Promoting High-Impact Technological Innovations In Korea: Case Studies and Government Policy

Kwang-Kuk Na
Ph.D. Candidate, KAIST Graduate School of Management

Jongseok Lee
Assistant Professor, Hallym University

Zong-Tae Bae
Professor, KAIST Graduate School of Management

Abstract

Managing radical, disruptive, or discontinuous innovations has emerged as a hot issue. This study introduces a new concept of high-impact technological (HIT) innovation, and defines HIT innovation as innovation that has a high impact on national economy and society from the technological, market, and strategic/social aspects. This study identifies the processes of HIT innovation based on six Korean cases of HIT innovation: DRAM, TFT-LCD, CDMA, network game, portal community, and digital communication services. The results show interesting findings on driving forces, characteristics, the key success factors, and key players of HIT innovations. This study can contribute to the designing of national systems for promoting HIT innovations.

1. Introduction

Science and technology development has been a critical engine for economic growth in Korea, and it has helped Korea change gears from being a developing country to an advanced country. These processes accompany many innovations that have high economic and social impacts. In this paper, a new concept of high-impact technological (HIT) innovation is defined and used in explaining the nature of radical innovation in developing countries.

To promote radical, high-impact innovations, business leaders and policy makers in developing countries should have differentiated approaches, such as new innovation strategies and systems. Korea started with many government-supported research institutes established in the 1970's to 1980's, and they supported several industries in localizing imported products and accumulating technological capabilities. Throughout the 1990's and 2000's, some government-supported research institutes and leading firms in Korea have shown many innovative products and technologies with economic and social impacts. These innovations include significant technological improvements, but are not so “technologically radical” compared to existing world-wide leading technologies or products. The have, however, greatly influenced Korea’s economy and society, and provided a basis for shifting Korea’s status to an advanced country.

There are many innovation cases of these types in Korea. In this study, we define HIT innovation as innovation that has a high impact on national economy and society from the technological, market, and strategic/social aspects. Some government-supported research institutes and leading firms have carried out HIT innovations and this study tries to analyze some HIT innovations based on the systematic research framework. Throughout in-depth case studies for HIT innovations in Korea, the processes of innovation, key players, success factors, infrastructure, and managerial/policy implications will be described and discussed.

2. Research Framework and Methods

2.1 Radical Innovation and High-Impact Technological Innovation

Technology innovation is one of the major factors of a nation's economic growth. Technology innovations increase productivity, develop new products and processes, and create new industries. More than 50% of long-term economic growth in advanced countries is made by technology innovation. As a result, science & technology development in advanced countries have played the core roles for these countries' industrialization (Kim, 1991).

In the early stages of the economic growth, developing countries mostly pursue simple imitation strategies. They continuously push technological innovation forward to catch up with the advanced countries or leading companies. But, in order to advance to the front-runner level, they need a very innovative technological development at the national/firm level. There are various definitions for innovative technology development. The most popular expression is 'radical innovation'.

Radical innovation concerns the development of new businesses or product lines – based on new ideas or techniques or substantial cost reductions – that transform the economics of a business. Radical innovation is usually defined as "one that has the potential to offer either (i) new-to-the-world performance features, (ii) a dramatic (5-10X) performance improvement in known features or (iii) a dramatic (30-50%) reduction in cost (Leifer et al., 2000).

Searching for radical innovation cases in developing countries that fit the advanced country standard is a very difficult task. Actually, it is even more difficult to find a technology innovation in developing countries that can be compared to radical innovation. Even though technology innovations are not as advanced at the technological level as radical innovations, the economical and social effects are larger than those of radical innovations. As described above, there exist technology innovations in developing countries of which the source of technology is not original or technically more advanced than existing technology, but more effective economically and socially. Nowadays, innovations are gaining more interest and are being defined as "high impact technology" or "critical technology."

In general, developing countries are not producers of radical and original technologies. Nevertheless, economically successful innovations that use the products from outputs of radical innovations in advanced countries, or totally new ideas, are gradually appearing. In this paper, we define these innovations as HIT innovations and analyze the characteristics and influencing factors of HIT innovations based on Korean cases of HIT innovation.

2.2 Selected HIT Innovation Cases

In this research, innovations or technological innovation-based products, or projects that have caused great changes economically or socially will be regarded as HIT innovations. To define HIT innovations in a more concrete and realistic manner, we set up the basis to measure the HIT innovation results which satisfy economical and strategic (social) perspectives in Table 1.

We have chosen six innovation cases that matched the detailed definition of HIT innovation. Mostly, they are conducted at hardware manufacturing firms and information-knowledge service providing firms. Among the six, three cases have been chosen from manufacturing and the other three are from service providing. As shown in Table 2, selected six cases satisfy the requirements from both economic and strategic (social) perspectives.

Table 1. Criteria for HIT Innovation - Measurement Basis

	Two Criteria for HIT Innovation	
	Economic Perspective	Strategic / Social Perspective
Requirements	− Increase revenue and export − Create new market − Substitute or expand existing market − Create great economical ripple effects − Penetrate into overseas market	− Create new industry and lead new standard − Strengthen global competitiveness − Create social and cultural ripple effects − Construct national infrastructure − Improve the quality of life

Table 2. Selected Cases of HIT Innovation

Case	Period	Development Objectives	Requirements for HIT Innovation		Case Firm
			Market	Strategy	
DRAM	1963 ~2003	Large scale memory design/ development	− Korea's main export item − Creating large scale memory market	− Elevating Korea's position to a leader in memory technology − Setting and leading industry standards	SEC
TFT-LCD	1984 ~2003	Next generation display development	− Korea's main export item − Creating new markets for parts / equipment	− Contributing to Korea's IT industry development − Making the image of an IT- strong nation	SEC
CDMA	1989 ~1996	Commercializing synchronized mobile communication	− Korea's main export item − Creating domestic mobile communication market	− Defending domestic communication market − Creating new strategic industry	ETRI
Network Game	1996 ~2006	Online multi-user game	− Creating domestic network game market − Penetrating into foreign markets (e.g. China)	− Creating new strategic industry in software sector	NCSoft
Portal Community	1997 ~2006	Forming a Cyber-community	− Creating the first domestic commercial model (Sayclub)	− Creating new strategic industry in internet/ entertainment	Neowiz
Digital communication Service	1999 ~2006	Digital Communication	− Creating the first domestic commercial model (Cyworld)	− Creating original business model (first in the world)	SK Communications

2.3 Research Framework for Analyzing HIT Innovation

Figure 1 schematizes the conceptual research framework for analyzing cases of HIT innovation. The HIT innovation cases to be analyzed in this research are divided into 3 categories: platform, process, and performance. The **platform** means the environment, infrastructure and context surrounding the HIT innovation process. By analyzing infrastructure, national culture, market environment, nationwide knowledge accumulation, key actors, and organizational culture and

strategy, we will try to identify the main factors and elements affecting the success of innovations. Therefore, the platform analysis is rather static compared to the process analysis.

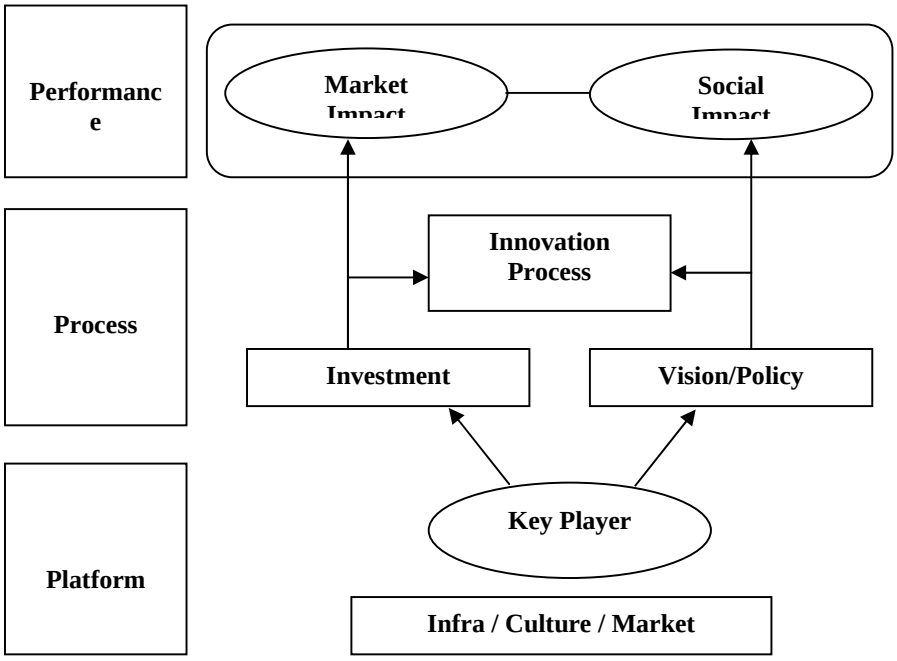

Figure 1. Conceptual Research Framework

The **process** part includes the analysis of cooperation between the innovative key-person and relative task contribution. In other words, it is about the roles of key persons and mutual learning. It mostly includes analysis on the developmental process, strategy, and investment. Through this analysis, we can deduct the dynamic characteristics of radical innovation cases.

The **performance** part mostly analyzes the economical and socio-cultural results, meaning the final product of actions and products created by networks between key persons. In this research framework, we want to focus our view on new market creation & social aspects in developing countries, rather than on technology innovation information.

2.4 Research Methods

This research is primarily exploratory using the case study method. The cases selected by the criteria of HIT innovation were analysed based on the research framework. The case study is used to explain the dynamic cause-and-effect characteristics in the complex real world, and for thorough analysis and explorative research (Yin, 1988).

Data and information for each case are collected from various sources. Those were mainly from secondary sources, such as company annual reports, published research reports and books, and academic papers. Interviews were used as supplements. From various sources, we collected data on platform, process, and performance of selected HIT innovations. Collected data were classified, analyzed, compared, and integrated, to get the results.

3. Results

In-depth case studies for six HIT innovations were carried out. Each case was analyzed based on the conceptual research framework and compared to find key facts and underlying principles.

3.1 DRAM

On September of 1991, Samsung Electronics Corporation (SEC) produced the world-first prototype of 64M DRAM. Since then, SEC achieved marvelous success in other Memory-related areas based on technical performance in DRAM.

Until the late 1980s, SEC's product development in advanced memory products, such as SRAM, VRAM, ROM and flash memory, as well as new product development, seemed to be sluggish compared to Japanese competitors. But the situation was significantly changed in the 1990s and now, SEC climbed to the level of its competitors in terms of the total number of product development.

In 2005, SEC became the world-largest DRAM supplier (approximate 33% of the world DRAM market share) with the most advanced memory-chip production technology in the world. As its semiconductor production capacity shared 50% of exports in electronics items of Korea, the semiconductor industry of Korea took its role as the core item to support the Korean economy.

In the 1990s, the semiconductor business was the most contributing industry to the developing economy of Korea. Since then the semiconductor industry prospered continuously and Korea obtained its reputation as the leading country in semiconductor sectors of the world. Table 3 summarizes performance, process and platform of DRAM development at SEC.

From the process of innovation, SEC showed its distinctive characteristics from other existing corporations. First, it executed several types of "parallel development systems" in the new product development process. Among them, the first type is operating several new product development teams simultaneously. For instance, it runs separate development teams for 1M, 4M and 16M to develop production know-hows for mass-production, develop basic process technique, and achieve establishing concepts of the new products' architecture all at once. The second type is developing the same product from two remote places, one in Korea and the other in the U.S., simultaneously. They developed new products such as 256K, 1M, and 4M semiconductors competitively and mutual complementarily. The third type is promoting new product development and constructing mass production line concurrently. This type of Parallel Development System was especially remarkably employed for initial product development of 64K DRAM and 256K DRAM.

Second, since the bottom line of competition in the DRAM business is the tacit knowledge of production, SEC implemented tremendous amount of "Learning by Doing" exercises prior to production of new items. The heart of learning relies on "On the Job Training" at production sites rather than theoretical education trainings. One example is having meetings at 11 o'clock every night, the so called "Eleven Meeting." The Eleven Meeting provided places to evaluate daily performance and progress and discuss each other's responsibility of the next day collectively or mediate for a better conclusion. This remarkable learning process and priceless efforts of workers allowed Samsung Semiconductors to promptly develop new products and achieve continuing success in mass production technology.

SEC differentiates itself from other companies in technology learning. During its initial stage of the company, it mainly relied on technology absorption, focusing on problem-solving to acquire technology in a short period of time. It was extremely difficult to identify problems and

find solutions because hundreds of complicated procedures were required in producing DRAM, but a problem-solving taskforce was formed to implement a large-scale search for solutions over the entire production process. For this, workforce, time and capital were used up. However, through supplies of the tremendous amounts of resources, SEC could comprehend the DRAM technology quickly and establish the solid foundation of production technology and skills.

Table 3. Consolidated Case Analysis of DRAM development in SEC

Area		Description of Event
Perform-ance	Market Creation	● 1974.12: Acquired 50% of Korea Semiconductor Corp.' stocks and made its debut to the semiconductor business ● 1983.3: Announced participation of VLSI level of semiconductor development project ● 1983.11: Able to develop 64K DRAM and established a 5-year technological gap to the leading country ● 1988: 4M DRAM and created a six-month gap ● 1992.11: 64M DRAM and almost preceding advanced countries ● 1996.10: 1G DRAM and preceding development ● 2001.2: 4G DRAM (world-first development of construction technology)
	Social Impacts	● Promotes the self-developed high-performance semiconductor technology as the industry standard ● Becomes an established semiconductor technology country ● Becomes main export item
Process	Investment	● 64M / 256M / 1G DRAM: 100-300 million dollars
	Business Strategy & Government Policy	● Late Mover Strategy up to 4M DRAM production by adopting and learning advanced technology from foreign countries ● First-Runner Strategy to maintain its position as the industry leader based on Self Developed Technology after 64M DRAM production ● Promoting the National Cooperative Research Project
	Networking	● Strategic Alliance with Foreign Competition after development of 64M DRAM ● Fostering domestic parts and equipment supplier for securing stable suppliers ● Contract with big computer manufacturers such as IBM, HP, Compaq, Intel, and SUN
	Leadership	● Overcoming initial barriers by providing a strong vision ● Encouraging research teams to concentrate on producing high quality products through consideration ● Outpacing leaders from determined and timely decisions
Platform (Infra)	Key Players	● Company, Government, Research Center, University
	Culture	● Self-confidence, courage, and determination to follow up the leader, Japanese companies, despite initial-stage difficulty ● Accelerated confidence and strong intention within research teams from successful development of 64K DRAM and 256K DRAM
	Market	● Memory products leads semiconductor market ● DRAM emerges as the main product due to its increasing market demand despite low level of absolute demand

Third, the SEC R&D team fully understood that a process of trial and error was inevitable. They devoted themselves to build a creative organization by promoting a self-study environment among team members and studying the rapidly changing trend of world semiconductor

technology so that all team members became self-confident about how to control impending crises. Also, during the early stage of product development, the company made the most of its consulting service from external professional groups. It certainly helped the company in the wide scope of, for instance, alleviation of procedural problems in its production lines and decisions in technology path selection. It increased the productivity of the company to spring up to the next level of the technological stage.

SEC called foreign technology aggressively into play from developed countries. The introduction of technology was the key contribution to Samsung's technology acquisition for those primary products, such as 64K DRAM and 256K DRAM. Brusquely, most advanced foreign corporations became afraid of disposure of their core technology and more reluctant to provide underlying technology to Samsung. Shortly after SEC advanced to the world-best level by developing 64M DRAM without any recourse and possessed competitive advantage in genuine technology, however, competitors in Japan and the U.S. looked for opportunities of strategic alliance with SEC.

Lastly, SEC could emerge as the worldwide company because it could make right decisions in their selection of a technology development path by joining the mainstream of semiconductor technology as swiftly as possible. These series of selections and choices must have been of high risk, but SEC devoted its best to deal with the ceaselessly changing trend of world markets.

3.2 TFT-LCD

Since large-size TFT-LCD manufacturing industry started its first production in 1995, the expansion of exports increased more than 80 percent annually and rose as the workhorse of Korea's exports. The TFT-LCD industry in 2002 has grown up as a major exporting business, much like the semiconductors, textile, automobiles, mobile phone, computers, electronics, and vessel industries. Due to the ripple effect, the TFT-LCD industry formed a group of enterprises with more than 200 manufacturers (approximately 20,000 workers) producing panels, modules, equipment, parts and material, and applications.

The Ministry of Commerce, Industry and Energy of Korea estimated that the export amount of display items in 2006 will be about 22.5 million dollars - 10 percent of total Korean export. In 2010, the total export amount of display items is expected to increase up to 40 million dollars, while the exports of memory will be 35 to 40 million dollars; that will make display items the biggest export item in the IT arena. SEC and LG Philips LCD should be two big main axes in display item production.

Between the two axes, SEC entered the TFT-LCD business in 1991, mainly focusing on the parts business that was established through the process technology and production of Braun tubes in the semiconductor business. But it struggled due to the higher technology gap of Japanese companies, lower returns and higher costs for the first few years.

SEC used the parallel development system to acquire manufacturing techniques and production techniques at the same time to expedite the process of supplementing their lagged technology to enter the TFT-LCD market. During its early development stage of TFT-LCD, SEC adopted a pilot line to develop a 10.4 inch sample and produce 9.4 inch items. Also, the company developed manufacturing techniques and production techniques simultaneously, by developing colour-filter technology and high-temperature poly product technology, for example.

SEC tried to maximize late-comers advantages through active technology learning from the front runners. SEC could reduce R&D costs by utilizing industrial infrastructure, such as

professional engineers and well-established, experienced equipment companies to work with Japanese companies. Also, SEC could make significant decisions - selection of keyboard size, selection of manufacturing companies, or targeting markets - without risks because leading Japanese companies had shown the relevant strategies and market trend so that SEC could benchmark, follow, and imitate them. For example, at the early stage of technology development, SEC developed colour filters based on technology documents from the Japanese company, NNT.

After SEC had acquired a certain level of its own technology, SEC could, then, acquire the wide view angle technology from a Japanese late-comer (Fujitsu) through a cross licensing agreement, by transferring the high aperture ratio technology to Fujitsu in exchange. SEC also utilized its outside network intensively, promoted the joint development of 15.1-inch XGA LCD monitor with Russia, succeeded to develop a reflecting LCD, and applied for a patent for the monitor.

Meanwhile, SEC overcame the existing semiconductor processing technology, which contained a similar process, like early models, through an intensive self-learning process. Because the TFT manufacturing process is similar to the DRAM manufacturing process, SEC could use existing semiconductor processing technology, quality control, patent management, cross-licensing, marketing channel and negotiation skills for companies with the necessary equipment.

Based on DRAM-related knowledge, SEC could accumulate absorptive capacity, identify the required technology for a more efficient technology, and eventually combine existing DRAM related knowledge with the new. Due to the transition from DRAM, it could achieve a 3-percent higher learning ratio compared to Japanese companies in the earlier 3rd generation. From this process, SEC acquires its unique patents combined with semiconductor processing technology and accumulated the core technology for big screen monitors.

Actually, in 1984, the TFT-LCD business was commenced from the TFT-LCD research group in Samsung Display Device (currently Samsung SDI), which executed the TN or STN-LCD project. TFT-LCD is a sort of display device, but it is also similar to semiconductors. It was determined to be inappropriate for Samsung Display Device to continue its business because this was a sort of display device that even Samsung Display Device thought had a culture of diligence, but no creativity, and lacked a huge investment resource for TFT-LCD development.

As a result, the TFT-LCD project was taken over by SEC from Samsung Display Device, who had been working in the display item business for a while. This allowed SEC to fully utilize huge investment resources and Samsung's semiconductor technology. It became the most significant foundation of creative group culture for new technology development.

3.3 CDMA System

Mobile communication in Korea began when the analogue-type of mobile phone service started in 1984. But due to increasing users and the necessity of reconversion to the digital system, the development of a digital mobile communication system was introduced in 1989-1996; and CDMA became the market standard. From 1996, the full-scale competition formation was begun.

In 1997, the introduction of PCS services started a competition system between 5 companies, with 3 companies at present, after mergers served approximately 33 million customers. The development of CDMA in Korea was coordinated by strong guidance and support from the Korean government. The strong policy from the government for technology development

eventually lead to an enormous level of success in obtaining CDMA technology, which originally did not have the possibility of technological success or protecting our markets.

When Koreans took their first step toward digital mobile communication technology development, they had little experience in analogue-system operation, with no primitive skills of mobile communication. But Korea could accumulate a significant amount of technology and experience in switchboard technology from existing TDX development, and applied it to the digital mobile communication system development.

Most of all, the TDX development team could participate in the digital mobile communication system development so that it could maximize the learning capacity, regarding new technology. It could use management skills obtained from finishing large-scale national projects. Also, it could produce systems at the stage of system development, give really strong incentives for technology study through direct participation of customer companies, and promote fast technology learning among members for better competitive power.

One of the most serious problems in the digital mobile communication system development is lack of knowledge and technology in the area. Therefore, Korea was desperate to participate in joint development or strategic alliances with foreign companies who had an advanced technology. The Ministry of Information and Communication of Korea selected CDMA as the national standard, did not fully approve of the GSM system when CDMA technology was not fully verified, and promoted joint development with the technologically strong company, Qualcomm.

Qualcomm empowered the CDMA prototype's technological foundation by providing commercial service with joint development with the Korean government. Qualcomm was very aggressive due to the matter of securing a stable market. The Korean government could obtain the necessary high-tech CDMA technology to protect the domestic market from foreign companies, so that it could advance to foreign markets. It was a win-win strategy!

In CDMA development, the Korean government defined the development process from the initial stage of development, by preparing a development process management guide and performed research according to the process, by defining each step's main task and results according to the system's improvement.

The development was divided into 3 steps, according to its progress. Execution of the next level can be determined through considerate evaluations at the end of each step for defining a planned development task, responsibility and duty.

In the first step, they created a detailed joint development plan and formed job descriptions through technology consulting for a general definition of the system, reviewing standards, and evaluation. In the second step, they finished writing system requirements, defining system structure, and designing system hardware and software through system design. In the third and last step, they tested a detailed design of the previously developed hardware and software, and wrote experiment reports regarding the on-site testing.

The stepwise development, like CDMA, was an appropriate approach to reduce complexity in a complicated system development, and to reduce risk of development failure. Hence, the general development process is defined by creating the size and the standards for each detailed item and making samples. These developed items could help companies to commercialize them.

3.4 Internet Game Lineage

The game industry is an IT entertainment industry in which all of following are combined: software programming, technology, such as artificial intelligence and imaginary reality, 3D

animation and character, computer graphics, background music and musical effects, game scenario, game design, planning, and producing. Therefore, the game industry is a comprehensive art industry that includes entertainment and art. It creates a high VAT due to its economic, industrial and product values and provides entertainment through interaction and psychological stimuli.

A double network game is a real-time game for multiple players that can be played through a connection to the host server via telecommunication networks.

Lineage is the most representative network game in Korea, developed by NCSoft. After Lineage's successful conversion to a fee-based system, many network game companies produced MMORPG-type games like Lineage, and also converted to a fee-based system. Lineage is even known to people who are not interested in games because of an unbelievable number of on-line gamers and it offers completeness, an addictive factor, and item transactions.

NCSoft was established in March of 1997, and the overall evaluation of the company is that "the company contributed to popularize the domestic network games since it started to produce Lineage in 1998." Currently, it advances to five different countries; Taiwan, Hong Kong, Japan, China, and the U.S. and provides services. NCSoft's main business field is its own network game service and the publishing of other game developing companies' network games.

NCSoft is looking for the conversion to a network game publisher with the intention of developing various game groups in addition to existing network games, and achieve a goal of diversifying internationalization. The performance, process and platform (infrastructure) of Lineage development at NCSoft is summarized in Table 4.

Table 4. Consolidated Analysis of NC Soft Lineage Case

Area		Description of Event
Perform-ance	Market Creation	● Critical role for online game boom ● Benchmark for other MMORPPG ● New International Market ● Stable profits from charging system ● Expansion of the online game market from various types of games
	Social Impacts	● Alleviate people's negative perception of Online Game ● Represent some negative factors in Online games, such as game addiction and item transactions.
Process	Business Strategy & Government Policy	● Increase games' completeness through consistent updates ● Introduction of a flexible charging system for customer's freedom of choice ● Receive royalty income from international businesses ● Conversion to online game publisher with multiple groups of games ● Consider government's grade system for online games
	Networking	● Promote joint venture with local companies in international business ● Bring in big names from the local community (ex. Garrott brothers)
Plat-form	Infra	● Expansion of the high-speed internet system ● Provide various payment systems-Credit card, Cellular Phone and etc.
	Culture	● Prefer to form various communities ● Proxy satisfaction from improvement of individual characters
	Market	● Dramatic expansion of the domestic online game market ● Expanded compatibility of online game from different platforms

Even though NCSoft's Lineage did not accomplish developing a core technology to shake the entire industry in its technology, it could cause a considerable level of economic and societal impact to the industry by properly responding to the environmental change and creating proper strategies, such as new brand development.

NCSoft's case can be summarized in terms of its noticeable distinction from other innovations. First of all, it fully utilized the multi and simultaneous product launching strategy through various channels of markets to promote its business.

Setting up its ultimate goal as the exclusive network game publisher, the company started to provide services by developing numbers of network games at the same time from inner product development teams and a third-party's participation.

While "Lineage2" was developed from the main office in Seoul, Korea, the U.S.-based affiliates, NC Austin and ArenaNet, developed "Tabula Rosa" and "Guild Wars" and the third-party teams are developing "City of Heroes," "EXarch," and "Auto Assault."

Foreign countries' culture and customs were melted into the games through the system of game developing by foreign affiliates and it was only possible through the Parallel System. In addition, it overcame the problem of insufficient development time and limited circumstance in developing different network games by utilizing the third party.

NCSoft concentrated on securing technology through outside networks. In developing Lineage2 based on their success of Lineage, the company did not develop a 3D graphic engine from their own resources, but rather invested more than 1 million dollars to acquire the Unreal 2 Graphic Engine - because its quality was already approved. But with respect to acquiring and using graphic engines from a third-party, the company could secure relevant technology by renovating its drawbacks and increasing the learning process about 3D graphic engines, instead of applying third-party products with no modification.

Lastly, NCSoft considered the expansion of infrastructure in communities as a business opportunity and entered the market where the opportunity could be fully drained. Its conversion to a fee-based game was a huge success because product differentiation using network was a big hit. The strong infrastructure was the core of the company's success for network industry.

The introduction of high-speed Internet must be the most important factor for the company's success in addition to the excellence of products. NCSoft’s performance data clearly shows that the number of internet subscribers and the increasing pattern of sales of NCSoft move in tandem with an apparent similar pattern. Except for several card games, most network games require a high-speed Internet subscription to enjoy the full excitement of the games. Therefore, increasing numbers of high-speed Internet subscribers should mean the expansion of markets for network game producers and content providers to provide their products and service.

NCSoft's case shows that it is important to move ahead in emerging markets. Analysing the market thoroughly and entering it at its early stage triggers the success of a business among well-established companies, and products even though the company possesses a lower level of technology.

3.5 Sayclub

Sayclub is an online portal community, operated by Neowiz, an internet portal company. Neowiz developed the world-first premium character profit model and is now considered as the benchmark of "innovative development and management systems" among domestic internet portal companies. Also, it continued to achieve higher investment returns and persistent

management innovations with continual development of profit models, like Oneclick, Internet automatic connection program, and web-based games.

Neowiz showed somewhat different innovative aspects of portal companies that were unlike others. **First**, Neowiz continued to have meetings for brainstorming ideas and it poured many profitable items to the company. And, once a profit model was determined, the development team would be engaged for technology development and knowledge sharing. Because creation of a profit model was not the core goal of Neowiz, its projects had never been over when the profit model was developed to launch. Actually, developing a model opened other meetings for new business items in the future. These simultaneous core seminars and meetings adopted the parallel development system, by which producing numbers of business models in a day, was possible.

Second, Neowiz ceaselessly emphasized the importance of learning new technology and common sense. At the same time, holding seminars of different areas provided opportunity to absorb knowledge and technology, but the monopoly of information by a single person was not encouraged. Gathered information was documented to distribute to workplaces and shared by everyone in the company. This information sharing allowed new comers to absorb technical knowledge without delay when a worker left the company. Information spilling was not an issue any longer. Documented information could be used to create new knowledge and develop new technology, so that it could be a solid foundation for new business development.

Third, Neowiz is an organization with an extremely creative culture. Once there is a new idea or an ongoing project, a task force (TF) will be formed swiftly. This creates a new team or disbands an old team after serious investigation and evaluation. Therefore, a lot of turning over of teams is inevitable and team leaders should be alert to move among projects so that a system where moving teams could create minimal abrasion from frequent transitions can be created.

Therefore, most job titles were changed from being an indicator of class to the responsibility of the member in teams. For instance, the team leader does not mean a higher rank but simply shows his or her responsibility to control and coordinate his or her team.

Another interesting culture in Neowiz is the email communication. In Neowiz, most communication can be done through emails; even consultations are emailed. Once you receive an email from the CEO of the company, requesting your own suggestion, you won't feel any distance between him/her and yourself. Sometimes, you can share your business opinion with the CEO and the CEO sends an email every month to report the present condition of the company. Neowiz utilized email as the main communication system because it could secure everyone's privacy and leave potentially valuable documents without having them unintentionally shredded.

Lastly, Neowiz defined the pioneer spirit and innovation, as the company's vision as "Innovation" was emphasized in business development. Also it built structural internal developing systems to buttress this vision. From idea meetings, they identified and developed an item, and Neowiz focused on profit model development by dispatching competent workforces.

In most business developments, the company emphasized a "user friendly environment" in product development as a single goal so that it could accelerate accumulating knowledge and information for each stage of development. Also, Neowiz provided various kinds of incentives for members in development teams to continuously stimulate the workers' self-motivation.

3.6 Cyworld

Cyworld is the newest type of provider of digital communication systems, and it is totally differentiated from other portal services. Cyworld members have reached up to 1.7 million. It

accounts for more than one-third of the Korean population and amazingly, 90% of people in their twenties are Cyworld members. It must be the most profitable fee-based Internet portal service company in Korea, with their 2006 expected sales of 220 billion wons, and a net income of 20 billion wons.

Cyworld could differentiate itself from other portal sites in many ways. First, while others provide web search, email and information services as main service items, Cyworld assists users to build "Mini-Homepages" as a one-person media collection, and allows users to use this Mini-Homepage as their own Internet place where they can manage their connection to others, share information with peers, and participate in different Internet activities.

Barebones service of Cyworld is a Mini-Homepage service, and it is a platform where it assists online users to create one-man media so that they can introduce and publicize themselves to anyone connected to the Internet. The Mini-Homepages imitate real-world relationships among people, and brings them into the Internet world with a networking function so that a personalized relationship can be created and maintained through the Internet.

Cyworld was able to effectively differentiate its service from other similar services by the unique function of "Ilchon." Ilchon is the feature that recognizes a buddy's connection to the Internet, and a change in the media of interest as quickly and efficiently as possible by organizing the users' own database in the one-user media. It took the most significant role in Cyworld's success, and their motto, "Binding all the people in the world in 'Ilchon'", shows the spirit of the service.

In conclusion, Cyworld became a driving force for the Walled Garden type of strategy, in which activity of users on the Internet could be embraced by Cyworld's circulation scope. Based on a unique service as their stepping stone, Cyworld brought a wave of surprising reactions with several distinctive aspects in their innovation.

Cyworld is currently operated by SK communications and provides collective Internet services to users. As a result, it acquires new technology and shares acquired information with SK communications and through the Internet service division in SK communications for new users.

The group of SK communication's Internet services contains a modem-based and text-based service (Netgo), the well-known portal site (Lycos-Korea), a service providing flexible communication with mobile communications to SK Telecom members (NateOn), and a cyber-money distribution company based on membership (OKCashBag, an affiliate of SK Corp.).

All of them have their separate websites, and it made Cyworld's conversion to a fee-based service a huge success. It is still considered to be the most influential decision in Cyworld's business history.

Cyworld provides the freshest services to users everyday based on Lycos-Korean's web connection technology, NateOn's On/Off line wireless data transfer and management technology, and OKCashBag's cyber-money transaction technology.

Second, Cyworld's expansion was possible by utilizing outside resources. Initially, Cyworld was founded by KAIST MBA students in 1999, and it was a community club to coordinate their existing networks. Despite 2 years of service, most resources were maintained by Internet consulting or system integration. However, consistent expansion and a Mini-Homepage service in 2002 required a larger size of financial support or resources for stability of business and new types of service.

At that moment, SK communications ran the existing Netsgo, Lycos-Korea, and NateOn but it desperately required competitive contents and a group of high loyalty customers to take over market leaders.

The two companies' needs and interest were perfectly matched, and finally, SK communications acquired Cyworld in 2002. Cyworld could finally reach its maximum expansion capacity with the support from SK communications. The success of this conversion to fee-based service was a decisive reason from the service proposition.

The number of Mini-Homepage users increased up to 17 million from 3 million, which means it has become five times larger in a period of 3 years, and annual sales for the first year after acquisition increased about 60%.

3.7 Integration of Case Studies

By analyzing the 6 HIT innovations with the presented research framework, some common characteristics in the process of HIT innovation could be identified as shown in Table 5. But these characteristics didn't appear in all the cases, and some appeared in specific parts of the cases.

Table 5. Characteristics of HIT Innovation from In-depth Case Studies

Key Characteristics	Detailed Descriptions	Matched Cases
Operating parallel development systems	● Operating several new product development teams simultaneously ● Develop product & producing technology simultaneously ● Operate plural development teams in the early stage (cooperation/competition between teams) ● By securing various channels for idea development, induce inter-team competition ● Simultaneous development of multiple functions with specialized teams in organization	- DRAM - TFT-LCD - Lineage - Sayclub - CyWorld
Aggressive learning & Technology accumulation	● Aggressive technology learning ● Technology accumulation using late mover advantage ● Use the accumulated knowledge documents for development	- DRAM - TFT-LCD - Sayclub
Creative organization differentiated from existing organizations	● Physical/cultural discontinuation between existing organizations ● Fostering risk awareness ● High motivation & sense of duty on learning ● Creative organizational culture	- DRAM - CDMA - Sayclub
Securing resources from outer networks	● Using strategic alliance, technology introduction ● Using technologies from existing, other division, or outer professionals ● Business launching by licensing original technology ● Optimization of performance through introducing specialized outer technology ● Securing growth momentum by M&A	- DRAM - TFT-LCD - CDMA - Lineage - CyWorld
Systematic development Process	● Setting clear objects and performing consumer researches ● Constructing new service systems by combining specialized techniques ● Market research of infrastructure and market environment ● Maximization of development capabilities through systematic human resource management	- D-RAM - CDMA - Lineage - Sayclub

By performing case studies, we have derived that 5 common characteristics appeared in the whole HIT innovation cases. **First**, HIT innovations utilized parallel development systems. They

simultaneously operated several new product launching teams, or simultaneously developed product & process technologies, or set several development teams to compete and cooperate. Such development systems caused competitiveness between teams in a favorable sense so that it can apply various results to the product.

Second, they had common characteristics, called aggressive learning & technology accumulation, such as aggressive technology learning, high learning motivation (engineers' sense of duty), and utilizing previously accumulated development experiences. For the innovations in developing countries, technology learning is very important because the subject is most likely to appear in visualized form in advanced countries.

The **third** characteristic seen in HIT innovation cases is the process which is discontinued from existing organizations. It appeared in a form which is discontinued physical/culturally, or created creative organization cultures. For a few cases, they constructed the risk awareness to induce successful radical innovation. The creative organizational culture played a major role for existing technologies to create a new added value. Also, the risk awareness worked as a catalyst, causing expectations for high intensity learning effort and success.

Fourth, they utilized various forms of strategic alliances and technology introduction. They also showed a common characteristic which could be called the utilization of external networks, as utilizing external resources for development. The action could be understood as an effort to supply their weakness with external networks. This could be evaluated positively in a sense that with this, they could be able to complete the radical innovation. Compared to the innovations in large enterprises, for a technology oriented small and mid size firm, the effort to collect resources other than core technology was one of key factors for successful innovation.

Finally, there have been systematic development process managements. Those are appeared in the forms of 'setting clear goals', 'incremental technology accumulation and systematic process management', and 'introducing an incentive system'. The early researches about needs, market and infrastructure helped in making an innovation channel selection, aided in quick entering to the mainstream market, and played a major role in minimizing technology and market risk. The systematic management of organization promoted the effective utilization of knowledge, which supports innovation.

The characteristics of HIT innovation shown above are definitely different from the incremental innovation claimed in prior literatures, and are shown frequently in developing countries, which needs national/firm level innovation and fast economic development via technology innovation.

3.8 Innovation Processes and Key Success Factors

By analyzing HIT innovation cases in Korea, we could find some similar characteristics. These characteristics were hardly found from the prior incremental innovations, were and promoted by some factors. The factors may differ among different cases. We found various factors from HIT innovation cases and they could be categorized as 1) the top leader's strategic intent (setting high goals), 2) drastic investment and support, 3) constructing and utilizing market environment and infrastructure, 4) aggressive technology learning and researchers' sense of duty, and 5) efforts for resolving uncertainty.

By HIT innovation cases, we could deduct that the top leader's strategic intents, such as high goal setting, sharing visions and providing risk awareness, affects the performance of HIT innovation greatly. The CEO or project manager's strategic intent encourages the researchers' morale, and leads drastic investment so that the performance level goes up. By analyzing cases,

we found that there is a tendency that setting high goals could face strong resistance at first, but by overcoming it with top's high intention, this finally affects the performance positively.

Another factor leading successful HIT innovation is drastic investment and support. The investment is based on the top manager or leaders' great interest, or the firm decision by the CEO in an owner-system company. For the start-up company, there existed frequent cases where they collected insufficient investment resources from external markets. The result shows that we need an effective marketplace to gain investment for innovative products.

Another factor influencing HIT innovation is constructing/utilizing market environment and infrastructure. The factor appeared as institution building through structuring consortium, aggressive utilization of existing market environment, aggressive usage of opportunities like global environment, and utilization of bargaining power. For an innovative product that is newly introduced to the market, a new form of market environment or infrastructure is required, or it needs set the environment by itself. It also requires aggressive efforts.

Aggressive technology learning and researchers' firm sense of duty is one of the major factors for successful HIT innovations. In some cases, the technology absorbing ability and the technology combining ability were mixed to promote aggressive technology learning.

Finally, HIT innovations, by its characteristic manner, have a lot of market uncertainties. So, it could face a lot of resistance during the beginning stages of a development. Therefore, the efforts to make uncertainties certain, like the government's clear strategic intent, and technology or parallel technology development, affect the performance of HIT innovation.

4. Implications and Directions for Further Research

4.1 Managerial Implications

HIT innovation requires strategic intent and aggressive investment of the CEOs, and the researchers' sense of responsibility and desire to learn. Additionally, since HIT innovation requires the utilization of knowledge and technology from various fields, it must be easy to cross the fields/boundaries. Also, HIT innovation is even possible for such fields as software or service industry. But the software and service sectors have different characteristics from other industries of which material assets are of the most importance, so the field must be reviewed more thoroughly and analyzed to have an optimized innovation promotion strategy.

The process to stage the strategy is largely divided into firm level and national level strategies. The firm's strategy to promote HIT innovation could be approached from three perspectives - setting goals, a technology innovation process, and a capability-enhancing process. The contents of perspectives are shown in Table 6.

With support of the firm's strategy for speeding HIT innovation, the nation's policy must be driven suitably in the same direction. HIT innovation, at the early stage, has characteristics that, not only technology itself, but the uncertainty of market, is enormous. So, to speed up such innovation, the government's political efforts are also needed. To support radical innovation, the government should undertake the following roles. First, the government must develop policies transparently and consistently. It has to construct technology roadmaps of national levels, control regulations realistically, so that the innovation could be performed easily.

Second, it has to invest aggressively in all the technology fields of high potential, so that the uncertainty goes down. It also should construct infrastructure, which could not be easily invested from private firms. For technologies, such as one with great potential, requiring too much

investment money for any private firms, or for the infrastructure necessary for the private firms' creative development, the government must perform R&D itself with national research institutes, so that the spreading effect maximizes.

Third, it must lower the market uncertainty. The government must open the markets for new-born technologies, and create stable markets through government buying. Also, in cases where the government let private companies do it on their own, the time and money consuming standard setting must be cared for by the government, so that it lowers the uncertainty and private companies can concentrate on technology innovation.

Table 6. Three Approaches of HIT Innovation

		Firm's Prior Strategy	Firm's Strategy for HIT Innovation
Goal Setting	Goal setting	● Fail-safe strategy	● Safe-fail strategy
	Active role of the CEO	● Logical, conservative decision making	● Intentional, enterprising decision making
	Utilizing infrastructure	● Utilizing existing markets	● Creating new markets, occupying early opportunity (needs pattern recognition)
Technology Innovation Process	Process Characteristics	● Management in an institutional frame	● Do the R&D process fluently & atypically ● Getting rid of any detailed scheduled management process (still need stepwise management)
	Ways of the R&D process	● Keeping schedules for independent processes	● Using various parallel approaches (joint research & mutual learning)
	Commercialization	● Emphasis on time-to-market	● Market creation / constructing successful cases
Capability Accumulation	Filling the ability gap	● Learning by doing	● Utilizing absorption, combining, and innovation capabilities
	Institutional effort	● Passive technology learning	● Maximize researchers' creativity

Finally, in the cases of developing countries, the technology, which can be the seed for HIT innovation, is very rare, so the government R&D policy must support the technological basis. And the government should make an R&D plan about select items, which can be the seed of HIT innovations. So, by modifying the education system, the government must support the interdisciplinary program which performs the education/research, and by organizing and supporting various consortiums, it must support the human resources from different fields in order to enhance communication.

4.2 Directions for Future Research Issues

We simply analyzed the characteristics and success factors, without considering the different industry characteristics in this research. So, it is irrational to expand and apply the results to many different industries. To generalize the research, we need following researches reflecting on the different characteristics. Furthermore, we could not show how innovation is different among manufacturing and service industries. More research regarding this matter would be appropriate.

Above all things, the cases in the study contain events from different markets and different periods of time, so we have to analyze many aspects for the results to be applied to various situations of the real world.

Even though the research was planned and performed to open the black box of HIT innovation, there existed many limitations. Nevertheless, the researches, including other countries' HIT innovation, explained HIT innovations which took place in developing places well. We hope that this research could contribute in some way to the planning, controlling, managing, and evaluating HIT innovations.

5. Concluding Remarks

This study introduces a new concept of high-impact technological (HIT) innovation - innovation that has a high impact on national economy and society from the technological, market, and strategic/social aspects. It is similar to that of radical innovation, but differs in the degree of technological originality and relative emphasis on economic impacts. This study tries to identify the processes of HIT innovation based on six Korean cases: DRAM, TFT-LCD, CDMA, network game, on-line portal community, and digital communication (web logging, mini-homepage, and new concept portal) services.

The results show several findings. First, HIT innovations can be realized through accumulating incremental innovations. Second, the processes of successful HIT innovations are characterized by parallel processes of development, active technological learning, creative and autonomous organization, active utilization of external network, and systematic project management. Third, key success factors for HIT innovation are high and difficult goal setting, strong top management (or political leadership) support and investment, successful institutional building, active capability accumulation, and an innovation system that reduces technological and market uncertainties. In addition, the roles of key players, including the government, are very critical in promoting HIT innovations.

The results are based on exploratory case studies and can not be necessarily generalized. But this study can bring many managerial implications for senior managers of high-tech companies and contribute to designing national systems for promoting radical and high-impact technological innovations.

References

Abbey, A. and J. W. Dickson, 1983, "R&D Work Climate and Innovation in Semiconductors," Academy of Management Journal, Vol 26, pp. 362-368.

Anderson, P. and M. L. Tushman, 1990, "Technological Discontinuities and Dominant Design: A Cyclical Model of Technological Change," *Administrative Science Quarterly*, Vol. 35, pp. 604-633.

Bartholomew, S., 1997, "National Systems of Biotechnology Innovation: Complex Interdependence in the Global System," *Journal of International Business Studies*, Vol. 28, No. 2, pp. 241-266.

Baumol, W. J., 1986, "Productivity Growth, Convergence, and Welfare," *American Economic Review*, Vol. 76, December, pp.1072-1085.

Boskin, M. J. and L. J. Lau, 1992, "Capital, Technology, and Economic Growth," in Rosenberg, N., R. Landau, and D. Mowery (eds.), *Technology and the Wealth of Nations*, Stanford University Press, Stanford.

Chae, Ji Hyung, 2005, *Cyworld's Secret of the Success*, Jaewoo Media, Seoul. [in Korean]

Cho, D. S., D. J. Kim and D. K. Rhee, 1998, "Latecomer Strategies: Evidence from the Semiconductor Industry in Japan and Korea," *Organization Science*, Vol. 9, No. 4.

Chun, K. J., 2000, "CDMA Evolution in Korea," *Proceeding of The 5th CDMA International Conference and Exhibition*, Vol. 1, November.

Chung, K. M. and K. R. Lee, 1999, "Mid-entry Technology Strategy: The Korean Experience with CDMA," *R&D Management*.

Henderson, R. M. and K. B. Clark, 1990, "Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms," *Administrative Science Quarterly*, Vol. 35, pp.9-30.

Kim, L., 1997, *From Imitation to Innovation: Dynamics of Korea's Technological Learning*, Harvard Business School Press, Boston.

Kim, Y. and B. Lee, 1998, "Surviving the Shakeout - Korean Small Firms' Strategies," *Long Range Planning*.

Leyden, D. and A. N. Link, 1992, *Government's Role in Innovation*. Kluwer, Boston.

LG Economic Research Institute, 2002, *The Next Generation Display*. [in Korean]

National Computerization Agency (NCA), 2004, *White Paper on National Computerization*. [in Korean]

Roberts, E. B. and A. R. Fusfeld, 1981, "Staffing the Innovative Technology-based Organization," *Sloan Management Review*, pp. 19-34.

Samsung Economic Research Institute, 1999, *The Miracle of the Second Semiconductor - The Success of TFT-LCD*. [in Korean]

Schnaars, S.P., 1994, *Managing Imitation Strategies: How Later Entrants Seize Markets from Pioneers*, Free Press, New York.

Schumpeter, J. A., 1934, *The Theory of Economic Development .Cambridge*, Harvard University Press, Boston.

Tidd, J., J. Bessant and K. Pavitt, 1997, *Managing Innovation: Integrating Technological, Market and Organizational Change*, John Wiley & Sons.

Tushman, M. and D. Nadler, 1986, "Organizing for Innovation," *California Management Review*, Vol. 27, No. 3, pp.74-92.