KOREA JOURNAL OF POPULATION AND DEVELOPMENT
Volume 26, Number 2, December 1997

TECHNOLOGY AND DEVELOPMENT: Impact of Technology on the Korean Economy*

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Korea has undoubtedly developed one of the most dynamic economies in the world. Having realized a successful industrialization, Korea now faces formidable challenges in science and technology. Korea has the problems of meeting competition from countries with more efficient industries as well as those with lower labor costs. Korea must muster the human capital, as well as financial and other resources for domestic R&D to maintain a continued industrial growth path, complemented by imported technology. Korea has to promote its own technological innovation with R&D efforts that are essential in meeting the constraints imposed on it in the changing global economy. This paper discusses the profound impact of science and technology on Korea's economy, as well as its implication for the global economy.

INTRODUCTION

Patterns of international trade and competition have been changing dramatically in recent years, with serious consequences for economic policy and business strategy. These changes are especially important for those countries searching out strategies for promoting trade-technological cooperation.

Regarding science and technology's impact on the economy in the past, Korean industrialization pushed both workers and management along a learning curve, resulting in economies of scale of capital goods and increased levels of human capital. On this foundation, Korea has now shaped its industries to meet international competition, and it finds itself in a constantly changing spectrum of industries in various stages of development. Its industrialization integrated international product cycles into production-export policy so as to realize dynamic comparative advantages by mixing endogenous inputs with imported capital goods.

Korea's industrial policy has shifted from the promotion of strategic industry to that of innovation-related activities. In the 1960s and 1970s, special incentives—tax exemptions, custom rebates, access to foreign

*This article is a substantially revised version of a paper presented at the Annual Conference on "Accelerating Change in Korea: Impact of Science, Technology and Communications on Korea and Culture" sponsored by the Center for Asian Studies, University of South Carolina, May 2-4, 1997.

exchange, etc.—were granted to these strategic industries. Korea's technology[1] and R&D policy have had both direct and indirect effects on the economic development process. Government has created a climate conducive to enhancing science and technology.

Since the 1980s, Korea has built up considerable technological capability through continued expansion of investment in indigenous R&D and imported technology. There were also improvements in communication facilities and increased adaptation and use of technology similar to that of advanced industrial countries (AICs). As AICs moved to higher technological levels, Korea's technology was not simply bought from AICs, but emerged from careful domestic support networks of indigenous technology that were developed at the same time.

The major feature of the Korean technological path was the fostering of indigenous technology through research centers established in both the public and private sectors. Korea has picked up existing machinery and technology at bargain prices. It has also established its own R&D institutes, which have brought together scientists and engineers to work on common problems with efficient utilization of research facilities. This is a significant shift from the past, in which the majority of attention was paid to labor.

Korea has to undertake a new technology policy to cope with the challenge imposed upon it under the changing world situation. With the world economy becoming both globalized and regionalized, and with the changing technology policy in AICs, Korea has to adjust to the new situation and must reformulate its technology policy and promote its technical cooperation with AICs. In a relatively short span of time, Korea has become one of the most industrialized nations in the world. It is the world's 11th-largest GNP economy, the 12th-largest trading nation, and its per-capita income in 1995 was $10,000.[2]

This paper discusses the profound impact of technology on Korea's

[1] Due to the geopolitics of the Cold War, Korea became one of the biggest recipients of US technical assistance. The US has built Korea's technological competence since the early 1950s. The American military local procurement program also offered opportunities to local manufactures to learn-by-doing so as to meet product specifications. Korea has relatively easy access to the technologies of Japan and the United States as the most important sources of imported technology. See The World Bank, *World Development Report 1991* (Washington, D.C.: The World Bank, 1991), p. 12.

[2] It took the U.K. 58 years to double its output per worker, the U.S. 47 years, and Japan 34 years. However, Korea only took 11 years. The reason for this is technological progress; Technology is far more transferable today than at anytime in history. Korea's catch-up was easier than for the technological leaders, since Korea has relatively easy access to technology introduced by AICs. See, p. 12.

economy as well as its implications for the global economy: 1) restrictions expected from World Trade Organization (WTO) membership; 2) intellectual property and copyright issues; 3) moving trade to high-tech items; 4) dual-use technology and third party transfers; 5) exporting industries abroad, especially to China.

RESTRICTIONS EXPECTED FROM WTO MEMBERSHIP

Technology is spread among nations about as unevenly as physical capital and human capital. The international technology market is typically oligopolistic and imperfect, and technology is the accumulated knowledge, skills, and techniques that are incorporated into the production function. It is posited to be the foundation of economic development, and it is associated with the scientific base and education of a country. Technology raises the marginal productivity of labor as well as that of capital. Technology mastery is the effective use of technological knowledge, through continuing technological efforts to assimilate, adapt, and create technology as well as to improve engineering.

While some technologies are available at low cost, many are expensive and subject to tight control. In addition, the ability to make use of imported technology depends on a country's absorptive capacity, which enables it to accept and modify imported technology so as to internalize this technology into its domestic production. Technology is one of the most important determinants of productivity and economic development. New dynamic competitive advantage can be created through technology transfer and conscious investment in R&D.

Technology not only possesses an expanding role in international trade, foreign investment and international knowledge diffusion; domestic production and productivity also depend on R&D activities. With more internationalizing trade, business, and technology, the WTO will promote the world economy toward globalized markets, more consolidation and greater efficiency in production. That is, national boundaries signify much less than they used to in terms of the flow of technology. The WTO, established on January 1, 1995, is the legal and institutional foundation of the multilateral trading system. It provides the principal contractual obligations determining how governments frame and implement domestic trade legislation and regulations.

The Uruguay Round (UR) negotiations tackled a broad range of issues including investment, IPR and the enforcement of GATT regulations. The agreement covers patents, copyrights, computer programs, databases,

semiconductor chips, layout designs of integrated circuits and business proprietary information. While IPR were formerly protected only bilaterally, this agreement standardizes IPR protection. The agreement makes unauthorized copying of foreign computer programs illegal. Korea has to rewrite laws and regulations to make them compatible with the new provision of the UR accord as well as WTO's revision. Thus industries and occupations related to IPR have to change the way they do business accordingly.

The WTO agreement on information technology, approved in December 1996, is considered significant in both its key role and in the dynamic expansion of the world economy. The WTO Singapore Agreement, which may well be a role model for other IPR negotiations, also involves some concessions offered in negotiations leading to the establishment of schedules annexed to the Marrakesh protocol. The Agreement could be a pace setter for forthcoming negotiations of trade-related industrial property rights and technologies.[3]

As a member of the WTO and the Organization for Economic Co-operation and Development (OECD), Korea has to comply with the new regulations and rules of the WTO and OECD by reevaluating and rewriting its laws and regulations on both formal and informal technology transfer. Formal transfer involves direct foreign investment associated with technology transfer, technology licensing, and capital goods. Informal transfer includes foreign training and studies and reverse engineering from imported products. Korea evolves its own research and development institutions. The formulation of the science and technology policy has been undertaken for the national R&D program, as the Korean government has changed the direction of science and technology policy during the 1990s (See Tables 1 and 2).

Korea's globalization should not only focus on international competition, but also direct the revitalization of domestic regional economies. Subsidies are not allowed for industrial restructuring and environmental control, but Korea can liberally provide for research and development under the WTO's rules.

High-tech friction in international trade and investment arise from two main sources: the international spillover from domestic policies designed to enhance the technological capabilities of home-based firms (including policies designed to increase technology inflows and decrease outflows) and

[3] As a reference, the patent agreement requires that 20-year patent protection be available for all inventions, whether of products or processes, in almost all fields of technology.

TABLE 1. R&D EXPENDITURES

		R&D Expenditure (million $)	Financed by Gov't Funds(%)	R&D Expenditure to GNP (%)	Number of Researchers (persons)
Korea	1980	465	64.0	0.77	18,434
	1992	6,224	17.6	2.17	88,764
U.S.	1980	62,582	41.7	2.29	651,200
	1992	157,400	43.3	2.60	949,200*
Japan	1980	20,657	25.8	1.95	302,585
	1992	94,426	16.8	2.80	504,966
Taiwan	1980	293	60.4	0.71	13,656
	1992	3,049	52.0	1.70	46,173

Source: Ministry of Science and Technology (Korea); Taiwan Statistical Data Bureau; and Korea Foreign Trade Association.

Note: *1988

TABLE 2. R&D EXPENDITURES IN KOREA

	R&D/GNP (%)	R&D Expenditure Share		Research Organizations (number)	Researchers (persons)
		Government (%)	Private (%)		
1981	0.81	55	45	662	20,718
1982	0.88	50	50	860	28,448
1983	1.01	34	66	1,080	32,117
1984	1.19	28	72	1,143	37,103
1985	1.48	25	75	1,291	41,473
1986	1.77	23	77	1,682	47,042
1987	1.87	25	75	1,864	52,783
1988	1.94	21	79	2,018	56,545
1989	1.99	20	80	2,077	66,220
1990	1.95	19	81	2,155	70,753
1991	2.01	20	80	2,351	76,252
1992	2.17	18	82	3,106	86,764

Source: Ministry of Science and Technology (Korea), *Science and Technology Annual 1993* (in Korean), p. 53; and Korea Foreign Trade Association, *Korea and the World Key Indicators 1994*, p. 58.

policies targeted at opening foreign markets for multinational enterprises (MNEs).[4]

There is a source of systemic friction in the Korean context. This is so for two reasons: the far greater diversity of culture, language, institutional governance and legal arrangements, and the increasing importance of

[4] On both these fronts, American policymaking has played a leading role and will continue to do so, whether in the WTO or other fora such as APEC and the OECD.

technology transfer to improve productivity growth. As the recent debate about the nature of the East Asian Miracle suggests, there are limits to growth which is largely driven by increased investment in physical and human capital and technology catch-up.[5] As the catch-up gap narrows, changes in both domestic and international policy strategies will be required and they may be more difficult today than they were in the industrialization decades (1962-1994), prior to membership in the WTO and OECD.

INTELLECTUAL PROPERTY RIGHTS AND COPYRIGHT ISSUES

The WTO seeks to ensure that adequate standards of intellectual property protection exist in all member countries, taking as a starting point the substantive obligations of the main pre-existing conventions of the World Intellectual Property Organization (WIPO)—namely, the Paris Convention for the Protection of Industrial Property and the Berne Convention for the Protection of Literary and Artistic Works (copyright). The WTO has placed a significant number of new or higher standards where the existing conventions were silent or thought to be inadequate.

The WTO extends and clarifies previous GATT rules that laid down the basis on which the government could impose compensating duties on two forms of unfair competition. The WTO Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) recognizes that widely varying standards in the protection and enforcement of intellectual property rights and the lack of multilateral discipline dealing with international trade in counterfeit goods have been a growing source of tension in international economic relations. With that in mind, the agreement includes the applicability of basic GATT principles and those of relevant international intellectual property agreements; the provision of adequate protection of intellectual property rights (IPR); the provision of effective enforcement measures for those rights; multilateral dispute settlement; and transitional implementation arrangements.

IPR can be defined as the acknowledgment of the right to financial compensation for a certain period of time for the creation or development of intellectual properties of economic value. The WTO has been seeking adequate international protection of emerging technologies, computer programs, integrated circuits, databases, etc. The importance of technology

[5] See The World Bank, *The East Asian Miracle*, New York: Oxford University Press, 1993, pp. 43-50.

diffusion and intellectual property rights demands better understanding of WTO technology policy. Trade-related aspects of intellectual property rights, and trade-related investment measures, are subjects that have never been negotiated in past GATT conferences. Intellectual property rights refer to exclusive use of the property in question (technology, products, printed materials). Intellectual property rights are granted to individuals and business firms by national governments for designated periods of time. Their purpose is to encourage invention, discovery, and innovation. Negotiation issues include the adequacy of existing protection afforded intellectual property rights; the enforcement of those rights by national governments, including action against counterfeit goods; and the abuse of industrial property rights for the purpose of restraining legitimate trade.

Korea IPR protection has been consolidated and adapted to the changing international environment.[6] The Patent Act is designed to promote the development of technology and contribute to industrial development by protecting and encouraging invention and its application. The Korean Copyright Act similarly contributes to the promotion of fair use of copyrighted works by protecting authors' rights and related rights.

Furthermore, Korea has gradually liberalized its technology transfer policy along with foreign direct investment (FDI), and foreign licensing has been opened to all industries and for all terms and conditions. Over 60 percent of total FDI and 71 percent of royalty payments in foreign licenses since 1962 took place in 1987-91, resulting from Korea's liberalizing policy (See Table 3). In 1996 the new provisions included the Korea Trademark Act and new Fair Trade Commission Guideline, and the revision of various other Korean laws related to intellectual property rights have also been passed in the Korean National Assembly in 1997 in order to accommodate the WTO/TRIPS Agreement.

Korea welcomes AICs firms in Korea's telecommunications sector along with Korean private companies within the agreement reached during the WTO talks. The government intends to reduce monopolization and promote small and medium-sized enterprise in this sector. The government will deregulate the industry, but at the same time monitor these companies to see that there is fair competition with equal access to resources and information.

Moreover, market presence is a two-way channel for both technology diffusion and technology access. Most importantly, impediments to effective

[6] See *Reviews of National Science and Technology Policy: Republic of Korea*, Paris, France: OECD, 1996, pp. 43-46.

TABLE 3. FOREIGN TECHNOLOGY TRANSFER TO KOREA (million $)

Source	1962-66	1967-71	1972-76	1977-81	1982-86	1987-91	Total
Foreign Licensing							
U.S.	0.6	7.8	21.3	159.2	602.7	2,121.9	2,913.5
Japan	–	5.0	58.7	139.8	323.7	1,483.9	1,991.1
All Others	0.2	3.5	16.6	152.4	258.5	853.6	1,284.7
Total	0.8	16.3	96.5	451.4	1,184.9	4,359.4	6,109.3
Technical Consultancy							
U.S.	–	3.1	6.0	16.7	159.1	619.8	804.7
Japan	–	12.1	7.7	20.8	89.2	217.6	347.4
All Others	–	1.6	4.8	17.2	84.0	413.5	521.1
Total	–	16.8	18.5	54.7	332.3	1,250.9	1,673.2
Direct Foreign Investment							
U.S.	25.0	95.3	135.0	235.7	581.6	1,482.1	2,554.7
Japan	8.3	89.7	627.1	300.9	875.2	2,113.6	4,014.8
All Others	12.1	33.6	117.3	184.0	309.7	2,036.1	2,694.8
Total	45.4	218.6	879.4	720.6	1,766.5	5,631.8	9,264.3
Capital Goods Imports							
U.S.	75	472	1,973	6,219	12,394	33,099	54,232
Japan	148	1,292	4,423	14,269	20,986	54,643	95,761
All Others	93	777	2,445	7,490	17,205	33,197	61,207
Total	316	2,541	8,841	27,978	50,585	120,939	211,200

Source: For foreign licensing and direct foreign investment, Korea Industrial Technology Association; For technical consultancy, Korea Engineering Service Association; For capital goods imports, Korean Society for Advancement of Machinery Industry. See Linsu Kim, "Absorptive Capacity and Industrial Growth: A Conceptual Framework and Korea's Experience," Institute Reports, East Asian Institute, Columbia University, March 1993, p. 11.

access are no longer confined to overt border barriers to trade or explicit restrictions which limit foreign investment. Rather, impediments to effective access can often arise from domestic regulatory policies, legal practices or private sector actions which have an exclusionary effect by accident or design.

MOVING TRADE TO HIGH-TECH ITEMS

Korea has moved to high-technology (See Table 4) and has accelerated toward high technology which changes the nature of tasks implementing technology, the interconnections and nature of physical, energy, and information flows, the skills required, the management and coordination, and the organizational culture along with technological progress. The government has undertaken its new R&D policy under the name of the

TABLE 4. WORLD MARKET SHARE (%) OF EXPORTS IN SELECTED HIGH-TECH INDUSTRY (1990)

Top Ten Exporters Ranking	Microelectronics (country / %)	Computers (country / %)	Telecom Equipment (country / %)
1	U.S. / 27.5	U.S. / 24.2	Japan / 28.4
2	Japan / 21.7	Japan / 17.3	U.S. / 15.9
3	Malaysia / 7.2	U.K. / 8.7	Sweden / 6.9
4	Korea / 6.7	Germany / 6.6	Germany / 6.5
5	Germany / 4.0	Taiwan / 6.3	Canada / 4.7
6	Taiwan / 3.8	Singapore / 6.1	Taiwan / 3.9
7	Singapore / 3.6	Netherlands / 4.2	Korea / 3.4
8	U.K. / 3.5	France / 4.0	Netherlands / 3.3
9	France / 2.7	Italy / 3.3	France / 3.1
10	Canada / 2.3	Korea / 2.5	U.K. / 3.1

Source: CIA, Economic Statistics, cited in Korea Foreign Trade Association, *Korea and the World Key Indicators 1994*, p. 118.

highly advanced national (HAN) project, and this policy is an evolutionary step from its previous approach.[7] The HAN approach concerns the public means for nurturing research institutions which can facilitate the aggregation of capabilities, facilities, knowledge, and organization (See Table 5).

The policy requires, therefore, the setting of a long-term national goal and pursuit of R&D by utilizing nonprofit research institutions, along with taking into account resource availability, research agenda, socioeconomic systems, and global technological trends. To meet growing requirements for high technology, the government introduced various new devices and incentives for product-oriented technologies[8] and fundamental technologies.[9] Thus this project serves to monitor developments outside of the industry and move quickly to introduce high-quality, lower-cost modifications and designs of products of technologies introduced elsewhere.

Korea's consumer electronics giants are trying to transform themselves

[7] Under the previous approach, the criticism was that researchers lacked strategic direction of research proposals and clear-cut objectives, for example.

[8] The product-oriented technologies are as follows: 1) highly integrated semiconductors; 2) integrated services and data networks; 3) high definition TV; 4) new medicine and agricultural chemicals; and 5) advanced production systems.

[9] The fundamental technologies are as follows: 1) new materials in information service, electronics, and energy; 2) next generation transportation system including machines and parts; 3) new functional biomaterial; 4) environmental engineering; 5) new energy resources; and 6) new atomic reactor and verification.

TABLE 5. HAN PROJECT: FUNDAMENTAL TECHNOLOGY DEVELOPMENT

Projects	Objective
Development of ultra-large-scale integrated circuits (ULSI)	Development and production of 256 Mega DRAM by 1996 Development of 1 giga DRAM by 2000
Development of new advanced materials for the information, electronics, and energy industries	Development of high value-added new materials and synthesis of ultra-pure raw materials that are important for the information industry and a highly developed industrial society
Development of advanced manufacturing systems	Development of computer-integrated manufacturing (CIM) by 1996 R&D on intelligent manufacturing system (IMS) by 2000
Development of new functional bio-materials	Development of high quality and high productivity biological resources expected to be important in 21st century industries but now in the early stage
Development of environmental technology	Upgrading technology to solve national and global environmental problems and to provide a better human and social environment, as part of cooperation for global environmental protection and conservation
Development of new energy technology	Development of highly efficient and clean energy; contribution to highly developed industry and society
R&D on next-generation nuclear reactor	Design and verification study for a new reactor concept; securing stable energy resources in preparation for the exhaustion of fossil energy

Source: MOST, cited in OECD, *Reviews of National Science and Technology Policy: Republic of Korea,* 1996, p. 74.

into a global force in the expanding field of multimedia appliances, which combine features of personal computers with consumer electronics. In their boldest moves to date, Korean companies have snapped up control of two US electronic firms—Zenith Electronics and AST Research — and are spending heavily trying to make them international stars. LG Electronics acquired control of Zenith in 1995. As part of its takeover plan, LG agreed to invest $350 million to modernize Zenith's picture tubes for computer monitors, and build a plant to make those big picture tubes. Despite vigorous turnaround efforts, AST has required several transfusions of cash and credit from Samsung. In July 1996, Samsung invested $60 million, raising its stake to about 46 percent. One encouraging sign is that AST has been gaining both market share and glowing reviews in computer magazines for a new product line that offers leading-edge technology at bargain-basement prices.[10]

Furthermore, Korea is still importing aircraft, but has rapidly improved in developing related parts and components. The most imminent problem is for Korea to develop core technology for designs, tests and appraisals, and maintenance. Korea was expected to record 900 billion won (approximately $1 billion) in sales of aircraft in 1996, a 28 percent increase from 1995.

Samsung Aerospace's new Sachon plant of fuselage sections for the F-16 in the Korean Fighter Program (KFP) was completed. With the KFP program, Korea's 3,500-member aerospace workforce has graduated to the integration of major aircraft systems. The next big step could come from the military with production of the KTX-2 advanced trainer-light combat aircraft, or it could come from the commercial side with regional transport lines. Opportunities may also exist in space manufacturing. The KFP program has helped to advance Samsung's production techniques and management style.[11]

Korea has been increasing investment in new technology and equipment, and initiated a drive for higher quality to meet the current competitive challenges. The aggregate foreign investment in Korea since 1962 totaled $11.2 billion at the end of 1993. New foreign investment in Korea amounted to $1.04 billion in 279 cases in 1993, a 16 percent increase from $894 million in 1992. By industry, $527 million of 1993's foreign investment was made in the manufacturing sector and $517 million in the service sector. Under the World Trade Organization (WTO) system, there will be greater investment in Korea by foreign countries, especially the U.S., as Korea gears up to globalize its economy, including a significant liberalization of restraints on investment.

Technological cooperation between Korea and the U.S. can overcome such constraints and realize mutual gains from technological cooperation. If the two countries are to make the most of their opportunities and reduce their trade deficits with Japan, it would be desirable that they develop economic policies which stress mutual comparative advantages of technologies.

Korea's vision of becoming an advanced information society is expected to give impetus to the progressive opening of its communications industries and the development of a fairer regulatory network. It has also led to a drive to improve the country's technological infrastructure and to strengthen the competitiveness of its information industries and overall national technological capacity. Given the country's need for technology

[10] See Kaar, Louis, "Guess Who's Betting on America's High-Tech Losers," *Fortune*, Vol. 134, No. 8, pp. 53-56.

[11] See *Aviation Week & Space Technology*, Vol. 145, No. 18, October 28, 1996, pp. 26-27.

transfer and know-how, this drive is expected to generate market openings and opportunities for foreign high-tech firms. The Korean government has been implementing the plan to build an information superhighway. The project is expected to be completed by 2015 and to cost an estimated $58 billion.[12]

The rapid spread of information technology is turning the struggle to seize the competitive high ground into a global free-for-all, and Asia's sky is considered the brightest area in information technology. The region represents the World's fastest-growing economies, including the largely untapped markets of China and India. Being established technologically, Korea has recently begun pushing its way into new markets in the region. Its national information plan includes 13 kinds of new economy-information databases, electronic libraries and museums, and information superhighway access in schools.

Korea Mobile Telecom and Shinsegi Telecom launched commercial code division multiple access (CDMA) digital cellular service in Korea in 1996. The Korean government's wholesale commitment to CDMA has become the foundation for a thriving development and manufacturing program, putting local high-tech companies such as Hyundai, Samsung, and LG among the world's leading producers of system and infrastructure and handsets, and leaving them poised to exploit export markets.[13]

Furthermore, Samsung Electronics's massive production increased so that in 1996 it will add up to a $2.07 billion total investment by all 3 manufacturers. Samsung has invested $308 million in its active matrix LCD line. By October, the company will achieve a monthly capacity of 180,000 10.4-inch screens.[14]

Korea should actively seek AICs' investments, the U.S.' in particular, as partners to facilitate joint ventures of R&D and production, and engage in fields like HDTVs, next generation automobiles and semiconductors, and new materials for the purpose of formulating a technological and industrial alliance, alleviating the trade deficits the two countries are suffering from, and preventing the deterioration of their competitiveness.

DUAL-USE TECHNOLOGY AND THIRD PARTY TRANSFERS

Worldwide sales of foreign affiliates in host countries in 1992 amounted to

[12] See *East Asian Executive Reports*, Vol. 18, No. 9, September 15, 1996, p. 8, 18.
[13] See *Telecommunications*, Vol. 30, No. 12, December 1996, p. 12, 17.
[14] See Guth, Rob, "LCD Screens Are on the Way," *Infoworld*, Vol. 18, July 15, 1996, p. 26.

$5.2 trillion, nearly twice the value of world exports of goods and services, and considerably more than twice their value in 1984, demonstrating the magnitude of the changing global economy.[15] There are a number of reasons why technology issues have featured more prominently in the international agenda over the past decade and a half. Perhaps the most fundamental was the emergence by the end of the 1970s of the 'convergence club' of the OECD countries, i.e., convergence in technological and managerial capabilities, capital intensity, and education levels. This convergence was largely a result of "catch-up." The main driver of catch-up was the diffusion of the advanced technology of the US, the undisputed postwar leader.

The U.S. advantage in technology lies in the production of high-technology capital goods and consumer goods, and evidence is strong that this advantage has been growing. High-tech industries have shown distinctive features. Their costs fall rapidly as production builds up, mainly due to economies of scale, the learning curve and technological innovation. And these leading-edge industries get replaced fairly frequently, mainly because of short product life cycles.

U.S. industries are overwhelmingly successful in big system software, computer, aerospace, basic science, telecommunications, and new product design, areas where the U.S. can meet Japan's industrial challenge head on and thus can improve the bilateral trade balance. America has a broad business, university and government technological base, and an overall environment conducive to basic research and development. It leads the world in high-tech areas.[16]

The U.S. has a huge financial capacity as well as technological advantages, whereas Korea has limited endowments of these factors; however, it has a disciplined, high quality work force and a proven record as a shrewd trader in the world market, producing quality products at low cost.

The convergence was greatly facilitated by the reduction of barriers to trade and financial flows promoted by postwar international institutions. So one source of the technology focus of the 1980s was rising concern in the US over challenges to American technological preeminence in both medium-tech (capital-intensive sectors such as autos and technology-intensive

[15] See Ostry, Sylvia, "Technology Issues in the International Trading System," *Major Issues for the Global Trade and Financial System*, edited by Il SaKong, Seoul: Institute for Global Economics, 1997, p. 62; see also UNCTAD, Division of Transnational Corporations and Investment Estimates, *World Investment Report 1995*, p. 37.

[16] See Kim, Youn-Suk, "Prospects for Japanese-U.S. Trade and Industrial Competition," *Asian Survey*, May 1990, pp. 498-503.

components and equipment) and high-tech industries.

In the Post-Cold war era, the U.S. has successfully implemented its dual-use technology program. The United States has established the Defense Advanced Research Projects Agency (DARPA), which has a $2 billion budget with $500 million in defense conversion programs in areas of regional technology alliance, agile manufacturing and dual-use critical technology partnerships.[17] It is the model for a proposed new commercial technological facility.[18] This agency has influenced many commercially successful innovations ranging from packet-switched telecommunications to artificial intelligence. The agency is a catalyst in strengthening American companies such as Sun Microsystems, Inc., the leading computer workstation maker since the 1970s.

DARPA involves commercial ventures just like those of Japan's MITI Agency of Industrial Science and Technology, and it even has an office in Tokyo for facilitating its access to Japan's new technology. DARPA supported microchip fabrication such as the Very High Speed Integrated Circuits program, and the spin-off of the program has resulted in development of the high-resolution X-ray lithography systems needed to produce the next-generation computer memory chips. In 1992, DARPA initiated a high-definition display manufacturing consortium to cope with Japan's lead in the manufacture of thin electronic screens, commercial display systems, and high definition TV.

Unlike America's application, Korea's dual-use technology presents a different approach. Major conglomerates (Chaebol) of Korea set up outposts in Silicon Valley to leapfrog into state-of-the-art technologies by monitoring technology trends. Locating in Silicon Valley gave another advantage to Chaebol: availability of top-notch Korean-American scientists and engineers. These outposts also serve as antennae for information on research activities and as training posts for scientists and engineers from Korea (See Table 6).

Chaebol have also organized strategic intelligence systems to gather information from sources both inside and outside the enterprise. Chaebol increased ties with multinationals to develop capability in high technology. In these strategic alliances, multinationals provide basic design while Korean firms supply manufacturing process technology, for which Korean

[17] Reliance on DARPA for development of dual-use, see U.S. Advanced Research Project Agency (ARPA), *Project Level Summary Report*, 1993.

[18] See Kim, Youn-Suk, "Technology Policies in Japan and the U.S.: Implications for Korea," *The US-Korea Economic Partnership*, eidted by Youn-Suk Kim and Kap-Soo Oh, Hants GU11 3HR, England: Avebury Publishing, Ltd., 1995, pp. 237-239.

TABLE 6. OVERSEAS RESEARCH CENTERS OF KOREAN FIRM AS OF OCTOBER 1994

Parent Firm	Country	R&D Personnel	Year Established
LG Electronics	Tokyo, Japan	25	1981
Kumho Tire	Akron, OH, U.S.	8	1991
Kia Motors	Detroit, MI, U.S.	8	1991
Kia Motors	Tokyo, Japan	18	1992
Dong-Ah Construction	London, U.K.	5	1993
Daewoo Automobile	Worthing, U.K.	300	1994
Daewoo Electronics	Metz Technopole, France	7	1994
Daewoo Electronics	Paris, France	4	1994
Maxon Electronics	Kansas City, MO, U.S.	30	1981
Samsung Electron Devices	Berlin, Germany	6	1994
Samsung Electro-Mechanics	Byungsong, Japan	6	1991
Samsung Electronics	Tokyo, Japan	8	1987
Samsung Electronics	Osaka, Japan	8	1990
Samsung Electronics	Surrey, U.K.	5	1994
Samsung Electronics	Moscow, Russia	22	1994
Samsung Electronics	London, U.K.	6	1994
Young Chang Akki	Boston, MA, U.S.	20	1991
Yukong	Fairfield, NJ, U.S.	16	1990
Cosmo Laser	New York, NY, U.S.	5	1994
Hankook Tire	Akron, OH, U.S.	14	1992
Hyundai Motor	Tokyo, Japan	5	1985
Hyundai Motor	Frankfurt, Germany	n.a.	n.a.

n.a.: Not available

Source: STEPI, 1995, cited in OECD, *Reviews of National Science and Technology Policy: Republic of Korea*, 1996, p. 118.

firms have the competitive edge.

There is rising competition over technology development in the world. Korea is no exception. Development of new and applied technology will contribute to innovating production and improving productivity. There is development work under study in all industrial sectors of Korea. The most important diffusion mechanism has been the mobility of experienced managerial and technical personnel between enterprises. Two-thirds of the new enterprises in the consumer electronic industry during the 1960s and 1970s acquired production and production design capability by luring experienced technical personnel from existing enterprises.

While some technologies are available at low cost, many are expensive and subject to tight control. The ability to make use of imported technology depends on a country's absorptive capacity and strategic intelligence, which enable it to adapt and modify imported technology so as to internalize this technology into its domestic production. Technology is one of the most

important determinants of productivity and international competition. New dynamic comparative advantage can be created through technology transfer and conscious investment in R&D.

Technological innovation is the process of realizing new production functions and new products, and it includes technical research, development, production start-up and improvements, and market information. Innovation affects foreign trade through higher factor productivity, changing production functions, and new products, producing more goods with the same inputs or producing the same quantity of outputs with less inputs.

EXPORTING INDUSTRIES ABROAD, ESPECIALLY TO CHINA

Criticism of imported technology from AICs has centered on the problem of absorption, since most developing countries (DCs) are unprepared to accommodate the modern technology of AICs. The technology of AICs tends to be physical-capital-abundant and human-capital-abundant in design. DCs need a different type of technology, because they tend to have abundant unskilled labor and little physical or human capital. The appropriate technology in such a situation is labor-intensive, and small-scale technology can play a role as a catalyst in international technological transfer between AICs and DCs.[19]

The major characteristics of Korean imported technology are its modification and adaptation; the country has developed its own way of using technology and capital goods, so-called indigenous production engineering. Machinery and technological application have been handled in simpler ways than originally designed, since workers were poorly equipped with skills. As long as the simpler way of doing a thing has resulted in the desired production with higher value added, not only have output goals been reached, but Korean management and workers have gained confidence and have themselves undertaken further improvement and adaptation of imported technology. Korea is providing DCs with technologies and industries suitable to their factor endowments and to their workers's skills in particular.

World competition is a powerful force for making Korea venture into the close linkage of trade and technology. Korea now has to accommodate its industrial workforce with higher wages, and at the same time compete in

[19] See Kim, Youn-Suk, "Managing Technological Transfer with Korea as a Catalyst," *Human Systems Management*, Vol. 8, No. 3, 1989, pp. 21-223.

TABLE 7. KOREA'S TECHNOLOGY EXPORTS BY COUNTRY AND INDUSTRY, 1978-94
(million $)

	China	Indonesia	Philippines	India	Malaysia	Thailand	DAEs	OECD	(U.S.)	(Japan)	Other	Total
Electronics	24	5	7	12	5	7	2	14	3	2	31	107 (19.9)
Petro-chemical	22	21	4	6	6	7	5	15	3	5	13	99 (18.4)
Machinery	37	8	6	12	7	2	3	1	–	–	9	85 (15.8)
Textiles	21	4	15	5	1	1	1	1	–	–	9	58 (10.8)
Other	49	20	14	10	14	5	10	19	1	10	48	189 (35.1)
Total	153	58	46	45	33	22	21	50	7	17	110	538(100.0)
	(28.4)	(10.8)	(8.6)	(8.4)	(6.1)	(4.1)	(3.9)	(9.3)	(1.3)	(3.2)	(20.4)	(100.0)

Source: KITA, cited in OECD, *Reviews of National Science and Technology Policy: Republic of Korea,* 1996, p. 89.

world markets and upgrade its industrial structure so as to produce high value-added products, while graduating from its traditional labor-intensive industries. Korea's obsolete machinery has been exported to Asian DCs such as China, for producing in local markets and for training workers employed in their export-oriented industries.

Technology can provide Korea with a "strategic bargaining currency" for expansion and trade-linked investment with Asian DCs (See Table 7).

Given that Korea has been able to develop the information sectors as strategic industries to reach international competitiveness, it can be a catalyst between AICs and DCs. A 150,000-metric-ton-per-year vinyl acetate monomer plant has been brought on stream at Ulsan, Korea, by a 3-way joint venture of BP chemicals, Union Carbide Corp. and the Samsung Group. The venture has undertaken a 100,000 ton acetic acid plant with BP technology under construction at Shanghai, China.

Utilizing its cheap labor and land, China is being transformed into the world's emerging manufacturing center. On the basis of purchasing parity, the World Bank has already announced that China is one of the world's economic giants, with a per capita GDP amounting to $2,460 and GDP of $2,890 billion. China has achieved so much since it adopted the policy of reform and openness by bringing a portion of the population, the 260 million people in coastal areas along the Yellow River and the Southeast China Sea, into the market-oriented economy.

Korea's trade with Southeast Asian countries and China could be significant to the U.S. interest. Korea's economy complements in many ways that of the US.. America could capitalize on its close ties with Korea and move into Asian markets in association with this partnership.

In Asian DCs, Korea competes successfully against local firms and against

some of Japan's multinational enterprises. Korean managers are in high demand due to shortages of supervisors in Asian DCs.

As Korea has moved to high value-added industries, low level labor-intensive industries have been shifted to DCs. This is an interesting example of technological transfer with Korea being the catalyst. It is now quite evident that a new economic trend is appearing, as Korean investment moves to DCs, where it competes successfully against local firms and multinational enterprises of AICs. The series will continue as long as AICs continue to funnel their technologies to newly industrialized countries (NICs), and NICs to DCs.

The cost of the production of Korean firms is usually low because of their use of appropriate technologies, and they are able to provide goods and services at prices below those of other multinationals or locally owned firms. Korean direct investment with its associated technology is considered to be largely aimed at production cost reduction; Korean investment is utilizing the abundant labor supplies and supplies of lumber, limestone and other raw materials of DCs so as to reduce the cost of products for domestic consumption as well as export. In other words, the countries which possess primary commodities and abundant labor have attracted Korean investors with their technology in export-oriented industries.

CONCLUSION

Having realized a successful industrialization, Korea has now to cope with competition from AICs with more efficient industries as well as from developing countries with lower labor costs. As a logistic, therefore, Korea has to cultivate its own science and technology, complemented by more Korean scientists trained abroad, and already returning scientists and engineers who have helped narrow the gap between Korea and AICs in high technologies. Incidentally, government support of big business has resulted in increasing domination of manufacturing by Chaebol. Chaebol are responding to the current competitive crisis in two ways: increased investment in new technology and new equipment. Chaebol expanded their in-house R&D capacity, and they are poised to develop key high-tech industries.

In the 1980s, government abolished all industry-specific promotion acts, and instead enacted a new industrial promotion act that ties incentives with specific industrial activities such as R&D and human resource development. Korea now faces formidable challenges in science and technology. Because of Korea's rising labor costs, China and Southeast Asian countries have

become competitive in labor-intensive industrial exports, and other more advanced NICs such as Taiwan and Spain present stiffer competition in the world market. Korea is seriously hampered from obtaining technology from AICs. Fearful of boomerang effects, AICs are reluctant to transfer technology to Korea which finds itself at the crossroads on the cutting edge of technology. Yet at the same time its big industries pose a major threat of inflexibility. Chaebol are unable to respond quickly to changes in AICs markets due to scale constraints in existing operating facilities.

In short, Korea faces problems of meeting competition from countries with more efficient industries as well as those with lower labor costs. Korea is now finding it increasingly difficult to rely on imported technology for product innovation and process technologies, which it must have in order to meet challenges in global competition under WTO and OECD regimes. Korea must muster the human capital, financial and other resources for domestic R&D to maintain a continued industrial growth path, complemented by imported technology. Korea has to promote its own technological innovation with R&D efforts that are essential in meeting the constraints imposed on it in the changing global economy.

Yet, whatever problems arise, Korea must recognize that technological capability is the major source of its international competitiveness. Granted that Korea's industrial technology has been developed from imported technology, the major feature of technological policy was the fostering of indigenous technology through research centers established in both public and private sectors.

As technology has been recognized as the driver of productivity and economic performance, the Korean government changed the direction of science and technology policy at the beginning of the 1990s. This recognition of technology stems from its fuller impact on the Korean economy. Korea must continue to push its R&D in realizing the HAN approach as its technological progression path. In pursuing its technology policy, Korea must seriously heed WTO rules concerning IPR, as the HAN program moves trade toward high technology along with mid-technology application.

Moreover, in this Post Cold war-world, Korea has to take into account dual-use technology with third party transfers, so as to realize strategic intelligence as well as strategic trade policy. Korean firms have successfully involved themselves in exporting industries and technologies abroad, especially in China and Asian DCs. Korea should continue to expand its trade and industries to those countries so as to realize their development as well as Korea's international competitiveness.

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