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Tutoring Technology through OEM Arrangement: Case of Japan's NEC and Korea's DEC*

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There have been many studies on technological learning, especially as it relates to the latecomer firms from developing countries. However, unlike the current literature, this study argues that in order to overcome various challenges in technological learning, close interaction between the learner and the technology's originator (i.e., tutor) is needed. Based on the tutorials, which begins with the diagnosis of the learner's initial capabilities, the learning firms are able to set a higher standard for learning, making them more successful and efficient. The article, which is based on the case study of two firms involved in original equipment manufacture (OEM), shows that the effectiveness of technological learning is determined to a great extent by the technology originator's tutorials. A simple analytical framework is presented to explain why this is so. This study also attempts to contribute to the growing literature on international production network, with OEM as its modality.

JEL Classification: F20, F21, O32
Keywords: technological learning, technology transfer, international production network, latecomer company literature, technological frontier company literature

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1. INTRODUCTION

The objective of this study is to analyze the process of technology development for developing countries (DCs) and highlight the significance of interaction between DC firms and multinational enterprises (MNEs). Ever since Adam Smith noted of a pin factory which increased the quality and quantity of output without equivalent input, the study of economic development has been giving its active attention to the impact of learning and specialization which seem to enhance not only productivity, but also overall product quality. Arrow's (1962) seminal work further linked the concepts of learning and productivity increase, and technological learning (TL) has been considered as an endogenous ingredient behind productivity increase and technology development as a whole. TL has also been included in the recent new growth theories as a component for increasing returns. For DCs, the TL literature has concentrated on the accumulation of technological capabilities (TCs) – that is, the process of DCs's accumulation of TCs and industrial competitiveness are considered part of the learning process.

Studies have identified a number of factors that influence the process and effectiveness of TL. In terms of its effectiveness, there has been a debate on the role of the government versus market forces as the key factor, for example. In terms of its process, the literature has identified the incremental steps (the trilogy of adoption, adaptation, and innovation) as well as leap-frogging steps (including the reliance of the others's, fore-runners's R&D expenditure). However, while the current literature has provided much understanding on TL, it has not analyzed in detail the significance of the interactive nature of TL. This study argues that as technology (as target of learning) becomes more sophisticated, its tacit elements become more significant, thereby increasing the importance of the role of the originator of technology (often MNEs) as the potential 'tutors' of technology. Hence, this article highlights and analyzes the process itself as a main determinant of TL's effectiveness.

This study explores this issue through a case study on the interactive learning process of Japan's Nippon Electronics Company (NEC) and Korea's Daewoo Electronics Company (DEC). NEC engaged in an original equipment manufacturing (OEM) arrangement with DEC during the 1980s, where Korea (and DEC) was considered as a learner.[1)] In asking DEC to provide specific sets of products (consumer electronics items), NEC has transferred not only hardware and blueprint-oriented technologies, but also the implicit, uncodified technologies that are based largely on practical know-how and experience. It was through this active interaction that DEC became an effective learner, learning what and how to learn. This article further provides a simple framework on the interactive nature of the TL, based on the case study and review of literature.

Overall, OEM mainly involves supplying firms manufacturing finished equipment to the buyer's specifications, to be sold under the buyer's brand name. OEM buyers specify the design, packaging, styling and quality requirements to the suppliers. They also investigate facilities, manufacturing systems and quality control programs, and provide advice to the suppliers. In many OEMs, the buyers also provide their own engineers who will act as trouble-shooters.

OEM can be further described as vertical quasi-integration (see Blois 1972) or as obligational subcontracting (see Williamson 1985). The major differences are that OEM is related to inter-firm arrangement that involves buyers (MNEs) and suppliers (DC firms), and that it usually lasts longer than 'typical, arms-length' subcontracting without necessarily involving equity investments. As indicated in the industrial organization literature, this type of arrangement can be advantageous for both parties, as both tend to form stable, long-term relationships that reduce transaction costs as well as principal-agent problems while establishing the inter-firm settings for technological partnership.

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[1)] OEM mainly involves supplying firms manufacturing finished equipment to the specifications of the buyer, to be sold under the buyer's brand name. For more detailed analysis, also see Cyhn (2002).

MNEs' vertical integration and subcontracting activities in international production network (IPN). With the increasingly globalized economic world, observers have witnessed a rapid rise in IPN, as indicated via increasingly inter-regional activities of MNEs and non-equity inter-firm strategic alliances. The reasons for the recent rise in IPN seem clear. For technology-sensitive sectors such as electronic products, the definition of standards is a critical element of competition: product life cycles are short, and technological change is rapid and subject to disruptive innovations. In such markets, cost-competitiveness must be combined with product differentiation and speed to market. Cross-border networks allow firms to combine these very different market demands effectively (Borrus *et al.* 2000).

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Currently, there is only a small number of studies recognizing the significance of OEM (see Cyhn, 2002; Ernst, 1994; Hobday, 1995). Although these studies have delineated its significance and described the benefits and costs to both suppliers and buyers, a more conceptualized analysis of OEM as an (IPN-oriented) arrangement is still lacking in the literature. These studies have tended to describe the arrangement, and then directly engage in the case studies to analyze its impact. This article hopes to make a contribution to this newly growing literature by offering a more detailed and theoretically conceptualized analysis on OEM (and IPN) – based on the literatures from the (i) multinational enterprises, (ii) subcontracting, (iii) vertical integration, and (iv) exporting and technology transfer. OEM's relation to IPN and TL will also be surveyed. Through this analysis, this article further aims to explain the motivations and strategies of both suppliers and buyers of OEM, and how it has allowed the selected East Asian firms to upgrade their technological and export competitiveness.

The next section provides a brief literature review on the study of TL. It is followed by an analysis of the interactive nature of TL, which highlights the significance of tutors of technology. Then, a case study of the interactive relationship between NEC and DEC is presented, based on their OEM arrangement. The Conclusion summarizes and identifies a number of implications arising from this study.

2. LITERATURE REVIEW

Before the main issues can be addressed, a brief list of concepts and terminology needs to be presented. Generally, technology can be defined as an applied collection and assembly of knowledge which may also include scientific innovations. It is considered as organized (formal or informal) discovery, learning, and application of mechanical engineering. For this study, technology is further considered as the accumulated set of experience, knowledge, and expertise that are commonly expressed through new management, organization, invention or innovation of processes and products. Technological change occurs when this new information is acquired and utilized in the production of goods.

There are three important aspects of technology as knowledge good. The first is the universal versus specific aspect – that is, some elements represent widely applicable understanding and direct scientific knowledge or knowledge related to well-known and pervasive applicable principles, while other areas of knowledge are specific to particular 'ways of doing things', the experience of the producer, the user, or both. The second aspect is articulated versus tacit – that is, some aspects of knowledge are well-articulated, even written down in considerable detail in manuals or articles, and taught in schools. Others are largely tacit, mainly learned through practice and practical examples that cannot be entirely transmitted in an explicit, algorithmic form. Lastly, there is the public versus private aspect – that is, some of the knowledge involved in the use and improvement of technologies is open and public. The most obvious examples are scientific and technical publications. However, other aspects are private, either 'implicitly' because they are tacit anyway, or explicitly in the sense that secrecy or legal devices such as patents protect them.

2.1. Definition and Process of Technological Learning

TL can be defined as 'the way firms build and supplement their knowledge bases about technologies, products, and processes, and develop and improve the use of the broad skills of their work-forces' (Hobday, 1994, p. 832). For DCs, TL begins with transferred technologies from more developed countries. Lall (1992, p. 181) stresses that '(DCs') ... technology development always needs technology imports from advanced countries'.

The literature suggests that TL is costly, systematic, and active. In stating that the learning processes of firms need to be routinized, Teubal (1987) believes that with constant market failures and other constraints, successful TL is a difficult but critical component of DCs's overall economic development. In stressing the importance of the accumulation of learning capabilities (or 'learning to learn'), Stiglitz (1988) believes that the past half century has been marked not only by greater specialization in production, but also by greater specialization in learning.[2)]

Technical knowledge and information often comes 'embodied' in foreign machinery and equipment; and since technology transfer does not necessarily

[2)] Termed as 'localized learning,' Stiglitz also emphasizes that learning capability based on one area cannot be easily transferred to another. Just as technology cannot be simply purchased off the shelf, neither can TL easily be attained by simple market transaction.

include knowledge transfer, much of the development (learning or ability to 'disembody' technological potential) remains the DC's own task. Technology is implicit in the sense that the seller always possesses more information about its use than could be embodied in the blueprints, training, etc. sold to the buyer, and that its transfer accordingly involves a significant degree of uncertainty. Based on the complex nature of technology as mentioned above, this also means that the DC's learning process should involve more than passively attaining foreign blue-prints from the 'freely available international shelf' (Katz, 1989).

Most of the TL studies tend to be a variation (and an extension) of a series of adoption, adaptation, and diffusion. In other words, when the detailed descriptions of the series of stages are simplified, they fundamentally address the stages of learning from foreign technologies into developing their own. Another way to interpret this process is acquisition and assimilation of foreign technology, followed by generation of own technology (Lee *et al.*, 1988). It should be noted, however, that these steps are not to be considered in a linear sense, but more interactively.

Overall, TL takes place within routine activities of production, distribution, and consumption, and produces important inputs to the process. The everyday experiences of workers, production engineers, and sales representatives influence the agenda determining the direction of innovative efforts as they produce crucial knowledge and insights. Such activities involve learning-by-doing (increasing the efficiency of production operations), learning-by-using (increasing the efficiency of the use of complex systems), and learning-by-interacting (involving users and producers in an interaction resulting in product innovation). Thus, the most important forms of learning may be fundamentally regarded as interactive processes. Furthermore, since innovation reflects learning and accumulated experience and know-how as much as it does novelty, and since learning arises partially out of routine activities, innovation will be firmly rooted in the prevailing economic structure.

2.2. Modalities for Technological Learning

The literature has also identified and distinguished between different modalities of learning, which can be divided into three broad categories. The first relates to the internal source of TL. This refers to those types that usually occur within the firm without necessarily having external input.[3)] It can be considered as a form of 'self learning' – the increase in productivity and efficiency at the production level as well as the adoption of new technologies (product or production-based) are the main emphases here. The second type is the external source of TL. This refers to those TL efforts that are largely dependent on external forces and refer to market mediation, such as purchasing or licensing new technologies. Lastly, the interactive learning types, which can be considered a combination of both internal and external modes for TL, are highlighted in this study.

For technology transfer and subsequent learning, arms-length, market-mediated contracts can be arranged although they may face certain principal-agent problems. In other words, because the learners do not have complete information on the technology involved, they are uncertain about its effectiveness. The transferability of TCs, as opposed to hardware, is critical to the DCs; and it further suggests that conventional market transaction may not be sufficient or appropriate. As will be seen later, it appears that the issue of incentives is a critical component not only for technology transfer but also for the subsequent TL involved. Thus, knowing that so much of technology can be based on experience and know-how – and other forms of implicit knowledge – it seems that the role of technology providers also play an important part.

In sum, the first part of the literature review has shown that one of the major challenges for effective learning is technology's tacitness, meaning that the knowledge behind technology needs to be uncodified. In terms of technology transfer, this also means that the buyer (also the learner) of

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[3)] It should be noted, however, that in essence, all types of TL involve absorbing foreign (external) technologies.

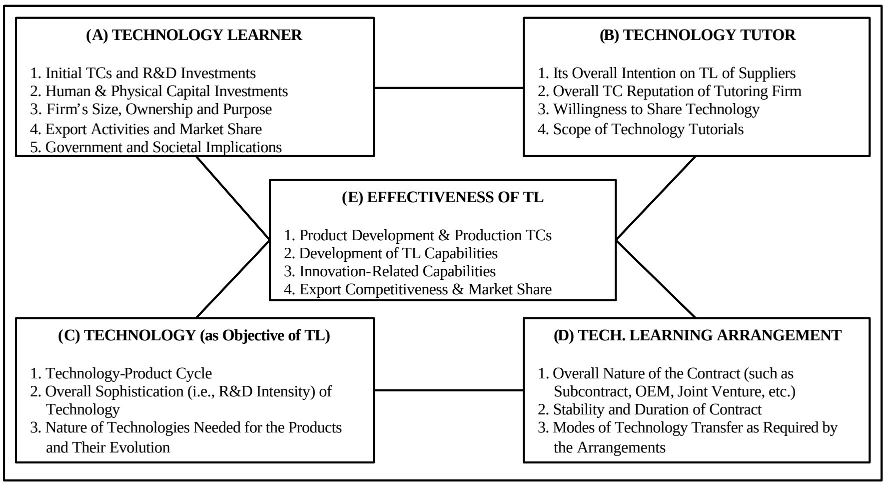
technology may not possess all the information necessary to fully absorb its uncodified elements. This is mainly due to the fact that technology's main characteristics are the skills, routines, and operational practices that accrue from collective learning processes. In terms of external sources of TL, technology cannot simply be purchased off the shelf. This means that while the potential for external sources of learning is significant, practicality (technology's price, availability, and learners's capacity, among others) dictates that this will probably not be fulfilled. With interactive learning, where the active involvement of the providers of technology is critical, it is important to determine if they have the incentives to offer the necessary knowledge on tacit elements to the learners. If not, as with external learning, interactive learning may not really be 'interactive' – that is, it may also involve a type of arms-length transaction. For the technology providers, such incentives are necessary if they are to actively assist the learners in disembodying the technology's tacitness. This is a critical issue which will be discussed in succeeding sections.

2.3. Framework for Interactive Learning

This study focuses on OEM-induced learning between NEC and DEC as a case study. OEM as an inter-firm arrangement seems to provide incentives for both learners and tutors for interactive TL opportunities. It would be erroneous to suggest, however, that OEM will automatically lead to effective TL by supplier firms. Observers require a more complex understanding of TL to study OEM, and it is that which this study aims to provide in the form of an analytical framework.

The analytical framework presented here has several purposes. First, it identifies four main factors of TL, namely: (i) technology importers (or learners), (ii) technology suppliers (or tutors), (iii) technology itself as target of learning, and (iv) arrangement in which technology transfer and learning occurs. Second, the four components were selected to emphasize the interactive nature of TL. Effective learners may induce more effective and

Figure 1 Analytical Framework



sophisticated tutors, technologies and so forth. Indeed, among the four factors, the learner's capabilities may be the most important. However, there may be also cases where the efforts of willing and capable learners are hampered by the lack of corresponding transferors (or technology tutors), technologies, or by inadequate arrangements. Thus, while these are overlapping components, there are also reasons why they need to be studied individually as well. Even though effective technology transfer requires a variety of actions, the main issue still depends on the nature of the technology and the transferees.

Third, this framework aims to allow a comparative study of OEM and other, more formal learning modes, such as licensing or FDI. The other modes of technology transfer also encompass learning opportunities although often in different forms. Also, as with other modes of technology transfer, OEM offers opportunities for both formal and informal means of technology transfer and subsequent learning. The combination of the two are necessary, for in many instances, together they will lead not only to the inflow of technologies but also the knowledge, experience, and know-how of more advanced firms and engineers. A more detailed description of the framework's major components is presented below:

(i) *Technology Learner (A)* refers to DC (Korea in this case), OEM-supplier firms, attempting to adopt and adapt foreign technologies. Here, the local firm's efforts in TL and TC acquisitions are largely analyzed through the levels of R&D and human capital investments, design capabilities, and export competitiveness. Their TCs before and after the learning experience (OEM or otherwise) are also compared, as are their efforts to get OEM contracts while increasing their exports. Their export activities and market share are analyzed. The firms' management decisions, in terms of the TL route taken and the willingness to import foreign technologies, are also considered.

(ii) *Technology Tutor (B)* usually refers to MNEs (i.e., OEM buyers), as they are also the source of technology for the DC firms. Their capabilities and incentives to teach technologies are considered. This includes the technologies they provide, the quantity and quality of the interactions (tutorials), and their effectiveness. The role of the technology providers does not end when technologies are transferred. The scope and effectiveness of technological support provided by them is an important factor for the overall success of the recipient's TL.

(iii) *Technology (C)* itself is relevant, for some technologies induce more learning than others. Through a more qualitative manner, the technology's scale, complexity, skill needs, and rate of change are also identified. Every industry faces either a fluid or maturity stage that has an impact on its pace of TL. In a fluid stage, product technologies change quickly and product differentiation is considered to be the most important aspect. In a maturity stage, production technologies (efficiency) and price become more important than product differentiation (which itself becomes standardized). Thus, in each type of technology, there are distinct (and evolving) dynamics for the learners and tutors.

(iv) *Arrangement (D)* in which the learning of technology occurs is analyzed. The incentives of both parties can be influenced by the arrangement in which they form their partnership. The most positive ones seem to be those that are stable and long-term, with limited friction between the two parties. The purpose of their arrangement (whether simply to meet short term OEM orders or as a long term strategic partnership) is identified. Thus, OEM can be compared with other learning arrangements, mainly licensing and FDI. The other important considerations are firm management, the nature of the contract, length of arrangements, and modes of transfer and learning.

(v) These factors largely account for the *Effectiveness of TL (E)*. This study will consider the effectiveness of factors such as changes in product and production development, especially in relation to technological upgrading. The development of TL capabilities is also important. TL capability describes the ability of firms to learn more sophisticated technologies efficiently and effectively. As the literature suggests, learning is not an automatic process and requires diverse capabilities. The term 'learning to learn' can be applied here as well. This leads the firm to more innovation-oriented activities, combined with (independent) technological upgrading of its products.

Even for TL at the firm level, the influence of government policies cannot be under-estimated, especially for Korea. Most notably, government measures can affect the capabilities and incentive of learners. This is particularly true of the Korean government, with its numerous promotional and selective policies. Government policy can also alter the motivation and incentive of the technology suppliers, such as the government's foreign technology import regulations.

3. CASE STUDY

This section present the case study of OEM and technology tutorial experience between Korea's DEC and Japan's NEC. It begins with a brief background analysis of the two companies, followed by the study on how DEC was able to learn from NEC within the modality of international production network (IPN) and OEM.[4)]

3.1. Background of DEC and NEC

DEC is part of the Daewoo Group, a major Korean chaebol. Woo-Choong Kim founded Daewoo in 1967 as a small-scale textile operation. In 1976, President Chung-Hee Park personally asked Kim to take over a loss-making, state-owned machinery plant, thus giving rise to Daewoo Heavy Industry. Since then Daewoo has diversified into cars, electronics, hotels, aerospace, chemicals, construction, computers and financial services. It has grown into a family of twenty-six cross-held companies, with group sales totaling $68 billion in 1996.

DEC was established in 1974 as an assembler of radios and amplifiers. It recorded exports worth $2.6 million in its first year. DEC then acquired Joo-Ahn Electronics in 1975 and Dae-Han Electronics in 1983; the former allowed DEC to become a major producer of radios, while the latter formed the core of its consumer electronics production. With a large-scale plant in Kumi in 1976, DEC, along with LG (then known as Goldstar) and Samsung, became a major electronics manufacturer in Korea.[5)]

By the early 1980s, DEC's four major plants possessed a high level of

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4) IPN refers to the increasingly globalized activities of MNEs based on non-equity inter-firm strategic alliances. Increasingly, international production – the production of goods and services in countries that is controlled and managed by firms headquartered in other countries – is becoming a core of the process of globalization.

5) From the beginning, Daewoo relied on OEM to export. The first was with the G.E. and radios. Later, it supplied amplifiers to Germany's Telefunken and Zenith of the U.S. By 1982, DEC diversified itself as a comprehensive consumer electronics maker, exporting televisions, VCRs, cassette recorders, car stereos, refrigerators, and washers.

Table 1 Growth of DEC During the 1980s

(unit: 100 million)

Item	1983	1984	1985	1986	1987	Total ('83-'87)
Sales	1,800	3,800	5,900	9,000	12,000	32,500
Exports	850	1,780	3,000	4,800	6,600	17,030
Investments	130	405	590	785	560	2,470
- Facilities	35	160	150	55	40	440
- Equipments	55	155	310	560	300	1,380
- R&D	40	90	130	170	220	650

Source: Daewoo Group (1998).

production capability, due largely to its 'deep pocket' advantage as a chaebol, in addition to government incentives.[6] The rapid growth of DEC occurred during the 1980s with increased exports and product diversification, as shown in the table below.

In comparison to the 1970s, sales have increased dramatically, fuelled by acquisitions and the expanding domestic market. The R&D expenditure during the mid-1980s increased five-fold, yet it mostly remained around two percent of total sales, while the expenditure on equipment was about four percent. The table above shows that the R&D share of total sales ($4.8 billion) has increased to about ten percent to over $500 million, a rapid rise from the two percent average during the 1980s. Nevertheless, the figures also indicate that DEC's R&D investment during the earlier learning period was not as extensive.

NEC Corporation was founded in 1899 (NEC, 1998). Originally called Nippon Electric Company, it was the first Japanese joint venture with foreign participation. Its partner was the Western Electric Company (presently known as AT&T Technologies, Inc.) of the United States. NEC's first overseas sales office was established in Seoul, Korea in 1908 when Korea was under Japanese rule. In 1924, NEC entered the radio communication

[6] During this period, Daewoo assembled over 1.5 million television sets, 60,000 video-cassette recorders, 1.8 million cassettes, 240,000 radios, 400,000 refrigerators, and 600,000 car-stereos. By 1987, television production increased to 2.4 million and video-cassette recorders to 420,000 (Daewoo Group 1998).

industry and formed a close alliance with the Sumitomo industrial group, while loosening its ties with Western Electric as well as the ITT Corporation. NEC became a public company in 1949 and by 1954 had entered the computer industry. As a leader of technology in fields of communications, computers, semiconductors, and other electronics, NEC posted sales of $43.4 billion in 1996.

3.2. OEM-Induced Technological Tutorial

When NEC looks for OEM suppliers, the most important qualities are, in order of importance: (i) quality of products, (ii) price of products, and (iii) reliable delivery. The process begins with NEC purchasing samples from potential suppliers. After rating their quality, NEC compares prices, which then leads to negotiations with a small number of potential suppliers. In choosing it Korean suppliers, NEC is especially concerned about their use of what its engineers call 'internal technology', such as semiconductors and quality control. On average, NEC sends around ten engineers to its suppliers for technological inspection and tutorials for about one month every year. NEC actually has a formal training program for its engineers on tutoring the OEM suppliers, but the details are not released to the public.

NEC at first buys only one product/model and then expands the relationship if it proves successful. Currently, in consumer electronics, NEC deals mainly with DEC and L.G. of Korea, as well as with some smaller Japanese firms. Usually, the Korean firms initiate the contact process with NEC. In negotiating OEM contracts, one key issue is to choose an exchange rate on which to base the arrangement. NEC also considers the management capabilities of the suppliers. In consumer electronics, NEC notes that market demands change very quickly. Hence, the need for the suppliers to change along with the buyers is critical. In fact, NEC notes that one of the main reasons why DEC became its main OEM supplier in consumer electronics was because their management was more flexible with the arrangement than others. NEC believes that OEM provides a good opportunity to exchange (or combine) their brand image and marketing networks for the Koreans's low costs and efficient production capabilities. The fact that NEC can attain quality goods at low prices allows it to seek OEM rather than its own FDI. This way, according to NEC, it can avoid the cost of setting up FDI operations in Korea. Furthermore, the FDI option became even more limited because of the Korean government's restrictive policies. This made OEM a more feasible choice for NEC to benefit from the location advantage that Korea could offer.

In transferring technology, NEC stresses the necessity of 'face-to-face' interaction. Technologies cannot be learned via simply transferring blueprints or components. Indeed, it is difficult to distinguish when technological transfer and learning actually occur. Clearly, learning does not occur automatically with the purchase of technology (in capital goods, etc.). Such learning/tutoring is an incremental and interactive process, involving many face-to-face discussions and much trial-and-error.

NEC asserts that most consumer electronics, such as television sets and videocassette recorders, now have standardized technologies. However, there are still many areas for improvement. In addition to audio and visual qualities, energy savings is now becoming more important. Beyond offering advice on product technologies, NEC feels that it has improved DEC's production capabilities considerably. For example, NEC helped DEC to create a quality control system that directly connects its R&D laboratories (designs) to the assembly lines (production). NEC found that while DEC had a reasonable level of quality control, it still produced many faulty products. To solve this problem, NEC asked DEC to implement modified NEC-style production lines. The new line allows each worker to have a particular responsibility, while maintaining the close teamwork important to high productivity. This in turn allowed each team to identify the source of the faults and ways to correct them. Implementing such new methods was neither easy nor quick. Many Koreans initially resisted the advice of the Japanese engineers. Yet, in the end, the implementation helped DEC to become a more effective producer.

NEC faced increasing competition from other Asian countries, such as China, using low wages as their main competitive advantage. However, the higher TCs of Korean firms (as its OEM suppliers) put them at an advantage when compared to the Chinese firms's lower product quality and less reliable delivery. Another concern is the quality of components. When products are assembled in a particular country, the firms are likely to use many intermediate goods from the same country. In a country of low TC, not only do the assemblers tend to be technologically inferior, but intermediate goods are likely to be faulty as well. This leads to faulty final products and delivery delays. NEC demands certain fault rates from its OEM suppliers, although these vary according to product and supplier.

It seems that to NEC and perhaps other Japanese firms as well, the increasing TCs of Korean firms through OEM is not a major concern. Korean firms still have weak brand image and marketing capabilities. NEC, therefore, mainly sees the Korean challenge not as a threat but as a motivation for it to create new products and technologies. Although the Japanese government at times attempts to restrict the outflow of technologies, some actually suggest that a greater flow of technology is better and that Japan needs to be the center of an 'Asian technology system'.

3.3. OEM-Induced Technological Learning

DEC's OEM arrangement with NEC of Japan started in 1981.[7)] According to the executives and engineers at Daewoo Television Research Center, NEC contacted DEC for an OEM arrangement because the high wages in Japan was preventing it from manufacturing mid-priced televisions on its own. NEC chose DEC with the help of outside consultants because,

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7) Of course, NEC is not Daewoo's only partner. For Daewoo, from colour monitors with RCA, to VCRs with Toshiba, air conditioners with G.E., personal computers with Fujitsu, and digital transmission equipment with Northern Telecom, creating and fostering global networks is an essential component of the firm's technology development. For the European market, it is also linked with Japan's Hitachi and Matsushita. Most of Daewoo's consumer electronics are exported under OEM.

as a chaebol, it was considered to have stable management and a capacity for large-scale production. Management stability and production capability were both seen as more important than DEC's initial TC since NEC had plans for active supervision of technology and quality control.

As is common for OEM suppliers, DEC provided prototype samples of their own 19-inch color televisions to be tested by NEC engineers. Prior to the arrangement with NEC, DEC was already manufacturing televisions for the domestic market and even exporting some to Australia. DEC had previously acquired its TCs through imitative reverse engineering and licensing a few key technologies. However, the technology transfer was not sufficient and the samples suffered from numerous inadequacies.[8)] To the surprise of DEC executives, NEC found over eighty problems, ranging from poor audio quality to faulty control knobs, with their television samples. In fact, lacking in experience and TCs, the DEC engineers state that (they) '...could not solve the problems ourselves, but were also unclear about knowing what to ask NEC so they can help us solve them...' Nevertheless, NEC was convinced that DEC could become a good OEM supplier and thus moved to establish the relationship. NEC assigned a group of engineers from Japan to the Daewoo Television Research Center. While the Japanese engineers were prohibited from revealing sensitive technologies, the relationship that was formed between NEC and DEC engineers fostered a high degree of tacit transfer of knowledge, experience, and know-how, as well as some technology blue-prints. As both parties had an interest in DEC's technology development and production of high quality goods, intensive interactions akin to technological apprenticeship took place.[9)]

The extent of technology transfer affected the price set for OEM transaction. When the potential for TL was significant, DEC reduced the

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[8)] Until the rapid TL from OEM occurred, one Daewoo engineer notes that its products were simply 'inferior imitations', sold overseas with lower prices. He also suggested that the earlier management lacked the genuine appreciation for technology, erroneously equating increasing exports with TCs.

[9)] Daewoo engineers note that about half of the corrections requested require a significant improvement in their TCs, while the rest only requires minor adjustments.

price of its OEM products to win the contract. There were a number of other factors which determined the price at which OEM products were contracted. Firstly, the capability of the supplier is important; if the firm is reputed to be a reliable and capable supplier, it can command higher prices. Secondly, the products themselves are considered; when sophisticated technologies are involved, the suppliers can claim higher margins. Thirdly, the quantity of the orders; the larger the order, the lower the price set by the suppliers. Lastly, the demand from the buyers to install new capital goods and facilities; the higher this demand, the higher the price becomes.

Technologically, televisions can be divided into four different quality categories: (i) visual quality, (ii) audio quality, (iii) safety, and (iv) overall design. As they believe that the core TCs are deeply rooted in experience, DEC engineers received much help from NEC in all these categories. For instance, in measuring the quality of sound and vision, DEC engineers initially relied on their 'eyes and ears'. Then their NEC counterparts introduced much more accurate electronic measuring devices. At the time, the Koreans had no idea that such devices existed. DEC adopted the devices and made them a part of its routine, having been instructed how to use them (i.e.: routinized TL) by NEC engineers. This routine had a spillover effect on other, non-OEM products as well.

DEC engineers maintain that the technologies and knowledge acquired from NEC were more significant than those from government research institutes (GRIs) or universities. Specific technical tasks (such as enhancing audio quality at a certain level) can be as complex and elusive as the effort to understand the science behind commercial technology, and no 'blue-print' may exist for such tasks. Interacting with engineers with more experience and knowledge is an invaluable way to learn, making stable technical assistance critical for technology transfer. Such technological assistance does not come only through OEM; they can also be found in licensing or importing capital goods. However, OEM tends to be more long term and can cover a wide-ranging spectrum of technologies. It also involves more detailed diagnostic analysis of a firm's TC needs and methods to solve technological problems, preferably interacting with more experienced and knowledgeable technicians and engineers. Thus, it is no surprise that DEC purchases much of its required technologies from the OEM buyers. Other transfer modes tend not to be as useful in these areas. International licensing, for instance, is often narrower in scope and the suppliers involved vary.[10] Technology licensers do not usually involve themselves in the wide-ranging technological needs of licensees over a long period of time.[11] Training offered by the licensers only concerns the licensed products; little else is addressed.

Perhaps the most important learning benefits of OEM are setting 'higher standards' for technologies and product quality. DEC could import or license some technologies from abroad, but identifying and reaching specific, tangible targets to enhance its TCs were not easy. Such targets also determined the technologies to be imported. Through OEM, the most important aspects of TL were adopting the buyer's technological standards and acquiring its methods of research and development, as well as testing and quality control methods. This has been very effective and efficient since the buyers, more than anyone else, could best locate DEC's weaknesses as well as the needed paths for TL. Thus, the first step towards enhancing TL capability via this partnership was the full technological diagnostic review of the learner by the tutor. This allowed DEC's learning to become more targeted and efficient. Afterwards, DEC needed ten to fifteen years to learn and fully internalize (and routinize) the technological standards of their OEM partners.[12] This is not to suggest, however, that the firm's TCs are now as high as those of NEC. Rather, DEC developed the capabilities sufficient to learn and absorb more sophisticated technologies. This was also seen in DEC's increased exports and R&D investments over time, as shown earlier.

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10) As noted earlier, the information failure on attaining technologies through licensing also hampered Daewoo's ability to seek this route (by increasing their transaction cost in acquired licensed technology).

11) The exception is when OEM buyers also become licensers.

12) One executive even said, '...transfer of technology can only happen between people, not between documents ...'

The OEM-induced TL from the buyers was most active during the 1980s. There were about ten separate meetings between the engineers, lasting for more than thirty days per year. During the meeting, various technology issues surrounding the OEM products were discussed and resolved. Such learning arrangements have been very effective according to DEC and more extensive and broad in scope compared to the others induced by technology licensing. One reason for this is the long-term relationship that developed between these two firms. On average, DEC seeks OEM arrangements that last at least five years.

TL was not the only motivation for DEC's seeking OEM. Another was to expand export capabilities and markets. The OEMs from NEC allowed DEC to enter more developed overseas markets. With a presence in such markets, DEC was able to further study the latest technologies available. This led to the improvement of its own product development and marketing strategies, complemented by purchased technologies.[13] Daewoo's brand image is weak in top export markets such as Japan, Europe, and the United States. Improving brand image, marketing and operational networks are very costly tasks and OEM offers an efficient alternative in building marketing skills. As an indication, DEC makes a larger profit from OEM products than from its own brands: it has been estimated that for a 19-inch color television, its OEM earns $109 in profits, while its own brand earns $95 only. The difference is due to the marketing costs of own-brand exporting. In fact, one DEC executive concludes that without OEM (to subsidize its own-brand exports), DEC could not have been a successful exporter, nor could it have sought product diversification.

OEM itself poses challenges. Constant negotiations with buyers take

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13) Daewoo continues to export own-brand televisions to the U.S. at a loss. This is felt necessary for long-term company growth. In order to enhance TC and brand image, they have to be present in the more developed markets. This shows the difficulties in OBM – even though Daewoo has attained a considerable degree of marketing capabilities via OEM. Due to the high costs involved, like many other Korean firms, Daewoo has decided to combine the two (OEM and OBM) modes of exports. As indicated later, while some OEM buyers place certain restrictions on OBM exports, it does not seem to be a major problem for the Korean firms – especially since such agreements have time limitations.

place on price, quality, and specifications. An important issue is the defect rate in products. NEC demanded that DEC maintain a fault rate of 1/500. While DEC agreed to this as the ideal, its immediate achievement was very costly. A further problem is the variability in quantities ordered. This poses capacity problems when buyers demand increased production from suppliers. Despite such problems, the freedom gained by DEC from marketing, distribution, and after-sales networks in OEM allowed them to concentrate their resources in enhancing technological and production capabilities. By the end of 1997, the OEM relationship with NEC ended as the Japanese firm decided to withdraw from the television market. DEC quickly secured another long-term contract with Sony, a larger and technologically advanced OEM buyer. This was a clear indication of DEC's enhanced TCs and reputation within the IPN.

To summarize, OEM has enhanced DEC's competitiveness and has allowed its production technology to reach capability levels that are comparable to other leading firms. Today, DEC has one of the largest production capacities in the world. Inspite of this, however, DEC has yet to achieve its goal of technological 'independence'.[14] While DEC claims that about ninety percent of key technologies are produced within the firm, the two fundamental areas where improvements are needed are intermediate goods technology (especially the memory and signal-related integrated circuits) and design capabilities. Because DEC still depends on foreign technology to meet its needs in those two areas, it trails behind its rivals in the development of new products. A third area of weakness is basic scientific research and capability. This means that the firm still lags behind in technological creativity (or innovation), the key component of design capability. Nevertheless, it should not mean that the limitations on technological independence were due to OEM (i.e., 'OEM Trap') as argued by Ernst. As the case study indicates, OEM has allowed for enhancement

[14] Daewoo considers its final goal to be full technological independence, to have the capacity to produce all of the technologies it needs. Its executives believe that the continued import of technologies has kept Korean firms behind their foreign rivals (in terms of new product development).

of DEC's TCs, it seems that its marketing and exporting costs have become a more significant cause for such a heavy reliance on the arrangement.

4. CONCLUSION

This study began with the question of how a Korean electronics firm was able to become an effective learner despite a low inflow of formal (hardware) technologies.[15] It is argued that DEC's participation into the IPN via OEM has been the indispensable component behind its TL capabilities acquisition. The OEM arrangement has worked well for the Korean electronics industry because, as a mode for technology transfer, it combined the incentives (and capabilities) of both buyers and suppliers for effective TL. As up to 80 percent of the industry's export was through OEM, its significance is clearly indicated. The case study verified this with the analyses of the TL efforts of DEC's major export item in television.

The case study also showed the significance of the tacitness challenge of TL, and through the analytical framework and case study, it analyzed how the incentives of OEM buyers allowed Japan's NEC to become an effective and necessary tutor. Tacitness in technology causes one of the most significant difficulties for firms attempting to learn. This means that firms are not always clear on what can be embedded within a given technology. Knowledge of this is essential, since it allows them to fully absorb, adapt, and later innovate from the technology. The case study verifies this and shows that DEC has been able to overcome the tacitness challenge in TL via their interactive learning through OEM.

Largely stemming from this 'tacitness' challenge, the study also shows a certain limitation on 'self learning' (reverse engineering, imitations, etc.), mainly because the firms lacked clear knowledge of each technology. The

[15] Daewoo Group, after the financial crisis of 1997, was disbanded. DEC is now operated more independently, with a level of foreign ownership. This issue is not addressed here as it is beyond the scope of this study.

tacit and implicit elements of the technologies discourage the learners from benefiting from them fully. As discussed, this is especially important since the transfer of TCs (and 'codifying' them), rather than mere hardware, has been the key challenge for the recipients. When foreign engineers explained the scientific and engineering details (also based on experience and know-how) behind the technologies, Korean engineers were better able to absorb the technologies and modify them further. Receiving assistance from the originator of the technology (i.e., MNEs) is not sufficient for effective TL. However, with the Korean firms willing to invest heavily in learning, it seems that such 'interactive learning' with the foreign MNEs became an essential component of their TL success.[16)]

One of the first and most critical steps of IPN (OEM)-induced learning is the in-depth technological diagnosis that the MNEs can provide. This is an important step towards effective learning since, partially due to technology's tacitness, the learners are not always clear about what and how to learn, nor are they clear about their overall TL capabilities. One example from the case study is that DEC engineers were surprised that the NEC engineers found over 80 problems associated with the television set that were being exported already. As the provider of technology usually possesses more information compared to the recipient, the latter struggles to fully exploit the technology's potential. This problem is more acute for DC firms, with their lack of capabilities, information, and resources. Furthermore, even if the transferors are willing to give as much information as possible, many of the capabilities that are mostly based on experience or know-how cannot be explicitly written down in 'blue-prints'. Thus, while many factors traditionally considered important for TL – such as R&D investments – are indeed important, learning also involves and requires active interactions with

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16) A counter-evidence (i.e., what would have happened if DEC did not engage in OEM) is not available for comparative analysis. Nevertheless, it is noteworthy to state that a majority of electronics exports during the period of through OEM – and thus DEC was not alone in this effort. Although it is beyond the scope of this article, another study (Cyhn 2002) finds that those without similar interactive learning processes led to much difficulties and even failures.

foreign technologies and their originators.

As analyzed, the transfer of technology not only involves hardware (in equipment) or blue-prints, but embodied experience and know-how as well. It is noteworthy that while licensed technologies allowed many Korean firms to initiate the product development process, it was insufficient – as noted by over 80 problems identified in the DEC television sets. Both firms began manufacturing those products with licensed technologies and some imitative reverse engineering. This is why this study compares TL to learning how to cook: even if all the ingredients and instructions can be obtained, they may not necessarily result in a gourmet dish. There are other elements in cooking that cannot be clearly written down or fully absorbed by the learners quickly. Similarly, TL entails a great deal of trial-and-error, with interactive learning from the 'teacher'. While some can quickly sweep this process away as a function of capital investment, it can be seen that it requires a much more complex analysis.

This article also argues that OEM is not merely a form of subcontracting but that it is part of broader global phenomena within IPN. From a technology-centered perspective, it seems that no firm (or country) is totally independent of others' knowledge. This means that a key challenge for the East Asians' development process involves learning how they can benefit from this active flow of technology, beyond the necessity of creating technologies of their own. This increasing economic globalization has had a significant influence on the industrialization of DCs – and for this article, the issue of TL and TC transfer through OEM is highlighted. Indeed, UNCTAD states that international production – the production of goods and services in countries that is controlled and managed by firms headquartered in other countries – is at the core of the process of globalization.

This article has further revealed that two factors determine the success of OEM and subsequent accumulation of competitiveness: capabilities and incentives. The East Asian firms were able to enter the IPN via OEM because they had a high degree of TCs compared to other DCs (even though their wages/costs are much lower). Then, in serving as the OEM suppliers, their TCs gave the MNEs more 'incentives' to further transfer the technologies and TCs that have been the foundation for the success of many East Asian firms. This way, the East Asian firms have not only been able to transform their comparative advantage from one of low wages to one of high TCs, but they have also been able to learn and overcome many of the tacit elements in technologies as well. The capabilities of learners and the incentives of MNEs have further fostered successful development in East Asia – working as collaborators rather than as competitors/distant subcontractors has been one of the key factors behind its success.

Two important (cautionary) notes before attempting to benefit from this form of economic globalization need to be made. First, as technology has become a more important proprietary good, firms are more protective of it. This is ironic since this increasing importance and protection is coupled with the free flow of technologies worldwide. Indeed, when MNEs export technologies, they take full advantage of the 'ignorance' of DCs as technology importers. One Korean engineer notes that 'the (technology) exporter does not disclose the scope and characteristics of the technology when he signs a contract'; nor is the price for technology fixed in the international market: the price differs according to who wants it and how badly (Interview). It may be beyond the scope of this study to extensively analyze both the opportunities and inequalities involved in this economic globalization, but by taking a narrower view of OEM, it seems clear that a certain level of initial TCs is a necessary entrance condition. It is no coincidence that Japan's OEM has been mostly geared towards East Asia, despite their relatively higher wages than those of other DCs.

Second, statistics indicate that, while MNEs' sales activities are global, their technological activities tend to be home-based. From 1980 to 1989, the DC firms only participated in 1.5 percent of total partnerships. Those involving the U.S., the E.U., and Japan amount to almost sixty percent of the total. Furthermore, ninety-eight percent of the MNEs' overseas research institute laboratories are located in OECD or NIC sites (Freeman and Hagedoorn, 1995, p. 43). Thus, the promise of a global economy with a freer flow of technologies to the The East Asians has yet to reach its full promise since the capacity to absorb the technologies is still limited for them. In addition, within this network there is still a need for location advantage; the MNEs would seek partnerships with the DC firms only for their low costs (wages). This also means that this type of partnership may not necessarily enhance TCs at the national level. Thus, while opportunities for learning and development may be present within the network, they may not actually be realized. The experience shows that when MNEs only seek a low cost advantage, most of the technology-related activities are not diffused to the DC firms, the latter's role being to serve mainly as offshore assembly plants.

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