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2013 Modularization of Korea's Development Experience:

ICT R&D System and Policy

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Ministry of Science, ICT and Future Planning

KISDI
KOREA INFORMATION SOCIETY DEVELOPMENT INSTITUTE

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ICT R&D System and Policy

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Preface

The study of Korea's economic and social transformation offers a unique window of opportunity to better understand the factors that drive development. Within one generation, Korea had transformed itself from a poor agrarian society to a modern industrial nation, a feat never seen before. What makes Korea's experience unique is that its rapid economic development was relatively broad-based, meaning that the fruits of Korea's rapid growth were shared by many. The challenge of course is unlocking the secrets behind Korea's rapid and broad-based development, which can offer invaluable insights, lessons and knowledge that can be shared with the rest of the international community.

Recognizing this, the Korean Ministry of Strategy and Finance (MOSF) and the Korea Development Institute (KDI) launched the Knowledge Sharing Program (KSP) in 2004 to share Korea's development experience and to assist its developing country partners. The body of work presented in this volume is part of a greater initiative launched in 2007 to systematically research and document Korea's development experience and to deliver standardized content as case studies. The goal of this undertaking is to offer a deeper and wider understanding of Korea's development experience in hopes that Korea's past can offer lessons for developing countries in search of sustainable and broad-based development. In furtherance of the plan to modularize 100 cases by 2012, this year's effort builds on the 20 case studies completed in 2010, 40 cases in 2011, and 41 cases in 2012. Building on the past three year's endeavor that saw publication of 101 reports, here we present 18 new studies that explore various development-oriented themes such as industrialization, energy, human capital development, government administration, Information and Communication Technology (ICT), agricultural development, and land development and environment.

In presenting these new studies, I would like to express my gratitude to all those involved in this great undertaking. It was their hard work and commitment that made this possible. Foremost, I would like to thank the Ministry of Strategy and Finance for their encouragement and full support of this project. I especially would like to thank KSP Executive Committee, composed of related ministries/departments, and the various Korean research institutes, for their involvement and the invaluable role they played in bringing this project together. I would also like to thank all the former public officials and senior practitioners for lending their time and keen insights and expertise in preparation of the case studies.

Indeed, the successful completion of the case studies was made possible by the dedicated efforts of the researchers from the public sector and academia involved in conducting the studies, which I believe will go a long way in advancing knowledge on not only Korea's own development but also development in general. Lastly, I would like to express my gratitude to Professors Kye Woo Lee, Jinsoo Lee, Taejong Kim and Changyong Choi for their stewardship of this enterprise, and to the Development Research Team for their hard work and dedication in successfully managing and completing this project.

As always, the views and opinions expressed by the authors in the body of work presented here do not necessary represent those of the KDI School of Public Policy and Management.

April 2014

Joon-Kyung Kim

President

KDI School of Public Policy and Management

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Chapter 2

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Acronyms and Glossary

ADSL	:	Asymmetric Digital Subscriber Line
APEC	:	Asia-Pacific Economic Cooperation
AXE	:	Automatic Cross-Connection Equipment
CDMA	:	Code Division Multiple Access
DMA	:	Direct Memory Access
DMB	:	Digital Multimedia Broadcasting
DRAM	:	Dynamic Random Access Memory
ETRI	:	Electronics and Telecommunications Research Institute
ETSI	:	European Telecommunications Standards Institute
FCC	:	Federal Communications Commission
GSM	:	Global System for Mobile Communications
HPi	:	High-speed Portable Internet
IC	:	Integrated Circuits
ICT	:	Information and Communication Technologies
IEC	:	International Electro-technical Commission
IEEE	:	Institute of Electrical and Electronics Engineers
IFI	:	Information for Industries
IMT-2000	:	International Mobile Telecommunication 2000
IPTV	:	Internet Protocol Television
IS-95	:	International Standard-95
ITEC	:	IT Technology Transfer & Evaluation Center
KCC	:	Korea Communications Commission
KCRI	:	Korea Customs and Trade Development
KECRI	:	Korea Electronic Communication Research Institute
KERTI	:	Korean Electric Research and Testing Institute
KETRI	:	Korea Electro-technology and Telecommunications Research Institute
KIET	:	Korea Institute of Electronics Technology
KIST	:	Korea Institute of Science and Technology
KMT	:	Korean Mobile Telecommunications

KTA	:	Korea Telecommunications Authority
KTRI	:	Korea Telecommunications Research Institute
LCD	:	Liquid Crystal Display
LTE	:	Long Term Evolution
LTE-FDD	:	Long Term Evolution Frequency Division Duplex
LTE-TDD	:	Long Term Evolution Time Division Duplex
MCI	:	Ministry of Commerce and Industry
MCST	:	Ministry of Culture, Sports, and Tourism
MEST	:	Ministry of Education and Science Technology
MIC	:	Ministry of Information and Communications
MKE	:	Ministry of Knowledge Economy
MOC	:	Ministry of Communications
MOCIE	:	Ministry of Commerce, Industry and Energy
MOCS	:	Ministry of Culture and Sports
MOSPA	:	Ministry of Security and Public Administration
MOST	:	Ministry of Science and Technology
MSIP	:	Ministry of Science, ICT and Future Planning
NCA :	:	National Computerization Agency
NIPA	:	National IT Industry Promotion Agency
PCT	:	Patent Cooperation Treaty
PDC	:	Personal Digital Cellular
PECoM	:	Planning, Evaluation, Commercialization and Marketing
PPP	:	Private-Public Partnership
RFID	:	Radio Frequency Identification
RFID/USN:	:	Radio Frequency Identification/Ubiquitous Sensor Network
SAN	:	Ship Area Network
SCM	:	Supply Chain Management
SERI	:	System Engineering Research Institute
SW	:	Software

Acronyms and Glossary

TDMA	:	Time Division Multiple Access
TDX	:	Time Division Exchange
TFT-LCD	:	Thin Film Transistor Liquid Crystal Display
TIA	:	Telecommunication Industry Association
TTA	:	Telecommunications Technology Association
USIM	:	Universal Subscriber Identity Module
WiBro	:	Wireless Broadband
WiMAX	:	Worldwide Interoperability for Microwave Access

Summary

This report studies a series of ICT R&D policies in Korea since the 1960s. Korea's systemic ICT research and development infrastructure establishment and continued R&D policy implementation have deeply contributed to the country's present stance as a global ICT powerhouse. The Korean government has successfully established and implemented policies for research institutions, universities and enterprises to build up their capacities to lead innovations on the front lines of ICT sector development. The country has effectively developed technologies such as TDX, DRAM, CDMA, WiBro and DMB; showed an exemplary case of dividing roles among industry, academia and research institutions in developing new ICT technologies; raised funds for information communication promotion to build one of the top-notch ICT networks in the world and performed stable government ICT R&D projects. Such series of achievements by the country are recognized as a benchmark case, not just for developing countries but also for advanced countries. Developing countries, in particular, as they tend to have weak ICT technological capabilities in the private sector, can study Korea's case as a benchmark where the basic technology development infrastructure was laid first by many government-sponsored research institutes followed by the nurturing of private sector capacity in a phased manner (Ko et al., 2012).

We provide an overview of Korea's ICT R&D policy in the following order: i) Objectives and Achievements; ii) Backgrounds and Needs; iii) Strategy and System; iv) Specifics of Policies in chronological order; v) Evaluation of Success Factors with three case studies of TDX, CDMA and WiBro; and vi) Implications for Developing Countries.

1) Objectives and Achievements

The purpose of ICT R&D policy in Korea has changed in line with the research capability of the R&D organizations, internal/external ICT market conditions and structural changes of the ICT industry. The government R&D efforts have been focused on large-scale nationwide projects in the ICT sector, which have broader technological, social, economic effects, high technology accumulation and deep relation to other areas, yet difficult for the private sector to conduct on its own. The government laid the foundation for the ICT industry and intensively invested in key ICTs from the 1980s via national informatization projects. As a result, technologies with very high ripple effects were developed such as TDX in the 80s, CDMA in the 90s, and WiBro and DMB in the 2000s.

Korea's IT industrial policies have changed from an equipment-centered policy such as the basic plan for government administrative computerization, etc. to a network-centered policy including the basic plan for national network infrastructure and to the IT 839 strategy and u-Korea plan, a policy based on the overall value chain system. The market characteristics of government intervention, in this sense, have developed from supply-focused to demand-focused, and to supply-and-demand-mixed type of policies (Lee & Kim, 2006).

Before the establishment of the national network infrastructure in 1987, Korea's IT industry policies focused on satisfying basic communication demand and building the foundation for further informatization development (Lee & Kim, 2006). Then the ICT R&D policy goal was to build up R&D institutions' technological absorptive capabilities and replace importation with own developed technologies. The TDX development in 1986 served as the occasion for a paradigm shift from reverse engineering-based technological development to a new structure of R&D investments. More specific development goals were set up for semiconductors, computers and electronic exchangers, laying the basis for strategic industrial promotion. The period from 1987 to 2003, a year before IT 839 strategy setup, was the time Korea made intensive endeavors at a nationwide level to jump as a global IT powerhouse. During the period, the country started to catch up with advanced nations' technologies, while building world class IT infrastructure. The Ministry of Information and Communication (MIC), established in 1994, played a central role in implementing such policies. The country succeeded in commercial CDMA provision in 1996, ADSL provision in 1999, synchronous CDMA-1A service in 2000, etc. During the period, Korea was efficiently commercializing foreign proprietary technologies. From 2004 to 2007, the IT 839 strategy and u-IT 839 strategy were implemented. These policy sets considered both supply and demand in a comprehensive way, along with an IT value chain structure under the trend of digital convergence. Their goal was to discover promising ICTs for sustainable growth based on the integration of service-infrastructure-device. The ICT

R&D policy moved beyond the country's previous catch-up strategy to focus on leading technology development. As a result, independently developed technologies of Korea such as WiBro and DMB were designated as an IEEE standard and a European standard respectively in 2005. WiBro was adopted again as an ITU international standard in 2007.

II) Background and Needs

The establishment of an ICT R&D system needs to be viewed together with the overall ICT industrial policy flow. Industrial policies, in general, are the activities of a government to allocate resources to industries, or change economic activities in each industry. They are to elevate the competitiveness of a specifically targeted industry. The purpose of industrial policies varies according to national economic development stages. In early developmental stage, governments try to intervene actively to achieve resource allocation efficiency. In mature stage, governments try to make up for market failures or other shortfalls of a market mechanism instead of playing as a market itself. That is, industrial policies are basically rooted in market principle, and can be largely divided into supply and demand sides. They take an appropriate structure for each targeted industry under the goal of market simulation (Lee & Kim, 2006).

Korean government, as an active measure of nurturing its ICT sector, has established an ICT R&D system and has accelerated its investment. It founded government-sponsored research institutions(GRI), planned large-scale technology development projects with the cooperation of industry, academia and research institute and formed diverse policies to build up university R&D capacity. After building R&D organizations' capability to some extent, the country redoubled investment in network infrastructure setup. And it also considered both technology supply and demand to converge ICT and industrial sectors as a way for more flexible technology development policy execution. Korea's ICT R&D efforts have been developed in order of reverse engineering, foreign proprietary technology commercialization, independent technology development and global standard-leading technology development. Such a series of changes were the consequences of the changes in technological absorptive capabilities of domestic R&D performers such as GRIs, universities and industry.

Transmission channels of foreign technology and technological absorptive capacity of developing countries interact to produce domestic technological achievements. The government, hence, implements policies to create competencies, build infrastructure and foster an innovation friendly business climate (World Bank, 2010). Korea's ICT R&D policy has been on the path of constant technological absorptive capacity building, learning and the acquiring of global knowledge.

III) Strategy and System

ICT R&D policy was implemented to facilitate nurturing of the technological absorptive capabilities of R&D organization and individuals. Five strategies adopted by the Korean governments are worth noting. They are: 1) Change of Government Organization System Responding to Change of ICT Market and Technology; 2) Establishment of Government Research Institute (GRI); 3) Organization of Laws and Institutions for ICT R&D Promotion; 4) Systematic ICT R&D Planning and Establishment of Managing Institution; and 5) Establishment of Cooperation System among R&D Performers. Each of these five strategies is explained in detail in this study.

Another important part of strategy for ICT R&D is the unique funding mechanism. While most countries include money secured by frequency auction, etc. into the general budget, the Korean government created Informatization Promotion Fund, under the premise that "government funds collected from ICT industry through new common carrier selection may as well be reinvested into ICT industry" and used it for technology development, ICT HRD, standardization, and research infrastructure, etc. The long-term and continuous investments in ICT R&D by the Korean government were possible largely because of the Informatization Promotion Fund. Thanks to the Fund, the Korean government was financially stable and had the flexibility to carry out high-cost ICT R&D projects that had nationwide impact. It also enabled the government to swiftly respond to changing market conditions and shifts in the ICT technology in implementing the ICT R&D policy (Ko et al, 2010).

IV) Specifics of Policies

ICT industrial and R&D policy of Korea can be divided into the basic competence reinforcement period (1960~1986), the infrastructure construction period (1987~2003), the demand and supply mutual growth period (2004~2007), and the ICT convergence emphasis period (2008~Present).

From the 1960s until the mid-1980s, the electronics industry was fostered based on foreign investment and the establishment of Korean technology R&D centers. KIST (1966) and KCRI (1976), the predecessor of ETRI, were founded and the "5-year Plan for Communications Business, Semiconductor Industry Promotion", and "Basic Administration Computerization Plans" were developed and executed. When both private and public research agencies had no experience in R&D, the government and public sector cooperated with the private sector to develop technologies as substitutes for imported goods and strategic export products. Technology transfer from abroad via foreign investment was an important tool for reinforcing the competence of research agencies as well. TDX and Korean-made mainframe computers were the two most important import substitutes that promoted the ICT industry and accelerated informatization, while semiconductor was selected as a strategic export product that would create income for the next generation. In 1986, the electronics industry achieved USD 10 billion in exports and successfully developed the TDX-1.

From the mid-1980s until 2003, Korea's technological development focused on building the world's best information infrastructure. The national computer network project, which had been put in place since 1987, built the network infrastructure and the "Informatization Promotion Basic Plan" has allowed the market to be built based on the infrastructure since 1996. In 1996, the ICT Promotion Fund (1993~1995), which relied primarily on contributions of telecommunications carriers, was expanded to set up the Informatization Promotion Fund. In the fund, a research and development account was made for IT R&D, which was significant since it allowed a new era of ICT R&D that could respond to changes in technological trends and markets. This was possible because flexible adjustments to project periods and resources were backed by the account. In the early days of the infrastructure construction period, the budget was mostly invested in research and development for semiconductors, computers, and electronic exchangers, which were selected as three strategic products during the early 1980s, and this enabled a number of achievements such as the development of 4MD semiconductor in 1988, TDX-10 in 1991, the world's first 256MD semiconductor in 1994, as well as the world's first commercialization of CDMA technology in 1996. From 1997 to 2003, after the Asian Financial Crisis, strategic core technologies for CDMA sophistication, internet penetration, education and industry informatization, and industrial infrastructure reinforcement received major investments. In 2000, the ICT industry surpassed USD 50 billion in exports and ranked first in ADSL penetration and internet usage rates in the world, while succeeding in the domestic production of IMT-2000.

Between 2004 and 2007, the demand and supply mutual growth period coincided with the promotion of the IT 839, u-IT 839, and u-Korea strategies. During this time, Korea's ICT research and development was pursued in consideration of the value chain that encompasses service, infrastructure, and devices. It is a general view that the IT 839 strategy marked a switch of ICT R&D policies from catching up with developed countries to leading technology development. WiBro, which was independently developed in Korea, was selected as an IEEE standard in December 2005, while the DMB technology was selected as a European standard (ESTI) in July 2005 as well as 3G standard of the ITU in October 2007 (Kim et al., 2007). However, both the IT 839 and u-IT 839 strategies supported highly competitive products made by large corporations, and there was insufficient demand for the new services. The government also placed too much focus on early adoption, while neglecting the development of business models in the process, as critics have pointed out. For example, WiBro, which was adopted in 2006, aimed at 8 million subscribers by 2010. However, the number of subscribers had barely reached 1 million by 2012. Also, the DMB service failed to create a business model and resulted in impaired capital for some businesses. Such criticism, in addition to the stagnation in the IT industry and acceleration of IT convergence, eventually led to the dissolution of the MIC after the launch of the Lee administration in 2008.

During the fourth period, the convergence emphasis period, policies for developing IT convergence industries, fostering new growth engines, and enhancing the competitive power of the SW industry were promoted. The Lee administration in 2008 dissolved the MIC, and ICT R&D policies were distributed among three government agencies: MKE, KCC, and MCST. The MKE, which was responsible for overall policies, promoted R&D policies such as the "New IT Strategy ('09)", "IT R&D Development Strategy ('10)", and "IT Korea Future Strategy ('10)" with related departments, and invested in developing IT convergence technologies. As a result, IT convergence was spread over different industries and the competitiveness of the IT parts industry was improved. The subsequent Park administration created the MSIP, which combined the Ministry of Science and Technology in the past and the MIC. The most well-known policy vision of the Park administration is the "creative economy." It is defined as "with creativity as the core value of the economy, convergence of science and ICTs leads to convergence between different industries as well as between culture and industry, and creates new added values and jobs." In 2013, the MSIP announced the "Mid-to-Long term ICT R&D Strategy (2013~2017)." This strategy aims to secure 10 core technologies in five fields including content, platform, network, device, and information protection (C-P-N-D-S) based on reinforced SW power, and creates 15 future services utilizing the technologies. While ICT convergence was led by other industries during the Lee administration, the ICT convergence technology innovation strategy of the Park administration is slightly different in that it facilitates convergence of ICTs and other industries through advances within the ICT industry.

V) Evaluation of Success Factors

In general, policy instruments available for fostering technological learning of various entities, firms, GRIs, and academia, and engaging in research and development can be categorized into three major components: i) Demand side policies that create market needs of technology, ii) Supply side policies that increase R&D capabilities, and iii) Policies that provide a linkage between the demand side and supply side of technology. The last category represents a good management model for an R&D system that effectively links demand and supply (Kim, 1997).

ICT technology development in Korea followed three key sequences in the flow of technology from abroad to the catching up countries; "transfer of foreign technology, diffusion of imported technology, and indigenous R&D to improve and assimilate imported technology and to generate its own technology"(Kim, 1997, pp.23).

In the phases of three sequences, ETRI played a pivotal role in linking the demand side and supply side of technology. ETRI was at the epicenter of development of TDX in 1986, the world's first commercialization of CDMA technology in 1996, and the world's first commercialization of WiBro in 2006. TDX was the child of reverse engineering aimed at localization of technology embedded in imported equipment. CDMA was developed through global joint research, in which a foreign company with proprietary technology, Qualcomm, a government research institute, ETRI, device manufacturers, and telecommunication service providers participated jointly in the research project. Although the technology originally came from Qualcomm, Korea succeeded in its actual commercialization. On the other hand, WiBro is domestic technology that was strategically developed into a global standard. The development of technology went together with the development of standard. IEEE's adoption of WiBro as a global standard in 2005 as well as ITU's adoption in 2007 transformed Korea's ICT technology capacity status from imitator to leader. The technological success of WiBro, however, has not been translated into market success. Since its commercialization in 2006, it has failed to secure subscribers domestically and internationally at the time of this writing in 2013. In this study, we have presented three cases of technological innovations; TDX, CDMA, and WiBro in detail.

VI) Implications for Developing Countries

Korea's ICT R&D policy has followed a typical path of technological absorptive capability building, catching-up with foreign technology, and indigenous R&D to improve and assimilate imported technology and to generating one's own technology (Kim, 1997). [Figure 2-1] of this report, which is quoted from World Bank (2010), shows the determinants of technology upgrading in developing countries. The developing countries can upgrade their technological capabilities in ICT by tapping into globally available knowledge and technology. Import of equipment and goods, multi-national corporations and skilled diaspora are important sources of foreign knowledge and technology.

In Korea, the establishment of government research institutes was the prerequisite element of building technological absorptive capacity, since the private sector had neither the technology nor human resources. ICT innovation germinates and develops within what we call ICT innovation systems. Korea's path of ICT technological development has been one such exemplary case. "The innovation systems are made up of private and public organizations and actors that connect in various ways and bring together the technical, commercial, and financial competencies and inputs required for innovations" (World Bank, 2010 pp. 8). If we put it differently, the innovation systems are about organizations and actors of innovation and interactions between them. Korea created organizations for ICT innovation by establishing government research institutes, and fostered interaction between actors of innovation by setting up a tripartite cooperation mechanism between GRIs, private firms and academia.

The World Bank (2010) compares the role of government as a facilitator of innovations to that of gardener who should water the plants, remove the weeds and pest, fertilize the soil, and prepare the ground. The preparing ground for ICT innovation includes the establishment of GRIs and fostering of ICT human resources. The process of improving technological absorptive capacities of GRIs, private firms and universities through appropriate incentives and mechanisms can be compared to the nurturing of soil. Removing weeds and pests in government's innovation policy takes the form of fostering competition and deregulation. Watering in innovation policy assmues the shape of financial and institutional suppport. The Korean experience in building an ICT R&D system, and the implementing R&D policy can be matched to the figurative role of a gardener for innovation, which can be emulated in developing countries. The details of that role is given in this study.

The public sector must focus on highly risky basic technology R&D that involves the public interest and external conditions. While the public sector must intensively foster the areas that have a high potential of future growth and a high ripple effect such as the CDMA commercialization in the case of Korea, it also needs to focus on basic and core fundamental technologies. The industry, the academy, and the public research institutes must join forces to select strategic areas and plan detailed projects. The R&D of the government should stimulate the R&D of the private sector rather than crowding it out, which can be achieved by clearly dividing the roles of the private sector and the public sector in R&D. That is, the ICT R&D should be led by the private sector, and the government must focus its R&D investment in the areas where the private sector cannot undertake R&D or where there is no incentive to undertake R&D.

The role of the government in ICT R&D is time-variant. The evolution of Korean ICT R&D policy explained in this report can shed light on policy making for developing countries. However, there are things that should not be emulated from the Korean case. Korea's private sector ICT R&D is led by a few large conglomerates like Samsung and LG, and is focused on investment in hardware-related technology. This is caused by the path-dependency of Korea's ICT industry and R&D experience. Korea promoted exports of hardware equipments, parts and components by providing preferential loans to large conglomerates in the 1960s and 1970s. This initial "select and focus strategy" has led to the polarization of hardware and software, large conglomerates and SMEs within the ICT industry in Korea today. It is a matter of degrees, but a more balanced approach of promoting HW and SW, and large firms and SMEs is recommended for developing countries.

Chapter 1

Objectives and Achievements

1. The Evolution and Achievement of Government ICT R&D in Korea
2. Input and Output of ICT R&D

Objectives and Achievements

1. The Evolution and Achievement of Government ICT R&D in Korea

Korea's systemic establishment of its ICT R&D infrastructure and continued R&D policy implementation have deeply contributed to the country's present stance as a global ICT powerhouse. The Korean government has successfully established and implemented policies for research institutions, universities and enterprises to build up their capacities to lead innovations on the front lines of ICT sector development. KIST, ETRI and other research institutes have been built under government sponsorship. Large-scale technology development projects have been organized through tripartite cooperation among industry, academia and research institutes under government leadership, along with diverse policies for basic university R&D capacity. After R&D players built up some capacity to some extent, the government reinforced network infrastructure investment and pursued more flexible technology development policies, such as the convergence between ICTs and industrial sectors by considering both technological demand and supply. This is one of the success recipes of the country. Korea has nurtured systems and a legal regime capable of flexibly responding to rapidly changing information communication technologies and markets, and has successfully developed and implemented policies granting appropriate incentives for R&D efforts.

The country has effectively developed technologies such as TDX, DRAM, CDMA, WiBro and DMB; showed an exemplary case of dividing roles among industry, academia and research institutions in developing new ICT technologies; raised funds for information communication promotion to build one of the top-notch ICT networks in the world and performed stable government ICT R&D projects. Such series of achievements of the country are being recognized as a benchmark case, not just for developing countries but also for advanced countries. Developing countries, in particular, as they tend to have weaker ICT technological capabilities in the private sector, can study Korea's case as a benchmark where the basic technology development infrastructure was laid first by many government-sponsored research institutes followed by the nurturing of private sector capacity in a phased manner (Ko et al., 2012).

Korea's information communication industry is a glaring example of government-led industry growth through the support for technology development and relevant system re-alignment. As in the cases of TDX and CDMA, some technologies developed directly by government-sponsored research institutions have been designated as industrial standards. Such government policies are sometimes criticized by some researchers for not being technically neutral but tilted toward specific technologies, while undermining market efficiency. However, most of the researches have agreed that the government-led technology development and standardization policies had largely contributed to stimulating the domestic market and domestic manufacturers' competitiveness (Ko, 2010).

The purpose of ICT R&D policy in Korea has changed in line with the research capability of the R&D organizations, internal/external ICT market conditions and structural changes of ICT industry. The government R&D efforts have been focused on large-scale nationwide projects in the ICT sector, which had broader technological, social, economic effects, high technology accumulation and deep relation to other areas yet difficult for the private sector to conduct its own. The government laid the foundation for the ICT industry and intensively invested in key ICTs from the 1980s via national informatization projects. As a result, technologies with high ripple effects were developed such as TDX in the 80s, CDMA in the 90s, and WiBro and DMB in the 2000s.

Table 1-1 | Korea's Information Communication and R&D Policy Goal and Outcome

Period	Main IC Policy	R&D Policy Goal & Outcome
1960s~ 1986 Device/ Supply-focused	- 5 year plan for electronic industry (1966~) - Foreign capital inducement act (1967) - 8 year plan for electronic product export (1969~1976) - 5 year plan for communication service (1961~1981) - Basic plan for administrative computerization (1978~1985) - Plan for semiconductor industry promotion ('83) - Comprehensive plan for semiconductor industry promotion (1985)	- Semiconductor, computer, electronic exchanger development - Reverse engineering for import substitution - Technology absorption capacity buildup - Network development and meeting the communication demand - Samsung 64KDRAM ('83), 256KDRAM ('84), 1MDRAM('86) development - TDX-1 development ('86)
1987~2003 Network/ Demand- focused	- Next-generation semiconductor technology development (1993~1997) - 1st/2nd basic plan for national network infrastructure (1987~) - Ministry of Information and Communication setup (1994) - Comprehensive plan for broadband infrastructure (1995) - Basic plan for Informatization (1996~2000) - Cyber Korea 21 (1999~2002) - e-Korea Vision 2006 (2002~2006) - Broadband IT Korea Vision 2007 ('03~'07)	- Focused on advance technology catch-up - Intensive investment in large national projects for strategic technology dev. - Global DRAM competitiveness upgrade - Mid/large computer development - Buildup World class IT infrastructure - TDX-10A dev. (1991) - Mainframe computer II Ticom (1991) - World's first CDMA Commercialization (1996) - ADSL commercial service launch (1999) - Synchronous CDMA-1x service (2000)
2004~2007 Overall Value Chain/ Supply and Demand- Integrated	- IT 839 strategy (2004~2006) - IT 839 technology roadmap (2005) - u-IT 839 strategy (2006~2007) - u-Korea strategy - Supply/demand-integrated policy using IT value chain approach under digital convergence - Toward a ubiquitous society including informatization service	- Promising ICT development for sustained growth - Independent global IT market-leading technology development - Narrowed technological gap with advanced countries (e.g., US: (2003) 2.5→(2006) 1.6) - WiBro adopted as IEEE standard (2005) - DMB adopted as European standard (2005) - WiBro adopted as ITU intl. standard (2007)

Period	Main IC Policy	R&D Policy Goal & Outcome
2008~Present IT Convergence, Broadcasting Communication Convergence	- MIC dismantled (2008) - IT R&D newly performed by MKE, KCC, MSCT, MOPAS, MEST - New IT strategy(2009) - IT R&D development strategy (2010) - IT Korea future strategy (2010)	- ICT convergence technology focused - Ship management network communication technology (SAN) adopted as 2011 IEC intl. standard - Secondary lithium battery global market share (2008) 22.0%→(2011) 40.0% - LED device producer ranking: (2008) 5th place→(2010) 2nd place

Source: Reconstructed and Complemented Lee and Kim (2006), and MSIP (2013b).

Korea's IT industrial policies have changed from an equipment-centered policy such as the basic plan for government administrative computerization, etc. to a network-centered policy including the basic plan for national network infrastructure and to the IT 839 strategy and u-Korea plan, a policy based on the overall value chain system. The market characteristics of government intervention, in this sense, have developed from supply-focused to demand-focused and to supply-and-demand-mixed type of policies. <Table 1-1> describes Korea's IT industry policies and IT R&D policy goals and performance in chronological order. Before the establishment of the national network infrastructure in 1987, Korea's IT industry policy focused on satisfying basic communication demand and building the foundation for further informatization development (Lee & Kim, 2006).

Then the ICT R&D policy goal was to build up R&D institutions' technological absorptive capabilities, and replace importation with own developed technologies. The TDX development in 1986 served as the occasion for a paradigm shift from reverse engineering-based technological development to a new structure of R&D investment. More specific development goals were set up for semiconductors, computers and electronic exchangers, laying the basis for strategic industrial promotion. The period from 1987 to 2003, a year before IT 839 strategy setup, was the time when Korea made intensive endeavors at a nationwide level to jump as a global ICT powerhouse. During the period, the country started to catch up with advanced nations' technologies, while building world class ICT infrastructure. The Ministry of Information and Communication, established in 1994, played a central role in implementing such policies. The country succeeded in commercial CDMA provision in 1996, ADSL provision in 1999, synchronous CDMA-1A service in 2000, etc. During the period, Korea was efficiently commercializing foreign proprietary technologies. From 2004 to 2007, the IT 839 strategy and u-IT 839 strategy were implemented. These policy sets considered both supply and demand in a comprehensive way, along with an IT value chain structure under the trend of digital convergence. Their goal was to discover promising ICTs for sustainable growth based on the integration of service-infrastructure-device. The ICT R&D policy moved beyond the country's previous catch-up strategy to focus on leading technology development. As a result, independently developed technologies of Korea such as WiBro and DMB were designated as an IEEE standard and a European standard respective in 2005. WiBro was again adopted as an ITU international standard in 2007.

In 2008, with the inauguration of the Lee Myung-bak administration, the Ministry of Information and Communication was disbanded and the country's IT industry policies, informatization policies and competition policies were separated to be performed by the Ministry of Knowledge Economy, the Ministry of Public Administration and Security, and the Korea Communications Commission, respectively. The Lee administration concentrated on ICT convergence technology development. The Ministry of Knowledge Economy integrated the 20 important industrial energy technologies (15 industrial sectors and 5 energy alternatives), which had been under the previous government's industry and resource ministry, together with 14 key ICTs previously managed by the information and communication ministry in order to reorganize them into 14 key technologies for industrial convergence. Along with such technological restructuring, the Ministry of Knowledge Economy , too, concentrated national technological development capacity on spreading ICT convergence across industries, developing key technologies and reinforcing national SW competitiveness. The Korea Communications Commission focused on developing a wired/wireless network, radiowave satellite, TV/broadcasting-related core technologies and other key technologies with broader effects throughout the market. The New IT strategy announced in 2008 aimed for triple goals - IT convergence with every industry, IT-assisted economic/social problem resolution, and key IT industry sophistication. Also, the IT Korea Future Strategy released in 2010 targeted IT capacity advancement and IT convergence with other industries for shared growth, between large and small enterprises in a friendly business climate. The strategy identified five strategic priority areas: IT convergence, S/W, major IT area, broadcasting and communication, and internet business.

The government ICT R&D investment scale was KRW 5054.5 billion in total, showing a huge increase from the participatory government's budget. As a result, the convergence between ICT and major strategic industries was well organized, and key technologies in network and broadcasting and communication were developed. The industrial ICT convergence was pursed in 10 sectors of automobile, shipbuilding, aviation, construction, energy, transportation, medicine, pharmaceuticals, textile and robot. Among these, the ship management network communication technology, SAN (Ship Area Network) in the shipbuilding area, was selected as an IEC international standard in 2011 and used by AP Moller, the No. 1 shipping company in the world, along with many other ICT convergence achievements. The market share of secondary battery in 2008 was 22% and rose to 40% in 2011. LED element production ranking of Korea was the world's fifth in 2008, and rose to second place in 2010, representing the country's enhanced IT parts industrial competitiveness. Tangible realistic broadcasting and communication technologies (3D TV, IPTV), full-HD 3D TV, and other innovative technologies were also attained (Ministry of Science, ICT and Future Planning, 2013a). However, criticisms exist over the R&D achievements of this period that there were more noticeable performance goals obtained, such as TDX development, CDMA commercialization, and terrestrial DMB's adoption as a global standard. Basic R&D investment during the period was insufficient to gain enough core technologies, and support for technology commercialization was inadequate as well (MSIP, 2013b).

Following the inauguration of the Park Geunhye administration in 2013, the Ministry of Science, ICT and Future Planning has returned to govern ICT development. The ministry generally manages the country's science, technology and ICT policies, and is even larger in its roles on ICT R&D policy management than the previous Ministry of Information and Communication, which was disbanded in 2008. The ministry announced the mid- to long-term ICT R&D strategy (2013~2017) in October 2013. The strategy was named ICT-WAVE strategy, since it incorporated its four visions in acronym form: i) World's Best ICT, where open and leading ICT R&D efforts will secure world-class ICT competitiveness; ii) Activating R&D Ecology where the national R&D environment will be overhauled; iii) Vitalizing Industry where ICT R&D support will be rendered throughout the whole period for better industrial outcomes; and iv) Enhancing Life where ICT R&D will be expanded for improved people's living quality. The Park administration set goals to improve the country's technology commercialization ratio which stayed, as of 2013, at 8.2% to 35% by 2017; its ICT R&D investment productivity from 3.42% to 7%; and its holding of international standard patents ranked at the world's sixth to fourth place during the period as well (MSIP, 2013b).

2. Input and Output of ICT R&D

Recent trends in Korea's GDP, total R&D and ICT R&D are shown in <Table 1-2>. In 2011, Korea's total R&D expenditure recorded 48.89 trillion won or 4.04% of GDP, while the ICT R&D expenditure increased by 12.0% year-on-year at 22.16 trillion won, accounting for 44.4% of the total R&D expenditure or 1.8% of GDP. In the same year, Korea's R&D expenditure for the public ICT sector, which encompasses public research institutes and public universities, posted 2.19 trillion won or 9.9% of the total. To date, large enterprises such as Samsung and LG have dominated Korea's ICT sector with aggressive R&D investments to enhance their competitiveness in the global market. For this reason, the percentage of Korea's public-sector R&D expenditure has remained at around

10% of the total since 2005. It is well known that the industrial policies of the Korean government have served as an enabler for the success of Korea's ICT industry, however, the government's investments in ICT R&D have been no match for private investments. Despite the fact that the private sector has played a leading role in financing ICT R&D, the Korean government has indeed contributed to the growth of the industry by planning and implementing essential R&D projects. The achievements of such projects include the development of groundbreaking technologies such as TDX, CDMA, WiBro and DMB. Still, it is necessary to readjust the roles of the public and private sector in R&D since there are an increasing number of private firms that outperform the public sector in terms of financial, technological and human resources (Ko, 2013).

Table 1-2 | Recent Trends in ICT R&D in Korea (2005~2011)

(Unit: 100 Million KRW)

	GDP(A)	R&D (B)	B/A	IT R&D (C)	Public IT R&D (D)	Private IT R&D (E)	D/C
2005	8,652,409	241,554	2.79%	112,830	12,030	100,800	10.7%
2006	9,087,438	273,457	3.01%	130,283	13,656	116,627	10.5%
2007	9,750,130	313,014	3.21%	133,849	14,367	119,482	10.7%
2008	10,264,518	344,981	3.36%	150,426	16,399	134,027	10.9%
2009	10,650,368	379,285	3.56%	162,982	19,431	143,551	11.9%
2010	11,732,749	438,548	3.74%	197,953	21,549	176,404	10.9%
2011	12,351,605	498,904	4.04%	221,662	21,969	199,693	9.9%

Source: Reorganized from MSIP (2013a).

Korea's ICT industry accounted for 12.3% of the nation's real GDP in 2012, while ICT R&D took up 44.4% of Korea's total R&D, resulting in a high R&D intensity of the Korean ICT sector. Korea's R&D expenditure as a share of value added for selected industries in 2009 is shown in <Table 1-3>. The R&D intensity of the ICT industry was the highest at 17.4%, followed by automobile at 13.1%, medicine at 9.3% and chemical at 9% (Ko, 2013).

Table 1-3 | R&D Expenditure as a Share of Value Added for Selected Industries in Korea in 2009

(Unit: %)

ICT	Oil Refinery	Chemical	Medicine	Steel	Automobile	Shipbuilding
17.4	2.4	9.0	9.3	2.3	13.1	2.1

Source: OECD STAN Database.

Since 2000, the ICT sector has continuously accounted for more than 50% of the total private sector R&D. The ICT manufacturing sector, in particular, has attracted the biggest amount of private investments. The telecommunications service industry and the SW & IT service industry, on the other hand, only took up 1.1% and 3.3% of the total business R&D expenditure in 2010, respectively (see <Table 1-4>) (Ko, 2013).

The R&D intensity of the SW and IT service sector, however, is still relatively high when comparing with other economies. For example, Korea's SW R&D expenditure is higher than that of Finland, but lower than that of other advanced nations such as the U.S., Japan and Germany. In 2008, the SW R&D expenditure in the U.S. stood at approximately USD 40.3 billion, about 36-fold higher than that in Korea. In the same year, Korea's SW service sector only accounted for 3.4% of the total private sector R&D expenditure, the second lowest number after Japan. Yet the R&D intensity of the SW sector (R&D expenditure/value added) appeared relatively high with a very low value added of 1.44%. The picture becomes clearer when comparing the numbers with those of the U.K. As mentioned above, the share of Korea's SW sector in the total private R&D expenditure was 3.4%, while that of the U.K. recorded 9.4% in 2008. The R&D intensity of the SW sector, however, posted 6.7% in Korea and 4.0% in the U.K. This is attributed to the fact that the Korean SW industry was not capable of generating added values. For this reason, complex indicators like R&D intensity should be carefully analyzed (Ko, 2013).

Table 1-4 | Business R&D Expenditure Trend in Korea

(Unit: Billion KRW)

	2000	2005	2010
ICT Industry	5,253 (51.2)	9,948 (53.6)	17,410 (53.1)
ICT Manufacturing	4,493	9,131	15,914
Telecommunications Service	364	175	347
SW & IT Services	396	642	1,149
Whole Industry	10,255	18,564	32,803

Note: Numbers in the parentheses indicate ICT R&D as a share of Total Private Business R&D. ICT industry includes office, accounting, and computing machinery (30), radio, television and communication equipment (32), telecommunications (642), computer related activities (72) according to ISIC rev.3.

Source: OECD STAN Database, Reorganized from Mun (2012), Quoted from Ko (2013).

Table 1-5 | R&D Expenditure and R&D Intensity in Software Sector for Selected Countries in 2008

(Unit: Hundred Million USD in PPP, %)

	US	Germany	Israel	UK	Japan	Korea	Finland
R&D Expenditure in SW	403.3 (14.2)	21.5 (3.8)	22.3 (29.2)	23 (9.4)	21.4 (1.8)	11.3 (3.4)	4 (7.2)
R&D Intensity in SW Sector	16.3	4.5	31.2	4	2	6.7	9.8

Note: For Germany, the UK and Japan Used 2007 data. R&D intensity is defined as R&D expenditure divided by value added. Numbers in parentheses denote SW's share in total private sector R&D.
Source: OECD STAN Database, Reorganized from Mun (2012), Quoted from Ko (2013).

ICT-related fields have been leading Korea in terms of patent application. The number of patent applications of major economies by field of technology between 2005 and 2009 is shown in <Table 1-6>. Korea was the third biggest holder of ICT patent applications from 2005 to 2009, following Japan and the U.S. In addition, the number of patent applications Korea had during this period is even higher than that of Germany, France, the U.K., Canada and Finland combined (Ko, 2013).

Table 1-6 | Patent Application by Field of Technology and Country of Origin: 2005~2009

(Unit: Ten Thousand)

	Japan	US	Germany	China	Korea	France	UK	Canada	Finland
ICT	67.5	49.5	9.8	16.8	28.0	4.5	2.5	2.6	2.3
Medical	5.2	13.9	2.5	1.4	0.9	0.8	0.9	0.4	0.1
Chemistry	34.6	42.1	14.9	21.5	7.3	5.7	4.2	2.0	0.7
Mechanical Engineering	52.7	25.2	21.4	11.0	9.5	6.1	2.8	1.8	0.9

Source: WIPO (2011), Reorganized from Mun (2012), Quoted from Ko (2013).

In terms of ICT-related patent applications as a share of the nation's total, Korea came to fourth place after Singapore, Finland and China. Under the Patent Cooperation Treaty (PCT), over 44% of the total number of patent applications from Korea were ICT-related. Considering the average percentage of the 27 EU nations (26.9%) and the OECD members (34.3%) for the same period, the figure is remarkably high and seems to be closely associated with the country's concentrated R&D investments in the ICT sector. Interestingly, the percentage of ICT patents out of the total coincides with the share of ICT R&D in the total R&D expenditure for the past five years at 44%, as mentioned in the previous section (Ko, 2013).

Table 1-7 | ICT-related Patents as a Percentage of National Total*: 2001~2009

(Unit: %)

	2001~2003	2004~2006	2007~2009
Singapore	64.23	56.49	48.23
Finland	51.65	58.19	47.41
China	37.77	49.13	46.30
Korea	42.23	44.18	44.06
Japan	43.36	45.17	42.96
Canada	36.78	38.77	39.93
Israel	46.36	44.86	39.66
Ireland	41.83	38.74	37.08
United States	41.17	39.37	36.45
OECD	37.91	36.76	34.32
United Kingdom	36.13	34.70	31.56
France	32.38	31.10	28.83
EU27	32.98	29.45	26.89
Germany	29.46	24.54	22.48

* Patent applications filed under the Patent Co-operation Treaty, at international phase, designating the European Patent Office.

Source: OECD, Patent Database, quoted from Ko (2013).
http://www.oecd.org/document/23/0,3746,en_2649_34223_33987543_1_1_1_1,00.html.

The reason behind the large number of Korea's ICT-related patents is the nation's world-leading organizations in the ICT field including Samsung Electronics, LG Electronics, and the Electronics and Telecommunications Research Institute (ETRI). The Information for Industries, Inc (IFI) said that five Korean organizations made the list of the top 50 global companies with the most US utility patents in 2011 including Samsung Electronics (No.2) with 4,894 new patents, LG Electronics (No.12), Hynix Semiconductor (No. 25), LG Display (No.41) and the Electronics and Telecommunications Research Institute (No.48). There was not a single non-ICT company made the top 50 list (Ko, 2013).

The Electronics and Telecommunications Research Institute topped the Patent Scorecard of the US Patent Board in 2011 and 2012, pushing down MIT, Stanford University, Fraunhofer research institute, etc. ETRI was found to have less industrial influence compared with other famous foreign universities or research institutes, but excelled the others in terms of the number of granted patents and the technological power index (MSIP, 2013a).

Table 1-8 | Top Ten Institutions in Innovation Anchor Scorecard™ by IPIQ in 2012

2012 Rank	2011 Rank	Institutions	Country	Patent Counts	Industry Impact	Technology Strength
1	1	ETRI	Korea	703	0.96	466.79
2	4	MIT	USA	257	2.46	437.41
3	2	University of California	USA	415	1.51	433.26
4	6	Stanford University	USA	213	2.03	297.77
5	12	Tsinghua University	China	184	2.3	291.64
6	3	Industrial Technology Research Institute	Taiwan	529	0.74	270.32
7	8	US Department of Energy	USA	319	1	218.52
8	5	US Navy	USA	362	0.78	194.76
9	10	Fraunhofer Gesellschaft	Germany	206	1.26	178.81
10	9	Caltech	USA	136	1.65	154.5

Source: IPIQ (2012), quoted from MSIP (2013a).

As of 2013, major Korean enterprises are found to have the largest market share in eight different ICT product items in the world. Samsung Electronics is the largest in eight product categories, including the mobile phone device market (23.5%), smart phone (30.2%), DRAM (41%), ultra-thin TV (27.7%), NAND-type flash memory (36.9%), organic EL panel (93.5%), etc. Samsung SDI is the No. 1 producer in the market of lithium-ion batteries (25.1%); and LG Display in the LCD panel market (24.6%) (MSIP, 2013a).

<Table 1-9> shows Korean companies' global market shares and rankings in main product items in the 2012 ICT industry environment. As for semiconductors, Korea's market share was 11.3% in 2007, and increased to 14.6%, elevating its rank from fourth to third place in the global market. For memory semiconductor and DRAM, the country's share rose and maintained the top position continuously. In the NAND flash area, the country kept first place, but its shares dropped. In system semiconductors, Korea increased its market share over two-fold, rising from fifth to fourth place. As for the tablet PC area, the country ranked second in 2012 with 14.5% and as its mobile phone market share mounted from 22.3% to 32.5%, it rose to the top position in the world. Korea's performance in the smart phone market was especially noticeable with a huge jump from 2% market share to 35.3%, leaping

to No.1 from seventh place. Korea increased its LCD panel market share to continue as first place, while mounting to No. 1 from No. 2 in the flat TV segment, thanks to share increases. In the lithium-ion secondary battery segment with soaring demand recently, Korea doubled its market share to be the largest in the global market (MSIP, 2013a).

Table 1-9 | World Market Share and Ranking of Key Korean ICT Products

	2007		2012		Source
	Market Share	Ranking	Market Share	Ranking	
• Semiconductor	11.3	4	14.6	3	iSuppli
Memory Semiconductor	43.9	1	52.2	1	"
DRAM	49	1	65.7	1	"
Flash Memory	42.7	1	42.7	1	"
Nand Flash	59	1	48.3	1	"
System Semiconductor	2.1	5	5.4	4	"
• Tablet PC (base on shipment)	-	-	14.5	2	"
• Handset	22.3	2	32.5	1	SA
(in quantities)	21.5	2	29.6	1	"
Smartphone (in sales)	2	7	35.3	1	"
• LCD Panel (Large)	43.5	1	52.7	1	Display Search
• Flat panel TV	28.9	2	42.7	1	"
LCDTV	27.2	2	40.9	1	"
PDPTV	36.3	2	64.6	1	"
• Lithium Secondary Battery	22	2	43.5	1	IIT

Source: MSIP (2013a).

Despite such excellent ICT R&D achievements of the country, its ICT technology trade balance has been in chronic deficit. In 2012, Korea's technology trade recorded exports of USD 5.31 billion, and import of USD 11.5 billion, showing a deficit of USD 5.74 billion. The main reason of this discrepancy was from the electronic and electronics sector and information communication sector. The electronic and electronics industry showed a negative performance of USD 4.47 billion, accounting for 77.9% of the whole shortage and the information communication sector showed USD 220 mil deficit, for 3.8%. Over 80% of the 2012 trade deficit was from the ICT sector. More than 50% of the technology trade deficit, despite slight changes in each year, has been from the ICT sector since 2006. Such a result implies the lack of Korea's ICT patent competitiveness in terms of both quality and quantity.

The technology trade balance ratio which divides Korea's technology export by its technology import, was 0.33 in 2010, one of the lowest levels of the 25 OECE members with available statistics. Japan showed the highest level with 4.6 followed by Estonia (2.47), Norway (2.07), Sweden (1.98), the UK (1.81), Austria (1.57), the US (1.46), Finland (1.23), Germany (1.21) and Belgium (1.18). Korea's technology trade balance ratio in 2012 slightly rose to 0.48. The Ministry of Science, ICT and Future Planning has been implementing policies to increase the ratio to 0.7 by 2020. To this end, ICT trade imbalance needs to be first addressed. The country plans to improve its patent competitiveness in areas that have not yet been dominated by advanced countries, by securing patents in new technology areas converging IC with nano, bio, etc. (MSIP, 2013c).

Table 1-10 | Technology Export, Import and Technology Balance of Payment by Industry in 2012

(Unit: Hundred Million dollars, %)

	Tech. Export		Tech. Import		Tech. Trade Balance	
	Amount	Share	Amount	Share	Amount	Share
Electric electronics	20.3	38.2	65.0	58.8	-44.7	77.9
Machine	10.3	12.5	12.5	11.3	-2.2	3.8
Information Communication	9.6	11.8	11.8	10.7	-2.2	3.8
Chemical	1.0	2.0	4.9	4.4	-3.8	6.6
Materials	0.1	0.2	2.3	2.1	-2.1	3.7
Textile	0.05	0.1	0.9	0.8	-0.9	1.6
Agriculture, Forestry, Fishery	1.1	2.1	1.2	1.1	-0.06	0.1
Construction	9.5	17.8	3.7	3.3	5.8	-10.6
Others	1.1	2.1	8.3	7.6	-7.2	12.5
Total	53.1	100.0	110.5	100.0	-57.4	100.0

Source: MSIP (2013c).

Chapter 2

Backgrounds and Needs

Backgrounds and Needs

Research and development make it possible to create new knowledge and technological advancements that enable sustainable economic growth. In 1990, countries around the world realized the importance of a knowledge-based economy and invested heavily in R&D efforts on information communication technologies, which played a key role in the economic shift toward a knowledge-intensive system. In the US, its IT R&D investment surged from 30% of the entire national R&D investment in 1980 to 44% in 1995 (Kim et al., 1999).

The establishment of an ICT R&D system needs to be viewed together with the overall ICT industrial policy flow. Industrial policies, in general, are the activities of a government to allocate resources to industries, or change economic activities in each industry. They are to elevate the competitiveness of a specifically targeted industry. The purpose of industrial policies varies according to national economic development stages. In the early developmental stage, governments try to intervene actively to achieve resource allocation efficiency. In the mature stage, governments try to make up for market failures or other shortfalls of a market mechanism, instead of playing as a market participant itself. That is, industrial policies are basically rooted in the market principle and can be largely divided into supply and demand sides. They take an appropriate structure for each targeted industry under the goal of market simulation (Lee & Kim, 2006).

The Korean government, as an active measure of nurturing its ICT sector, has established an ICT R&D system and accelerated its investment. It founded government-sponsored research institutions, planned large-scale technology development projects with the cooperation of industry, academia and research institutes and formed diverse policies to build up university R&D capacity. After building R&D organizations' capability to some extent, the country redoubled investment in network infrastructure setup. And it also considered both technology supply and demand to converge ICT and industrial sectors as a way for more flexible technology development policy execution. Korea's ICT R&D efforts have made it possible to change from reverse engineering, foreign proprietary technology commercialization, to independent technology development and global standard-leading technology development. Such a series of changes were the consequences of the changes in technological absorptive capabilities of domestic R&D performers such as GRIs, universities and industry.

<Table 2-1> presents innovation mechanism for developing and emerging states, purpose, types along with each corresponding Korean examples. Korea's TDX-1 technology development in 1986 is a good example of gradual innovation to tailor an imported technology in line with domestic conditions and needs. This was developed through reverse engineering to respond to the surging telecommunication demand. The TDX-1 development also can be categorized as an inclusive innovation. TDX-1 itself can be installed in a remote rural place or small town. Korea's CDMA commercialization in the 1990s can be viewed as the case of innovation capacity building pursued to escape from the middle-income gap. Although its original technology was from Qualcomm in the US, Korea's CDMA commercialization was possible only after competing with other advanced and already-commercialized technologies such as TDMA, GSM, etc.

Table 2-1 | Why Innovating is Important for Developing and Emerging Countries

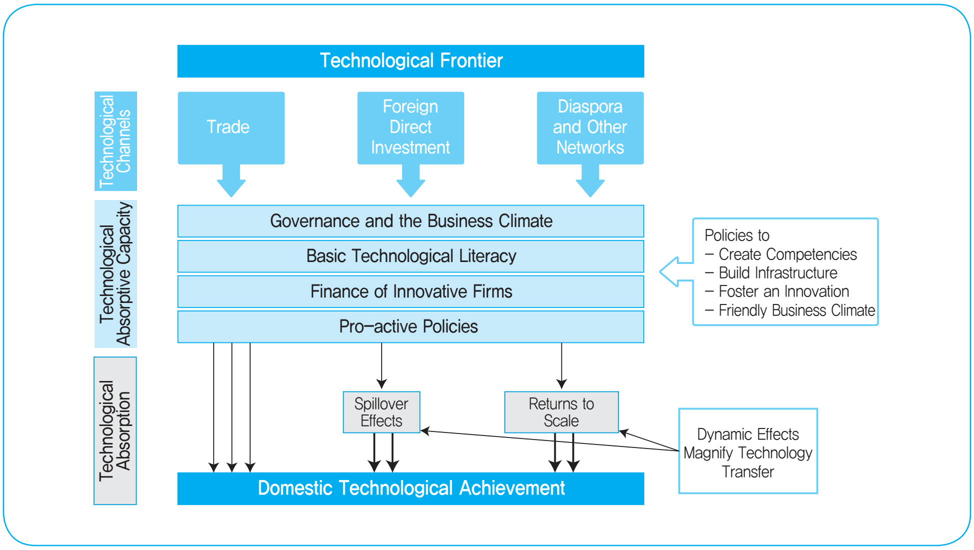
	Mechanism/Objective of Innovation	Type/Source of Innovation, Korean Example
Developing/ Low-income Countries and Emerging/ Middle-income Countries	• Adoption requires adaptation: Innovation needs to respond to specific "local" conditions for outcomes	• Incremental innovation based on foreign innovations and technologies • Korea in the 1980's: TDX-1
	• Inclusive innovation: for/ by low- and middle-income households to improve welfare and access to business opportunities	• Incremental innovation based on foreign technology and/ or local, traditional knowledge generated "out of necessity" • Social innovation helping to introduce technical innovations in communities

	Mechanism/Objective of Innovation	Type/Source of Innovation, Korean Example
Mainly Middle-income countries but also some opportunities for Developing/ Low-income countries	• Build up innovation capacities that will be key for reaching the world technological frontier in many industries, esp. relevant to avoid "middle-income traps"	• Incremental and radical innovation capacity to compete with leading world innovators • Korea in the 1990's CDMA commercialization
	• Address environmental, health and social challenges through global innovation efforts and local efforts to address them	• Major innovations and scientific research conducted in global partnerships but also marginal innovations to address welfare of poor people • Korea in the 2000's Green ICT R&D, u-Health R&D
	• Build-up niche competencies i.e. growth/ exports in sectors of comparative advantage	• Incremental innovations based on applying foreign innovations and technologies strategically to support industrial development • Korea in the 1990's Semiconductor, TFT-LCD, Handset
Mainly Emerging/ Middle-income countries after initial progress on dimensions above	• Climb the value ladder in global value chains	• Incremental and radical innovation capacity to differentiate contributions • Korea in the 2000's: WiBro, DMB Technology Development
	• Keep competitiveness in frontier industries when the country is already at the frontier	• Innovation is identical to developed countries exposed to developments in the global market • Korea in the 2000s: Semiconductors, TFT-LCD, Smartphone, Lithium Secondary Battery

Source: OECD (2012), Korean case is added by the author.

The semiconductor, TFT-LCD, mobile phone developments in the 1990s represented cases of targeting a niche market. WiBro and DMB technology development in 2000 was a brand new product and service creation. Finally, Korea's R&D investment in semiconductors, smart phones, TFT-LCDs, lithium-ion secondary batteries, etc. have resulted in the country maintaining its status as a top performer in these areas.

Figure 2-1 | Determinants of Technology Upgrading in Developing Countries



Source: World Bank (2008), quoted from World Bank (2010).

[Figure 2-1] depicts the determinants of technology upgrading in developing countries. Transmission channels of foreign technology and technological absorptive capacity of developing country interact to produce domestic technological achievement. The government, hence, implements policies to create competencies, build infrastructure and foster an innovation friendly business climate (World Bank, 2010). Korea's ICT R&D policy has been on the path of constant technological absorptive capacity building, learning and acquiring the acquirement of global knowledge.

Korea's technology policy, including that of ICT, has evolved in unison with industrial policy. <Table 2-2> shows development of industrial policy and technology policy from 1960s to 2000s. IT has been at the center of industrial policy and technology policy since the 1990s.

Table 2-2 | Industrial Policy Development and Technology Policy Development in Korea

	Industrial Policy Development	Technology Policy Development
1960s	• Develop import-substitution industries • Expand export-oriented light industries • Support producer goods industries	• Strengthen S&T education • Deepen scientific and technological infrastructure • Promote foreign technology imports
1970s	• Expand heavy and chemical industries • Shift emphasis from capital import to technology import • Strengthen export-oriented industrial competitiveness	• Expand technical training • Improve institutional mechanism for adapting imported technology • Promote research applicable to industrial needs
1980s	• Transform industrial structure to one of comparative advantage • Expand technology-intensive industries • Encourage manpower development and improve productivity of industries	• Develop and acquire top-level scientists and engineers • Perform national R&D projects efficiently • Promote industrial technology development
1990s	• Promote industrial restructuring and technical innovation • Promote efficient use of human and other resources • Improve information networks	• Reinforce national R&D projects • Strengthen demand-oriented technology development system • Institutional Reform
2000s	• Move towards High tech and high value-added industries • Develop IT industry • Search the next generation engine of growth	• Strengthen national and regional innovation system • Internationalize R&D systems and information networks • R&D increase in IT, BT, NT, ET, CT

Source: Hong (2005).

Chapter 3

Strategy and System

Strategy and System

1. Strategy for Policy Making and Implementation

1.1. Change of Government Organization System Responding to Change of ICT Market and Technology

To ensure the advancement of the IT sector and related areas such as equipment, software and communications network need to grow in a consistent and consolidated manner. Before the Ministry of Information and Communications (MIC) was launched in Korea, many different areas of the IT sector had been monitored and regulated by different government agencies: the equipment sector by the Ministry of Commerce, Industry and Energy (MOCIE), the software sector by the Ministry of Science and Technology (MOST), and the communications network industry by the Ministry of Communications (MOC), resulting in overlap and duplication in tasks and responsibilities. For this reason, during the government reshuffle in December 1994, the MIC was newly established to take charge of all the IT-related areas and functions. The responsibilities shifted from other government agencies to the MIC include: to promote and support telecommunications equipment, multimedia, computers and peripherals, and the overall IT industry by MOCIE; to help develop, distribute and protect computer systems and programs; to nurture the overall system development industry by MOST; and to issue licenses to cable TV operators and supervise the cable broadcasting industry by the Ministry of Information. In other words, the MIC emerged as a single agency in charge of the entire IT industry and therefore was capable of making an accurate and comprehensive analysis of the current status of the nation's IT industry and informatization process, coming up with more thorough and consistent strategies for different IT fields and better responding to changes in the domestic and overseas markets.

MIC was a department specializing in information communication from sophistication of information and communication infrastructure, including the IT industry policy and high-speed internet, to informationization to promote the use of information communication. For instance, the e-government project and competition policy maximized the benefit of consumers through proper regulation of the communication businesses. The Ministry successfully fostered the IT industry by establishing the information superhighway, commercializing CDMA, and adopting effective competition in the communication market. However, MIC was at the risk of being closed at the end of 2007 after controversy over the Galapagos syndrome, which means smart phone was introduced later because of the exclusive wireless platform WIPI, and the failure of WiBro, the independently-developed fourth generation mobile communication.[1] From an industrial standpoint, as the growth of the ICT industry stagnates and the productivity improvement of non-IT industries by using IT becomes an important issue, it has been suggested that MOCIE, which is responsible for promotion of all industries, take charge of IT promotion policy. Also, in terms of regulation, critics point out that it is like a player acting as a judge if MIC, which is responsible for regulating the communication market, also deals with network promotion and that there should be an independent regulatory body like FCC of the US.

With the launch of the Lee Myungbak administration in 2008, MIC was disorganized and the IT industry, informationization, and competition policies were to be taken over by Ministry of Knowledge Economy (MKE), Ministry of Security and Public Administration (MOSPA), and the Korea Communications Commission (KCC), respectively. The restructuring of government departments was promoted under the premise that new task distribution would enable more flexible responses to new changes such as accelerating convergence between IT and other industries, and broadcasting and communication, and increasing demand for policy to take measures against the adverse effects of informationization. The decentralization of ICT policy generated two problems: First, it was a cooperation between departments. Decentralization often led to unnecessary competition rather than the promotion for cooperation among different departments. Secondly, the distribution of tasks did not accelerate the convergence of IT and other industries to a considerable extent. In the Korean industrial structure, where large corporations dominate most of the industries that require IT convergence, critics point out that a government department responsible for industrial support cannot be very effective in accelerating the IT convergence. Large corporations would embark on IT convergence without direct involvement of the government, based on the presupposition that the problem lies in the supply rather than demand.

1. The term "Galapagos Syndrome" was coined by Natsuno Takeshi, professor of Keio University, and refers to deterioration of the competitive power of Japanese mobile phones in the global market due to isolated evolution for the domestic market and negligence regarding international standards.

With the inauguration of the Park Geun-hye administration in 2013, ICT promotion again was handed over to Ministry of Science, ICT, and Future Planning (MSIP), which became a major department that handles science, technology and ICT policies. ICT policies from the MSIP encompasses convergence and promotion of broadcasting and communication and radio wave management, which used to be handled by KCC, ICT research and development, industrial promotion, and SW industry convergence by MKE, national informationization plan, information security, and information culture policies by MOPAS, and digital contents policies by the Ministry of Culture, Sports, and Tourism (MCST). Five years after ICT policy promotion system was rebuilt after disorganization of MIC, the centralized policy promotion system returned as regulations, promotions, and informationization were handled by one department. This, in part, meant a return from demand-oriented policies to supply-oriented policies, which reflects the recognition that the policies should focus on supply in order to promote ICT entrepreneurship and small and medium businesses in the industry. However, the foundation of the ICT policies created during the Lee Myungbak administration, which aimed to activate convergence of IT and broadcasting and communication in order to improve productivity and maximize the growth potential of the IT industry, has been maintained while paying more attention to fostering software and service industries.

Table 3-1 | ICT Policy Functions Transferred to MSIP

Previous Departments	ICT Function
MKE	- ICT industry, mail, money order, and mail transfer, R&D
KCC	- Convergence and promotion of broadcasting and communication, radio wave management
MOSPA	- National informationization· information protection · information culture
MCST	- Digital contents promotion · broadcasting and advertisement

Source: MSIP (2013a).

1.2. Establishment of Government-Funded Research Institutes (GRIs)

Electronics and Telecommunications Research Institute (ETRI) represents the history of Korean IT R&D. The institute placed the footstone for Korea to lead the world mobile communication and semiconductor markets. ETRI was established in 1985 as a result of integrating three research institutes in electric, communication, and electronics fields. The Korea Electronic Communication Research Institute (KECRI) established in 1976 newly introduced electronic exchangers with the aim of improving the nation's telecommunications infrastructure. With the Ministry of Communications (MOC) becoming a new umbrella body for the KECRI in 1977, the name of the institute was changed to the Korea Telecommunications Research Institute (KTRI). The title of the organization changed once again to the Korea Electro-technology and Telecommunications Research Institute (KETRI) in 1981 after a merger with the Korean Electric Research and Testing Institute (KERTI), which was one of the affiliated organizations of the Ministry of Commerce and Industry (MCI). KETRI then served as a key research institute for the nation's telecommunications industry and led the localization of electronic exchangers. The Korea Institute of Electronics Technology (KIET) initiated projects that aimed at converting the UNIX operating system to run on 16-bit or 32-bit mini computers as well as developing 8-bit and 16-bit mini computers. It also took on the responsibility to create unique local designs, production processes and mass production technologies for different types of semiconductors. Later, in 1996, KIST-affiliated system engineering research institute (SERI), which was launched in 1967 as an electrical calculation office of KIST, was transferred to ETRI as a subsidiary division and integrated into ETRI in 1998. By 2012, ETRI became the largest public IT research institute in Korea with annual budget of 600 billion KRW and more than 2,000 employees (ETRI, 2012).

1.3. Organization of Laws and Institutions for ICT R&D Promotion

After establishment of MIC in 1994, it was the Informationization Promotion Act that was effectuated January 1, 1996, that enabled policies for strong promotion of the IT industry. Informationization Promotion Act aims to promote informationization, establish the foundation for a sophisticated ICT industry, and to improve the quality of life and economy of the people. According to the Act, the government was supposed to establish the basic plans every five years, and it had to include "matters related to the foundation of the ICT industry such as research and development for ICT and fostering ICT professionals."

In addition, the act stated that the government should plan and promote development and improvement of technologies needed for creating the foundation of the ICT industry, which includes i) research of the level of technology, research and development, evaluation, and utilization of technologies, ii) cooperation, guidance, and transfer of technologies, iii) smooth distribution of technological information, iv) promotion of academy and industry cooperation, and v) other matters related to technological developments. In addition, the act encompasses establishment of an informationization committee headed by the prime minister to deal with: standardization of ICT, protection of personal information and intellectual property rights, sophistication of ICT infrastructure, establishment of an ICT industrial complex, and the creation of an ICT promotion fund.

With the dismantlement of MIC, promotion and regulation of the ICT industry and informationization were distributed among MKE, KCC, MOSPA, and MCST, as were the laws related to ICT. The Informationization Promotion Act was all amended as the National Informationization Act, which belonged to MOSPA, while MKE created the foundation enacting the ICT Industry Promotion Act in 2009 and the Industry Convergence Promotion Act in 2011. KCC enacted the Broadcasting and Communication Development Law in 2010 in order to systemize the basics of broadcasting and create broadcasting and communication funds for the efficient promotion of broadcasting and communication policies. MCST enacted the Contents Industry Promotion Act by amending the entire Digital Contents Industry Development Act to create a promotion system and development of the contents industry at the government level (MSIP, 2013a).

After the launch of the Park administration in 2013, the Government Organization Act, which was entirely amended from March 23, 2013, and MSIP was established as an organization dedicated to ICT, and ICT-related laws that used to be distributed among four departments were integrated under MSIP. To establish a system for integration, adjustment, and regulation of government-wide ICT policies, and build an institutional ground to activate entrepreneurship in ICT fields and create high quality jobs, MSIP enacted the Special Law for Promotion and Convergence of ICT (MSIP, 2013a).

1.4. Systematic ICT R&D Planning and Establishment of Managing Institution

To establish an effective ICT R&D planning and management system, various policies have been enforced. From 2003, the PM (project manager) system was adopted in order to expand the efficiency of IT R&D investment and practical performance. PMs were given the responsibility over the entire R&D process including project planning, management, and commercialization. This system allowed PMs with expertise to manage milestones, responding to the changing environment. As a result, it improved the flexibility and responsiveness of the government regarding ICT R&D. And then, from 2005, the PECoM (Planning, Evaluation, Commercialization and Marketing) system was built and operated to systematically manage the entire process and output of R&D. It is an R&D management system that standardizes performance management and post-management during the planning in order to effectively support R&D projects by adopting the product life cycle for them. The head of a research signs an agreement with the PM (project manager) and has to submit the target and schedule including the performance checklist, while the PM regularly evaluates performance and, if the R&D progress does not meet expectation or becomes unnecessary due to change in external environment, changes the target or stops the support (TTA, 2012).

To respond to the changes in ICT efficiently, a plan to strengthen technology planning was enforced from 2006 after the amendment of ICT R&D management regulations in 2005. This policy enabled IT prediction, research on the level of technologies, design and research of IT innovation indices, patent trends and rights analyses, and IT road-mapping. Patent trend research and IT road-mapping are performed every year, and IT prediction and technology level research, every two to three years. Furthermore, a system has been established to develop statistics and indices for effective performance management, to analyze IT R&D policy trends, and to provide rapid information services regarding major R&D issues.

1.5. Establishment of Cooperation System among R&D Performers

The Korean government actively attracted foreign capital enterprises during the 1960s and 1970s, the early period for the Korean electronics industry. Enacting the 'Foreign Capital Inducement Law' in 1967 provided a platform for multinational corporations to actively come into the Korean market, as the law significantly simplified the import and export procedures of products made by electronics companies that received approval for independent or joint investment. These foreign investment companies were given the benefits from the government on the condition of exporting the entire amount of parts and electronic products produced in Korea. Multinational corporations established in Korea by the end of 1969 totaled 22, with 10 companies based on 100% sole investment and 12 based on joint investment with domestic capital. Among them, only one sole investment company and two joint investment companies were launched before the enactment of the 'Foreign Capital Inducement Law', which shows how this law made an immense effect on inducing foreign capital to Korea. Foreign companies entering the domestic market not only provided a platform for Korean companies and workers to obtain technologies, but it also helped the government realize the necessity of establishing a specialized science research institute (Ko, 2012).

After the 2000s, by which time the Korean IT industry had begun showing signs of growth, policies to attract R&D centers of major global IT companies in Korea were focused on securing technologies, fostering high-level specialists, and entering global markets. <Table 3-2> shows examples of R&D centers of global IT companies that had been built in Korea between 2004 and 2006. After the Roh Moo-hyun administration, local governments in association with research clusters actively attracted global companies' R&D centers, as shown in the case of research clusters like Pangyo Techno Valley Global R&D Center, in which GE and other companies built their R&D centers, and Songdo u-IT cluster with Cisco R&D Center.

Table 3-2 | Examples of R&D Centers of Global IT Companies in Korea

Year	Company (research field)
2004	Intel (Digital Home, wireless communication), Fraunhofer IGD (virtual evaluation simulation), IBM (Telematics, embedded S/W, RFID), Siemens (network equipment), HP (RFID)
2005	Agilent (wireless RF module), Microsoft (mobile Device & Solution), Sun (mobile S/W, embedded S/W), On-Semi (mobile solution and part development), AMD (electronics and portable multimedia platform)
2006	SAP (information system management), TI (mobile multimedia platform), Motorola (USN), Oracle (embedded S/W, RFID), BEA (communication service solution)

Source: Kim, et al. (2007).

Together with programs that strengthen cooperation with foreign research agencies, policies were promoted to enhance the links between domestic industries and the public sector. R&D projects based on PPP (Private-Public Partnership) system, in which the private sector provides R&D funds and the government-funded research institutes perform joint research with the private sector, were promoted. This system enabled more market-oriented R&D projects and strengthened the public R&D services because the private sector could lead R&D unlike when the public provides funds for private R&D projects. The portable internet technology (WiBro) was developed as a result of the PPP system, with the KRW 39 billion of R&D funds provided by Samsung Electronics between 2003 and 2005, and through a joint development with ETRI (Kim et al., 2007). Companies with active R&D activities like Samsung Electronics exist in Korea because of active R&D projects based on the PPP system. According to published data, in 2012, Samsung Electronics had invested 11,892.4 billion KRW in R&D endeavors.

Another system was established to support the management of intellectual property rights of small and medium businesses, and to design an effective response to increasing IT-related patent disputes. In 2005, the IT intellectual property rights center was set up under the National IT Industry Promotion Agency and support was provided for disputes over intellectual property rights of small and medium IT companies, based on patent research analyses and patent law services related to technology development projects. To spread R&D results, holders of intellectual property rights were switched from the management organizations to main research organizations, and, as for joint research, the rights were decided by a voluntary agreement between the research organizations and participants. To accelerate support for commercializing successful results of technology development, ETRI set up ITEC (IT Technology Transfer & Evaluation Center) in 2004, which was expanded and reorganized as a technology commercialization office in 2008. Technology transfer refers to a process by which results (technology, knowledge, and information) developed from national research projects are applied to, and used for, businesses. Article 2 of the “Law for Technology Transfer and Commercialization Promotion” defines technology transfer as “transfer of a technology from the holder of the technology to another by means of assignment, license permission, technology guidance, joint research or investment, or merger and acquisition.”[2] ETRI, through the technology commercialization office, establishes technology evaluation and support for technical difficulties, while providing close technical support by dispatching their researchers to private companies.

2. Funding for Public ICT R&D

Under the slogan of “We were late in industrialization. But we will lead the information age,” the Korean government had sought to raise public awareness of the need to advance the nation’s information capabilities since the 1990s, and legislated the Basic Law of Informatization Promotion with the objective of promoting and pursuing nation-wide informatization. In addition, the government built up the Information and Communication Promotion Fund (1993~1995), which was financed by contributions from telecommunications operators and later called the Informatization Promotion Fund, to provide finances to its diverse IT projects and initiatives.

While most countries include money secured by frequency auctions, etc. into the general budget, the Korean government created the Informatization Promotion Fund under the premise that “government funds collected from the ICT industry through new common carrier selection may as well be reinvested into the ICT industry” and used it for technology development, ICT HRD, standardization, building research infrastructure, etc. The long-term and continuous investment in ICT R&D by the Korean government was possible largely because of the Informatization Promotion Fund. Thanks to the fund, the Korean government was financially stable and flexible enough to carry out high-cost ICT R&D projects that had nationwide impact. It also enabled the government to swiftly respond to changing market conditions and shifts in ICT technology by implementing ICT R&D policy (Ko, 2010).

2. Depending on the form of the transferred technologies, it can be divided into transfer of industrial property including patent, know-how technology, and both industrial property and knowhow technology; depending on transfer of ownership, into technology sale (transfer) and technology execution; depending on the type of the technology execution right, into limited and general execution rights, and exclusive and non-exclusive right (ETRI technology transfer website: http://www.itec.re.kr).

Table 3-3 | Purpose and Source of Informatization Promotion Fund

	Purpose	Source
General Account	- Build broadband network and promote its utilization - Facilitate informatization in different areas: public, regional and industrial areas - Build a foundation for the growth of the IT industry	- The government's contribution - Profit from the operation of the Fund - Borrowings and other revenue
Research and Development Account	- Develop IT technologies - Nurture skilled IT resources - Develop and set IT standards - Build a foundation for IT research	- The government's contribution or loans - Mandatory contribution collected from telecommunication operators - Profit from the operation of the Fund - Borrowings and other revenue

Source: Ko (2010).

The Informatization Promotion Fund, which was mainly used to make investments in or finance the nation's informatization and other IT-related projects, had two accounts: the General Account and the Research Development Account. The fund was renamed the Information and Communication Promotion Fund, in order to shift the focus to IT research and development, when the establishment of high-speed Internet networks, the first phase of the e-Government initiative, and other large-scale informatization projects were completed.

After large-scale informationization projects such as high-speed networks and the step1 e-government project were completed and the purpose of the general account of the Informationization Promotion Fund was achieved, the general account was abolished in 2005. The name of the fund was changed back to ICT Promotion Fund, focused on investing in IT R&D. The following table shows the major history of the fund.

Table 3-4 | Major History of ICT Promotion Fund

Fund	History
ICT Promotion Fund (1993~1995)	• Jan, 1993: Creation and operation of ICT Promotion Fund - Article 5, Law on ICT research and development (enacted Dec.14, 1991) - Foundation to systematically promote national informationization and ICT industry (Ministry of Postal Service changed to MIC)

Fund	History
Informationization Promotion Fund (1996~2004)	• Jan, 1996: reorganized into Informationization Promotion Fund (Article 33, Informationization Promotion Act) - Enactment and declaration of Informationization Promotion Act (Aug. 4, 1995) - It was divided into general account for informationization promotion and R&D account for ICT industry, the R&D account succeeded ICT Promotion Fund
ICT Promotion Fund (2005~present)	• Jan, 2005: reorganized into ICT Promotion Fund (Informationization Promotion Act amended) - In Informationization Promotion Fund, the general account was abolished and R&D account succeeded - Feb, 2008: following the government reorganization, managing agency of ICT Promotion Fund change from MIC to MKE (Informationization Promotion Act amended) - Aug, 2009: The legal basis for ICT Promotion Fund changed (ICT Industry Promotion Act enacted) - Mar, 2013: following the government reorganization, managing agency of ICT Promotion Fund changed from MKE to MSIP (ICT Industry Promotion Act amended)

Source: NIPA website (http://www.nipa.kr), Sookmyung Women's University Industry-Academic Cooperation Foundation (2013).

Thanks to the fund, the Korean government was financially stable and flexible enough to carry out high-cost IT projects that had nationwide impact. It also enabled the government to pursue the nation's informatization without budget, time and human resource constraints, and to swiftly respond to the technological environment since the main purpose of the fund was to financially back the government in implementing related projects. The success of the projects financed by the fund also had spillover effects to other related fields and industries, and opened up new business opportunities, thereby accelerating the nation's informatization process.

The specific results include Korean medium-sized computers, 256M DRAM, TDX, CDMA, DMB, and WiBro. Also, the fund contributed to a balanced development of the IT industry through nurturing demand-oriented professionals, creating an ecosystem for small and medium IT businesses, and fostering IT parts, material, high-added-value SW industries, as well as improving convenience of people's live by wide distribution of mobile phones and internet. <Table 3-5> shows notable results of the IT R&D projects based on the fund.

Table 3-5 | Major Research Output of ICT Promotion Fund

Year	Description of Technology Development	Remark
1994	- Developed medium-sized computers (mainframe computers III) - Developed 256M DRAM	The world's first
1995	- Developed TDX-10, electronic telephone exchanger	
1996	- Developed CDMA digital mobile communication system	The world's first
1998	- Had CDMA technology adopted as international standards - Developed mainframe computers IV	Europe and the U.S.
2000	- Launched synchronous CDMA-1x service	The world's first
2002	- Launched synchronous CDMA-1x EV service	The world's first
2003	- Developed a terrestrial DMB system	The world's first
2004	- Developed a pilot product of mobile Internet device (WiBro)	The world's first
2005	- WiBro adapted by the Institute of Electrical and Electronics Engineers (IEEE) as global standards - Terrestrial DMB adopted by the European Telecommunications Standards Institute (ETSI) as European standards	IEEE 802.16e

Source: Ko (2012).

Table 3-6 | ICT Promotion Funds by Year

(Unit: 100 Million KRW)

Year	2008	2009	2010	2011	2012	Total 1993~2012
Total amount (A)	6,442	5,552	7,153	10,671	3,095	117,996
Contributions of Telecommunication Carriers*	4,536	4,399	4,851	9,956	2,253	84,650
Total expenditure	8,157	8,006	8,329	6,782	6,587	111,208
Current expenditure (B)	7,750	7,745	8,137	6,615	6,421	104,249
Net fund (A-B)	△1,715	△2,454	△1,177	3,889	△3,493	6,788

Notes: *The size of Contributions of telecommunications carriers is determined and renewed at each time of spectrum allocation.

** Total of 2012 is accumulation since 1993.

Source: NIPA (2013), Sookmyung Women's University Industry-Academic Cooperation Foundation (2013).

Since its creation in 1993, ICT Promotion Fund raised a total of 11,799.6 billion KRW by the end of 2012, among which 11,120.8 billion KRW was used, and as of the end of 2012, the net fund amounts to 678.8 billion KRW. The net fund declined between 2007 and 2010 by around 200 billion KRW each year, before increasing by 388.1 billion KRW in 2011 and then decreasing again in 2012 by 349.3 billion KRW (Sookmyung Women's University IACF, 2013). Since 2008, in the last five years, investment in ICT Promotion Fund amounts to 3,989.9 billion KRW, while it decreased by an average of 7.5% per year. Considering that the overall R&D investment by the government increased 9.7% per year on average, from 1,178.4 billion KRW in 2008 to 1,624.4 billion KRW, in 2012, investment into ICT fields using the fund seems to have significantly decreased. Considering that the net fund increased only in the years when frequencies were allotted, which results in the fluctuation between years, and more ICT-related investments have been made from other fields such as biotech and green technology, the actual decrease of the government in ICT R&D must have been negligible.

According to the ICT Industry Promotion Act, the ICT Promotion Fund is to support the promotion of ICT assets such as relevant R&D, standardization, professional training, and industrial infrastructure. The act also defines the major projects of the fund for R&D, standard development, establishment, and distribution, professional training, and infrastructure related to ICT. The source for the fund include contributions and loans from the government, R&D shares and frequency payments by telecommunication carriers according to the Frequency Act, profits and loan payables from fund operations, and other profits. As of 2013, the direct managing agency of the fund is the ICT policy office of the ICT department at MSIP, and the NIPA fund management committee is acting as a consigned manager. Three committees – fund operation council, asset management committee, and fund evaluation advisory – are taking part in fund operation. The fund operation council was set up based on the ICT Industry Promotion Act and reviews operations and management of fund such as operation plans, changes, and reports. Also, according to the article 76 of National Finance Law, the managing agency of a fund whose surplus fund exceeds 1 trillion KRW, as of the two previous fiscal years, must set up a fund management council to review important issues related to the operation of the fund. The current fund operation committee is composed of a total of seven people, and chaired by the head of NIPA. To improve transparency and efficiency of the fund and establish result-oriented operation and management system, NIPA made a ICT Promotion Fund evaluation advisory, which is composed of experts from the private sector since 2003. The operation system of ICT Promotion Fund can be summarized as follows: First, MSIP makes mid-term or annual plans, with help of the fund operation council and asset management committee. And then, the plans regarding project selection and management are executed by NIPA. MSIP leads the closing and performance assessment about executed projects, and, again, the fund operation council, asset management committee, and fund evaluation advisory cooperate in this process. Preliminary budget allotment and adjustment, and fund operation and R&D evaluation is handled by the Ministry of Strategy and Finance, while the National Assembly is in charge of closing accounts and budget reviews, and the Board of Audit and Inspection conducts audits.

Chapter 4

Specifics of Policies

Specifics of Policies

ICT industrial and R&D policy of Korea can be divided into the basic competence reinforcement period (1960~1986), infrastructure construction period (1987~2003), demand and supply mutual growth period (2004~2007), and ICT convergence emphasis period (2008~Present). This chapter explains Korea's R&D system and policy establishment based on the basic competence reinforcement period, infrastructure construction period, demand and supply mutual growth period, and ICT convergence emphasis period.

1. ICT R&D Policy during the Basic Competence Reinforcement Period (1960~1986)

Although Korea began to rise as an ICT powerhouse with the full-scale development of the Korean ICT industry after the establishment of the MIC in 1994, the Korean government and businesses had quickly responded to the changing IT environment and had been internalizing new products and services for even longer. Korea predicted growth of the PC industry, digitalization, and wireless communications service, and concentrated on fostering the semiconductor, display, and mobile phone industries. Apple launched the first PC in 1978, and the IBM PC based on the MS-DOS operating system was introduced in 1981, while Korea borrowed USD 29 million of credit from the World Bank in 1979, and the Electronic Technology Research Institute led semiconductor development with the fund. In December 1983, Samsung Electronics succeeded in the production, assembly, and inspection of 64KD RAM. Even in the communications service sector, in 1982, a year after the launch of the IBM PC, the government led the foundation of Korea Data Communication, which suggests that the country had strong tendency to embrace new IT technologies to create new opportunities (Ko, 2011).

Table 4-1 | ICT R&D Policy during the Basic Competence Reinforcement Period (1960~1986)

Policy Objective	Enhancement of Basic Competence for ICT R&D
Policy Tools	• 5-year plan for electronic industry promotion (1966), electronic industry promotion act enacted (1969) • KIST(1966), and the predecessor of ETRI, KCRI (1976) established • 5-year communication business plan (1961~1981) • Semi-conductor industry promotion plan • The 1st and 2nd administration computerization basic plan
Key Success Factors	• Development of electronic industry through export-oriented policy, foreign investment attraction, and opening of domestic R&D centers • Leap of communication field
Implementing Body	• Science and Technology Department, Ministry of Commerce and Industry, Ministry of Postal Service
Limits and Shortcomings	• Distributed policy promotion system • Lack of mechanism to secure resources
Outcome	• In 1986, the electronic industry achieves 10 billion dollar export and develops TDX-1

Source: Supplemented and reorganized from Ko et al. (2012).

From the 1960s until the mid-1980s, the electronics industry was fostered based on foreign investment and the establishment of Korean technology R&D centers. KIST (1966) and KCRI (1976), the predecessor of ETRI, was founded and the "5-year Plan for Communications Business, Semiconductor Industry Promotion", and "Basic Administration Computerization Plans" were developed and executed. When both private and public research agencies had no experience in R&D, the government and public sector cooperated with the private sector and developed technologies to produce substitutes for imported goods, and strategic export products. Technology transfers from abroad through foreign investment was an important tool for reinforcing the competence of these research agencies. TDX and Korean-made mainframe computers were the two most important import substitutes that promoted the ICT industry and accelerated informatization, while the semiconductor was selected as a strategic export product that would create incomes for the next generation. In 1986, the electronics industry achieved USD 10 billion in exports and succeeded in developing the TDX-1.

An ICT industry generally refers to an industry related to the production, delivery, and consumption of information. Specifically, this encompasses information and communications service, devices, software, and computer-related services. However, before the mid-1960s, the word "electronics" was rarely used, not to mention information and communications. Instead, an "electric industry" or "electric and mechanical industry" was used. From the mid-1960s, however, the government began to adopt policies for the electronics industry.

Within the Ministry of Commerce, Industry and Energy (MCIE), the electronics industry department was newly established in 1964 and the telecommunications industry team under the department was largely divided into two parts in charge of telecommunications and electronic appliances, respectively. The part responsible for the electronic appliance industry was upgraded into a team in early 1966, and this shows that the electronics industry became a major focus of the government and its policies, and that businesses in the industry began to be monitored and supervised by government authorities.

The 5-year Electronics Industry Promotion Plan, which later acted as a basis for the 8-year Electronics Products Export Plan, was also announced in 1966. The major objectives of the Plan included: to maximize the use of Korean-made parts in electronics products instead of imported ones; to adopt a division of labor and specialization in parts supply and assembly; to reduce export costs; to nurture highly-skilled workers; and to expand overseas export markets. As part of the Plan, the Electronics Industry Promotion Act was enacted and went into effect in January 1969 with the aim of encouraging the growth of the industry. The Act provided a legal ground for the MCIE to become an official government agency that is responsible for the development of the electronics industry and to come up with necessary plans and policies.

A mid- to long-term master plan called the 8-year Electronics Products Export Plan was also announced in addition to the enactment and promulgation of the Act. It was initially designed to last for five years but extended to eight years, considering the timeline of the third 5-year Plan for economic development. The major target of the Plan was to help the electronics industry hit the USD 400 million mark in exports by 1976, the last year of the Plan, by injecting KRW 14 billion worth of fund into the industry during the eight-year period. In addition to achieving the export target, the Plan had two other objectives — developing a list of items to localize and improving the level of localization. To this end, the Plan presented a number of specific measures including building a industry-wide development structure that integrates the manufacturing processes of various materials, parts and machines; promoting the industry as one of Korea's strategic export industries; and creating a promotion fund.

As stated in the Plan, a total of 95 target items including 12 materials, 29 parts and 54 different kinds of equipment were selected by the MCIE and promoted in two phases – the first between 1969 and 1971 and the second between 1972 and 1976. This 8-year Plan proved to be a great success and the industry recorded USD 1.036 billion in exports in 1976, a 260%

greater achievement than the initial target of USD 400 million. In that year, Korea's total export volume stood at USD 7.715 billion and the electronics industry made up 17.6% of the total.

With the rise of the electronics industry, electric communications became modernized and infrastructure was expanded. The Korean communications industry rapidly grew thanks to the "5-year Plan for Communications Businesses" adopted during the second half of 1961. To respond to the rapidly growing demand for telephones, the government took advantage of the U.S. international development loan (1961), the 1st West Germany loan (1962), and U.S. AID loan (1965) to bring in electric communications facilities and equipment to modernize and expand operations. The 5-year Plan for Communications Businesses" completed in 1981 accommodated the increasing demand for communications as a result of the nation's economic development, with the modernization of domestic and foreign communications systems, nationwide integration of telephone lines, establishment of research institutes at different levels, and launch of satellite communications base stations.

The following quantitative indices indicate the growth of Korean communications infrastructure in the 1960s and 1970s. First, while the number of telephone lines was only 123,000 in 1961 with the number of subscribers 0.44 per 100 people; the number had increased to 3,263,000 by 1981, at the end of the fourth 5-year Plan, a 26.5-fold increase, and the number of subscribers per 100 persons grew to 8.4. During the same period, the percentage of automation of telephones rose from 52.6% to 87%, the number of long-distance telephone lines from 1,777 to 88,571, and DDD, which was non-existent in 1961, increased to 26,320 lines in 147 areas by 1981.

For the financial stability of the industry, the Korean government also took action to attract foreign investments and passed the Foreign Capital Inducement Law in 1967 to encourage the market entry of multinational corporations. After the Law was introduced, the export and import procedures became much simpler for electronics companies to which the government had given permission for single or joint investments. As a condition for this preferential treatment, foreign investors were required to export all the electronics parts and goods produced in Korea.

By the end of 1969, the number of multinational enterprises that had entered the Korean market reached 22. Ten of them were established with 100% foreign investment, while 12 took the form of joint ventures with local partners. The law was indeed very successful in attracting foreign investors to Korea in that there had been only one solely invested company and two joint ventures before the Law was enacted.

With regard to the type of products multinational companies manufactured in Korea, regardless of investment types, U.S. firms tended to produce semiconductors, integrated circuits (IC), transistors and other computer-related products, while the Japanese focused on electronics goods such as resistors, electric condensers, transistors and speakers. These global companies made a great contribution to solidify Korea's industrial base on which local companies can prosper and enhance the nation's technological capabilities. The products those foreign companies manufactured in Korea in the 1960s included radios, televisions, refrigerators, automatic exchangers, cables and others that were easy to assemble without much knowledge of source technologies.

Acknowledging the need to set up research institutes specialized in science and technology, the Korean government began to make large-scale investments in establishing such institutes during the late 1960s. Korea's first-ever research institute in the field called the Korea Institute of Science and Technology (KIST) was launched in 1966, to lay the ground for the development of Korea's science and technology sector. With a growing demand for more diverse and specialized research functions, area-specific research units were set up under the guidance of KIST for further technology advancements. Then President Park Chung-Hee, who was much concerned about export expansion and technology localization, strongly supported the initiative and, as a result, 16 state-run research institutes were established between the launch of KIST in February 1966 and 1979 to undertake a wide range of research activities.

The Korea Electronic Communication Research Institute (KECRI) established in 1976 introduced electronic exchangers with the aim of improving the nation's telecommunications infrastructure. With the Ministry of Communications (MOC) becoming a new umbrella body for the KECRI in 1977, the name of the institute was changed to the Korea Telecommunications Research Institute (KTRI). The name changed once again to the Korea Electro-technology and Telecommunications Research Institute (KETRI) in 1981 after a merger with the Korean Electric Research and Testing Institute (KERTI), which was one of the affiliated organizations of the Ministry of Commerce and Industry (MCI). KETRI then served as a key research institute for the nation's telecommunications industry and led the localization of electronic exchangers. The Korea Institute of Electronics Technology (KIET) initiated projects that aimed at converting the UNIX operating system to run on 16-bit or 32-bit mini computers as well as developing 8-bit and 16-bit mini computers. It also took on the responsibility to create unique local designs, production processes and mass production technologies for different types of semiconductors.

In the 1980s, many countries around the world began to compete in earnest for establishing their information society and underwent enormous changes with the introduction of computers and communications services. Especially, private companies of developed countries seized new market opportunities, thanks to deregulation and more autonomy, and the governments around the world also strongly promoted informatization to respond to the market. Korea, too, became more determined to promote informatization and the government recognized the value of investing in the information industry and opened up a new horizon for the computer industry by, for instance, declaring 1983 as “the year of the information industry.” The declaration marked the start of a range of measures to foster the information industry and relevant government departments also began to develop various plans (NIA, 2005).

Starting from the 1980s, the Korean government contemplated over how to improve the added values of the electronics industry. The responsibility of development plans to promote the industry fell into the Presidential Secretariat for Economic Policy, while a task force consisting of 20 working-level officers from the Ministry of Commerce and Industry, the Economic Planning Board, the Ministry of Finance, the Ministry of Communications, the Ministry of Science and Technology, the corporate circle and research institutes was given the task of implementing the plans. As a result of a three-month project, the Electronics Industry Promotion Plan was drawn up. It made an innovative proposal that the focus of the electronics industry be shifted from household electronic appliances to industrial electronic goods and components. As a way to achieve this goal, it selected three products to strategically develop including semiconductors, computers and electronic switching systems, and encouraged collaborative R&D efforts among manufacturers of these three products to prevent excessive and hostile R&D competition.

One of the most comprehensive measures was deregulation of the industry and more diverse and systemic finance and tax support. Consequently, a project designed to ease administrative regulations on the industry was initiated so that businesses in the industry could grow at a faster pace and the free enterprise system in which firms are free to make their own economic choice to satisfy their consumers could be achieved. Overall, the Korean government’s policy on the electronics industry in the 1980s was more partial towards deregulation rather than stronger support.

Since the Electronics Industry Promotion Plan was announced, the government took a range of actions to achieve the goals including: lifting restrictions on the market entry of new businesses; giving electronics companies more autonomy in product selection; facilitating the introduction of new technologies; making it mandatory for government agencies to purchase electronic goods made in Korea; applying provisional tax rates to special excise taxes; and providing support to electronics firms in securing plant sites. Thanks to these thorough and strong measures, Korea’s electronics industry hit the USD 10 billion mark in exports in 1986 and the figure doubled in 1988 to USD 20 million, realizing economies of scale especially in the materials and parts sector.

The abovementioned three strategic products selected by the Electronics Industry

Promotion Plan were developed as follows. First, regarding semiconductors, the Korea Institute of Electronic Technology (KIET) was in charge and invested USD 29 million worth of fund, which was a loan from the World Bank in 1979. In 1983, Samsung Group entered the picture and announced its decision to invest in semiconductor production. Samsung succeeded in producing, assembling and inspecting 64K DRAMs in December 1983, only six months after its announcement. Against this backdrop, the KIET merged with the Korea Electro-technology and Telecommunications Research Institute (KETRI) in 1985 and became the Electronics and Telecommunications Research Institute (ETRI). In 1984 and 1986, Samsung succeeded in producing 256K DRAM and 1M DRAM, respectively, placing Korea in the ranks of global semiconductor producers. In 1986, the Korean government in collaboration with the private sector took on the development of 4M DRAMs, boosting the nation's technological capabilities up to par with advanced countries. In 1988, Korea announced its success in producing 4M DRAMs, which was followed by the development of 16M DRAMs and 64M DRAMs. In 1994, the country successfully produced 256M DRAMs for the first time in the world.

For computers, there were a number of obstacles from the beginning in terms of R&D capabilities and domestic demand shortage. The Oil Shock and predictions of the advent of an information society in the 1970s, however, prompted the Korean government to start the construction of the national backbone computer networks to get ready for the coming of the information age. As part of the initiative, IT infrastructure for administrative agencies was built and it generated demand for mainframe computers, propelling local businesses to develop their own mainframes. In 1987, to introduce mainframe computer technologies to Korea, the government signed a contract with Tolerant, a U.S. mainframe producer. In 1988, four Korean electronics firms - Gold Star, Daewoo Telecom, Samsung Semiconductor Telecommunications and Hyundai Electronics – began manufacturing medium-sized computers in earnest. As a result, the first locally designed and produced minicomputer, TICOM, was rolled out in 1991 and followed by Mainframe III and IV.

Lastly, in terms of electronic telephone exchange systems, the TDX (Time Division Exchange) system was introduced in Korea in the late 1970s. Although the system was expected to address the chronic problems such as phone line backlog and poor speech quality, the complete adoption of this new technology was delayed due to its different mechanical properties and other issues. Starting from the early 1980s, more aggressive measures were employed to facilitate the introduction of the second generation of TDX and the designation of local partners. In 1981, the first TDX development project was initiated with an R&D budget of as much as KRW 24 billion. The aim of this large-scale project was not only to develop homegrown electronic phone exchangers, but also to accelerate the advancement of the entire electronics industry. The fact that electronic telephone exchange systems were selected as one of three strategic products along with semiconductors and computers in the Electronics Industry Promotion Plan highlighted the government's great attention to this technology. By March 1986, four local companies had launched a total of 24,000 phone lines in four different regions of Korea including Ga-pyeong, Jeon-gok, Mu-ju and Go-ryeong as a result of the TDX project. The first developed telephone exchange system called TDX-1 was later upgraded into TDX-1A or TDX-1B, and TDX-10 was developed in 1991 to cover 100,000 telephone lines and TDX-100 followed. In a nutshell, the development process of the TDX system enabled the greater penetration of telephones and contributed to the overall growth of the IT industry.

2. ICT R&D Policy during the Infrastructure Construction Period (1987~2003)

From the mid-1980s until 2003, the technological development of Korea was focused on building the world's best information infrastructure. The national computer network project, which was enforced since 1987, built the network infrastructure and the "Informatization Promotion Basic Plan" allowed the market to be built based on the infrastructure since 1996. In 1996, the ICT Promotion Fund (1993~1995), which relied primarily on contributions of telecommunications carriers, was expanded to set up the Informatization Promotion Fund. In the Informatization Promotion Fund, a research and development account was made for IT R&D, which was significant in that it allowed ICT R&D that could respond to changes in technological trends and markets because flexible adjustments to project periods and resources became possible with the account. In the early days of the infrastructure construction period, the budget was mostly invested in research and development of semiconductors, computers, and electronic exchangers, which were selected as three strategic products during the early 1980s, and this enabled a number of achievements such as the development of the 4MD semiconductor in 1988, TDX-10 in 1991, the world's first 256MD semiconductor in 1994 as well as the world's first commercialization of CDMA technology in 1996. From 1997 to 2003, after the Asian Financial Crisis, strategic core technologies for CDMA sophistication, internet penetration, education and industry informatization, and industrial infrastructure reinforcement and so forth received major investments. In 2000, the ICT industry surpassed USD 50 billion in exports and ranked first in ADSL penetration and internet usage rate in the world, while succeeding in the domestic production of IMT-2000.

Table 4-2 | ICT R&D System Establishment Policy during the Infrastructure Construction Period (1987~2003)

Policy Objectives	Technology Development for the World's Best Information Infrastructure
Policy Tools	• Development of next-generation semiconductor foundation technology • Development of host • 1st informatization promotion plan • CYBER KOREA 21 • e-Korea Vision 2006 • Broadband IT Korea Vision 2007
Key Success Factors	• In 1994, MIC was founded to supervise ICT policies • Semiconductor, computer, and electronic exchanger were fostered as three strategic products • In 1988, KISDI founded as an ICT policy think-tank • ICT Promotion Fund was set up
Implementing Body	• Ministry of Postal Service, Science and Technology Department, MIC
Limits and Shortcomings	• In 1997, economic crisis in Asia • Unbalanced growth focused on HW
Outcome	• In 1988, USD 20 billion in export • In 1988, development of 4MD semiconductor, and, in 1994, world's first 256MD semiconductor • In 1991, development of TDX-10 • In 1996, commercialization of CDMA technology

Source: Reorganized from Ko et al. (2012).

The establishment of the national computer network contributed to advancing the Korean computer industry. In 1967, in the government sector, computers were introduced for the first time in the research and statistics office of the economy planning bureau, and, from the late 1970s, the public sector also began to adopt and utilize computers in some of individual projects, although there was no government-wide national computerization plan until the mid-1980s. Despite the growing interest in informatization following the adoption and use of ICTs as a supplementary tool for several unit tasks, this did not lead to specific actions or government policy at that time (Sung, 2003). Computerization was expanded to the national level as the "Act on Expansion of Dissemination and Promotion of Utilization of Information System" was enacted in 1986 and, a basic plan was drawn for the national computer network in 1987.

The computer networks built under the national computer network project were classified by function into the administrative network (government & government investment organizations), financial computer network (bank-insurance-stock agencies), education and research computer network (universities and research institutes), national defense computer network (national defense-related agencies), and public security computer network (public security-related agencies). To provide a legal ground and system to support this project, "Act on Expansion of Dissemination and Promotion of Utilization of Information System" was enacted in May 1986. Especially from 1987 to 1991, a total of KRW 147.9 billion of budget was invested in the administrative computer network project, which adopted "top-down" and "invest first and pay later" strategies, based on the judgment that the computerization project, which was sporadically promoted by different government agencies, had caused technical issues such as standardization and compatibility and thereby had limitations in terms of returns on investment. The "top-down" approach means a switch to policy implementation by task, instead of by department, and six priority fields of projects – citizen, real estate, employment, customs, car, and economic statistics – were chosen. The "invest first and pay later" strategy refers to a radical financing method by which the business in charge first invests in a project, and the government pays back the business after the project is finished. This not only lessened the risks of large-scale projects, but also helped overcome budget limitations (MIC, 2003).

In 1987, to bring mainframe computer technology to Korea, the government signed a contract with Tolerant, a U.S. mainframe producer. In 1988, four Korean electronics firms - Gold Star, Daewoo Telecom, Samsung Semiconductor Telecommunications and Hyundai Electronics – began manufacturing medium-sized computers in earnest. As a result, the first locally designed and produced minicomputer, TICOM, was rolled out in 1991 and followed by the development of Mainframe III and IV.

To ensure the advancement of the IT sector, other related areas such as equipment, software and communications network need to grow in a consistent and consolidated manner. Up until the Ministry of Information and Communications (MIC) was launched in Korea, however, many different areas of the IT sector had been monitored and regulated by different government agencies: the equipment sector by the Ministry of Commerce, Industry and Energy (MOCIE), the software sector by the Ministry of Science and Technology (MOST), and the communications network industry by the Ministry of Communications (MOC), resulting in overlap and duplication in tasks and responsibilities. For this reason, during the government reshuffle in December 1994, the MIC was newly established to take charge of all the IT-related areas and functions. The responsibilities shifted from other government agencies to the MIC include: to promote and support the telecommunications equipment, multimedia, computer and peripherals, and overall IT industry by MOCIE; to help develop, distribute and protect computer systems and programs and to nurture the overall system development industry by MOST; and to issue licenses to cable TV operators and supervise the cable broadcasting industry by the Ministry of Information. In other words, the MIC emerged as a single agency in charge of the entire IT industry and therefore was capable of making an accurate and comprehensive analysis of the current status of the nation's IT industry and informatization process. It could also come up with more thorough and consistent strategies for different IT fields to better respond to changes in the domestic and overseas markets.

The reason behind the Ministry's success in implementing those responsibilities was the Informatization Promotion Fund. The Korean government launched the fund because it believed that government revenues generated from various administrative processes for IT service operators such as the new telecommunications operator selection process should be returned to the IT industry in the form of investments. Since then, the Fund acted as a valuable financial source for the country's IT R&D projects, and enabled the launch of the CDMA and IMT-2000 services, as well as the establishment of world-class IT infrastructure. It also significantly contributed to the advancement of the nation's IT industry and to a better quality of life for Korean citizens.

Table 4-3 | Size of Production and Growth Rate of ICT Industry (1995 vs. 2004)

(Unit: Trillion KRW)

	1995	2004	Growth Rate
ICT Industry	51.4453	229.2322	346%
ICT Service	11.1445	45.9941	313%
ICT Device	38.6256	83.1233	115%
S/W and Computer-related Service	1.6752	18.6588	1,014%

Source: KAIT IT statistics information center database.

In terms of the achievement in production and export, the production volume of the Korean ICT industry grew by 346% from KRW 51,445.3 billion to KRW 229.23 billion in 2004. By field, first, the production in ICT service grew by 313% from KRW 11,144.5 billion in 1995 to 45,994.1 in 2004. ICT devices recorded KRW 83,123.3 billion in 2004, a 115% increase from KRW 38,625.6 billion in 1995. In the 1980s, production in the software industry was minuscule. However, from the 1990s, the system integration business began to rapidly expand with a large production volume of about KRW 1,675.2 billion in 1995, growing at an annual average of more than 30% for 10 years and reaching about KRW 18.66 trillion in 2004. Meanwhile, exports from the ICT industry increased by 195%, from about USD 31.7 billion in 1995 to about USD 93.7 billion in 2004. The trade balance in the ICT industry rose 191% from USD 15.1 billion in 1995 to USD 43.9 billion in 2004.

3. ICT R&D Policy during the Demand and Supply Mutual Growth Period (2004~2007)

Between 2004 and 2007, the demand and supply mutual growth period coincided with the promotion of the IT 839, u-IT 839, and u-Korea strategies. During this time, Korea's ICT research and development was pursued in consideration of the value chain that encompasses service, infrastructure, and devices. It is a general view that the IT 839 strategy marked a switch of ICT R&D policies from catching up with developed countries to leading technology development itself. WiBro, which was independently developed in Korea, was selected as an IEEE standard in December 2005, while the DMB technology was selected as an European standard (ESTI) in July 2005 as well as 3G standard of the ITU in October 2007 (Kim et al., 2007).

Table 4-4 | ICT R&D Policy during Demand and Supply Mutual Growth Period (2004~2007)

Policy Objective	Mutual Growth of Service, Infrastructure, and Devices
Policy Tools	• IT 839 strategy • u-Korea basic plan
Key Success Factors	• Consideration of entire IT industry including service, infrastructure, and devices • Branding of policies • Strategic acceptance from the value chain standpoint • Correlation among It strategies in different fields • Secured predictability and responsibility of industrial policies
Implementing Body	• The Ministry of Information and Communication
Limits and Shortcomings	• Insufficient demand for new service (WiBro) • Absence of business model for services like DMB (impaired capital by some companies) • Criticism on favoring large corporations
Outcome	• In 2005, WiBro selected as an international standard for IEEE • In 2005, ground wave DMB selected as an European standard • Royalty: 20.1 billion KRW in 2001→55.2 billion KRW in 2006 (2.5 fold increase) • International standard patents: 30 in 2002→111 in 2006 • Narrowed technology gap from developed countries (2.6 in 2003→1.6 in 2006)

Source: reorganized from Ko et al. (2012).

The previous IT industry policies received constant criticism that they were so focused on government-led technology development, distribution and development of homegrown communications services while neglecting the exploration and development of new convergence technologies and services based on IT. The IT 839 strategy and u-Korea policy were laid out to address this issue and secure global competitiveness in response to the drastic change in technology trends, namely, digital convergence based on IT (Lee et al., 2006). The IT 839 strategy was created reflecting the IT industry value chain, organically linking eight services, three types of infrastructure, and nine new growth engines, in order to establish a virtuous circle in the IT industry and achieve mutual growth of the entire industry. In the circle, the government first opens a new initial service market by granting business licenses, deciding service types, standardizing, and implementing pilot projects, then service providers invest in infrastructure and develop various products and solutions based on more advanced infrastructure, thereby improving competitiveness of the overall ICT industry (Min, 2006).

The IT 839 strategy was composed of eight services, which were considered effective in creating new demand and expected to bring synergistic effects, through the convergence of fixed and wireless communications and broadcasting, three types of infrastructure that would support the services, and nine new growth engines that were deemed competitive and had potential for high growth. At the time of making the initial strategy, the new eight services included WiBro, DMB, home network, Telemetics, RFID, W-CDMA, ground wave DTV, and VoIP service. The three types of infrastructure were BcN, u-sensor network and IPv6, while the nine new growth engines and solutions were next-generation mobile communications devices, digital TV broadcasting devices, home network devices, IT SoC, next-generation PC, embedded SW, digital content and SW solutions, Telemetrics devices, and intelligent service robots. The IT 839 strategy was made up of technology development, professional training, and industrial infrastructure, and government support was applied to all the products (Min, 2006).

The government designed the IT 839 strategy with three basic principles: First, the strategy to foster the industry must be switched from catching-up with advanced nations to technology innovation. In other words, the fields where Korea has the upper hand and those with high added-values need to be fostered the most in order to improve global competitiveness of the IT industry. Second, the role of the government needs to be changed from an active developer and supporter of new technologies, to a mediator with its focus on policies that aim to open the market through government purchase and pilot projects, and to create the foundation through technology standardization and certification. Third, to encourage the private sector's continuous investment in informatization, the government needs to adopt new services early on (Min, 2006).

Under these basic principles, five strategies were developed. First, service, product, and technology goals were proposed on a one-year or half-year basis, to clarify the target of technology development, and modularize unit technologies, which was called “Lego-type technology development.” Second, to improve responsibility and professionalism in R&D, the project manager (PM) system was adopted so that project managers from the private sector could supervise the entire process from technology planning to commercialization and post-management. This enabled top-down planning, management, evaluation, and adjustment, which improved the consistency and quality of policies, and, PECOM (Planning, Evaluation, Commercialization & Marketing) was set up within the Korea Information Society Development Institute, which is a specialized planning, evaluation, and management agency. Also, project performance review meetings, in which Ministers and PMs participated, were regularly held so that technology development can be promptly reflected in technology and service policies. Third, the government promoted the creation of a new convergence service market through an early adoption of new services, while leading standardization and strengthening export support. Fourth, the links between front and rear industries were reinforced and companies were encouraged to innovate technologies. The R&D system among services, systems, and parts was made to be transparent from the planning and early development stages, while establishing an integrated research system for standard development, system installation, and service implementation. Fifth, infrastructure was built and professionals were fostered so that Korea could establish itself as an “IT Hub of North East Asia.” To this end, Nuritkum Square in Sangamdong Digital Media City and u-IT cluster in Songdo were built. To foster IT professionals suitable for the market demand, the SCM (Supply Chain Management) model was adopted in Korea’s human resources management system (Min, 2006).

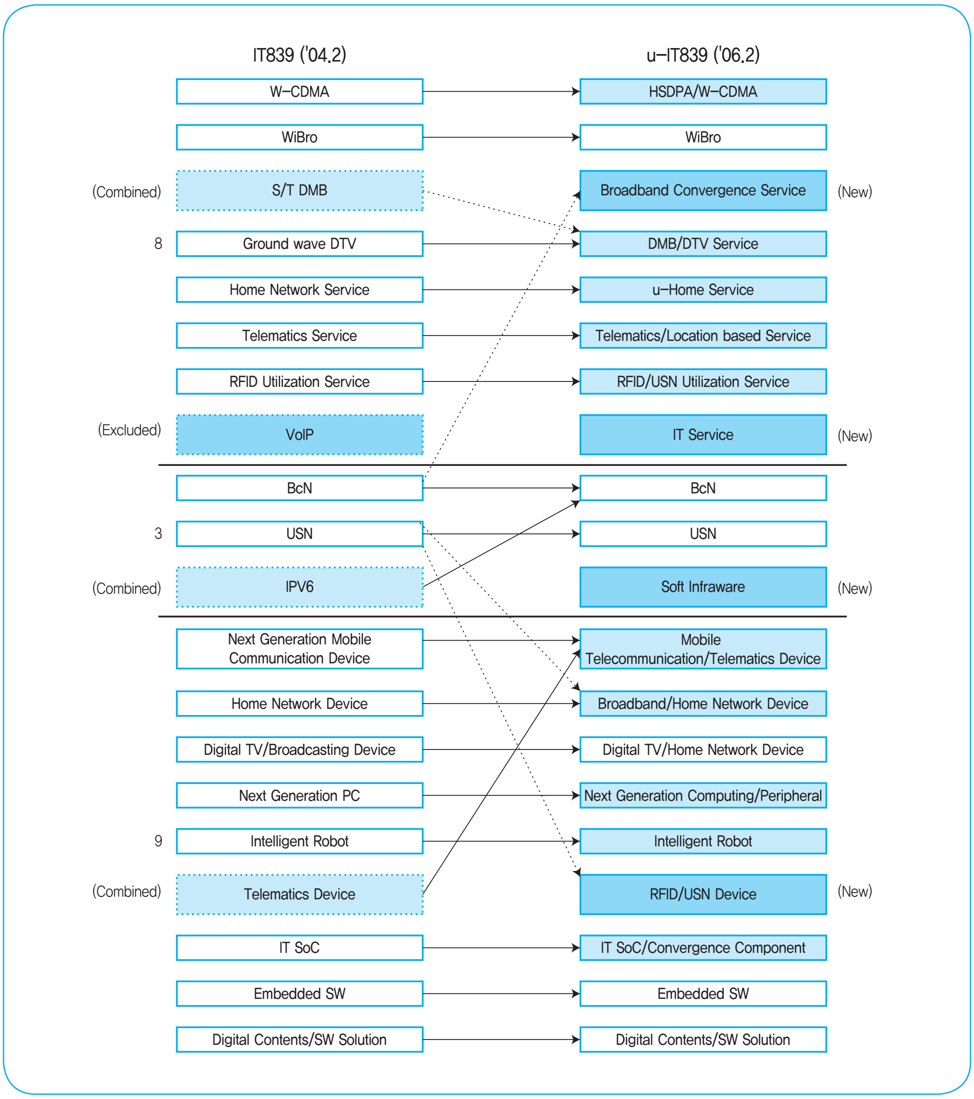
With the IT 839 strategy, Korea was able to take the lead in cutting-edge IT technologies such as the next-generation mobile communications and mobile broadcasting, thanks to its success in developing WiBro and DMB technologies for the first time in the world, and in having these technologies adopted as international standards by the ETSI and IEEE. In 2005, WiBro was adopted as an international standard by the IEEE, and the ground wave DMB as a European standard. With such success, the royalty jumped 2.5 times in five years, from KRW 20.1 billion in 2002 to KRW 55.2 billion in 2006, in addition to the number of international standard patents up from 30 in 2002 to 111 in 2006. The technological gap with developed countries was estimated to have narrowed from 2.6 years in 2003 to 1.6 years in 2006 regarding new growth engines picked and promoted under the IT 839 strategy (Kim et al., 2007).

New services to lead the virtuous cycle of IT development were also adopted, and, in July 2004, the controversy over the digital TV transmission system ended and DMB service and ground wave DMB commercial service started in May and December 2005, respectively, for the first time in the world. In 2005, the adoption of Internet telephony was finalized and, in 2006, WiBro commercial service was introduced for the first time in the world. Despite some tangible achievements of the IT 839 strategy such as WiBro and DMB, there were several problems in executing the strategy. First, as Korea became a leading player in IT, competition with developed countries and challenges from developing ones became fiercer. In the high-end IT field, Qualcomm acquired Flarion in August 2005, and Intel and Micron collaborated for the development of NAND Flash in November 2005, while developing countries like China dominated the low-end market and began to narrow the technological gap with Korea. Also, the world IT device market, in which Korea showed strength, was expected to slow down with an average annual growth rate of 2.8% between 2005 and 2009, whereas the SW and service market, in which Korea was relatively a weak player, was to rapidly grow at 5.7%. Internally, there was increasing demand for software and parts reinforcement for the balanced development of the IT industry and job creation. Therefore, the government radically reformed the strategic areas of the IT 839 and announced the u-IT 839 strategy in February 2006 (Min, 2006).

The u-IT 839 strategy focused on promoting the commercialization of new technologies and revitalization of the market with less emphasis on pilot projects. Broadband convergence and IT service, which were closely linked to one of the three types of infrastructure, BcN, were added to the eight services, while Internet telephony was excluded from the eight services with its adoption completed. Also, DMB was integrated into ground wave DTV and classified as a new service. In the three types of infrastructure, software infrastructure was newly created and IPv6 was integrated into BcN. In the nine new growth engines, RFID/USN devices, which were combined with USN, one of the three types of infrastructure, were added, while Telemetrics devices were combined with next-generation mobile communication devices and reclassified as mobile communication/telemetrics devices. Home network devices were expanded to broadband/home network devices, and next-generation PC to next-generation computing and peripheral devices. The scope of IT SoC was also adjusted to include convergence parts.

The major characteristic of the u-IT 839 strategy was that it prioritized software and IT parts, as a response to changes in internal and external environments. To do so, a system was built to focus on managing the overall SW value chain including IT service, soft infraware, embedded SW/package, and digital/SW content, and convergence parts. Also, RFID/USN devices, etc. were added to the nine new growth engines. The use of RFID and sensors was encouraged in all industries including transportation, logistics, national security, and procurement for the early establishment of the u-sensor network and R&D of the IT-BT-NT convergence field was expanded. These were the differences between the u-IT 839 strategy and IT 839 strategy.

Figure 4-1 | Areas of IT-839 and u-IT 839 Strategies



Source: Min (2006).

However, both the IT 839 and u-IT 839 strategies supported highly competitive products of large corporations, and there was insufficient demand for the new services. The government also placed too much focus on early adoption, while neglecting the development of business models in the process, as critics have pointed out. For example, WiBro, which was adopted in 2006, aimed at eight million subscribers by 2010. However, the number of subscribers had barely reached one million by 2012. Also, the DMB service failed to create a business model and resulted in impaired capital for some businesses. Such criticism in addition to the stagnation in the IT industry and acceleration of IT convergence eventually led to dissolution of MIC after the launch of the Lee administration in 2008.

4. ICT R&D Policy for ICT Convergence Period (2008~ 2010)

Table 4-5 | ICT R&D Policy for ICT Convergence Period (2008~2010)

Policy Objective	Promotion of Convergence ICT
Policy Tools	Acceleration of ICT convergence
Key Success Factors	• New IT strategy • Basic plan for national convergence technology development • Strategy to foster new growth engines
Implementing Body	• Strategy to foster new growth engines Implementing Body • Technology development strategies were made considering the level of technology and competence of Korea, and classifying the leading agents into the private/ private-government cooperation/ and government
Limits and Shortcomings	• MKE, KCC, MEST, MCST, MSIP
Outcome	• Rapid growth of ICT mobile sector through smart revolution • Criticism that competence reinforcement in ICT industry is more important than ICT convergence • MSIP created by combining science and technology with ICT

Source: reorganized from Ko et al. (2012).

During the fourth period, the convergence emphasis period, policies for developing IT convergence industries, fostering new growth engines, and enhancing the competitive power of the SW industry were promoted. The Lee administration in 2008 dissolved the MIC and ICT R&D policies were distributed among three government agencies: MKE, KCC, and MCST. The MKE, which was responsible for overall policies, promoted R&D policies such as the “New IT Strategy (’09)”, “IT R&D Development Strategy (’10)”, and “IT Korea Future Strategy (’10)” with related departments, and invested in developing IT convergence technologies. As a result, IT convergence was spread over different industries and the competitiveness of the IT parts industry was improved. The subsequent Park administration created the MSIP, which combined the Ministry of Science and Technology in the past and the MIC. The most well known policy vision of the Park administration is the “creative economy.” It is defined as “with creativity as the core value of the economy, convergence of science and ICTs leads to convergence between different industries as well as between culture and industry, and creates new added values and jobs.” In 2013, the MSIP announced the “Mid-to-Long term ICT R&D Strategy (2013~2017).” This strategy aims to secure 10 core technologies in five fields including content, platform, network, device, and information protection (C-P-N-D-S) based on reinforced SW power, and to create 15 future services utilizing the technologies. While ICT convergence was led by other industries during the Lee administration, the ICT convergence technology innovation strategy of the Park administration is slightly different in that it facilitates convergence of ICTs and other industries through advances within the ICT industry.

In 1994, with the objective of consolidating the government’s IT functions and responsibilities scattered across a number of government bodies such as the Ministry of Science and Technology (MOST), the Ministry of Communications (MOC) and the Ministry of Commerce, Industry and Energy (MOCIE), the Ministry of Information and Communication (MIC) was launched. The major task of the Ministry was to provide intensive support to the IT industry so that the industry could lead the growth of the overall economy. The Ministry indeed made enormous contribution to the emergence of Korea as one of global IT powerhouses. Yet, with the greater influence of IT and blurred boundaries between the IT and non-IT sectors, the government’s IT policies became less effective in facilitating convergence between different technologies and industries, and in identifying new business opportunities. In addition, some of the Ministry’s functions and responsibilities were still overlapped with other government agencies and undermined efficiency in administrative processes. For example, the robot, home network and Telematics businesses covered by the IT 839 strategy was also dealt with by MOCIE, while the digital content industry was supported by both the MIC and the Ministry of Culture. To address these issues and build a knowledge-based society based on Information and Communication Technologies (ICT) and other industrial technologies, the Korean government decided to close the MIC and set up new government bodies to take over the responsibilities of the MIC during a government reshuffle. The responsibility of coordinating and implementing informatization projects such as the e-Government project fell into the Ministry of Public Administration and Safety (MOPAS), while he Korea Communications Commission (KCC) became in charge of the establishment of IT infrastructure and related policies. The task of supporting content development was given to both the KCC and the Ministry of Culture and Sports (MOCS), and the Ministry of Knowledge Economy (MKE) took the responsibility to lead the overall prosperity of the IT industry.

Accordingly, ICT policies were executed by reorganized departments, especially by the MKE and KCC. First, the MKE, which took charge of software and devices, made and announced the New IT Strategy in July 2008, which aimed at spreading the energy of national growth led by the IT industry to other industries. The New IT Strategy was executed between 2008 and 2012 with a vision of updating the industrial structure and solving social problems by means of IT, and the three strategic fields of the strategy were convergence of all industries and IT, solution to socioeconomic problems utilizing IT, and state-of-the-art core IT industries.

To converge IT and other industries, convergence between IT and major industries was first carried out. As part of the efforts, the Industry IT Convergence Forum was set up, which expanded cooperation and exchanges between IT and non-IT industries and collaboration between the IT industry and other departments such as national defense and construction. In addition, more resources were distributed for IT convergence, and the focus was placed on selecting convergence target areas and fostering specialized companies. Furthermore, by applying RFID/USN to major industries, a RFID leading model was drawn, while IT convergence in business process was promoted as well by promoting cooperation between IT-based companies and enhancing the use of IT solutions like the ERP system especially in business. Another policy was to improve productivity of the services industry by using IT, developing IT utilization models and carrying out pilot projects. Lastly, to adopting SW in all industries, embedded SW technology development and related projects were carried out.

The two largest social issues faced by the Lee administration were high oil prices and an aging society. The administration, whose most representative brand of economic policies was green growth, emphasized Green IT. To solve social issues, the government gave priority to technology development for Green IT, the LED industry, medical equipment, intelligent home networks, and remote telemedicine. Technologies were developed to improve energy efficiency of IT products and make the IT industry more environment-friendly, and to improve the competitiveness of the LED industry. The demand for LEDs was created at post offices and public buildings, while the LED Mutual Fund was created so that it could be used for developing technologies that would be in demand by the private sector. A plan was drawn to develop the medical equipment industry to the world's fifth overall by adopting IT, for which a couple of u-hospitals (IT+hospitals) were built and the u-Healthcare industry was supported. Lastly, to provide a safe, convenient, and healthy lifestyle through IT, technologies were developed for intelligent home networks, remote healthcare, and information security. The New IT Strategy aimed to create ten KRW 1 trillion IT convergence markets, and foster 1,000 IT companies and ten SW companies with KRW 50 billion of sales by 2012. Increasing the number of IT businesses to 23,000, with a total employment of 910,000 people was another goal of the strategy.

To develop a sophisticated IT industry, strategies were developed for network wireless communications, semiconductor and display, and high-added value propositions for the

IT parts and software industries. To advance the mobile communications industry, mobile phone parts began to be produced in Korea and government support was also provided to respond to the fourth generation international standardization. Also, a policy aimed to improve technology and management capabilities of small and medium businesses was also pursued, so that the success of major firms could spread to SMEs in Korea and elsewhere. System semiconductor, memory device and material industries were strategically fostered to support the growth of small and medium businesses, while the display industry promoted strategic R&D to dominate the next-generation display market. Also, a virtuous cycle system was established between the IT manufacturing business and broadcasting and communication service companies, while enhancing technologies through cooperation between the supply and demand side and international joint R&D. Joint entry into strategic nations, including developing countries, was also pursued. To improve the competitive edge of promising products and IT parts, the development platform for "RFID/USN industries" was created, measures and technological supports for promising IT products by field were implemented, while the government sought to attract more investment in IT parts and strengthen joint overseas research. Lastly, the government also carried out a plan to foster ten SW companies with global competitiveness.

Table 4-6 | Comparison between IT 839 Strategy and New IT Strategy

	IT 839 Strategy	New IT Strategy
Concept	Strategy to consolidate service, network and equipment	Advancement of ICT industrial structure into high value-added one and resolution of social problems
Characteristic	• Supplier- oriented technology push strategies • Strengthening the correlation among each phase of the value chain of the IT industry • Services, networks content can be promoted all together	• Expansion of IT into the whole industries for IT industrial convergence - Creation of high-added value and improvement of productivity in key industries from increased use of IT - Resolution of social problems such as aging and rising oil prices • Generation of new demand in the IT industry
Similarity	• Advancement of the IT industry by promoting the virtuous cycle within the IT industry • Technology development, standardization, human resources development, etc. for the sophistication of the IT industry	

	IT 839 Strategy	New IT Strategy
Difference of the New IT Strategy	• Focusing on improving the competitiveness of Key industries using IT not confined to IT industry itself • Government as a facilitator : conversion from a government-led model to a private sector-led model • Creation of new global markets in addition to enlargement of domestic markets • Exploration of cooperation between IT and other areas based on industrial convergence and collaboration among companies • Conversion from large companies-oriented growth to mutual growth of large companies and SMEs	

Source: Ko et al. (2011).

<Table 4-6> compared similarities and differences between the IT 839 and New IT strategy. Both strategies enhanced the virtuous cycle within the IT industry to advance the industry and, for this, took measures such as technological development, standardization, and human resource development. However, the New IT Strategy is different in that it focuses on improving competitiveness of not only the IT industry itself but also major industries using IT. This meant that the private sector would become the main agent of the policy, with the government playing a supporting role. The purpose of the strategy is to seek cooperation between IT and other fields, and the policy target changed from large corporations to small and medium businesses.

The KCC, which was newly established with the launch of the Lee administration, focused on developing technologies that can create high added-values through broadcasting and communications convergence. The aim of the policy was, based on the world-best technologies of Korea in the broadcasting and communications fields such as mobile phones and digital TVs, to enhance competitiveness of the entire related industries such as content and distribution infrastructure, to create an environment for the convergence of broadcasting and communications and to lead the country to become a powerhouse in broadcasting and communications convergence. Accordingly, in 2008, to revitalize broadcasting communications services, IPTV and other convergence services were supported and a policy to improve the competitive advantages of broadcasting and communications content was pursued. To help consumers easily choose their telecommunication carrier, the USIM lock and mandatory use of WIPI was abolished, while deregulatory measures such as the introduction of various communications integration products, expanded discounts for mobile phone fees and eased regulations on ownership of broadcasting businesses were taken to reduce the burden to consumers in using communications services, thereby enhancing the competitiveness of the broadcasting industry and communications services. The abolition of mandatory WIPI led to the introduction of iPhones in the Korean market and created an enormous impact on the IT market. The KCC, in 2008, after the reorganization of the government, supported R&D investment in association with the MKE through the ICT Promotion Fund; however, since 2011, the KCC has conducted independent R&D projects with the support of the broadcasting communication development fund.

In 2013, after the launch of the Park administration, the department responsible for promoting ICT changed back to the MSIP. Because the MSIP is in charge of both science technology and broadcasting communications, it could strengthen the link between government agencies in ICT R&D. Recently, the MSIP announced its ICT R&D strategy called the “Mid- to Long-Term ICT R&D Strategy (2013~2017)”, reflecting the changed role of ICT in the era of the creative economy. The objective of the strategy is to create an environment for ICT convergence and transparent R&D, to expand the growth potential of the creative economy and improve quality of life (Kim et al., 2013).

The four policy directions are as follows. First, ten core technologies to lead the global market should be developed and, based on them, 15 future services need to be realized. This is to discover and develop leading core technologies in the C-P-N-D-S field and connect them to future services to solve social problems such as low fertility, an aging society, and the four social vices, and to provide happiness for the people. Second, the innovative capabilities of the SW field, which became more important and influential with the establishment of a smart ecosystem and acceleration of ICT convergence, should be strengthened. This would result in fostering SW professionals both in the private and public sectors, enhancing field-oriented education and improving quality of SW professionals. Projects such as SW Grand Challenge and Global Creative SW will strengthen SW foundation and core research, and the budget for SW convergence from the relevant departments will be expanded. Third, technology commercialization will be promoted to improve the efficiency of R&D and quality of technological achievements. To do so, creative ideas will be nurtured and linked to R&D, while performing R&D that reflects market demands of small, medium, and venture businesses. Furthermore, in order to spread the effects of ICT R&D and improve the success rate of commercialization, different evaluation and management systems should be applied according to the characteristics of ICT R&D, and a platform for technology trade needs to be developed to invigorate the market. Fourth, the participation of citizens will be expanded to enhance R&D innovation capabilities and promote preemptive standardization. A platform will be built so that anyone with a good idea can further develop and utilize it, thereby expanding the scope of ICT developer, and promoting universities as bases for R&D innovation and entrepreneurship. In addition, a swift response to the market needs to be improved through preemptive and international de facto standardization for market dominance. ICT R&D policies in the creative economy focus on R&D planning and diffusion of R&D results to improve the efficiency of R&D, which is different from the past R&D policies that concentrated on R&D projects themselves (Kim, 2013). Only time will tell how effective these changes in policy will be. The MSIP aims to, through the mid-to-long term R&D strategy, increase the technology commercialization rate from 18.2% in 2012 to 35% by 2017, investment productivity of ICT R&D from 3.42% to 7%, and the number of international standard patents from the current world's sixth place to fourth (MSIP, 2013b).

Table 4-7 | Direction of Mid-to-Long Term ICT R&D

Direction	Content
Strategy Technology Development	• 10 core technologies development • 15 future services realization
SW Power Enhancement	• SW professional fostering and ecosystem creation • SW base, core and SW convergence and R&D enhancement
Activation of Technology Commercialization	• User-oriented, convergence R&D planning • R&D system and result diffusion system
R&D Base Creation	• Enhancement of creative capabilities • Standardization customized for consumers

Source: MSIP (2013b).

Chapter 5

Evaluation

Evaluation

The Korean government played an important role in promoting innovation in the ICT sector; by supporting the development of technology directly, and by creating favorable conditions for innovation through laws and appropriate incentives schemes indirectly.

In general, policy instruments available for fostering technological learning of various entities, firms, GRIs, and academia, and engaging in research and development can be categorized into three major components: i) Demand side policies that create market needs of technology, ii) Supply side policies that increase R&D capabilities, and iii) Policies that provide linkage between the demand side and supply side of technology. The last category represents a good management of an R&D system that effectively links demand and supply (Kim, 1997).

ICT technology development in Korea followed three key sequences in the flow of technology from abroad to the catching up countries; "transfer of foreign technology, diffusion of imported technology, and indigenous R&D to improve and assimilate imported technology and to generate its own technology" (Kim, 1997, pp.23).

In three distinct phases, ETRI played a pivotal role in linking the demand side and supply side of technology. ETRI was at the epicenter when the TDX was developed in 1986, the world's first commercialization of CDMA technology in 1996, and the world's first commercialization of WiBro in 2006. TDX was the child of reverse engineering aimed at localization of technology embedded in imported equipment. CDMA was developed through global joint research, in which a foreign company with proprietary technology, Qualcomm, a government research institute, ETRI, device manufacturers, and telecommunication service providers participated jointly in the research project. Although the technology originally came from Qualcomm, Korea succeeded in its actual commercialization. On the other hand, WiBro is domestic technology that was strategically developed into a global standard. The development of technology went together with the development of a new standard. IEEE's adoption of WiBro as a global standard in 2005 as well as the ITU's adoption in 2007 transformed Korea's ICT technology capacity status from one of imitator to one of leader. The technological success of WiBro, however, has not been translated into market success. Since its commercialization in 2006, it has failed to secure subscribers domestically and internationally at the time of this writing in 2013. In the following, we will present three successful cases of technological innovations; TDX, CDMA, and WiBro.

1. TDX (Time Division Exchangers)

In the early 1980's, Korea was still suffering from chronic congestion and poor quality of telephone calls. With rapid economic growth in the 1960's and 1970's, the demand for telephone services skyrocketed, which was addressed by the government's four consecutive five-year telecommunication development plans from 1961 to 1981. Yet supply did not keep up with the increases in demand. Telephone subscribers in Korea increased rapidly from 0.12 million in 1961 to 0.5 million in 1970 and then to 2.8 million in 1976, yet there was a chronic excess demand for telephones. More than 600,000 telephone-lines, over one fifth of the installed capacity remained in back order and it took more than a year to arrange for a new telephone service after the initial request for installation (ETRI, 2012).

During the 1970s, subscribers had two choices to purchase a phone - a white phone or a blue phone. The white phone allowed the subscriber to resell the number to anyone, or to trade it. At one time, the price of a white phone in the black market raised as much as a 3- bedroom apartment in Apgujung-Dong, one of the wealthiest districts in Seoul. The blue phone could not be traded or resold and it had to stay at the subscriber's location (R. Shuster and C.W. Yeon, 2009).

The bottleneck was caused by the inadequate capacity of the existing electro-mechanical stepping switch telecommunication exchange system, such as the EMD and Strowger. These electro-mechanical systems were not scalable due to technical problems of rising maintenance costs and declining quality of service when capacity is expanded. In addition, the telecommunication exchange system was moving toward digital switches. The Korean government decided to localize production technology of digital switch and formed a research consortium consisting of Korea Telecommunications Authority (KTA), ETRI, and four private firms (Goldstar, Samsung Electronics, Daewoo Telecom and Hanwha Telecom) to develop proprietary digital switching systems (ETRI, 2012).

In this process of development of technology, ETRI purchased digital switching designs and engineering technologies for AXE-10 from Ericsson and on the basis of this technology developed a proto-type, called the model TDX-1X, in July 1982. Thereafter, in December

1983, a Korean team succeeded in developing a differentiated product called the TDX-1, which was more effective than AXE-10. ETRI transferred the TDX-1 technology to four private manufacturing firms, such as GoldStar or Samsung. The research consortium led by ETRI continued to improve the technology to produce more advanced versions, such as the TDX-1A in 1986. The TDX-1A was quickly disseminated to manufacturers that mass-produced the systems initially targeted for rural and small-city markets. Only after the success of the experimental installation in these areas did Korea Telecom decide to install the model in a large-scale, a project that began in late 1986 (Lee et al., 2012).

The Korean government implemented several polices to support the growth of local firms that produced the locally developed telephone switches. First, it imposed import limits on foreign switches after local development of the switches was realized. Second, the Korean government set a quota system for the market shares of the four manufacturing firms, in order to encourage manufacturers to learn the technology and promote investment. Third, it instituted a special law for the procurement of developed TDX and guarantee sustained funding for ETRI's future research by requiring a portion of profits earned by domestic TDX manufacturers to be allocated to ETRI's R&D expenses (Hwang 1993, quoted from Lee et al. 2012).

The most important success factor behind the TDX project was the careful planning and consistent support provided by the government. The amount of money ETRI requested for the development of the TDX, KRW 24 billion, was unimaginable for a single research project at that time (ETRI 2012). ETRI's proposal to develop a digital switching technology was greeted with skepticism by many observers, since it had no such prior experience. Yet the Korean government put trust in ETRI's research capabilities as well as that of the manufacturing firms in the research consortium, and gave the go ahead for a risky project (UNDP, 1999).

The second success factor behind the TDX project was the tripartite cooperation mechanism. The TDX case is the first and best example of successful cooperation among the government research institutes, private firms and the government. The government research labs were in charge of R&D, the private firms were in charge of production, and the government was in charge of marketing in the form of direct procurement or protection by tariffs (Lee et al., 2012). This first example of cooperation mechanism was extended to subsequent large-scale targeted technology development such as CDMA, DRAM and TiCom. The experience of TDX development helped build the nation''s confidence in meeting various R&D challenges in a host of other critical areas (UNDP, 1999).

With the development and commercialization of TDX, Korea became the first country that leapfrogged into the production of digital electronic switches without having any experiences of producing electro-mechanical or analog switches. Korea became the tenth country to have ever produced or the sixth country to export a digital exchange system. Leaving aside the broader implications of the TDX initiative, the project has served as a model for dealing with the nation''s other core telecommunications R&D projects, such as the CDMA(ETRI 2012, UNDP 1999). ETRI estimates that the economic benefits of TDX up to 2011 amounted to 20.5 billion Won (ETRI, 2012).

2. CDMA (Code Division Multiple Access) Technology Development

The commercialization of CDMA technology was carried out from 1989 to 1996, through a mega R&D development project consisting of 1,042 researchers and costing 99.6 billion won. Like the TDX project, the government and the private sector collaborated to develop CDMA technology. Unlike previous technological developments, which were mere imitation endeavors to catch up with products from advanced countries, the CDMA project was to develop a new product. CDMA technology existed only as a theoretical patented concept that belonged to a small American company, until it became commercialized by Korean telecommunications service providers in 1996 (Mani 2007). ETRI estimates that the commercialization of CDMA created approximately 54.392 trillion Won in economic value until 2011, which is 540 times more than the total investment poured into the project. The factors behind the successful commercialization of CDMA technology and consequent development of CDMA industry in Korea point to lessons in policy, technology, and market.

2.1. The Policy Factors for Success

The policy for the development of CDMA technology was formulated and orchestrated by the then MIC. The MIC designated CDMA as a national standard, formulated the R&D structure for CDMA, mobilized research funds, and instituted handset subsidies policy to stimulate demand (Han, 2007).

Beginning from the 1980s, as new communications technology became available, the importance of the mobile telecommunications industry started to gain recognition among policymakers. In 1988, the Seoul Olympics sparked an explosion in demand for mobile telecommunications services that was until then suppressed for national security reasons. By the end of 1988, subscribers to mobile services reached 20,000 and by the end of 1990 totaled 80,000, recording more than a 100% yearly growth rate. However in 1990 the mobile penetration rate was only 1.72 per 1000 persons in Korea, while Sweden scored 53.53, the U.S. scored 20.76 and Japan scored 5.56. Lack of facilities and technical capacity often resulted in disconnection or poor voice service, creating constant demand for improved service and quality. The need for second generation mobile communications system was raised by experts, as the existing analog system exhibited clear limitations (ETRI, 2012).

Advanced countries were already developing mobile communications systems based on digital technology. As the size of the global mobile communications market was growing rapidly, and as major telecom operators around the world were expected to compete fiercely for market leadership, there was agreement that Korea needed to develop its own digital mobile communications system. The most important element in the development of a digital mobile communications system is the technology standard used for access/connection to the nation's frequency bands. Korea had to decide what access technology to employ to effectively use the existing spectrum. At that time, the United States was using the TDMA standard while Europe was using the GSM standard and Japan, the PDC standard. As a global universal standard was not yet established, each country was attempting to globalize the access technology used in its respective markets. In this atmosphere, Korea's ETRI researchers came up with the CDMA technology, which had not yet been commercialized (ETRI, 2012).

After intense discussion in the early 1990s, the MIC shunned proven time division multiple access (TDMA) technologies and designated CDMA as a national standard in 1993. It was two years after ETRI had signed a joint research contract for commercializing CDMA technology with Qualcomm, the owner of the technology. The subscriber capacity of CDMA is 10 times that of analog technology and three times that of TDMA, and its radio wave efficiency and base station assignment are better than those of TDMA; but the problem was that the technology was an unproven technology, yet to be commercialized. Other ministries, including the Ministry of Commerce Industry and Energy (MCIE) favored TDMA on the grounds that if TDMA, which had been already commercialized, was adopted, development could be completed in shorter periods, and since many countries around the world had already adopted the technology, its prospect for export was brighter. The MIC emphasized the technical superiority of CDMA and signified the meaning and benefits of commercializing the newest digital mobile communication system for the first time in the world. The MIC also argued that completion of the technology development could be brought forward to 1995 with active participation from domestic companies. The CDMA commercialization schedule was shortened by two years to complete its deployment in 1995-the original plan was 1997 (Han, 2007, Ko et al., 2011).

The second key success factor in terms of policy was the adequate arrangement of the R&D structure for the commercialization of CDMA technology. The development of a commercial CDMA system was led by ETRI and four domestic manufacturers, Hyundai Electronics Industries, LG Information and Communications, Samsung Electronics, and Maxon Electronics, with the objective to develop a commercial CDMA system with a target date for commercial service by early 1996 (Mani, 2007). In the beginning, the manufacturers were unwilling partners. They asked for reduction of their shares in the joint development costs, and that resulted in the delay of the selection of companies for joint development. As the CDMA joint development project went through such difficulties, the prospect for a shortened schedule of commercialization seemed very difficult (Ko et. al, 2011).

The government established the Mobile Communication Technology Development Project Administration Division within Korea Mobile Telecommunications (later renamed SK Telecom), a mobile service company and a leading customer for CDMA products, in September 1993, to thoroughly manage the entire R&D process and push ahead with the project in accordance with the planned schedule by having the participating companies conduct commercialization tests as soon as possible (Mani, 2007).

The third factor for success was the handset subsidy. When the first CDMA were introduced in 1995, the handsets were very expensive. To help create a market for the new technology, the Korean government allowed mobile providers to lock subscribers into two-year, exclusive contracts in exchange for free handsets (Han, 2007). Although there are some caveats about the unfairness done to subscribers who were not subsidized or relatively less subsidized, the handset subsidy was an effective policy for creating an initial demand for relatively expensive services.

2.2. The Technology Factors for Success

The technological factors contributed as importantly as the policy factors to the successful commercialization of CDMA. The technical system capabilities were secured in a timely manner; the global joint research system was efficiently operated; and technology development and technical information support were appropriately carried out by national projects under the leadership of the government. CDMA technology is technically superior to GSM; it can accommodate three times as many users as GSM at the same frequency and its security aspects and speech quality are better. Without this technological superiority, commercially unproven CDMA technology could not have been chosen over commercially proven TDMA technology.

The ETRI was, again, in the epicenter of the commercialization project of CDMA technology. Since the ETRI had the experience of successfully developing large systems such as TDX and Ticom, it possessed technology management capabilities required for execution of large projects as well as capacities for system development technologies. Such capabilities were instrumental in the commercialization process of CDMA technology (Ko et al., 2011).

The mobile carriers and equipment makers were encouraged to get actively involved in R&D activities through an incentive mechanism designed by the government for the project. They were required to invest large amount of money for the project in the form of pre-paid royalties. Once they made large bets, they had to exert themselves for the success of the project. ETRI researchers were frequently dispatched to research department of involving firms for joint research. Especially, the joint researches with mobile carriers, the customers of CDMA technology, were evaluated as a key factor for the reduction of lead time and rapid commercialization of developed technology. The joint research facilitated the sharing of research outputs and the developed technologies were transferred to system and equipment makers in real time. This project was an example of successful concurrent engineering where R&D, field tests, and commercialization of technologies were realized concurrently (Han, 2007).

Lastly, the role of the abovementioned Mobile Communication Technology Project Administration Division within KMT (Korean Mobile Telecommunications) was instrumental in the effective development and commercialization of CDMA technology. It was a research management body for the overall coordination of the project, and served as a mechanism for automatically reflecting customer needs and an agency for quality control (Han, 2007).

2.3. The Market and Firm Factors for Success

There are three market factors that contributed to the success of commercialization of CDMA in Korea; the rapid growth of the demand for mobile communication, the shift in the wireless communications from voice calls to data communications and the adoption of CDMA as a standard technology by foreign countries. First, the rapid growth of the domestic demand for the mobile communication market led to the expansion of the domestic CDMA industry, and this in turn became the basis for enhancing global competitiveness of CDMA technology. Analysis of the market at that time suggested that the domestic mobile communication market achieved rapid growth thanks to the increase in quality of service by the success of the CDMA technology development and the cutthroat competition in the mobile communication market. Second, the changes in the paradigm of the wireless communications had been rapidly shifting the mainstay of global wireless communications from voice calls to data communications including wireless internet, and this gave a boost in demand for CDMA technology. Third, in July 1993, when Korea was in the middle of developing CDMA, the TIA (Telecommunication Industry Association) of the US adopted CDMA as an IS-95 standard (International Standard-95) that the era of dual standard where both CDMA and TDMA adopted as international standards began. In addition, China had been seeking to set its own standard based on CDMA technology (Oh et al., 2002, Ko et al., 2011).

Lastly, there are company factors for the success of commercializing CDMA technology. Behind the growth of the domestic CDMA industry lie the rise of the parts and equipment manufactures that had enhanced their competitiveness through cutthroat competition. As the number of parts manufacturers increased, the competition among companies intensified, and price reduction and technology innovation accelerated. Some of these firms sought out foreign markets through strategic alliances with foreign companies. These changes brought the virtuous cycle of increases in partnership and collaboration with foreign companies, expansion of international joint R&D activities in foreign countries, and the consequent increase in the localization of components industries for CDMA technologies.

According to one survey, the most important factor for CDMA success was policy factors, followed by technology factors. It is evaluated by survey participating engineers, scientists, IT scholars and technical bureaucrats that policy factors such as the designation of CDMA as the national standard, formulation of a cooperative R&D structure among mobile carriers, equipment producers and GRIs, appropriation of adequate funds, and demand creation through the handset subsidy policy were more important than the technology, market and firm factors for the success of commercializing CDMA (Oh et al., 2002).

3. Case of WiBro Technology Development

3.1. The Success in Technology Development

With the increasing demand for more convenient and faster wireless internet service since the launch of CDMA service, WiBro emerged as a key technology that could give mobility to fixed broadband Internet access as well as improve the quality and speed of wireless LAN. This technology was expected to provide up to a 3Mbps Internet speed on the move in urban areas and have enormous market potential with its low costs. Acknowledging the potential of the technology, the Korean government decided to include WiBro in the list of eight new key areas of the "IT 839 Strategy", a national strategy to support the development of the nation's IT industry. The government was convinced that WiBro would meet the needs of the market, while helping the country become less dependent on foreign technologies, if it succeeded in developing core chips based on homegrown technologies.

In 2003, under the supervision of ETRI, the HPi (High-speed Portable internet) project began and Samsung Electronics, KT, Hanaro Telecom, SK Telecom as well as KTF participated to develop a standard and prototype for WiBro service. In 2004, Korea's own WiBro system was developed and Samsung Electronics made additional financial contributions of KRW 3 billion to support the research efforts by ETRI. From 2003 to 2005, a total of KRW 39 billion was invested in the R&D of the technology. As a result of these efforts, the world's first WiBro Internet connection was made through the prototype of a WiBro base station and devices developed at the lab of the Communication Research Group at ETRI on November 27, 2004. On the exact same day, Samsung also successfully connected the devices developed by ETRI into its own developed WiBro station.

It was a remarkable feat for Korea in that the WiBro system, regarded as a 3.9-generation (3.9G) mobile communication technology, the world's first portable internet connection system developed by Korean researchers at ETRI, Samsung Electronics and other institutions. The collaboration of local experts from the industry, academia, and research institutes resulted in the development of the WiBro service concept as well as the world's first IEEE (Institute of Electric and Electronics Engineers) 802.16e-based equipment.

In November 2005, WiBro service made a global debut at an APEC meeting and was also successfully demonstrated at the 2006 Winter Olympics held in Torino, Italy, proving the nation's technological prowess. In 2006, ten years after the world's first commercialization of CDMA, ETRI once again succeeded in WiBro commercialization, setting another major milestone in the history of Korea's IT industry. In June 2006, KT and SK Telecom launched their pilot WiBro services in subway lines, college districts and other areas of Seoul, opening the era of WiBro. The focus of the pilot services was mainly placed on interactive multimedia content such as network games, VOD, messenger chatting, personal broadcasting, etc.

The IEEE was the official organization responsible for the international standards for wireless broadband communication technologies. In July 1999, the IEEE 802.16 Working Group was formed to establish the standards for wireless MAN (Metropolitan Area Network) and approved Mobile WIMAX (802.16e), the WiBro technology, as a global standard in December 2005. In order for Korea's WiBro technology to be adopted as a global standard, ETRI took a strategic approach. It pursued the development of WiBro systems and standards simultaneously and also actively participated IEEE wireless communications standardization meetings. After a year of such great efforts and dedication, WiBro was finally chosen as a global standard by the IEEE.

The Telecommunications Technology Association (TTA) contributed significantly to the process as well. In June 2003, the TTA launched a project group to undertake the standardization of portable Internet access technology, and the outcomes of the project were incorporated to the IEEE standard 802.16 after ETRI and Samsung Electronics successfully developed WiBro technology.

In June 2004, the TTA Project Group 302 newly introduced the 802.16-2004 standard, but soon began to take on the establishment of the 802.16e standard in order to add more mobility to the 2004 standard. One month later, the IEEE 802.16 standard and five functional requirements were adopted by the Ministry of Information and Communication for 2.3GHz WiBro service. As the IEEE 802.16 standard and functional requirements Korea adopted were in full accordance with international standards, the questions the U.S. had raised about Korea's development of WiBro technology tailed off and trade disputes involving WiBro became unlikely.

After the introduction of 3G mobile communications, countries across the world had fiercely competed for scientific and technological dominance in the global market. With its homegrown WiBro technology adopted as an international standard, Korea once again made its presence felt in the global IT market and opened a new era in Korea's IT history. Plus, the fact that Korea was entitled to issue permission for export of WiBro equipment and devices opened up opportunities for domestic manufacturers to take a more favorable position in overseas markets. In August 2006, for the first time in the history of Korea's mobile telecommunications, WiBro, a mobile Internet access technology developed by Korea, made inroads into the U.S. market, the biggest and most advanced IT market in the world.

3.2. The Failure in the Market

WiBro development in South Korea started in full scale as the government confirmed policies assigning 2.3GHz band for the use of mobile internet in October 2002. In January 2005, mobile internet service operators were selected (KT and SKT) and in December of the year commercial WiBro system was developed for the first time in the world. In June 2006, KT and SKT commercially launched the world's first mobile internet service then in October 2007, ITU adopted it as the 6th IMT-2000 standard. In January 2012, ITU adopted WiBro-Adv together with LTE-Adv as the 4G standards. In March 2013, frequencies were re-allocated to existing operators for the assigned period of 7 years (Mar. 30, 2012~Mar. 29, 2019). As shown in <Table 5-1>, presently South Korea has operated WiBro network in 83 cities, main nationwide expressways, subways, etc. and its WiBro coverage is 88.2% (KT) and 72.4% (SKT) of its population.

Table 5-1 | Korea's WiBro Coverage Status

Service Area	KT	SKT
City	83 cities, 26.1% of the size 88.2% of the population	83 cities, 10.9% of the size 72.4% of the population
Expressway	National expressways 53.4% (2,090/3,912km)	National expressways 9.5% (373/3,912km)
Subway	National subway 81.2% (463/570km) Metro-railway 91.9% (532/579km)	National subway 96.3% (549/570km) Metro-railway 88.1% (510/579km)

Source: WiBro task force (2013).

Despite the sluggish performance of commercial service, WiBro is viewed as a success in the industrial and technological perspectives for achievements as its first recognition as international standard. WiBro is the first South Korean mobile communication technology adopted as an international standard, facilitating domestic communication technology development and its competitiveness. OFDM and MIMO technologies first used in WiBro are further used in LTE, playing the role of bridge for LTE technological advancements. And based on the technological capabilities accumulated during WiBro development, Korean companies have held multiple LTE patents as well to maintain their competitive edges. Also after releasing the world's first commercial WiBro use equipment, Korean firms have dominated the initial WiBro market and expanded their relevant equipment export such as base stations. WiBro was the first opportunity for Korean firms such as Samsung Electronics to advance into the world's major market for mobile communication equipment, which had previously been dominated by foreign enterprises such as Ericson. As shown in <Table 5-2>, the number of other countries with Korean firms' presence has increased from 4 in 2006 to 44 in 2011 and related total export value until 2011 is KRW 3 trillion 5.3 billion (WiBro taskforce, 2013).

Table 5-2 | Foreign Countries with Korean WiBro Presence and the Size of Export

(Unit: 100 Million Won)

	2006	2007	2008	2009	2010	2011
Number of Countries	4	4	8	10	41	44
Size of Export	-	91,207	401,000	766,597	1,234,692	511,800

Source: Korea's presence in foreign countries with its strategic broadcasting and communication items (KAIT, Dec. 2011), quoted from WiBro Taskforce (2013).

The LTE market is estimated to continue its growth, along with the fast LTE commercial service open and expansion by world mobile operators. As of July 2013, 194 operators in 75 countries launched LTE (including TDD) service and the number is expected to rise to 260 firms in 93 countries (GSA, July, 2013). A market for LTE TDD is being shaped as of now in 2.3 and 2.5GHz bands thanks to global WiBro operators' shift to LTE and parallel LTE establishment, etc. China (China Mobile) and India (Aircel, etc.) are planning for commercial launch in 2013, elevating the expectation on the LTE TEE market expansion in the future. As of July 2013, 18 operators in 14 countries are providing LTE TDD services and 41 firms are working for or considering the service launch. Major global WiBro operators are pursuing to shift to LTE or parallel LTE development as explained in <Table 5-3>.

Table 5-3 | LTE Development Status by Major Global WiBro Operators

Country	Company	Developments
US	Clearwire (No. 1 WIMAX operator)	Building network for parallel provision of WiMAX and LTE TDD in 2.5GHz
Japan	UQ (No. 2 WIMAX operator)	Received additional frequency in 2.5GHz band and building network for parallel provision of WiMAX and LTE TDD in the 2nd-half of 2013
Russia	Yota (world's No. 3 WIMAX operator)	Ceased WiMAX in 2.5GHz, approved for license change and has completed LTE FDD shift (May '12)
Malaysia	P1 (world's No. 5 WIMAX operator)	Received additional frequency in 2.5GHz band and building network for parallel provision of WiMAX and LTE TDD

Source: GSA (Global Mobile Suppliers' Association), etc. (July, 2013), Quoted from WiBro Taskforce (2013).

The number of South Korean WiBro service subscribers increased steadily until 2012, but has stayed around 1.03~1.04 million since 2013. The number of WiBro user and traffic statistics are illustrated in <Table 5-4>.

Table 5-4 | South Korea's WiBro User and Traffic Situation

(Unit: Persons, TB)

Year	2010	2011	2012	2013.1	2013.3	2013.5	2013.7
No. of Subscribers	454,994	798,363	1,049,788	1,046,639	1,047,078	1,043,598	1,031,381
Traffic (monthly)	930	1,935	3,077	3,522	3,595	3,810	3,884

Source: WiBro taskforce (2013)

The number of LTE subscribers, on the other hand, has surged rapidly along with release of new smartphone models, progressive investment marketing activities, etc. LTE users in the country numbered 1.19 million in December 2011 and rose to 23.99 million in July 2013. WiBro is used mostly for 3G and LTE traffic distribution, and the share of WiBro traffic for all wireless traffic has decreased to 9% in January 2013, 6.2% in December 2013 and 5.1% in July 2013. Samsung Electronics, which had previous dominated the WiBro market, has stopped the WiBro business to focus on the LTE market. Other WiBro-related smaller enterprises have realigned their efforts to develop LTE TDD products, due to the uncertainties in the WiBro market and LTE TDD's expansion, etc. LTE TDD is similar to LTE FDD in technologies (95% technological similarity), which therefore means that LTE devices, chipsets and terminal makers can release both FDD and TDD products. The global base station market is ruled by six major companies, with Samsung's market share growing. Qualcomm is a dominant player in the world LTE modem chip market with Samsung and GCT (GCT Semiconductors Inc.) collectively accounting for 12%. Korean smart phone terminal producers, based on their top-notch competitiveness in the world, are expected to maintain their edge in the LTE TDD terminal device market.

As discussed above, the need to change WiBro policies in South Korea has been highlighted amid limited domestic market growth, uncertainties in WiBro's market outlook, TDD competition, etc. As WiBro can present only an uncertain future outlook in technological development, working solely for WiBro development could lead to isolation in the global market. South Korean companies, with their accumulated technological capabilities in TDD, will be able to maintain their competitive edge in the LTE TDD market as well.

Chapter 6

Implications for Developing Countries

Implications for Developing Countries

Korea's ICT R&D policy has followed a typical path of technological absorptive capability building, catching-up with foreign technology, and indigenous R&D to improve and assimilate imported technology, and to generate one's own technology (Kim, 1997). [Figure 2-1] of this report, which is quoted from World Bank (2010), shows the determining factors of technology upgrades in developing countries. The developing countries can upgrade their technological ICT capabilities by tapping into globally available knowledge and technology. Imports of equipment and goods, multi-national corporations and skilled diaspora are important sources of foreign knowledge and technology.[3]

In Korea, the establishment of a government research institute was the prerequisite element to build technological absorptive capacity, since the private sector had neither the technology nor human resources to make this possible. ICT innovation germinates and develops within what we call ICT innovation systems. Korea's path of ICT technological development has been one such exemplary case. "The innovation systems are made up of private and public organizations and actors that connect in various ways and bring together the technical, commercial, and financial competencies and inputs required for innovations" (World Bank, 2010 pp. 8). If we put it differently, the innovation systems are about organizations and actors, and of the innovation and interactions between them. Korea created organizations for ICT innovation by establishing a government research institute, and fostered interaction between actors of innovation by setting up a tripartite cooperation mechansim between GRIs, private equipment firms and telecommucations service firms.

3. Although we have not tackled the issue of brain drain and reverse brain drain in this report, high-caliber scientists and engineers trained in prominent foreign universities, who came back to Korea with the establishment of GRIs in the 1960s and 1970s, played a pivotal role in accelerating Korea's technological learning and assimilation from advanced countries.

The World Bank (2010) compares the role of government as a facilitator of innovations to that of gardener who should water the plants, remove weeds and pests, fertilize the soil, and prepare the ground. The preparing ground for ICT innovation includes the establishment of GRIs and the fostering of ICT human resources. The process of improving technological absorptive capacities of GRIs, private firms and universities through appropriate incentives and mechanisms can be compared to the nurturing of soil. Removing weeds and pests in government's innovation policy takes the form of fostering competition and deregulation. Watering in innovation policy assmues the shape of financial and institutional support. The Korean experience in building an ICT R&D system, and the implementing R&D policy can be matched to the figurative role of a gardener for innovation, which can be emulated by developing countries.

1. Preparing the Ground

Korea prepared the ground for ICT innovation by establishing relevant organizations. The establishment of government research institutions, such as KIST and ETRI, was the starting point of assimilating foreign technology, and provided the foundation for developing Korea's own technology. ETRI was the epicenter of the development of TDX in the 1980s, the CDMA in the 1990s and WiBro in the 2000s. These achievements took the path from reverse engineering of foreign technology embedded in imported equipment (TDX), to the commercialization of proprietary technology of a foreign firm (CDMA), and indigenous technology strategically developed into a global standard (WiBro).

2. Nuturing the Soil

The enactment of the law for ICT R&D promotion and the fostering of cooperation mechanisms among organizations and actors of innovation can be classified as activities related to nuturing the soil of ICT innovation. According to the Informatization Promotion Act of Korea, the government must establish a basic plan for Informatization every five years, and it should include "matters related to the foundation of the ICT industry, such as the research and development of ICT and fostering of ICT professionals." The law acts as the basis of the government's ICT R&D policy making. This law stipulates that the basic plan of R&D policy elements should include i) Research area and level of technology, research and development, evaluation, and utilization of technologies, ii) Cooperation, guidance, and transfer of technologies, iii) Smooth distribution of technological information, iv) Promotion of academy and industry cooperation, and v) Other matters related to technological developments. Developing countries can emulate this kind of legal framework which formed the foundations for the government's ICT R&D policy.

Korea has fostered cooperation among organizations and actors of ICT innovations. Back in 1960s and 1970s, cooperation with multinational companies played an important role in ICT R&D. It was a period of learning and assimilating foreign technology. The tripartite cooperation among government research institutes, private equipment firms and telecommunication service firms was fostered through large scale national R&D projects such as TDX, semiconductors, mainframe computers, CDMA, WiBro and DMB, among others. The tripartite cooperation was instrumental in building technology absorptive capabilities of GRIs and private firms.

After building up a certain level of technological capacity, private firms lead research cooperation. As in the case of WiBro, R&D projects based on the PPP (private-public partnership) system, was carried out by private firms providing R&D funds, and the government-sponsored research institutes performing joint research with the private sector. Developing countries need to benchmark the PPP system, because it enables GRIs to perform more market-oriented R&D projects.

Building ICT research clusters that attract R&D centers of major global IT companies is another policy that developing counties should emulate, since it can help secure state-of-the art technologies, foster high-level specialists, and allow them to enter global markets.

3. Removing the Weeds

Korea fostered deregulation and competition to facilitate ICT innovation. The enactment of "Foreign Capital Inducement Act" in 1967, which simplified the export and import procedures for electronics companies, was instrumental in accelerating foreign technology inflow and consequent technology absorption by domestic firms. The export oriented development strategy drove domestic industries into the international market, putting them under fierce pressure to compete with foreign companies; such pressure generated continuous demand for R&D and innovation (Chung, 2010).

The Korean government took a top-down approach in developing important technologies such as the TDX, CDMA and Wibro. The Korean government selected eight new services, three essential infrastructure, and nine future growth engine products under a policy plan titled "IT 839 strategy". This kind of targeting requires lots of information. To set the priority area of national ICT R&D, current situation and future prospect of technologies and market have to be taken into account. The government needs information about technological capability, availability of necessary skills, the private sector's willingness to participate in the project, the size and expected growth of the global market for related products, the current and expected market share of domestics firms and the potential ripple effects of a particlular project among others. After considering all these factors, the government has to decide whether intervention is necessary. If it is necessary, the government in turn needs to find out the methods of intervention in order to minimize market distortion. The top-down ICT R&D priority setting in Korea has followed this kind of an exercise. However, this kind of select and focus strategy has been the subject of constant criticism, on the grounds that the government cannot be an efficient resource allocator or an omniscient picker of winners. As we explained in the case of WiBro in the previous chapter, this criticism deserves our attention. The WiBro project succeeded in terms of technological develpment but failed to secure sufficient subscribers to become profitable. When removing the weeds, developing countries need to consider whether if there is any possibility that they are in fact removing a valuable plant and neglecting to pull out weeds.

4. Watering Innovation

The promotion of the ICT industry and ICT R&D requires large investments, calls for cooperation among related organizations, and will take at least several years to implement. It is therefore difficult to finance projects using the government's general budget. In Korea, the "Informatization Promotion Fund" was created to finance the promotion of e-Government, the rollout of a national broadband network, to support government ICT R&D, standardization, and ICT human resources development. Developing countries can emulate Korea's unique policy of establishing its own "Informatization Promotion Fund".

In order to do this, some actions need to be taken first. First, a country needs to create consensus on establishing a special fund promoting the ICT industry and ICT R&D. The Korean government had two major reasons for setting up the fund. One was that the ICT sector is the most important growth engine of the knowledge economy, and is characterized by rapidly changing technology. The flexible financing strategy of the fund would give the government the capability to enhance the efficiency and effectiveness of its ICT R&D policy making. Another reason was that revenues from spectrum auctions should be reinvested in the ICT sector. The latter argument is still controversial in many countries since the money from spectrum auctions is usually used to finance the general budget of the government rather than being set aside for the ICT industry. Any government which would like to benchmark the IPF of Korea should first create a consensus for establishing a special fund for the ICT industry and infrastructure promotion. Second, the government needs to set up a legal framework for the fund. In the case of Korea, the "Framework Act for Informatization Promotion" was enacted. The law should specify the funding mechanism, management agency, the scope of disbursements, and the governance structure of the fund. Since a share of the proceeds from spectrum auctions will be contributed to the fund, an inter-ministerial coordination body needs to be established to monitor the fund independently of the fund's managers.

5. The Role of Government in ICT R&D

The public sector must focus on highly risky basic technology R&D that involves the public interest and externality. While the public sector must intensively foster the areas that have a high potential of future growth and high ripple effects, such as the CDMA commercialization in the case of Korea, it also needs to focus on basic and core fundamental technologies. The industry, the academy, and the public research institutes must join forces to select strategic areas and plan detailed projects. The R&D of the government should stimulate the R&D of the private sector rather than crowding it out, which can be achieved by clearly dividing the roles of the private sector and the public sector in R&D. That is, the ICT R&D should be led by the private sector, and the government must focus its R&D investment in the areas where the private sector cannot undertake R&D, or where there is no incentive to undertake R&D. The priority of the public ICT R&D, in theory, should be given to the following areas where the private sector cannot carry out: i) R&D in areas that entail high risk in terms of the time or finances, ii) R&D in basic research areas required to create new future technologies and pioneering R&D, iii) R&D aimed at effectively transferring the results of basic researches to the private sector, iv) R&D in areas closely related to public interest, v) Interdisciplinary R&D, Large R&D that the private sector cannot afford to undertake (Ko et al., 2011).

The role of the government in ICT R&D is time-variant. The evolution of Korea's ICT R&D policy explained in this report can shed light on the policy making of developing countries. However, there are things that should not be emulated from the Korean case. Korea's private sector ICT R&D is led by a few large conglomerates like Samsung and LG and is focused on investment in hardware-related technology. This is caused by the path-dependency of Korea's ICT industry and R&D experience. Korea promoted exports of hardware equipments, parts and components by providing preferential loans to large conglomerates in the 1960s and 1970s. This initial "select and focus strategy" has lead to the polarization of hardware and software, large conglomerates and SMEs within the ICT industry of Korea today. More balanced approach of promoting HW and SW, large firms and SMEs together is recommended for developing countries.

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