STI in History:

Korean STI Policies in the Institutional Building Stage

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1. INTRODUCTION

Korea is surging as a strong technological country that competes with technology advanced countries and is positioned as one of world top 10 countries in terms of economic volume. Korean products, traditionally seen as cheap imitations, now occupy advanced product areas in foreign sales rooms and have globally established Korean products as technologically advanced. Many still remember the devastation of the Korean War; however, it is marvelous to see Korea's remarkable current developments. It is unprecedented for an underdeveloped country to enter the ranks of an advanced country in such a short time. In addition, it is miraculous for a country to develop advanced technologies in 50 years from the state where it had almost no modern S&T capacities.

The marvelous advancement of Korea was possible to the successful execution of export-oriented economic development and the advancement of educational system to develop competent human resources; however, they cannot be fully explained without explaining the development of modern Korean S&T. This paper examines the contexts and implementation efforts of major S&T policies in the 1960s and 1970s when Korea started S&T development with domestic efforts to support industrialization and achieved the rapid economic growth known as the 'Miracle of Han River'. This paper also assesses outcomes of S&T policies in that period and suggests some implications to developing countries.

Underlying tone of S&T policy during this period was put in institution building of domestic R&D capability building to provide the driving forces for fast S&T advancement. First, the technological base for strategic industries were provided and implemented as economic development plans to emphasize technological supports for industrialization. Second, institutional foundations were established to enable fast S&T advancement, while a high priority on S&T was given in national development strategies. Third, the government provided a momentum to activate R&D activities by building domestic R&D capabilities to promote the transfer and localization of advanced technologies under the circumstance that modern Korean technologies almost exclusively relied on overseas countries. Fourth, to prepare for increased technological demands along with economic growth, the

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government established institutions to develop competent S&T human resources in order to lead provide problem solving for scientific and technological upgrades. Fifth, the government created a favorable climate for the quick popularization of S&T in public life to overcome the high rate of scientific ignorance and insufficient science and technology education. S&T policy in this period played a critical role as an engine for industrial and technological development that evolved Korea towards a dynamic developing country. These initiatives provided the opportunity for Korea to appear as a newly industrialized country in the 1980s.

2. BACKGROUND

Korea was a very poor country until the 1960s. Korea's per capita income was 79 USD and was lower than North Korea, the Philippines, and many African countries. In the 1970s, Korea's income per capita was merely 254 USD at the end of the Second *Five-Year Economic Development Plan*. Korea's primary industries such as mining, agriculture, and fishery etc. occupied 40.2% of industrial production in 1961 with a typical industrial structure shown in underdeveloped countries. In addition, the domestic technological level was very low and most of required industrial technologies including plant engineering, production technologies and quality control of products relied on overseas technology (Hwang, 2010). Total R&D expenditures were only 4 million USD in 1960 and 30.3 million USD in 1970; therefore, the R&D capabilities of public research institutes and private firms were very weak.

The military regime that acquired government control by force in the early 1960s initiated the modernization of Korea with the slogan 'Let's live well by solving people's economic hardship on the blink of despair and starvation' (MOST, 2008). Under strong and charismatic leadership of Park Chung-hee, the government established the *First Five Year Economic Development Plan* in 1961. In this plan, the direction of industrialization was determined to nourish light industries in order to replace imports as well as to increase exports in a short time. Technological demands during this period placed emphases on technology absorption by the transfer of overseas technology to Korea, importation of technology-embodied capital goods to build factories, and the security of technicians to operate factories (Choi, 1983). These demands had to rely on advanced countries because the domestic industrial and technological bases were weak. However, the progress of industrialization showed the need for the cultivation of S&T human resources and establishment of endogenous R&D capabilities to adopt, assimilate, and internalize advanced technologies (Hwang, 2010).

Recognition of the importance of S&T was intensified as the strategy to promote heavy and chemical industries was adopted in 1973 along with subsequent policies to promote defense industries (MOST, 2008). The Korean industrial structure that produced and exported finished products assembled with low labor costs and unskilled labor based on the import of intermediate products and capital goods and assembled was difficult to maintain in an evolving world market. Therefore, the government strategically selected and intensively invested in six heavy and chemical industries (steel, non-metallic, machinery, shipbuilding, electronics, and chemistry) that were believed to have great interlinked effects in the front and back of the industry. With these, government expedited the development of defense industries in tandem with heavy and chemical industries to cope with intensified tensions between South Korea and North Korea. Technological requirements emphasized the importation of technology-embodied capital goods and plants, acquisition of skilled technological personnel to operate modern factories, assimilation and internalization of imported technologies, and technology diffusion across major industries. These technological demands required a higher

level of technological ability and it was difficult to meet those demands without in-house technological capabilities though. Besides, Korea was not able to afford the costs of technology imports due to a shortage of foreign currency.

In line with implementing economic development plans, wide areas of key industries were nourished and many large-scaled modern factories were built. Consequently, technological demands rapidly increased in a short time (MOST, 2005). How could Korea secure science and technology human resources to operate new factories and plants that could produce internationally competitive products and solve industrial problems? How could Korea prepare R&D capabilities that make it possible to absorb, assimilate and internalize advanced technologies, support the demands of specialized technologies in specific industrial areas, and intermediate technological problem solving for companies with insufficient technological capacities? How could Korea prepare systematic arrangements to develop industries and support S&T in connection with economic development plans? How could Korea create a public climate to enhance understandings and recognitions for S&T' disregarded under traditional Confucian sentiments?

These challenging S&T tasks gave rise to Korea's S&T policies at the institutional building stage. President Park's leadership supported a national willingness and power of execution to accomplish these tasks.

3. POLICIES

3.1 Underlying Tone of Policies

Past S&T polices focused on how Korea could mobilize S&T efforts to effectively support industrialization. Adoption and utilization of overseas technologies were inevitably stressed in the early industrialization era; however, in-house R&D capabilities were urgently required along with the progress of industrialization (Choi, 1983). The build-up of in-house R&D capabilities strongly implied stepping towards 'self-reliance of technologies" that would equip Korea with necessary and long-term S&T capacities. Ideas on technological self-reliance that formed the basis for S&T policies were developed from several motives. First Korea needed to escape from heavy technological reliance on foreign technologies. New factories were built through the importation of turnkey-based technologies and their operation was almost impossible without foreign engineers. This indicates that industrialization was impossible unless advanced countries provided technologies and equipment; in addition, it was not possible for Korea to select suitable technologies by itself. Second, there was recognition of the need to overcome the heavy reliance on expensive overseas technologies through the enhancement of self-reliant and indigenous technology. The reduction of the demand for foreign currency was an important issue in the environment where industrialization investments relied almost exclusively on foreign capital. Korea adopted an export-oriented economic development strategy partly as a counter-measure to the increased demand for foreign currency. Korea faced a 1.149 billion USD trade deficit in 1970 and 4.787 billion USD trade deficits in 1980 that showed the difficult foreign currency situation of Korea. Third, Korea had to supply component technologies by itself in order to deliver finished products that were approved by export markets. In accordance with this, the government set goals to enhance the localization ratio of major manufacturing products and made efforts to manage the degree of annual goal attainments that were directly connected to the efforts to enhance technological self-reliance. Fourth, there was recognition in the 1970s that Korea had to achieve technological self-reliance to avoid perpetual technological dependence. At that time, there

was a concern that a country could suffer from technological dependence as long as they were not technologically self-reliant as shown by the cases of Latin American countries.

Efforts to promote technological self-reliance were reflected in overall S&T activities and S&T policies (Hwang, 2010). Industrial sites began to independently develop simple technologies through reverse engineering that adopted and acquired matured technologies from advanced countries. The government established government-funded research institutes to assimilate advanced technologies suitable for domestic industries and transfer advanced technologies to domestic industries. For technological self-reliance, it was very important to enhance the capabilities of S&T human resources to acquire technologies and solve technological problems. Subsequently, the government expanded the capacities of technical high schools, job training institutes, and science and engineering universities. The government not only provided training opportunities to acquire new technologies for technological personnel but also made efforts to cultivate high-caliber S&T personnel and attract overseas S&T talent. However, there were limitations in the achievements of technological self-reliance at that time because of the insufficient R&D capabilities of industry, academia, and research institutes. The government systematically managed nationwide efforts for technological self-reliance and maintained their mid and long term consistency through the systematic execution of S&T plans, the establishment of dedicated administrative agency for S&T, the arrangement of legal systems to promote S&T, and the fostering of technology development. However, the technological self-reliance efforts were confined to the imitation or modification of advanced technologies during this period due to initial stage of domestic R&D.

In the 1960s, the main focuses of S&T policies were on the formulation and implementation of government S&T plans, establishment of modern research institutes, institutionalization of a dedicated S&T administrative agency, arrangement of a legal framework to build the foundations for mid and long term S&T promotion, adoption and utilization of advanced technologies, and the expansion of education capacities to acquire skilled technicians. In comparison, the main focuses for S&T policies in the 1970s were on extending supplying capacities of technological personnel, building educational capability to cultivate high-caliber S&T human resources, establishment of specialized research institutes for strategic industrial areas, and fulfilling technological demands in line with the promotion of heavy and chemical industries. Besides, S&T policies in the 1970s focused on the enhancement of public understandings of S&T, the promotion of S&T popularization, and arrangements of legal systems to promote technological development and technological engineering (MOST, 2008).

3.2 Establishment of S&T Plans in Connection With Industrialization Strategy and Their Implementation

The onset of Korean S&T plans begin with the establishment of economic development plans. Under the circumstance that American aid was rapidly reduced, an economic development plan was established amid the necessity to develop economic self-reliance. The *First Five Year Economic Development Plan* established in 1961 favored consumable products in light industries to replace imports and expand exports as the direction for industrialization. Fertilizer, cement, plywood, textiles, and electricity were selected as major strategic industries. A plan for S&T was not considered during the establishment of the first economic development plan since the government focused on a strategy to import and absorb overseas technologies to promote these industries. However, President Park who oversaw that plan in 1962 said, "We're about to build new factories and is it possible to build them only by our technological capacities and technological personnel? Otherwise, is there any other op-

tion?" With these questions, the *First Five Year Technology Promotion Plan* was established as a supplementary plan for the *First Five Year Economic Development Plan* (MOST, 2005). This plan selected its 3 major policies: supplying technicians and engineers for industrialization, fostering importation of foreign technologies to meet the industry's technological needs and enhancing the national technological level that required a strong promotion of S&T. This plan provided the foundation for systematic advancement of S&T as a long-term national policy agenda. Starting with this plan, S&T plans continued to be established as parts of economic development plans. Accordingly, the *Fourth Five Year S&T Promotion Plan* was established and implemented by end of the 1970s. Of note is that the *Fourth Five Year S&T Promotion Plan* reflected technological support with importance in the connection with promotion of heavy and chemical industries such as machinery and electronics.

An important long-term S&T plan was established during that period. *The Long-term Comprehensive S&T Promotion Plan* (1967-1986) was prepared in 1968 under the very poor S&T environment. It is evident that Korea's S&T polices had long-term perspectives of 10 years and 20 years in their approach together with solving immediate S&T problems. This plan set its goal of, "reaching at the upper level among industrializing countries by equipping development capabilities of self-reliable technologies". This was an ambitious goal considering that Korea had almost no modern S&T in the 1960s; however, this goal was nearly achieved within 20 years.

3.3 Build-up of Domestic R&D Capabilities

Attempts to establish domestic R&D capabilities in Korea were made in the 1960s. Full-fledged economic development plans were carried out in the 1960s and Korea was urgently required to establish modern S&T research institutes that would help absorb and assimilate advanced technologies necessary for industrialization. Heavy and chemical industries were promoted in the 1970s and Korea needed to build specialized research institutes to fulfill the technology demands of technology-intensive industries (MOST, 2008). Korea established the Korea Institute of Science and Technology (KIST) as a modern comprehensive S&T research institute that was able to provide the cornerstone for the advancement of Korea's S&T and was a visible public reminder of the need for a strong economy and industries. Thanks to the establishment of KIST, Korea was equipped with modern S&T facilities to carry out R&D activities for advanced technologies. The government has stimulated world-class research activities by inducing S&T brains since the establishment of KIST (Chosun, 1995). Subsequently, there have been established many specialized research institutes with spinning-offs from KIST or transformations of government research institutes. Many researchers from KIST and specialized research institutes became main players at domestic research circles, industries, and universities in the initial stage of S&T development (KIST, 1994). The establishment of government-funded research institutes was a creative and strategic decision to support the technological demands of industries in the process of industrialization. The demands for technology increased in the 1960s due to the progresses of industrialization; however, it was very difficult to find organizations equipped with R&D capabilities. Existing national and public research institutes could not be alternatives to support technologies required for industrialization due to limited budgets, insufficient research facilities, stiffness of research activities, poor research environment, lacking of understandings for the technological demands of industries. For this reason, the government determined policies to establish modern science and technology research institutes newly. Korea was able to finally establish KIST with the help of development assistance by USA in 1966 and carry out its initial research activities through cooperation with the USA experts.

In the meantime, the establishment of government-funded specialized research institutes extended the domestic R&D system for the creation of in-house R&D capabilities. Recognizing the fact that research for industrial technologies by KIST helped industrial sites, the government established specialized research institutes to shorten the technological self-reliance of industry. Specialized research institutes established in 1970s mainly originated from the KIST model (Hwang, 2010). Specialized research institutes were established primarily in 4 classes; 1) restructuring national and public research institutes into non-profit organizations like the Resources Development Research Institute, 2) establishing affiliated research centers like the Korea Shipbuilding Research Institute, and then independently separating them, 3) establishing another research institutes with spinning-offs from organizations or personnel from KIST like the Korea Electronic Technology Research Institute, d) establishing new research institutes like the case of Korea Chemical Research Institute. However, specialized research institutes followed the model of KIST at every aspect of management and the research activities of institutes. Many researchers from KIST played key roles in establishing specialized research institutes. The Agency for Defense Development was also established as a government-funded research institute to support self-reliance in defense technologies and the promotion of defense industries. These kinds of government-funded research institutes were established as non-profit foundations that government funded with certain construction funding, operation budgets, and research grants without any conditions (KIST, 1994). This intended to give autonomy and independence in the operation of research institutes in order to enable these institutes to overcome the limitations of national and public research institutes. Along with these purposes, the government provided government-funded research institutes financial stability and modern research environments; for this, it enacted the *Law on nourishing Korea Institute of Science and Technology* for KIST and the *Law on nourishing specific research institutes* for specialized research institutes. One distinctive feature in the operation of government-funded research institutes was that they adopted a contract-based research system. This contract-based research system was to conduct research on a contractual basis with research customers such as industry and government. This system resulted in effects to support the financial stability and autonomy for operating research institutes as well as guaranteed the responsibility of research activities by reflecting the needs of research customers (KIST, 1977).

The government began to build Daedeok Research Complex in 1973 to provide a foundation for specialized research institutes. The Daedeok Research Complex was established to enhance the effectiveness of research activities by grouping research institutes in one region and the promotion of interaction by researches across S&T areas; recently it has changed into an innovation cluster beyond an isolated research complex (DDI, 2003).

3.4 Institutionalization of S&T Administrative Agency

The government adopted the promotion of S&T as an important national strategy for modernization and began to consider the establishment of a dedicated government organization for S&T. The government came to recognize the importance to institutionalize an independent administrative organization for S&T in order to establish and implement S&T plans, to establish and support modern S&T research institutes, to manage nationwide S&T activities and to build legal and institutional foundations to promote S&T (MOST, 2005). For these reasons, the Korean government established the Ministry of Science and Technology in 1967 as a dedicated S&T administrative agency. The Ministry of Science and Technology was established as an umbrella department of the Prime Minister's Office since it needed to plan and coordinate overall S&T strategies across ministries. However,

the Ministry of Science and Technology had executive functions as it had a primary responsibility to promote overall S&T matters related to centralized practicing powers (MOST, 2008). The establishment of a dedicated S&T administrative agency was an exceptional case for developing countries at that time. Besides, the government established the Council for Economy and Science because industrialization and S&T policies were interlinked and roles of S&T should be considered in the framework of the national economic strategy.

The government established the Korea Science and Engineering Foundation (KOSEF) in 1977 in recognition of the importance to promote long-term basic research. Its establishment was due to the belief that promoting research activities and allocating research funds for science and engineering needed to be carried out by an organization with autonomy and expertise.

3.5 Creation of a Foundation to Raise S&T Human Resources

Policies to develop S&T human resources became a main S&T policy issue in the 1960s and 1970s. Policies to develop S&T human resources in the 1960s were focused on the development of technicians; however, those of the 1970s focused on the development of qualified engineers (MOST, 2008). Industries needed a large number of technicians as the *First Five Year Economic Development Plan* was implemented in the 1960s; subsequently, major S&T policy issues were the acquisition and utilization of quantitative and qualitative technicians and skilled workers. The government consequently deployed policies to extend technical high schools and highlighted vocational training. The government greatly enhanced the qualitative level of onsite skilled technicians in a method that provided scholarships to induce gifted students to enter technical high schools. In the 1970s, high quality S&T human resources became a main S&T policy issue as industrialization progressed and domestic R&D capacities expanded. However, the role of graduate schools to deliver high quality human resources was unsatisfactory since the education systems of universities at that time were premodern. However, the development of high-calibre scientists and engineers who could meet specialized technological demands of strategic industries was urgently required in the 1970s as the heavy and chemical industries started to grow. In these circumstances, the government proposed the need to establish a new science and engineering graduate school and the USA promised to support this proposal. Consequently, the Korea Advanced Institute of Science (KAIS) was established in 1971 through a cooperative project between Korea and USA. It had its goal to develop high-caliber S&T human resources that would lead industrial R&D and innovation. Unlike national universities, KAIS was established as a government-funded non-profit organization that made it possible to guarantee as much flexibility as possible in order to establish special education systems. Despite strong objections from academia and the Ministry of Education, the government established KAIS under the Ministry of Science and Technology and not under the Ministry of Education thanks to the resolute will of President Park (MOST, 2006). It made it possible for KAIS to autonomously perform intensified and specialized education to develop advanced scientists and engineers. KAIS focused on the cultivation of practical S&T human resources to become factory managers in local companies. Although KAIS was equipped with the best facilities and faculties, it intended to develop scientists and engineers for industry rather than to develop scientists that pursued a Nobel Prize (Benedict et al., 1970; MOST, 2006). This policy to target on industrial needs enabled KAIS to quickly earn a strong industry reputation. KAIS came to have a distinctive position in the development of high-caliber S&T human resources while it developed 25% of the master's and 33% of the doctor's science and engineering degrees in Korea by the end of the 1970s.

The government enacted the *Law on National Technology Certificates*; it integrated, classified, and systematized existing technology certificates and licenses. The government integrated technological qualifications and educational training curricula by reflecting the patterns of technological personnel demands from industry so that graduate students and job trainees from science and engineering universities, industrial professional colleges, technical high schools and trainees were obligated to acquire national technology certificates (MOST, 2005). These national technology certificates contributed to it that S&T human are treated as specialized human resources.

4. EVALUATION AND IMPLICATIONS

The 1960s and 1970s were periods of institutional building for Korea's S&T advancement. These periods became a cornerstone for the evolution and development of S&T policies.

First, the government formed the foundation to extend modern research capabilities of S&T through the establishment of government-funded research institutes such as KIST, specialized research institutes, and the construction of Daedeok Research Complex. Domestic R&D activities began to bloom and secured the internalization of advanced technologies for self-reliance of technologies. Research experiences of government-funded research institutes were disseminated across industry and universities, and enhanced the catching-up of technologies with advanced countries.

Second, S&T policies came to be planned and promoted consistently with official backing through the establishment of the Ministry of Science and Technology as a dedicated S&T administrative agency. The operation of a dedicated S&T administrative agency contributed to highlight the priority of S&T. It became an important mechanism for the selection of policies and actions to focus on while it efficiently mobilized limited domestic S&T resources and capacities.

Third, major key industries were formed early in these periods through technological assimilation of advanced technologies and technological aggregation of strategic industries. At that time, S&T policies were primarily to support industrialization and focused on coping with technological demands to nourish export-led light industries and capital/technology intensive heavy and chemical industries.

Fourth, Korea acquired and extended potential S&T powers for economic development through the quantitative and qualitative enhancement of S&T human resources under the situation of poor resource endowment. Korea shortened the periods necessary to learn and assimilate advanced technologies through the quantitative expansion and qualitative development of technicians and engineers that corresponded with directions of industrialization. In addition, Korea prepared the foundation for advanced education in domestic science and engineering graduate school through the establishment of KAIS.

Fifth, the establishment of modern research institutes such as KIST and specialized research institutes equal to the levels of advanced countries provided opportunities to overcome the common and persistent problem of brain-drain in developing countries. These institutes shortened the time to internalize advanced S&T through the prevention of brain-drain to overseas and inducement of talent to return to Korea.

Sixth, during these periods, the government established legal systems to become the foundation to promote and activate technology development. Enactments of the *S&T Promotion Act, Technological Development Promotion Act*, and *Technological Engineering Promotion Act* made it possible to institutionally guide S&T policies and activities. The S&T climate was created to enhance the recognition

and understanding of S&T in these periods as well as the support for S&T socio-economic development.

S&T policies primarily focused on institution building for scientific and technological support for industrialization in connection with economic development strategy. Institution building was carried out with long-term perspective amid fulfilling the immediate needs for S&T. This policy perspective provided a big move forward for Korea's current economic development.

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