazali and Raduan (2011)

Table 2. Various Definitions of Technology Transfer

Scholars	Viewpoints
Hall & Johnson (1970)	A technology system in terms of whether it is embodied in people (person-embodied), things (product-embodied) or processes (process-embodied).
Rogers (1962)	A process by which an organization adopts an innovation made by another organization.
UNCTAD(1973)	The act of transferring the needed technical knowledge that has been designed and managed.
Gigch (1978)	The transfer of 'inventive activities' to secondary users.
Jeannet & Liander (1978)	Technology transfer consists of any element or combination of research, development and engineering transferred across national borders.
Sherman (1981)	The application of technology to a new use or user.
Derakhsahani (1983)	An acquisition, development and utilization, of technological knowledge by a country other than in which this knowledge originated.
Kanyak (1985)	The transmission of know-how to suit local conditions, with effective absorption and diffusion both within and from one country to another.
Rodrigues (1985)	An application of new technology to a new use or user.
Tepstra & David (1985)	A cultural system concerned with the relationships between human and their environment.
Shiowattana (1987)	A learning process wherein technological knowledge is continually accumulated into human resources that are engaged in production activities; a successful technology transfer will eventually lead to a deeper and wider accumulation of knowledge.
Derakhshani (1987)	A country's acquisition, development and use of technical knowledge.
Das (1987)	Technology transfer can be the production of new product (product or embodied technology transfer) and more efficient production of existing products (process or disembodied technology transfer).
Hoffman & Girvan (1990)	Technology transfer needs to be perceived in terms of achieving three core objectives: the introduction of new techniques by means of investment of new plants; the improvement of existing techniques and the generation of new knowledge.
Williams & Gibson (1990)	The process of transferring the knowledge and concepts from developed to less-technically developed countries.
Hayden (1992)	The kind of knowledge that can be used as inputs, such as patents rights, scientific principles and R&D, but which must be able to be used to make products.
Zhoa & Reisman, (1992)	The *economists* tend to define technology on the basis of the properties of generic knowledge, focusing particularly on variables that relate to production and design. The *sociologists* tend to link technology transfer to innovation and to view technology, including social technology as a design for instrumental action that reduces the uncertainty of cause-effect relationships involved in achieving a desired outcome. The *anthropologists* tend to view technology transfer broadly within the context of cultural change and the ways in which technology affects change. The *business* disciplines tend to focus on stages of technology transfer, particularly relating design and production stages, as well as sales, to transfer. *Management* researchers are more likely than others to focus on intra-sector transfer and the relation technology transfer to strategy. The recent researchers have focused on alliances pertain to the development and transfer of technology.
Roessner (1993)	The movement of know-how, technical knowledge, or technology from one organizational setting to another.
Levin (1993)	A socio-technical process implying the transfer of cultural skills accompanying the movement of machinery, equipment and tools. Transfer of technology is both the physical movement of artifacts and also, at the same time, transfer of the embedded cultural skills.
Gibson & Roger (1994)	The application of information where the process usually involves moving a technological innovation from an R&D organization to a receptor organization.
Autio & Laamanen (1995)	An 'intentional, goal oriented interaction between two or more social entities, during which the pool of technological knowledge remains stable or increases through the transfer of one or more components of technology.
Farhang (1996)	Transfer of technologies in cases of manufacturing processes requires not only the transfer of technological knowledge in the form of process sheets, blueprints, products, and materials specification, but also the transfer of know-how of high-calibre engineering and technical personnel.
Phillips (2002)	The process by which ideas and concepts that move from the laboratory to the market place.
Mascus (2003)	Any process by which one party gains access to another's technical information and successfully learn and absorbs it into the production function.

Source: Sazali and Raduan (2011)