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Building an IT Economy: South Korean Science and Technology Policy

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EXECUTIVE SUMMARY

Underlying Korea's remarkable post-1961 economic development has been the development of a strong science and technology capacity. During the authoritarian regimes (1961-1988), the state created a rudimentary research capacity, primarily focused on creation of government-run research institutions, a technical university, and a central research park, as the private sector gradually began to muster its own applied research capacity. The late 1980s to late-1990s saw a change of direction, as Korea's *chaebol* conglomerates became the lead actors in R&D. The well-funded National S&T Technology Program became the focus of state efforts, later superseded by the 21st Century Frontier Program and specified research funds. By the turn of the century, Korea had achieved strong aggregate performance in terms of numbers of researchers and funds spent on R&D, and has continued to build on that for the past decade.

The IT industry and, to a lesser extent, biotech have become the major drivers of technological development. The shift from the old industrial to new high tech economy facilitated a recasting of national efforts. A refocused state helped midwife the nascent IT sector, through a combination of privatization of the national telephone service provider, creation of infrastructure, and dispute moderation. Even so, recent doubts about Korea's overall IT competitiveness have arisen.

Meanwhile, since the mid-1990s, Korean policymakers have been captivated by the possibilities of "Big Science," i.e., basic or foundational science. Korea participates in various international basic science programs, and has created another big state funding effort (the 577 program) to support basic science. The government has spent much policy effort on drafting "visions" of future technological development, but its technological future may depend on maintenance of economic competitiveness.

The fast post-war development of South Korea is one of the most remarkable economic stories of the twentieth century. The small Asian nation in 1960 was one of the world's poorest countries, with a Gross Domestic Product roughly equal to that of Ghana. By 1995, it rose to become the twelfth largest economy, and Asia's fourth largest. How Korea was able to accomplish this remarkable feat is a much analyzed story in international political economy, but at its heart was a largely autonomous state that employed a combination of state-directed bank financing, light and then heavy industrial export promotion, fostering of large industrial conglomerates (the fabled *chaebol*), and suppression of labor unions to create workplace peace. A hard-line military regime gave way to democracy from the late 1980s onward, and the state committed to thoroughgoing economic liberalization as a result of the calamitous 1997-1998 Asian Financial Crisis. Since the late 1990s, Korea has generally been accepted as an addition to the developed world and, as a mature economy, has seen economic growth slow and population size plateau. Koreans have become intense users of electronic media, with broadband computer connectivity and cell phone service achieving nearly universal penetration.

Underlying Korea's strong economic development has been a consistent effort to create a robust science and technology (S&T) capacity. From the beginning of Korea's export-oriented drive in the 1960s, this has followed two parallel tracks: creation of a state-led research and educational capacity, centered on state-run research institutes, and in-house research and development efforts by the *chaebol* and some medium-sized firms. Universities were a relatively weak S&T player, at least until the late 1990s. After the mid-1990s, the focus of state S&T policy shifted from industrial technology to promotion of the information technology (IT) industry.

To get a better understanding of Korea's technological development, this article examines the post-1961 history of technology development, and the transition to an IT-dominated economy in the 1990s. It then examines state policy and institutional changes, and promotion of the technologies of the twenty-first century. It considers state policy in global science and technology, what Korean technology writers call "Big Science," and Korea's future as a technology power.

Creating Technology Capacity: State Policy, 1961-1993

The Korean state began a serious effort to develop science and technology policy soon after a military coup d'état led to the presidency of Park Chung Hee. Technology policymaking changed greatly in the years of military rule. During the Third Republic (1963-1972), the president made most major policy decisions, in consultation with a few key advisors. The state focused on development of basic institutions to support the adaptation of foreign technology. These included the Ministry of Science and Technology (MOST), one of the first government organs in the developing world dedicated to technological development, and the Korean Institute of Science and Technology (KIST), a government R&D facility dedicated to applied technology. The U.S. government provided seed money and an administrative consultation team to help with the institute's set-up, as well as continuing assistance. For the first five years, KIST established operations and hired staff, and only began to do research work in the

1970s. The state also established the Korean Advanced Institute of Science (KAIS), intended as one of the first science and engineering universities in the developing world. KAIS was later renamed KAIST, and today is Korea's leading technical university.

The Fourth Republic (1972-1980) saw decision making become more diffuse, as the president merely ratified key decisions made by MOST and the Economic Planning Board (EPB). The private sector started to play a small role in decision making, and began to set up its own in-house R&D organizations. The state established a string of specialized research institutions, and laid the groundwork for the Daedeok Science Town, intended as a dedicated industrial science park, in Taejeon (in the late 1990s, it was renamed Daedeok Science Valley, or DSV, to suggest a Korean equivalent of Silicon Valley). There are now thirty government-supported research institutes, many of them located at DSV. Daedeok now hosts 242 research organizations with 24,000 employees, including 6,200 Ph.D. researchers, and is divided into four sectors: IT, biotech, nuclear technology, and nanotech.[1]

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During the Fifth Republic (1980-1987), Korea became a leading exporter and technology power. The *chaebol* now became partners of the state, and S&T policy was made more by committees and technology conferences led by the president, Chun Doo Hwan. The focus of national R&D became the highly funded National Research Projects.

The early years of the Sixth Republic (1987-present) witnessed a transition to democracy. The *chaebol* took the lead in technology development, while the government focused on prestige programs, such as the G-7 Project, designed to catapult the country to the rank among the richest countries by the twenty-first century. It concentrated on several large-scale efforts, such as electric cars and HDTV, but attained only marginal results.

Changes in Direction of Technology Development

The institutional centers of Korean S&T policy in the 1980s were the Ministry of Science and Technology (MOST), which supported basic and applied research through KIST and its specialized research institutes, and the Ministry of Trade and Industry (MOTIE), which promoted purely industrial research. MOST is now called the Ministry of Education, Science and Technology (MEST), and MOTIE became the Ministry of Knowledge Economy (MKE). From the 1980s, the National R&D Program (NRDP) had been the focus of MOST's activities. This was supplemented by a major new program: the 21st Century Frontier R&D Program began in 1999 to develop science and technology competitiveness in emerging fields, and over the subsequent decade the government poured $3.5 billion into twenty-three projects in such fields as bioscience, nanotechnology, space technology. Each grant has been for roughly $1 million.[2]

Five new specified research funds under the NRDP were created in the 1990s. The oldest of these is the Space and Aeronautics Program, dating to the early 1990s. It became the core of Korea's nascent space program, focused on satellite development. Since then, seventeen

[1] British Embassy, Seoul. 2011. "Science and Innovation in Korea." July 11, p. 2. www.ukinrok.fco.gov.uk/en/about-us/working-with-korea/science-innovation/science-and-innovation-in-korea
[2] Ministry of Education, Science and Technology. 2010. "National R&D Program," p. 1. http://english.mest.go.kr/web/1715/site/contents/en/en_0217.jsp; British Embassy, Seoul, op. cit., p. 1.

satellites have been developed, including communications, multi-purpose, and scientific satellites. The Creative Research Initiative (CRI) started in 1997, intended to support a shift "from imitation to innovation" research. Fifty-seven research centers were selected, each receiving $500,000 per year. The National Research Laboratory (NRL) chose several research centers of excellence, aimed at improving competitiveness. Individual projects receive up to $250,000 per year, and the majority of projects are at universities and research institutes, with only about ten percent at corporate research labs. The Nanotechnology Development Plan of 2001 was dedicated to this emerging technology, spends about $170 million per year, and established two new national nanotechnology labs. The Biotech 2000 Plan brought together several ministries with interests in development of biotech, and the plan was intended to boost the biotech component of the NRDP.[3]

The Korean government prides itself on steadily increasing aggregate figures for R&D expenditures and numbers of researchers. In 2008, Korea devoted 345 billion won ($286 million) to R&D, accounting for 3.37 percent of GDP, almost a full percent increase over 1998 (it reached 3.48% in 2010). In PPP terms, it equaled about half of the figure for the U.S.[4] Also in 2008, the government employed over 4,000 researchers in its R&D labs, nearly doubling the figure for 2000. Researchers employed in corporate labs were 197,000, and private facilities accounted for two-thirds of both total spending and researchers, while eighty percent of the rest toiled at universities. Unsurprisingly, most corporate researchers work on applied technologies.[5] As impressive as these figures may be, Korea still lags in amount of expenditures per researcher, behind Japan, the U.S., and several Western European nations.[6] Also, amounts of expenditures as a ratio of sales lag for many industries. Korea has among the highest rates in semiconductors, medical and precision equipment, and communications and broadcasting, but languishes under one percent in telecommunications, utilities, and construction.[7]

The IT Industry and Biotech Lead the Way

Over the past seventeen years, Korea has become one of the leading IT nations. It ranked number one among 152 countries on the ICT Development Index in 2011, followed by the Scandinavian countries of Sweden, Iceland, Denmark and Finland. The Index measures the level of IT development of International Telecommunications Union (ITU) countries. It uses three measures: accessibility, use and competence. Korea ranked first in use, second in competence, but only tenth in accessibility. Koreans also rated highly in internet access (first), number of wireless broadband subscribers (first), and wired broadband subscribers (fourth).[8]

[3] "National R&D Program," op. cit., pp. 1-2.
[4] Ministry of Education, Science and Technology. 2010. "Total R&D Expenditure," pp. 1. http://english.mest.go.kr/web/1750/site/contents/en/en_0240.jsp
[5] Ministry of Education, Science and Technology. 2010. "R&D Personnel," pp. 1-2. http://english.mest.go.kr/web/1750/site/contents/en/en_0241.jsp; British Embassy, op. cit., p. 1.
[6] Ministry of Education, Science and Technology. 2010. "Synthetic analysis of R&D," pp. 1-2. http://english.mest.go.kr/web/1750/site/contents/en/en_0242.jsp
[7] Ministry of Education, Science and Technology. 2010. "The Result of R&D Activities," pp. 1-2. http://english.mest.go.kr/web/1750/site/contents/en/en_0240.jsp
[8] "Korea ranks global No. 1 in ICT field." 2011. Korea Communications Commission. September 15, pp. 1-2.

Broadband and CDMA services comprised 15.8 percent of real GDP in 2005.[9]

How did Korea leapfrog to the top in only a few years? The state is widely regarded as having created the IT sector. In the 1980s, state research organizations developed telephone switching systems, and an IT policy think tank recommended full privatization of the industry. By the mid-1990s, a thorough liberalization began, as several new firms entered the market. What were the major state efforts? First, state intervention has fostered close ties between public organizations and private actors. Second, the state has built infrastructure (the Korean Information Infrastructure, or KII, project) mainly through wired and wireless broadband networks. Third, the state coordinated R&D and mediated disputes between private and public actors through its research and policy organizations.[10] Fourth, the Ministry of Information and Communication (MIC) has led IT development since the mid-1990s, introducing several key development plans, such as the IT839 Policy in 2004, i.e., eight new services in three years, involving nine hardware and software components.[11] Fifth, since the 1980s, Korea has computerized most government operations (what it calls "e-Government).[12] Finally, in 2001, the government created a "Gold Visa" to allow more foreign IT researchers to work in Korea.[13]

Despite becoming one of the top IT nations, Korea has gradually lost competitiveness in the IT industry.

Despite becoming one of the top IT nations, Korea has gradually lost competitiveness in the IT industry. In the IT Industry Competitiveness Index of the Economist Intelligence Unit, Korea fell from third place in 2007 to nineteenth place three years later.[14] The industry saw profits drop sharply in 2010-2011, and IT significantly fell as a component of Korean exports in the same period (despite overall Korean exports reaching $1 trillion in 2011).[15] It took Korea's major IT producers, Samsung, LG, and Hyundai, two years after introduction of the iPhone before they introduced their own smartphones. Korean producers have not been able to gain a dominant position vis-à-vis Apple in the emerging tablet technology in terms of either hardware or software.[16] For many Koreans, failure to compete with Apple in these two key product areas signified a general lack of innovation in the sector.[17]

MKE outlined in 2010 a major plan to restore competitiveness. This effort included cutting-edge areas such as development of a 3-D industry, merging of medical and IT technologies, and applying IT technologies to more traditional industries, such as automobiles,

[9] Song, Jung-Hee. 2006. "IT839 Policy Leading to u-Korea." *VLDB '06*. September 12-15, p. 1103.
[10] Bang, Suk-ho. 2010. "Looking Back over 25 years of IT Policy." *IT Times*. November 4, pp. 1-2; Kwang-Suk Lee. 2009. "A Final flowering of the developmental state: the IT policy experiment of the Korean information infrastructure, 1995-2005." *Research Online* (University of Wollongong). pp. 6-12.
[11] Song, op. cit., p. 1103.
[12] Ministry of Public Administration and Security. 2011, *e-Government of Korea: Best Practices*. pp. 4-9.
[13] "Gold Visa for IT Manpower, toward Korea." 2001. *Gate4Korea.com*. http://www.gate4korea.com/about_goldvisa.htm
[14] "Korean IT Industry Keeps Dropping in Competitiveness Rankings." 2011. *Chosun Ilbo*. September 28, p. 1. http://english.chosun.com/site/data/html_dir/2011_09/28/2011092800865.html
[15] "Korea No Longer Relying on IT Products to Boost Exports." 2011. *Chosun Ilbo*. June 27, p. 1. http://english.chosum.com/site/data/html_dir/2011/06/27/2011062700939.html; "Korea's Trade Volume Tipped to Pass $1 Trillion By Year-End." 2011. *Chosun Ilbo*. July 4, p. 1. http://english.chosum.com/site/data/html_dir/2011/07/04/2011070400389.html; "Korean IT Industry Posts Poor Quarterly Results." 2011. *Chosun Ilbo*. July 22, p. 1. http://english.chosum.com/site/data/html_dir/2011/07/27/2011072200410.html
[16] Lee, Shin Yeong. 2010. "Korea's IT Industry Falling Behind." *Worldyan News*. April 14, p. 1. http://www.worldyannews.com/news/articleView.html?idxno=1063
[17] "Apple iPad Underscores Korean IT Industry's Lack of Innovation." 2010. *Chosun Ilbo*. January 29, p. 1. http://english.chosum.com/site/data/html_dir/2010/01/29/2010/01/29/20100012900652.html

robotics, machinery, and shipbuilding.[18]

Biotechnology has a shorter history in Korea than IT but, over the past decade, has grown substantially. In the 1990s, most R&D was pursued by universities and a few pharmaceutical firms, but Korea now has a diversified R&D capacity in bio-science and product development. Medical uses account for nearly sixty percent of the industry, by income, and food products amount to nearly forty percent. The industry bounced back from a major scandal involving human biotech experiments, and now boasts roughly 600 firms, most of which are located in the Seoul area. The industry employs over 12,000, over half of whom are researchers, and the rest in production. The industry produced $2.42 billion in volume, along with $1.1 billion in exports, in 2004.[19]

The Pull of "Big Science"

The Korean government, while continuing to promote applied research in high tech and emerging technologies, since the 1990s has sought to put more stress on basic and fundamental science.[20] Before the Frontier 21 Program in 1999, there was much discussion about but little support for major basic science efforts. Korean policymakers think that the country now has the critical mass of scientific assets to allow it to become a leading "Big Science" nation: a tech-savvy people willing to spend money on key technology products, with a young population possessing significant technology skills, whose consumption funds leading-edge technical development.[21]

Korea participates in several "Big Science" programs. It is a member of the International Thermonuclear Experimental Reactor (ITER) consortium, and has drafted a National Fusion Energy Development Plan for 2006-2035 that contributes $884,000-30.9 million to individual research projects. Its Space Technology Development Program includes three key elements: "core technologies," launch vehicles, and satellite technology. The government has created a launch site on the southern coast, which has sent most of the above mentioned satellites into orbit. Since 2008, the Korean Space Agency has been cooperating with NASA on civil aeronautics, geodesy, solar and space physics, and weather research. Support for climate change research projects ranges from up to $45.4 million, while oceanic and polar regions research programs provide a maximum of $4.54 million for research projects.[22] Korea also has major S&T cooperative agreements with the U.S., Japan, Russia, France, Italy, Israel, Switzerland, and the EU, and works with such multilateral organizations as APEC, the OECD,

[18] "S. Korea introduces new IT policy drive." 2010. *The Korea Herald/Asia News*. March 31, pp. 1-2. http://www.asiaone.com/Business/News/Story/A1Story20100331-207696.html

[19] "Biotechnology." 2007. Ministry of Knowledge Economy Special Report. pp. 1-2. http://www.mke.go.kr/language/eng/policy/news_view.jsp?seq=5&srchType=1&srchWord

[20] The Samsung Institute of Science and Technology lists ten "Big Science" categories: space use and study, near-Earth object observation, satellite observation of Earth, polar and deep sea exploration, genetics research, biodiversity study, nuclear fusion, and particle physics. "To revive industry, tackle 'big science.'" 2009. Samsung Economic Research Institute (SERI) Report, August 30, pp. 1-2. http://article.joinsmsu.com/news/article/article.asp?Total_10=3751089

[21] British Embassy, Seoul, op. cit., pp. 1-2.

[22] Ibid., pp. 1-2; National Research Foundation of Korea. 2012. "Big Sciences." pp. 1-2. http://www.nrf.re.kr/html/en/programs/programs_03_05_01.html; NASA. 2010. "NASA and Republic of Korea Representatives Hold Bilateral Meeting." December 3, p. 1. http://www.nasa.gov/topics/people/features/NASA_Korea_agreement.html

and the ISTC.[23]

To further support “Big Science,” the government enacted another grand program, the 577 Program , i.e., to raise R&D investment to five percent of GDP, to focus on seven major technological areas, and to achieve global top seven status in terms of scientific citations and international patent applications. While traditional industrial automotive, electronics, and military technologies were included, the space program, nuclear development, and “convergence technology” (nanotech and robotics) were emphasized. In 2008, MEST announced that it intended to devote half of the government research budget to basic science during this decade (but has not yet reached that goal), and sought to more than double to percent of university professors in technical fields who receive research grants.[24] A 2009 Samsung Economic Research Institute (SERI) survey of Korean researchers suggested that, going forward, the country should focus on five areas of basic research: space exploration, earth satellite studies, genetics research, nuclear fusion, and particle physics.[25]

…Since the 1970s, various Korean governments have made “regional science and technology promotion” a key national goal.

A Korean Model for S&T?

Korean S&T policy is marked by its tendency for establishing broad goals or “visions.” For instance, since the 1970s, various Korean governments have made “regional science and technology promotion” a key national goal. This was largely due to the over-concentration of state and corporate activities in the Seoul region, and the long-standing economic development inequality between the southern Kyongsang and Cholla provinces. In the 1990s, regional programs centered on largely unrealized efforts to build Daedeok-style science towns throughout the country (a research center and technical university were actually built at Kwangju in Cholla-Namdo). By 2003, this had morphed into a comprehensive plan to promote, among other things, “local competencies in strategic technologies,” creation of “regional centers for technological innovation,” and boosting R&D spending by local governments.[26] By 2010, the government had downshifted to creation of a “Science City” in the Chungchong region, not too far from the existing Daedeok Science Valley.[27]

In the 1990s, Korea aimed to achieve G-7 status early in the twenty-first century.[28] While this did not happen, the goal drew attention to the need for grander technology projects than the kind of reverse engineering of industrial products that were common in the 1970s and 1980s. The G-7 project was followed by the Five-Year S&T Principal Plan and the National Technology Road Map in 1999. The Five-Year Plan focused on management of investment, national R&D programs, promoting public awareness of S&T, development of human resources, improving technology transfer and commercialization of technologies, and

[23] Ministry of Education, Science and Technology. 2010. “International S&T Cooperation.” pp. 1-2. http://english.mest.go.kr/web/1716/site/contents/en/en_0218.jsp
[24] Stone, Richard. 2008. “South Korea Aims to Boost Status as Science and Technology Powerhouse. *Science*. December 23, p. 1. http://news.sciencemag.org/scienceinsider/2008/12/South-Korea-aim.html
[25] “To revive industry…,” op. cit., p. 2.
[26] Ministry of Education, Science and Technology. 2008. “Directions for the 21st Century.” p. 1. http://english.mest.go.kr/web/1702/site/contents/en/en_0214.jsp
[27] “South Korea unveils plan for science city.” 2010. Australian Broadcasting Corp. (ABC) News. January 11, pp. 1-2. http://www.abc.net.au/news/2010-01-11/south-korea-unveils-plan-for-science-city/1204654
[28] Ministry of Science and Technology. 1996. “Science and Technology Policy.” pp. 1-3. http://park.org/Korea/Pavilions/PublicPavilions/Government/most/policye1.html

globalization of S&T activities.[29]

A recent effort was the Long-Term Vision for Science and Technology Development, put forward in 2010. It listed four key goals: shifting the locus of the "national innovation system" from government to private sector, enhancing the efficiency of R&D investments, upgrading R&D to world standards, and trying to "harvest the opportunities presented by new technologies." [30]

The Ministry of Knowledge Economy sketches an amazing high tech future for Korea. Based on a 2009 survey of 3,000 IT industry experts and researchers, they listed such futuristic technologies as home medical checks for common diseases, mobile phones that only need to be recharged once annually, home appliances that respond to brain waves, automatic temperature adjustments for in-door climate control, super high-definition televisions, universal language translators, and efficient solar cells providing most electrical energy. [31] While all this may be remarkable, similarly astounding technologies were predicted in Korean government reports twenty years ago.

Conclusion: Korea's Tech Future

In the end, all the numbers and vision statements may not help Korea remain a tech power, and the nation's future in science and technology could ultimately depend on its economic competitiveness. A RAND Corporation Report suggests that the key will be shifting to a higher quality technology capacity. Korea does not possess the "depth of knowledge" in either basic science or innovation enjoyed by America and Japan, and yet it is not upgrading its applied technology or technological infrastructure as quickly as nearby China. While it has a fairly high R&D intensity (high number of researchers and labs), its efficiency is fairly low, and needs higher quality scientists and engineers. One of the quickest ways to do this may be to establish stronger international networks in a "global brain pool." Koreans also need to build a greater stock of technological knowledge. To ward off the China challenge, Koreans can channel China's strengths in production and growing technological capacity to complement their own abilities. Like Japan, Koreans need to inject more creative or innovative thinking into science and technological education. The highly educated labor force should be better equipped to apply technical knowledge to production problems. Finally, complete economic openness could provide a special comparative advantage that China is unlikely to know for some time.[32]

Korea has tied its economy to technological development. Caught between still dominant developed nations and rising developing countries, Korea has neither the resources of Japan and the U.S., nor the cheap technological manpower of China. Whether Korea can capture the future of IT and biotech, while mastering the technologies of the future, could determine its continued viability as a major economy.

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[29] Ministry of Education, Science and Technology. 2008. "Directions…," pp. 1-2.
[30] Ministry of Education, Science and Technology. 2008. "Directions…," pp. 1-2.
[31] Ministry of Knowledge Economy. 2009. "A High-Tech World Appears on the Horizon." MKE Special Report. March 6, pp. 1-2.
[32] Seong, Somi, Steven W. Popper, and Kungang Zheng. 2005. *Strategic Choices in Science and Technology: Korea in the Era of a Rising China*. RAND Corporation Report. pp. xxv-xxviii. http://www.rand.org

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