African Journal of Business Management Vol.5 (7), pp. 2874-2889, 4 April, 2011
Available online at http://www.academicjournals.org/AJBM
DOI: 10.5897/AJBM10.1370
ISSN 1993-8233 ©2011 Academic Journals

Full Length Research Paper

A spiral process model of technological innovation in a developing country: The case of Samsung

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Accepted 30 December, 2010

This article presents a spiral process model of indigenous technological innovation capabilities (ITICs) that shows how firms in a developing country initiate, imitate, improve and make innovative technologies. Any technological innovation passes through four stages: (1) technological innovation (TI), (2) transfer of technology (imitation), (3) adaptive technological innovation (improvement), and finally (4) indigenous technological innovation (local innovation). This paper reviews models and frameworks related to technological innovation capabilities (TICs) which are proposed in the context of developing countries. It then analyzes the Late-Starter, Samsung Electronics as a case in point to illustrate how Korean firms have built their ITICs. The model shows four developmental stages at Samsung Electronics as: (a) Entrance of foreign companies into the Korean market and their refusal to transfer their technologies to Samsung initiating its ITICs, (b) Samsung started TICs by means of reversing the engineering of imported foreign technologies and transfer of technology, (c) it improved TI by means of adaptive technological innovation strategy and finally (4) the capability to establish their own ITICs, to become one of the leading companies in the world which challenges firms from advanced countries in the global market. The paper also highlights the developmental changes in the semiconductor (DRAM technology) of Korea. Keeping past experiences in consideration, we conclude that this model provides useful implications for newly industrializing countries (NICs) following the same pattern of technological development.

Key words: Indigenous technology innovation capabilities, innovation in developing countries, spiral process model of technological innovation, Samsung Electronics Korea.

INTRODUCTION

Technological innovation and management is considered to be a key driving force in the development of an economy. The economic growth of both developed and developing countries depends upon it. Likely, the concept of indigenous technological innovation capabilities (ITICs) is also inevitable in both developed and developing countries. ITICs have grown considerably in the last few decades and it seems that this growth trend will continue. The case of Japan, South Korea, Taiwan (China) and Singapore shows that the development of their ITICs is based on "initiation-imitation-improvement-innovation". Even the U.S's development in technology and innovation is also based on the same model (Kim, 1980; Ozawa, 1974; NAS, 1973; Bolton, 1993).

The electronics industry of South Korea (hereinafter Korea) has made significant contributions in the electronics industry of the world. The Korean electronics industry has also accounted for the lion's share of economic growth in the country. The electronic industry of Korea started its remarkable rapid expansion and development during 1960s with the production of black and white TV sets, stereos and radio communication equipment through the international transfer of production technology (Kim, 1980). In the early stage of Korean development initiation, when the government sanctioned

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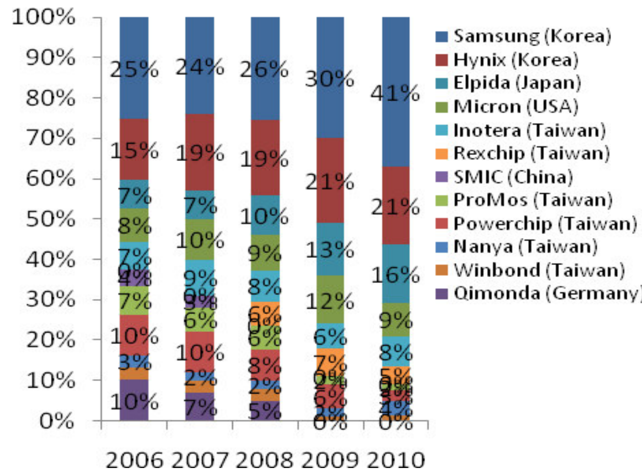

Figure 1. Global DRAM production share by firm. Source: Frank (2010) and iSuppli (2010).

imports of consumers electronic products as a means of "import substitution" as the national industrial policy and pursued an export-oriented industrialization strategy (Kim, 1997), it created opportunities for local entrepreneurships and companies to develop their ITICs. This creative crisis construction has proven to be a great source of ITICs for the latecomers-Korean electronics companies. During the 1970s, these companies have achieved remarkable achievement and rapid development in terms of process and production, speed and time, size and capacity, TICs and financial performance, and as such, have had a great impact on the electronics market of the world (Lee et al., 2004).

In its early stages of development, Samsung Electronics Company (SEC, hereinafter Samsung) had no proper technical skills and technologies. Many US and Japanese companies refused to transfer technology to Samsung, since it was dependent on foreign technologies. Samsung's initial strategy was "imitation" acquisition, assimilation, transformation and exploitation of products and processes from the US and Japanese companies. At that time, it was unclear and could not be anticipated that a company which mostly rely on imported foreign technology, having inferior products, with low and cheap prices, and poor quality and design would become one of the world's leading companies in the electronics market. It was also not predictable that it would become a "challenge to compete with" those companies which once denied to share and provide technology to it. It does not only catch-up, but also surpassed many leading DRAM manufacturing firms like Micron, Toshiba, Motorola and IBM in the global market. More than a decade, it is sustaining its No.1 industry rank in the DRAM market with the highest market share of 41% in 2010 as shown in Figure 1.

It is planning to invest a total of KRW 26 trillion (US$23 billion) in 2010, to include a capital expenditure of KRW 18 trillion (US$16 billion), semiconductors of KRW 11 trillion (US$9.7 billion), memory business of KRW 9 trillion (US$7.9 billion), system LSI business of KRW 2 trillion (US$1.8 billion), LCD of KRW 5 trillion (US$4.4 billion) and an investment in R&D for KRW 8 trillion (US$7 billion).

Technological capability is "the firm's ability to make effective use of technological knowledge in efforts to implement, assimilate, improve, use, adapt, change and create new technology" (Kim et al., 1989). Indigenization means to create technologies appropriate for the situations where they are applied (Shrivastava, 1985). Chen et al. (2006) defines ITICs as "a process to explore potential market with indigenous (in-house) R&D activities and foreign (external) knowledge acquisition". Some of the factors at a country level which can greatly contribute to ITICs are local technological capabilities, research and development investment, expertise of human resources, socio-cultural factors, education and universities, government support and entrepreneurships.

This study is a distinctive departure from the previous studies as it attempts to propose a spiral process model of TICs which builds up a continuous link in the three development stages. Since most of the previous studies have addressed the developmental prcocess by elucidating a model of three development stages, it did slight to deal with new trends in technological innovation activities (Choi, 2010). What would probably be the next stage or phase is the concern of the researchers. This study attempts to propose the spiral process on the basis of a new research scheme and a different model in TICs on the firm's level which differentiate it from the previous studies.

This paper also attempts to analyze the ITICs in a developing country by analyzing various case studies of TICs at Samsung as a case in point. The paper also reviews models and frameworks related to TICs which are proposed in the context of developing countries. The objective of this study is to examine the spiral process model of ITICs (Ali and Park, 2010) by analyzing the case of DRAM technological innovation at Samsung. Samsung's rapid technological innovation and emergence as the first innovative company of Korea in a very short time raises several research questions. (1) If Samsung was a late comer and many international firms were leading the electronics industry, what are the factors that contributed to Samsung's success? (2) How has Samsung surpassed the market leaders in the electronics industry? (3) If Samsung has emerged as one of the leader in electronics industry, especially in semiconductors, LCD and mobile phones, what are the innovative strategies that Samsung has developed that led to its success? (4) Can other firms in developing countries imitate the TICs model of Samsung? This paper also discusses Samsung's global strategy and its competitive advantages. The paper briefly reviews theories and concepts related to ITICs. It then analyzes Samsung as a case in point to illustrate how semiconductor firms in Korea initiated their technological capabilities which made Korea one of the world's leading countries in the electronics industry. Since the current literature is progressing, it is believed that this paper will also make a timely contribution to the existing literature on ITICs in developing countries. The remaining parts of the work are structured as follows. Both the theoretical and empirical researches are discussed to understand how developing countries developed their ITICs, followed by how technological capabilities are developed by a spiral model of technological innovation capabilities, after which a case study of Samsung which is applied to the model is presented and the work is concluded.

RELATED WORKS

Based on both quantity and quality analysis, many researchers (Xu and Chen, 2005; Chen, 1997; Chen et al., 2006; Xu et al., 1998; Kim, 1980, 1999, 1997; Lee et al., 1988; Lee, 2001; Kim, et al., 1989; Kim and Lee, 1987; Kim, 1998; Choi, 2010; Dahlman et al., 1987; Lee et al., 1988) have proposed different analytical frameworks and stage models for improving TICs in developing countries. This paper focuses only on stage models and frameworks which are related to the spiral process model of TICs. In both developed and developing countries, the pattern and nature of TI is different (Xu et al., 1998).

The models of TI in developing countries are based on several stages, for example, imitation stage, improvement stage and innovation stage. Although many researchers have proposed different stages and they have called upon them with different titles as shown in Table 1, basically there are three stages.

In developed countries, technological improvement efforts are based on scientific or applied research, but in developing countries it comes from imitation and improvement of imported technology. On the basis of Chinese's technological innovation experience, Xu et al. (1998) proposed a model "3-I Strategy" or "3-I Pattern" which stands for imitation, improvement and innovation as shown in Figure 2.

Some researchers have linked the models and frameworks developed in advanced countries to the models and frameworks proposed in developing countries. Lee et al. (1998) has linked the Korean's stage model of TI proposed by Kim (1980) with the well-known dynamic model proposed by Utterback and Abernathy (1975) as shown in Figure 3. Korea's three stage model follows a dynamic model in a reverse direction and evolves from a mature technology stage to an intermediate technology stage and finally to an emerging technology stage as shown in the lower part of Figure 2.

The upper part of Figure 3 shows the Utterback and Abernathy model which illustrates that a process innovation follows product innovation through three stages: fluid, transition and specific. Firms in new technology pursue a fluid stage in which the rate of product innovation is the largest while the rate of process innovation is less. On the basis of product innovation, a "dominant design" emerges and causes a reduction in product innovations in the transition stage. The focus of innovation is shifted to incremental process innovation in specific stage while competitive emphasis is on cost reduction and seeking cumulative improvements in productivity and quality. Kim (1997) views Korea's dynamic process of technological capability through imitation to innovation. He concludes that the technological development in Korea passed through three stages: duplicative imitation, creative imitation and innovation. Earlier, he also proposed a three stage model (Kim, 1980) of a development pattern of industrial technology showing that after acquiring foreign technologies, firms assimilate and improve imported technologies. Initially firms pursue "duplicative imitation" and establish through reverse engineering and implementation of imported "packaged" technology from developed countries. Firms then follow "creative imitation" and accumulate experience in product and process improvement providing a basis for their indigenous initiatives for the assimilation of the imported technology. Finally, to strengthen firms' competitiveness, assimilation together with imported technology, leads to gradual "innovation" of imported technology as shown in Figure 4. The specific stage in advanced countries can correspond to the acquisition stage in developing countries (for example, Korea) and then moved into the assimilation and improvement stages, but in a reverse direction. For developing countries, Xu et al. (1998), Kim (1997) and Kim and Lee (1987) suggest that process innovation is more crucial than product innovation at the early stage of technological development.

Using the case of TI in Korea, Lee and Lim (2001) have identified three kinds of technological catching up

Table 1. Stage models of technological innovation capabilities.

References	Stage I	Stage II	Stage III
Utterback (1969)*	Idea generation	Problem solving	Implementation and diffusion
Utterback and Abernathy (1975)*	Fluid	Transition	Specific
Kim (1980)	Implementation	Assimilation	Improvement
Dahlman et al. (1987)	Production capacity	Investment capacity	Innovation capacity
Lee et al. (1988)	Initiation	Internalization	Generation
Boltan (1993)	Imitation	Reflective imitation	Innovation
Kim (1997)	Duplicative imitation	Creative imitation	Innovation
Xu et al. (1998)	Imitation	Improvement	Self-innovation
Kim (1999)	Mature technology	Intermediate technology	Emerging technology
Lee et al. (2001)	Path-following	Path-revealing	Path-creating
Lee and Lim (2001)*	New product concept	Low/high-tech parts development	Assembly production
Lee and Lim (2001)	Assembly production	Low to high-tech parts development	New product concept creation
Choi (2010)	Collective learning	Collective recombination	Collective creativity

*Developed countries

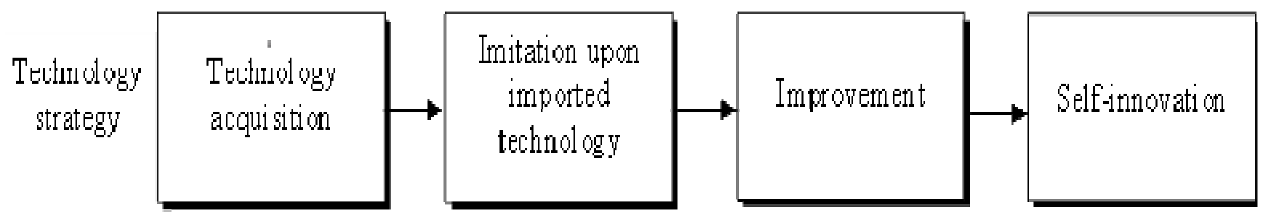

Figure 2. A stage model of technological innovation pattern in Chinese firms.

processes development which are termed as path-creating, path-skipping and path-following. Boltan (1993) compared innovation in American firms and imitation in Japanese *keiretsu* (business groups). She proposed that the competitive strategy as "imitation" is more viable than "innovation". The industry characterized this as: (1) weak property rights, (2) technological interdependence, (3) high technical and market uncertainty, (4) rapid technological change and (5) extensive information flow. She also states that many firms in the US are pursuing a "learning-by-doing" strategy involving primarily experiential learning within the firms. In contrast, Japanese firms are focusing on the external development of new knowledge and importing of ideas and technology across organizational boundaries which are characterized as a "learning-by-watching" strategy. It shows that imitation is a competitive strategy for developing countries in their early stage of TCs. Imitation as simply copying and transferring knowledge is not sufficient but rather adapting current technology to a new setting which is termed "reflective imitation" as in the case of Japanese firms. Table 2 distinguishes between reflective imitation and pure imitation. Many Japanese firms represent "reflective imitation" which is not simply copying and transferring knowledge; but rather it is a proper adaptation of technological capability to a new environment and constitutes an astute strategy in the early stage of technology development.

The World Economic Forum (WEF, 2000) has been set up using three indicators for evaluation of TICs: (1) indigenous ability to innovate, (2) the ability to obtain technology transfer from abroad and (3) the overall technological capacity. Chen (2005) describes six ways for successful TICs, for example, the dominant role of companies, technology innovation strategy, technology and research centers, TI resources, TI environment and improving entrepreneurs' motivation for TI. Chen (2005) also proposes another total innovation management (TIM) system as a basis for indigenous TI. The goal and purpose of TIM is to cultivate core competence and enhance core competitive capabilities with strategy as direction and TI as the core. It combines and harmonizes organizational, culture, strategic, management, market and institutional innovations (Xu, 2005).

Although these models and frameworks provide useful approach to understanding catch up TI in developing countries, most of them also show current states of the TICs environment. Choi (2010) has revisited Korean's

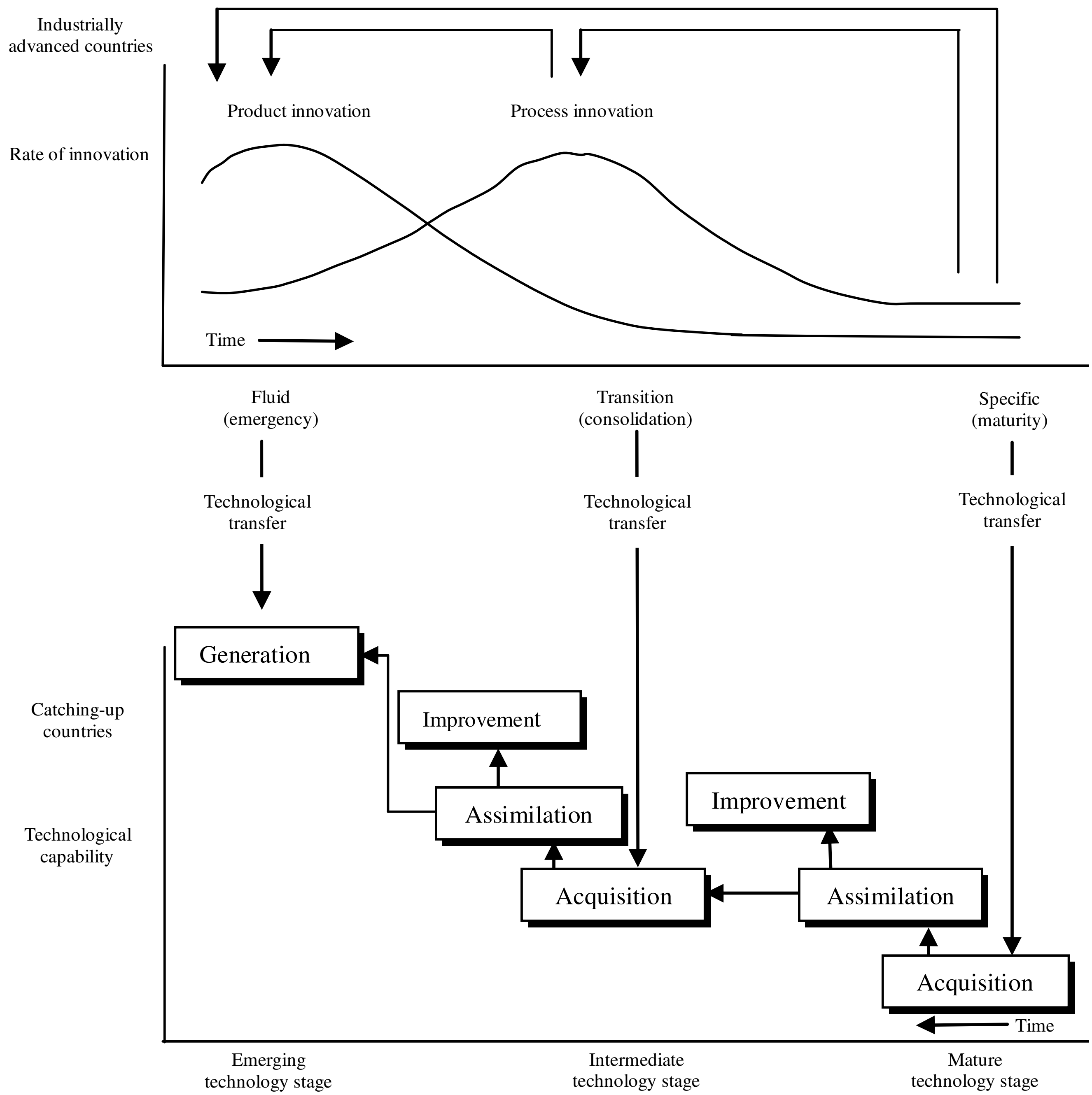

Figure 3. Linkage models proposed in developed and developing countries. Source: Kim (1997: 89). This figure borrows ideas from Utterback (1994) and Lee et al. (1988).

model. He viewed that the Korean innovation model has developed through three phases: (1) collective learning, (2) collection recombination and (3) collective creativity. He calls these three phases "collective creation" which can correspond with the three-stage model of Kim (1997). His study has suggested a search for a new model. What would probably be the next stage or phase is the concern of the researchers.

THE SPIRAL PROCESS MODEL OF TECHNOLOGICAL INNOVATION

Ali and Park (2010) propose a spiral process model of TICs. This model comprised four stages, that is, (1) technological innovation (TI), (2) transfer of technology, (3) adaptive technological innovation and finally (4) indigenous technological innovation (ITI). Most of the TICs

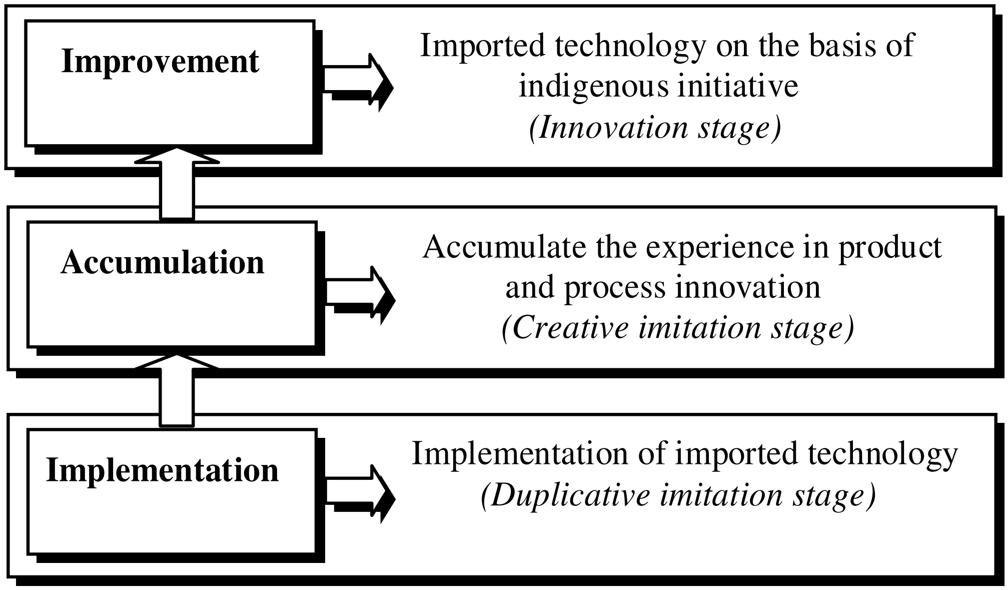

Figure 4. Three stages of Korea's technology management.

Table 2. Competitive strategies for developing new knowledge.

Strategy	Imitation	Reflective imitation	Innovation
Primary process	Transferring	Learning-by-watching and adaptation/modification	Learning-by-doing
Major source of knowledge	External	Internal and external	Internal
Major asset type	Generic	Generic first, leading to specialized	Specialized
Required R&D investment	Low	Moderate	Heavy
Information flow	One-way	Two-way	Internal
Type of knowledge	New to the company	Some entirely new and some new to the company	Entirely new
Dominant national strategy	Peru*	Japan	United States

Source: (Boltan, 1993). * It was identified by another author during his study of Peru.

are developed through the spiral process as shown in Figure 5. Sources of many innovations in developing countries are breakthrough innovations in developed countries. Even the TICs of advanced countries are based on the same process. To cite just one historical example, Americans imitated British technology (steam engine), Japan imitated the US technology (for example, automobiles) and Korea imitated Japanese and the US technologies (for example, automobiles). Sometimes, the emergences of multinational firms in a local market also create opportunities for developing TICs in the local firms. The spiral process model of TI proposed in this study comprised four stages. The first stage is "technological innovation". Many developing countries borrow the idea of imitation (implementation), improvement (assimilation) and innovation from firms in advanced countries. After successfully passing through the other three stages of the spiral process model, many firms in developing countries finally enter into this stage. For instance, in the case of DRAM technology, Samsung has successfully entered into this stage. Samsung initiated DRAM technology in Stage I. The second stage is "transfer of technology". Firms in developing countries import foreign technology which is usually known as transfer of technology or international transfer of technology. Large multinational firms are a major source of this technology. Due to the dependence of other stages, this stage becomes crucial. Many recipient countries have no detailed idea of what kind of technology they need. They are not only lacking in ability to identify the appropriate technology but also the exact implication of what technology is necessary to solve their problems (Mason, 1974). They are also lacking ability in the selection of appropriate technologies to be acquired for the "driving sector", in the selection of appropriate technologies to be developed for the "evolving sector" and emerging technologies to be developed for the "leading sector" (Salimuddin, 2004). Samsung transferred DRAM

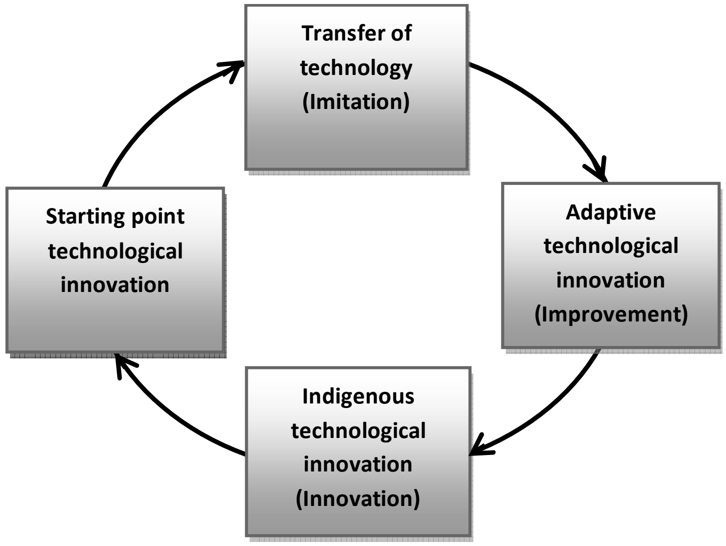

Figure 5. The spiral model of technological innovation.

technology by means of acquisition and imitation of the US and US and Japanese firms. The third stage is "adaptive technological innovation". After successfully identifying and importing appropriate technologies, the firms in developing countries do not simply imitate technology but gradually improve the technology by instituting a proper adaption strategy. Since most of the transferred techno-logies could not fulfill the requirements of receiving firms, so these technologies needed to be modified according to available resources and the local environment in which the modified technology will be operated. Sometimes the receiving firms make attempts to make the imported technology more advanced. They also make efforts using their own resources and technological capabilities to be less reliant on the firms in advanced countries. Adaptive technological innovation involves adapting the existing product to the needs of indigenous markets, adapting the existing process technologies suitable for indigenous resource endowments and climate change and adapting a technology delivery system and organizational structure suitable to indigenous social, cultural and political environments. Samsung did not simply imitate imported DRAM technology, but actively adapted and improved the technology in Stage III. The fourth stage is "indigenous technological innovation". In this stage, the firms are fully capable of generating their own innovation by using their own R&D. The recipient firms become competent to innovate without any assistance from firms once they borrowed a technology. Many firms in newly Industria-lized countries for instance, Samsung, LG and Hyundai in Korea have successfully entered into this stage. After this stage, many firms enter into Stage I again to complete the spiral process. As a result, those firms that once imitated technologies become innovative and lead companies to generate their own innovations. These new emerging firms are now becoming a "challenge" for "challenge" for established firms in advanced countries from which they once borrowed technologies. Similarly, other poor and less capable firms would follow the same pattern and would imitate those firms which once relied on imitation themselves. In Stage IV, Samsung was fully capable of developing its own DRAM technology and was not relying on imported technology. Finally, Samsung entered in Stage I again and become a leading company in developing DRAM technology.

A SPIRAL PROCESS MODEL OF TECHNOLOGICAL INNOVATION CAPABILITIES: THE CASE OF SAMSUNG ELECTRONICS

Samsung Electronics: An overview of the company

Samsung Electronics has grown to become one of the world's largest electronics company with revenue of US$ 119.1 billion and an operating profit of US$ 9,920 million. It is also the first Korean company that exceeded KRW100 trillion (US$88 billion) in sales and KRW10 trillion (US$8.8 billion) in net income. It has achieved a tremendous market share in domestic as well as in global market as shown in the Table 3. In 2005, Samsung exceeded its Japanese rival (Sony) by becoming the world's largest consumer electronics company and was ranked nineteenth in Interbrand's Best Global Brands (2009). In 2007, it surpassed Motorola by becoming the world's second largest mobile phone maker, while in 2009, it became the world's largest technology company by overtaking Hewlett-Packard (HP, USA) and Siemens (Germany) with a KRW139 trillion (US$125 billion) in sales globally. Samsung profits come from four main businesses as shown in Figure 6.

Table 3. Samsung global and domestic market share (%).

Division	Product	2007	2008	2009	Remarks
Semiconductor	DRAM	27.8	30.1	34.0	GMS[a]
LCD	TFT-LCD	20.0	21.9	24.5	GMS[b]
Telecommunications	Mobile phone	14.4	16.7	20.1	GMS[c]
Digital media	Color TV	51.6	51.4	54.5	DMS[d]
	Refrigerator	44.1	44.4	44.2	DMS[d]
	Washing machine	45.0	41.9	43.6	DMS[d]
	PC	38.4	39.8	42.0	DMS[d]
	Monitor	42.7	44.6	46.0	DMS[f]
	Printer	27.4	30.7	27.1	DMS[f]

GMS: Global Market Share; DMS: Domestic Market Share.[a] Own estimate, [b] Display search, [c] Strategy analytics, [d] GfK, [e]Gartner, [f] IDC Korea (SEC, 2010b; Annual report).

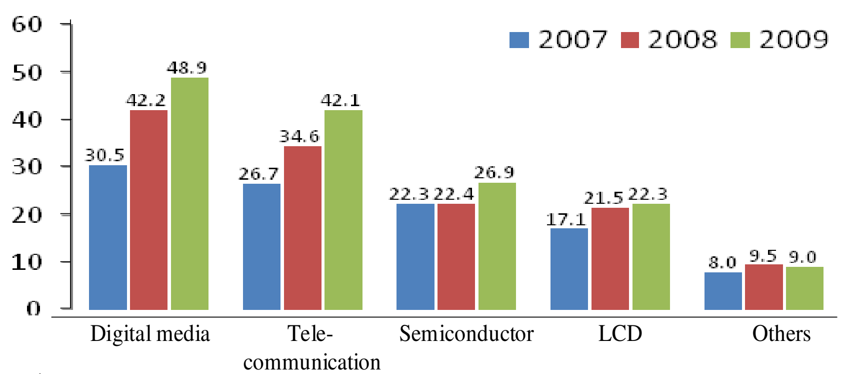

Figure 6. Sales of SEC by Division (KRW[3] trillion).

Samsung (meaning “three-stars” in Korean) group, including Samsung Electronics Company (SEC), which is the largest conglomerate (termed as *chaebol*) in Korea was founded by Lee Bung-Chull in 1938. Its business primarily focused on trade. Samsung joined the electronics industry in the 1980s with tremendous efforts and investment in the electronics and semiconductors. Primarily, Samsung emphasized mass production, reliance on imported foreign technology and a follow-the-leader strategy and government support (Kim, 1998) as shown in Figure 7.

Samsung was initially famous for producing inferior products and low quality with design, in that it was exporting cheap, original equipment manufacturer (OEM) products in the early 1990s (Chang, 2008). Most of its product development strategy was based on imitating its rivals in Japan and the US. Table 4 shows Samsung’s technological capabilities and developments from the 1970s to the 1990s. The early infrastructure of Samsung which greatly contributed to its internal technological capabilities is shown in Figure 8. Today, it is becoming a product innovative company by converging, diversifying and integrating its products, technologies and business into a network as shown in Figure 9.

THE SPIRAL PROCESS MODEL OF TECHNOLOGICAL INNOVATION CAPABILITIES: THE CASE OF SAMSUNG ELECTRONICS

The electronics industry of Korea has passed through the spiral process of technological innovation capability. Entering of foreign companies into the electronics industry of Korea and when they refused to transfer their technology to local firms originally initiated the developmental growth in the electronics industry of Korea. Considering the case of Samsung, when the multinational companies refused to share their technology with it, it actually initiated Samsung’s technological innovation. Samsung developed its technological capability by means of reverse engineering and transfer of technology. It implemented, accumulated and made innovative imported technology as shown in Figure 10. The four developmental stages at Samsung are discussed thus.

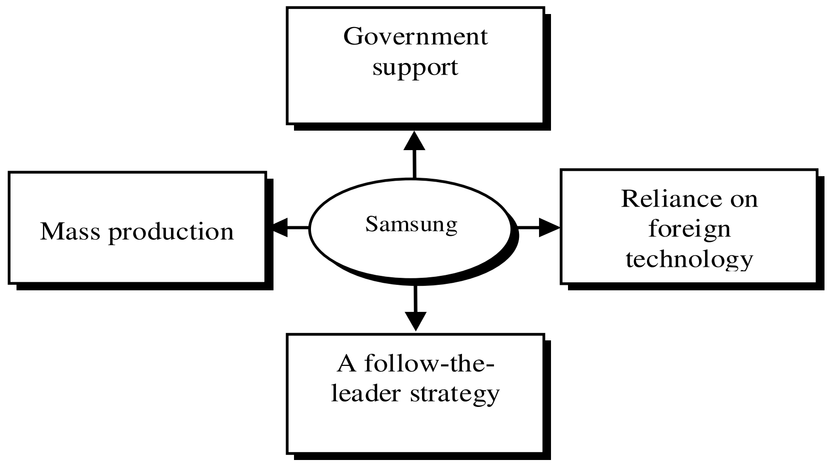

Figure 7. Samsung strategies model in the 1980s in electronics industry.

Table 4. Samsung's technological innovation capability.

Variable	1970s	1980s	1990s
Key activities	Conglomerate diversification	Entry into DRAM market	Organizational reform, Internationalization
Main sources of capabilities	J/V partners, Original Equipment Manufacturer (OEM) buyers and overseas training	OEM buyers, foreign licensing, reverse engineering	Acquisitions, strategic alliances, in-house R and D.
Level of technological capabilities	Capabilities in mass production (TVs)	Broader product range (VCR, MWO and DRAM, components), but very weak in ability to introduce a major change of product.	Continued weakness in product development
International production and scope of interaction		US and EC for low-end markets (limited success). Centralized intra-firm interaction.	International production of low-end items in peripheral regions. Moving toward decentralized intra- and inter-firm interaction.

Stage I: Technological innovation (TI)

In Stage I, in the mid 1960s, many multinational firms from the US and Japan entered into Korean markets and refused to transfer technology to local firms. It was the developmental start of technological innovation capability for local small firms including Samsung. Multinational firms such as Toshiba, Motorola, Fairchild, Signetics, Control Data and AMI (Kim, 1997) initiated the assembling of discrete devices. Their early production line was simple. All components were imported in the form of "package" from the parent firms and were assembled in a simple form. The denial of these firms created new self-development opportunities for the local firms. As a result, a Korean-American scientist with a doctorate degree and experience at Motorola established the first local semiconductor firm. Already, Samsung had realized its fortune in the semiconductors business. In spite of facing huge challenges due to its limitations in technology, such as lack of technical skills and poor quality, Samsung ventured into the semiconductor business (Kim, 1980). Initially, it acquired DRAM technology from Micron Technology, a US semiconductors firm. Table 5 shows that Samsung originally imported technologies from other foreign firms in developed countries.

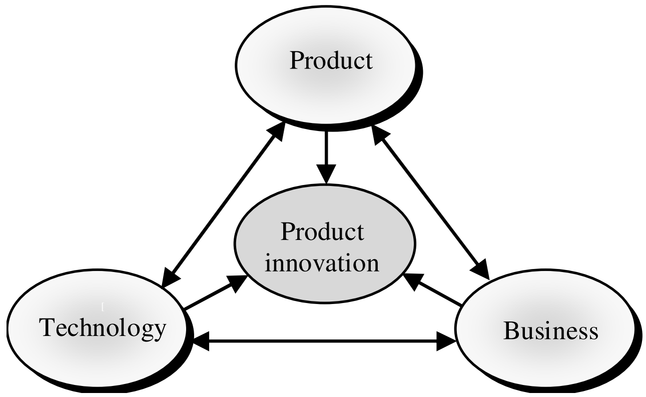

Figure 9. Product innovation at Samsung.

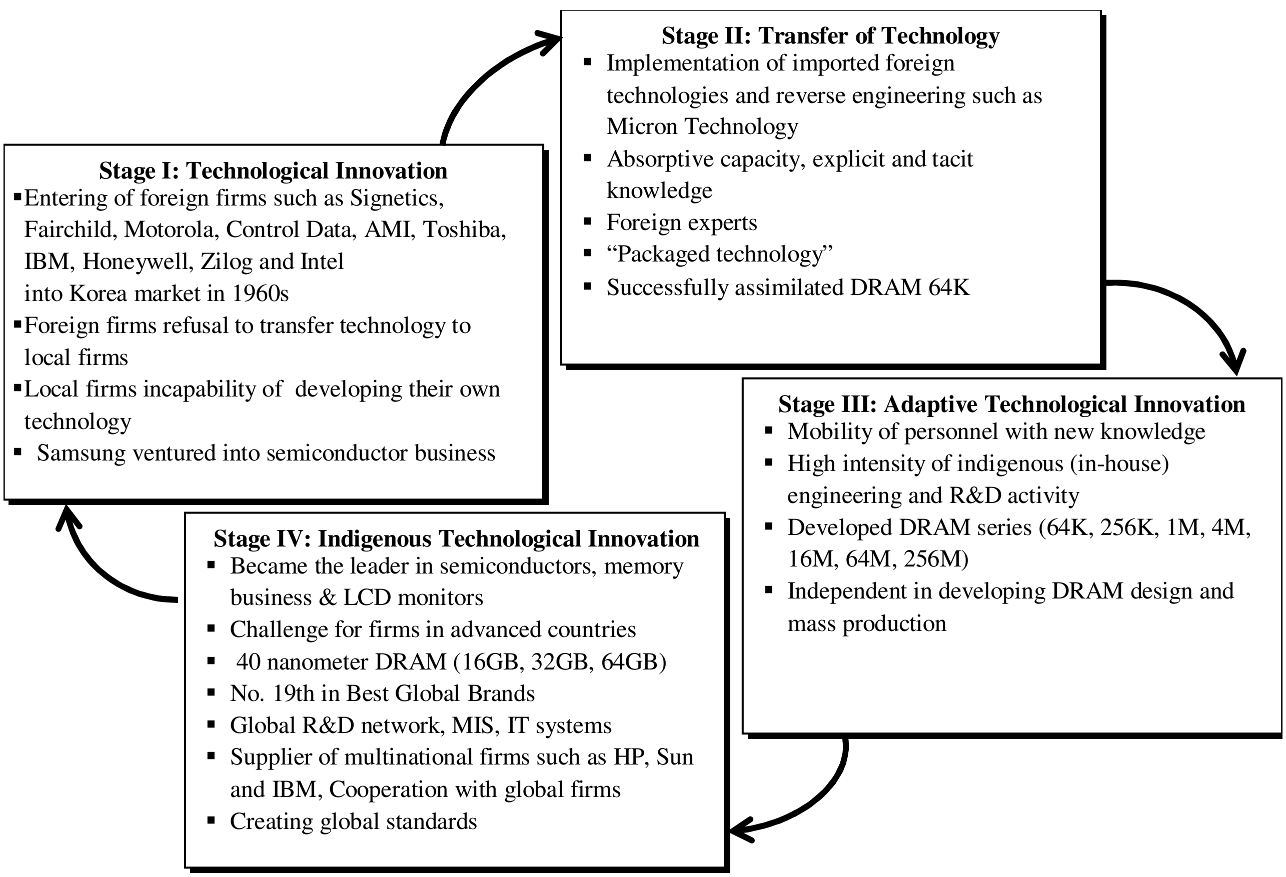

Figure 10. A spiral process model of Samsung's technological innovation capabilities.

Stage II: Transfer of technology

In Stage II of the spiral model of technological innovation, the multinational firms had already created opportunities for Samsung to establish new businesses. Samsung initiated its developmental progress by implementation of imported foreign technologies. Its progression was established through transfer of technology. Since it was the initial stage, Samsung faced many challenges regarding technology, source of technological change, technical know-how, capability of skilled human resources, research and development (R and D) and absorptive capacity (Cohen and Levinthal, 1990). Samsung's initial strategy was imitation. Kim (1997) calls it "duplicative imitation", that is, an implementation of foreign technology through reverse engineering.

Table 5. Technology originally imported from other firms.

Technology	Technology imported from other firms	Country
Color TV	Matsushita	Japan
Microwave	Ampherex	USA
64K SRAM	Sharp	Japan
256K ROM	Sharp	Japan
64K RAM and 256K DDRAM	Micron Technology	USA
High-speed MOS process	Zytrex	USA
Process technology (DRAM)	Sharp	Japan

Samsung had acquired eight years experience in producing transistors and integrated circuit production through transfer of technology and reverse engineering. After that, it was ready to enter into the VLSI (very large scale integrated) semiconductor business. A task force was formed to spend six months in collecting all explicit and tacit knowledge regarding VLSI. They also conducted a market analysis. The team then spent one month in the US and met experts in the industry and in the market. They concluded by identifying the potential technology suppliers. Although, many established firms refused to transfer their technologies to Samsung, it succeeded in acquiring many technologies from foreign firms. For instance, it succeeded to acquire 64K DRAM technology from Micron Technology (USA) and process technology from Sharp (Japan) (Table 3). In the beginning, Samsung imported the "packaged technology" and only assembled 64K DRAM chips. Having experience in LSI chips, it faced no problem in assembling 64K DRAM chips. In 1983, it succeeded to develop its technological capability in 64K DRAM. The next challenge it faced was the "process development" for 64K DRAM.

Stage III: Adaptive technological innovation

In Stage III, Samsung increased its technological learning by absorptive capacity. Samsung accumulated its existing knowledge base and intensity of effort by assimilating 64K DRAM technology and developed its technological capability. It had already successfully implemented DRAM technology imported from Micron Technology and diffused it in Korea. Samsung organized two task force teams, one based in the US and another in Korea. These teams were led by highly experienced Korean-American scientists, who already had doctorate degrees with experience and expertise at international established firms in the US. These teams also included highly-trained researchers and engineering personnel from both the US and Korea. They were paid handsome salary packages. The Korean engineers also participated in training and research in the US. These teams exchanged their research. However, the mobility of local experienced technical personnel at Samsung also played a pivotal role in the diffusion of DRAM technology. These personnel were also trained by technology suppliers. As a result of these task force teams, Samsung engineers developed the capability to assimilate the imported technologies of 64K DRAM in a very short time. The teams then started for their next challenge which was to develop the "production process" for the mass production of 64K DRAM. The teams again gathered all explicit and tacit knowledge regarding mass-production plants and they succeeded to import Sharp's process technology for 64K DRAM mass production. In the middle of 1984, Samsung started the mass production of 64K DRAM. Samsung became the third country after the US and Japan to introduce DRAM chips (Kim, 1997). The mass production of 64K DRAM had developed a platform to produce the 256K DRAM. Samsung had adopted a "dual strategy" approach for the development of the 256K DRAM. Again two teams were formed for the development of the 256K DRAM, one in the US and the other in Korea, but they were assigned different tasks. They analyzed the entire available material about the 256 K DRAM. This time, they again contacted Micron Technology, but only for circuit design. The development the 64K DRAM provided them enough experience for developing the process technology for the 256K DRAM. In October 1984, the Korean team succeeded in achieving its assigned task and developed the 256K DRAM, while the US based team developed it in early 1985 and its mass production was also started at the same time. Accumulating the explicit and implicit knowledge, licenses from the foreign firms, establishing two R&D centers in the US and Korea at the same time, mobility of engineers, strong collaboration between the two centers, management strategies such as "crisis construction mode" (Kim, 1997) and government support, immensely contributed to Samsung becoming the world's largest producer of DRAM technologies. Samsung's technological capabilities then increased expeditiously. Soon it developed 1M, 4M, 16M, 64M and 256M DRAM successfully. The gap between Korea and advanced countries (the US and Japan) in developing the 64K DRAM was 4 years. This gap was reduced to 2 years in the case of developing the 256K DRAM, while Korea was ahead of Japan and the US in developing the 256M DRAM (Kim, 1997b). Samsung had moved on to

Table 6. History of DRAM technology development.

Year	1983	1884	1986	1988	1990
Progress	64K DRAM	256K DRAM	1M DRAM, 1M SDRAM	4M DRAM	16M NAND Flash
Year	**1992**	**1995**	**1996**	**1997**	**1999**
Progress	256M DRAM	32M	1GB	64M	256MB NAND
Year	**2000**	**2001**	**2002**	**2003**	**2004**
Progress	516MB NAND	1G NAND	90nm 2GB NAND	4GB NAND	60-nano 8GB NAND Flash
Year	**2005**	**2006**	**2007**	**2008**	**2009**
Progress	16G NAND	60nm 8GB, 40nm 32GB	30nm 64GB NAND Flash	2GB 50 NANO	40nm DRAM

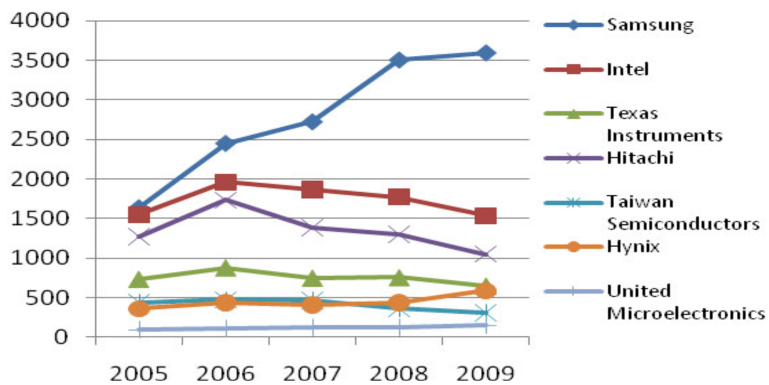

Figure 11. Samsung's patents granted by USPTO in 2009.

"creative imitation" (Kim, 1997) by not fully relying on foreign technological capabilities.

Stage IV: Indigenous technological innovation (ITI)

Increasing its technological capability by absorptive capability and accumulated explicit and tacit knowledge, Samsung is now leading the global market in high-tech electronics and e-digital media. Beginning with the imitation strategy through transfer of technology and reverse engineering, Samsung has moved on to improvement strategy, accumulating and adapting imported technology. Finally, Samsung emerged as the first innovative company of Korea which has been recognized globally. The international firms which refused to transfer technology to Samsung are now facing big challenges from it. Samsung is now generating technology innovation by using its own technological capabilities to challenge firms in advanced countries in the global market. Samsung is now relying less on imported techno-logies. It has developed series of DRAM technology as shown in Table 6 using totally their own technological innovation capabilities and resources. It has been investing tremendously in its global R and D network, having six centers in Korea and twenty four centers in North America, Europe and Asia. Among the world top DRAM manufacturers, Samsung has granted the highest patents of 3,592 in 2009 as shown in Figure 11. In 1994, it became the world's first supplier of 64M DRAM to Hewlett-Packard, Sun and IBM. Today, Samsung's quick response to any kind of environmental change, in all parts of management process such as administration management, customer management, supply change management and R and D management, is integrated by the information technology (IT) process as shown in Figure 12 (SEC, 2010).

E-COMPANY AND DIGITAL CONVERGENCE

Today, Samsung is leading the digital convergence revolution with its effort to become a digital e-company by developing innovative digital products and e-processes (SEC, 2010). "Digital convergence" is a digital technology including the convergence of various digital services, networks, devices, platforms and business models. Samsung is now gathering cutting-edge technologies and core competences and striving to re-emerge as a world

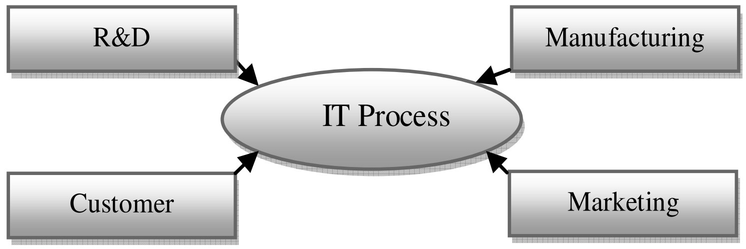

Figure 12. Samsung's IT process.

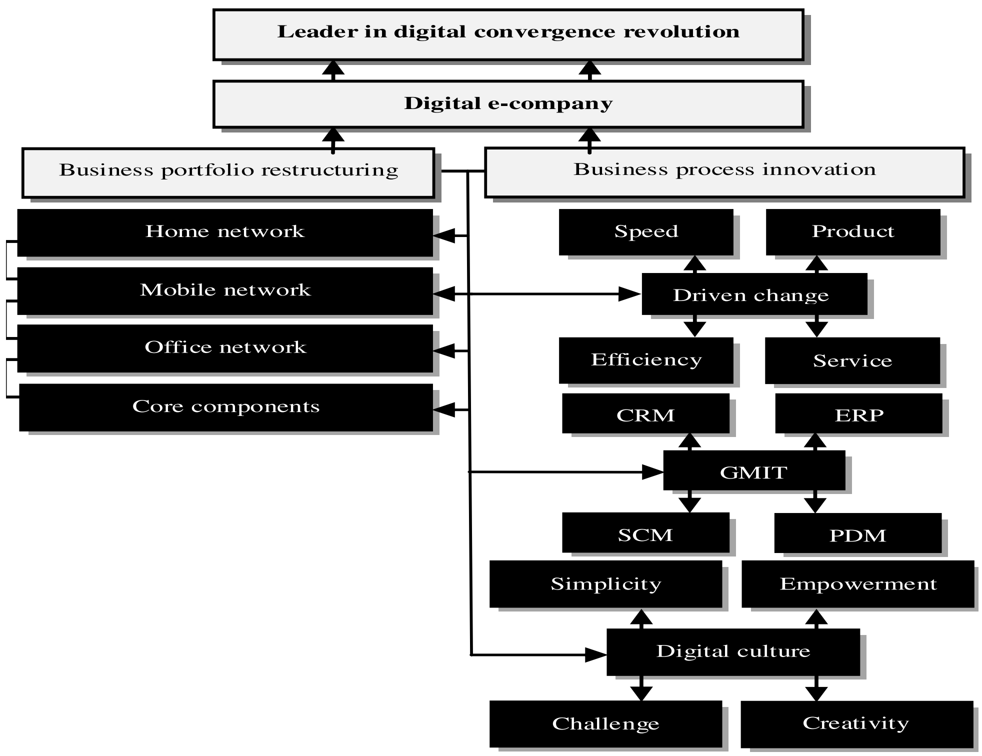

Figure 13. Samsung's strategic processes and practices framework for e-company.

class e-company leading the digital convergence revolutions. It is focusing on and developing new strategies for mobile network, home network, office network and core components to achieve its "product innovation" as shown in Figure 13 (SEC, 2010). It is making its corporate culture more dynamic by means of innovation of management processes so that its organizational culture can respond effectively to any environmental change as shown in Figure 13. Today, Samsung is establishing a global real time management information system (MIS) by customer relationship management (CRM), supply chain management (SCM), enterprise resource planning (ERP) and product data management (PDM) into a network (SEC, 2010) as shown in Figure 13. As the businesses are switching from product oriented to customer oriented, market driven change places the market and customer as its main concerns of management. The factors affecting market driven change of Samsung comprised product, service, speed and efficiency as shown in Figure 13.

GLOBALIZATION STRATEGY AND NETWORK

Samsung's globalization was expanded after 1994 when its strategic management launched the New Management Movement in 1993 (Chang, 2008). Today, it has around 196 subsidiaries including production 39, sales 53, R&D centers 24 and other 80 (including distribution centers, design centers, branch offices etc) and R&D centers in 61 countries as shown in Table 7.

Samsung is currently pursuing strategic alliances with

Table 7. Samsung global network.

Region	Production	Sales	R&D	Others	No. of employees
North America	3	6	9	9	7,543
South America	2	6	-	7	3,904
Europe	4	16	4	15	8,985
CIS	1	4	2	6	2,174
China	12	5	6	11	31,995
Middle East	-	4	1	11	752
Southwest Asia	1	1	5	3	6,583
Southeast Asia	7	9	-	9	9,898
Africa	-	2	-	2	185

Source: SEC, 2010b.

Table 8. Samsung's catch-up: A gap with advanced countries in the semiconductor industry.

Development time	64K DRAM	256K DRAM	IM DRAM	4M DRAM	16M DRAM	64M DRAM	256M DRAM
Pioneer in the US and Japan	1979	1982	1985	Late 1987	Early 1990	Late 1992	Mid- 1995
Pioneer in Korea	1983	1984	1986	Early 1988	Mid- 1990	Late 1992	Early 1995
Gap	4 years	2 years	I year	6 months	3 months	Same	Ahead of the US and Japan
Simple shipment time							
Pioneer in the US and Japan	1st half of 1980	2nd half of 1984	2nd half of 1986	2nd half of 1989	2nd half of 1991		
Pioneer in Korea	1st half of 1984	1st half of 1986	2nd half of 1987	2nd half of 1989	2nd half of 1991	2nd half of 1994	
Gap	$3^1/_2$ years	$1^1/_2$ years	1 year	None	None	First in the world	

Source: Kim (1997: 158).

advanced companies from abroad regarding technology cooperation, standardization, marketing and supplier parts. It is pursuing strategic alliances with leading companies in LCD monitors, high speed memory, semi-conductors, DRAMs and CDMA mobiles (SEC, 2010).

It is also pursuing comprehensive corporation with media companies, products, marketing and advertising with the prominent companies around the world leading the IT industry such as Sears-Roebuck, JC Penny, GTE, RCA, Crown Corporation (SEC, 2010; Kim, 1997, 1997c), intel, IBA, HP, Dell, NEC, MS, Apple, Sony, Compaq, Time Warner, Yahoo, Toshiba and AOL. Consequently, it is expected that Samsung will continue to pursue acting strategic alliances with leading companies and lead the global market in the digital media, semiconductor and IT industries with the best technology and products.

DISCUSSION AND CONCLUSIONS

Since indigenous technological innovation capability building is a new development agenda for developing countries, this paper explored how the semiconductor industry (DRAM technology) in Korea developed through ITICs. Using the case of Samsung, this paper shows that electronics firms in Korea have developed their ITICs through a spiral process model of TICs as shown in Figures 5 and 10. In the mid of 1960s, many multinational foreign companies entered into the Korean market and they refused to transfer their technologies and knowledge to local firms or Samsung initiated Korea's TICs. Due to the lack of resources and technological capabilities, Samsung started their TICs by means of reverse engi-neering of imported foreign technologies and succeeded to acquire design and process technology from Mircon Technology (USA) and Sharp (Japan). Samsung improved TI by means of adaptive technological innovation strategy. Finally, Samsung got the capability to establish their own ITICs, and achieved the No.1 market share in the DRAM technology, to catch-up those firms in advanced countries (Table 8) that once denied giving their technologies to Samsung and now it is challenging the firms from advanced countries in the global market.

As a late starter, Samsung in the beginning relied on borrowed technologies, but aggressively invested on time, focused on technologies with clear trajectories (Chang, 2009), followed late comers' strategies as shown in Figure 7 and internal infrastructure as shown in Figure 8. These are the factors that contributed to Samsung's success. Samsung strong R and D capability, successful integration of process and production innovation as shown in Figure 9, success in DRAM development, product portfolio and solution, production efficiency, cost effectiveness and speed are the early competitive advantages that made it succeed in the industry. Realizing the sense of a "digital convergence" and becoming a digital e-company, Samsung is approaching three strategic innovation strategies, which are creativity, talent and partnership management. Other firms in developing countries and especially the latecomers have lessons from Samsung's experience. The late starters having limited resources and less technological capabilities can learn how to catch-up by initiation, imitation, improvement and innovation. The model needs empirical research for generalizibility in different industries and different countries which have similar developmental structures as Korea. It will provide useful implications not only for policy makers and managers, but also for those developing countries which attempt to follow the same pattern of technological development. Future research by the authors will focus on how Korean firms (Samsung and LG, etc) can compete with emerging Chinese companies such as Haier in China and succeed globally, and what are the features that are critical to succeed in the electronics industry and to become a global leader?

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