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INNOVATION AND TECHNOLOGICAL LEARNING IN KOREA

par

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PRÉSENTATION par le Dr Dongyoub SHIN

Historical Background

Korea has 2,000 years of history as a nation, and produced some of the world's firsts: the astronomical observatory, the odometer, movable metal printing, etc... However, under the Chosun Dynasty (1492-1910), the Confucian class structure repressed technological and economic development.

During the invasion and occupation by Japan (1910-1945), Korea was severely exploited. 94% of the manufacturing capital was held by the Japanese, and formation of technological skills was minimal. Only 11% of technicians in manufacturing sectors were local.

In 1945, Korea was divided into South Korea and North Korea. Most manufacturing bases and infrastructures happened to be located in North Korea, with 90% of electric power and 75% of coal and iron. South Korea was left with agriculture and light industries (textile).

The Korean War (1950-1953) destroyed most industrial facilities and infrastructures. South Korea remained an agricultural economy (46% of GNP and 64% of employment in 1960).

The period 1961-1995 was characterized by rapid growth and technological learning. GNP per capita rose from $80 in 1962 (101st in the world) to $10,000 in 1995 (11th in the world). Korea is now 1st in shipbuilding, 2nd in consumer electronics, 3rd in semiconductor, 6th in automobile and steel/iron.

Three Main Actors in Korea's Transition to a Technology-Intensive industrial Economy

A Strong Government

The authoritarian government of President Park orchestrated technological learning through an export-drive and protection of the domestic market, and allocation of financial resources to companies, using the Chaebols as vehicles of technological transformation.

Chaebols

They are groups of large companies in diverse industries controlled by a family. Six Chaebols are ranked among the world's 100 largest global enterprises. Many of them operate in technology-intensive industries.

High-quality workforce and R&D Personnel

Korea boasts a high educational level, with the highest ratio of high school and college graduates and lowest illiteracy. Among R&D scientists, Korea has the highest ratio of PhD’s per capita, most of which US educated. The Korean are hard working people, the weekly work duration being 58hr/wk versus 43hr in OECD.

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Government's role in technological learning

Starting in 1961, President Park Chung-Hee pursued a single-minded program of industrialization and economic growth led by a highly centralized and authoritarian government, advised by competent technocrats and researchers educated in the US. That approach combined the American and Japanese Models.

Chaebols were used as the engine of technological learning, receiving preferential finance, tax concessions, and subsidies for R&D activities plus protection of domestic markets. The commercial banks were nationalized and used to allocate resources for industrial projects according to national priorities. That helped initial capital formation and subsequent diversification into strategically designated industries.

The Government forced Chaebols to compete in international markets. Export targets were assigned to each Chaebol, and monthly export promotion conferences were held using such mottoes as: “life or death struggle of the nation” or "Export Patriotism".

Strategic industries were designated for export-promotion and import-substitution. Export-oriented industries achieved superiority in technological learning and produced most technological innovations. The annual growth rate from 1973 to 1985 increased to 7.7 % versus 2.5 %.

Competition in international markets and technological learning created demand for foreign technology transfer and internal technological capacity. Chaebols had to acquire, assimilate and improve advanced foreign technologies in order to survive.

Local industries lacked technological basis until the end of the 1960’s. Establishing technologically advanced industries (electronics, automobile, steel/iron, ship-building, heavy and chemical industries) as national priority forced to seek aggressively for foreign technology transfer and rapid development of internal technological capacity.

Domestic markets for strategic industries remained protected until the end of the 1970’s. Reverse engineering was used as the most important device for technological learning in catching-up with other countries. Korea refused to honor foreign copyrights and product patents until 1986 (Japan did the same until 1976 and Switzerland until 1978).

During the 1960s and 1970s, the Foreign Technology Transfer Policy placed restrictions on foreign licenses and foreign direct investments, and set royalty ceilings and equity limits. The import of foreign capital goods was favored in order to allow for reverse engineering by Korean firms. From 1962 to 1993, foreign direct investment amounted to $11 billion, foreign licenses to 8 billion, capital goods imports to $278 billion. Care was taken to enable Korean firms to maintain managerial independence from multinationals and to take the initiative in technological learning.

Two Government R&D Institutes were created in the 1970s, to facilitate technology diffusion and joint R&D with firms: the Korea Institute of Science and Technology (KIST, 1966), an integrated research center for industrial technologies, and the Korea Advanced Institute of Science (KAIST, 1975), a research-oriented graduate school of applied science. They undertook promising basic research not undertaken by firms, supplied R&D human resources and gave birth to about 70 industry-specific spin-offs.

The Government also initiated National R&D projects, as either Industrial Generic Technology Development Projects (IGTP) for current problems in existing technological

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areas with high economic externalities, or National R&D Projects (NRP) for future problems in new technologies with high risk and high economic externalities (new material development, semiconductors, super-mini computers, biotechnology, localization of nuclear energy fuel). Investments were $18 million in 1982, $124 million in 1993.

In addition, Highly Advanced National R&D Projects (called G-7 Projects) were undertaken in order to lift Korea's technological capability to the level of G-7 countries by 2020. The main topics were new drugs and chemicals, broadband integrated services, digital networks, next-generation vehicle technology, HDTV, ultra-large-scale integrated circuit, advanced manufacturing systems, new materials for information technology, alternative energy technology, next-generation nuclear reactors. The Government, universities and industries will jointly invest $5. 7 billion on a 50-50 basis.

In the first 3 years, $1.3 billion have been invested involving 13,000 researchers, 2,542 patents, 2,000 academic papers, in such areas as quinolon-based antibiotics, liver disease medication, HDTV, 256M DRAM memory chips.

In total, R&D investment has been increasing rapidly, from $28.6 million representing 0.32 % of GNP in 1971 to $1.925 billion representing 2.61 % of GNP in 1994. As a comparison, the R&D/GNP ratio for the UK in 1994 was 2.12 %. The role of corporate R&D is increasing as well. There was only one corporate R&D Lab in 1970, versus 2,272 in 1995; corporate R&D accounted for 2 % of total R&D in 1963, 84 % in 1994.
The recent years saw trade liberalization and a decrease in government intervention. Most incentives and subsidies for exports were abolished during the 1970s and completely liberalized by 1982. All industry-specific promotion acts were abolished in 1986. Chaebols became internationally competitive in various technology-intensive industries without government's assistance by the early 1980’s.

The Case of Samsung Semiconductor

In the mid 1990’s, Samsung is the world's largest memory chip producer and the 7th among all semiconductor producers, the world leader in Dynamic Random Access Memory (DRAM) and dominant in 4-Megabyte DRAM, ahead of Japan in 16M, 64M and 256M DRAM chips.

Samsung achieved that status in a decade, starting from scratch. The Korean semiconductor industry started as wholly-owned subsidiaries of multinational firms (Signetics, Fairchild, Motorola, Control Data, AMI) until the mid 1960’s. It assembled discrete devices based on cheap labor. All parts were imported and re-exported and no technology transfer took place except a six month training of unskilled workers.

In 1974, Dr. Kidong Kang established the first semiconductor design firm, Korea Semiconductor co, which was subsequently bought by Samsung in 1975. In 1982, Samsung decided to enter the industry on a full scale and established a semiconductor R&D Lab.

In 1975, the Government put in place a 6 year plan to promote the semiconductor industry. This plan was poorly responded to by the Chaebols due to the difficulty in foreign technology acquisition and high risk. In 1976, the government established the Korean Institute of Electronic Technology (KIET) for semiconductor R&D, which turned out to be not dynamic enough to adapt to a rapidly changing technological environment. It closed in 1984, but had in the meantime produced a large number of R&D engineers in semiconductors.

64K-DRAM

In 1982, Samsung attempted to obtain a license for 64K-DRAM, but was turned down by TI, Motorola, NEC etc. It then identified troubled small US firms willing to license 64K-DRAM technology: Micron Technology and Zyrex, and dispatched its engineers for training and technology transfer. In 1983, Samsung organized two R&D task forces in Silicon Valley and Seoul to assimilate and commercialize 64K DRAM.

The Silicon Valley Team was made of 5 Korean-American scientists with semiconductor design experience and 300 American engineers. Its task was to conduct R&D for 64K-DRAM and collect cutting-edge information.

The Seoul Team was made up of 2 Korean-American scientists plus Samsung engineers trained at the American technology suppliers. Its goal was excessively demanding: to develop a working production system for 64K-DRAM within 6 months. The task forces operated in "emergency mode", working around-the-clock and living together in the labs. They had unlimited support from the Chairman, and were free from budget constraints.

In 6 months, the Seoul team succeeded in developing a working good die of 64K-DRAM. Early 1984, Samsung hit the world market (3rd in the world, 40 months after the US and 18 months after Japan).

256K-DRAM : Head-to-head against the industry leaders

Early 1984, Samsung organized 2 new taskforces in Silicon Valley and Seoul for 256K-DRAM development, working independently in competitive mode, again in "emergency mode".

The Seoul team licensed circuit design from Micron Technology but developed process technology independently. In October 1984, after 8 months, they succeeded in developing a working good die and hit the world market in early 1986 (18 months after the world's first).

The Silicon Valley Team was ordered to develop the entire circuit design and process technologies without technology licensing. Through intensive reverse engineering, they succeeded in developing a working good die with a superior quality in July 1985 (10 months behind the Seoul Team). As a result, Samsung possessed an independent internal technological basis for next-generation chips.

At that time, the industry was shaken by fierce competition by Japanese producers, creating a financial burden on American producers. Samsung survived based on financial cushions provided by other subsidiaries within the diversified group. As a result of Japan's hasty transition to 1M DRAM and the exit of American firms, Samsung became the dominant supplier of 64K and 256K DRAM.

1M DRAM

In September 1985, Samsung again organized two R&D taskforces in Silicon Valley and Seoul. Despite the possibility of licensing, it decided to go completely alone this time. The teams were independent and in competition and used the emergency-mode operation.

In July 1986, Seoul team developed a working good die (12 months after Japanese). In October 1986, the Silicon Valley team succeeded too. Samsung took the risk to build a mass-production system in parallel with the R&D, and hit the world market in late 1987 (one year after the Japanese).

4M DRAM

In October 1986, the Government designated 4M DRAM as a national R&D project and formed a consortium of three Chaebols with 57 % contribution from the government. However, since researchers from the Chaebols were unwilling to work together, the consortium dissolved and the three Chaebols went separate ways. In 1988, Samsung succeeded 6 months after Japan.

64M DRAM and beyon : Samsung as the world leader

The Government designated 64M and 256M DRAM as national R&D projects and organized consortia which Chaebols refused to join. In 1992, Samsung developed 64M DRAM simultaneous with Japan and became the world's first commercial supplier of 64M DRAM in 1994.

In August 1994, Samsung succeeded in developing the world's first fully working sample of 256M DRAM.

Conclusions and implications

From imitation, improvement to innovation

Imitation involves duplication, no internal R&D investment, no technological learning, no sustainable competitive advantage. This was practiced in the 1960’s and 1970’s.

Improvement implies creative imitation, internal R&D, technological capacity, sustainable competitive advantage. This is the Japanese model, practiced in the 1980’s and 1990’s and still dominant in the present.

Innovation means being a pioneer on the technological frontier. It is possible only with accumulated internal technological capacity and intense in-house R&D. This is the American model, where the boundary between improvement and innovation is blurred. In Korea, it is practiced in the 1990’s in a few industries such as semiconductors, biotechnologies and multi-media.

Success Factors in Korea's Technological Learning

The Government acted as an efficient quasi market. It effectively disciplined the Chaebols for national priority projects, penalizing poor performers and rewarding only good ones. Entrants into risky but technology-intensive industries were highly rewarded with industrial licenses and preferential financing.

The Chaebols acted as efficient resource mobilizers. They proved capable of mobilizing large amounts of financial, human and organizational resources. They also provided diversification and buffering effects from risk.

Korea maintained the initiative in technological learning. It relied heavy on foreign capital goods for foreign technology transfer. It made conscious efforts to maintain initiative and independence in technological learning even at short-term costs.

The most important factor of learning was the intense commitment of the Government and of Chaebols' to technological learning, setting excessively demanding goals and operating in “emergency mode” R&D task forces.

The whole project had to face a highly adverse situation. Korea’s situation was viewed as requiring death-or-life programs with no alternative, calling for high risk-taking and high returns.

Korea had an outstanding capacity for absorption of foreign technologies. Tacit knowledge and intensity of commitment were complemented by socio-cultural proximity to two major sources of advanced technologies, Japan and the US.

Current Problems and Issues

Government involvement is now seen as a liability. From the orchestrator of technological learning, government has evolved to a rigid bureaucracy of regulations. It is no longer effective in innovation-generation under dynamic environments.

The Chaebol system is now seen as a liability. Heavy economic concentration (48 % of GNP by 10 largest Chaebols in 1980) puts them in an advantageous position to attract best human resources. They were the only actors possessing financial, technological, organizational capacity for technological learning at the international level. Yet, over-diversification is now counterproductive, making the chaebols reluctant and slow to change. They are often poor performers, but still survive and dominate.

The development of small-and-medium size firms is lagging behind. The monopoly of technological capabilities by Chaebols has for a long time prevented the emergence of capable Small and Medium Enterprises. A small number of those now exists in new high-tech areas.

The recent financial crisis shows the limits of a high growth strategy and place a burden on R&D investments by Chaebols and government. As part of its bailout, the IMF is applying pressure for the disintegration of Chaebols, but alternatives cannot be implemented easily and quickly.

DÉBATE

Task forces

Q. : *What motivates Korean people to work so hard ?*

Dr Shin : It is the cultural tradition in the country, sustained by strong social pressure and an organized hierarchy.

Q. : *What happens to the teams at the end of the project ?*

D. S. : The results obtained by the two teams are merged as far as possible. Having two teams in parallel speeds up the process.
New teams are formed for each successive project. They may overlap in time or use individuals from previous similar efforts. The new teams receive relevant information from the previous task forces.

Q. : How did Samsung attract American engineers into their task forces ?

D. S. : The Americans were paid higher than average in the Silicon Valley and were also attracted by the freedom they enjoyed during the project. This is going to be more difficult in the future.

Q. : *Having worked in the US, why do Koreans come back ?*

D. S. : It is a fact that most of them want to return to their home country. It may be due to the difficulty of setting up personal ties in a culturally different world.

Korean compagnies learning through alliances

Q. : *How does the strategy used by Samsung compare with that of the car makers ? That latter industry seems to rely more on joint ventures, but to be less successful. Why ?*

D. S. : The car industry in Korea started only in 1972, when Hyundai got a licence from Mitsubishi. In certain areas of the production system, Hyundai is now more advanced than Toyota.
Daewoo started a joint venture with General Motors in 1978, and transplanted the GM mass production system, but the quality remained low. The venture lost money in the period 1984 to 1992 and was eventually broken up. Daewoo then imported the Honda system, with significant improvements in quality. However, there are still important differences 3 years later. Very recently, a new partnership was formed between GM and Daewoo, mainly to address the Chinese market.
The key difference is that Hyundai sought for autonomy from the outset while Daewoo remained highly dependent on GM and Honda.

Q. : *The Korean production system appears as geared to mass production in a few selected sectors. What are the key differences with the American and the Japanese systems ?*

D. S. : Korea encountered difficulties in importing the US and Japanese models, because they assume that large companies can rely on a strong network of small specialized firms as subcontractors or suppliers. Such firms do not exist in Korea. Korea needs to invest in building up such a network of cooperating companies, which is alien to the Chaebol mentality.

Q. : *Who dared to lend money in the 1960's and why ?*

D. S. : Few bankers were willing to take that risk, but investors were protected by the traditional practice of government guarantee for their investments. That practice is now creating problems.

The futur of Korea

Q. : *Can independent small and medium enterprises develop in Korea ?*

D. S. : The Government has to create the conditions for that. Today, there is very little infrastructure such as venture capital to support them. It is likely that they will be able to develop if venture capitalists become active in the country, otherwise some other similar provisions must be put in place.

Q. : *Is there a plan in Korea to improve the small and medium enterprises ?*

D. S. : Yes, but the current financial crisis creates a most unfavorable environment.

Q. : *What about unemployment in Korea ?*

D. S. : Until now, the unemployment rate was around 2 %, but is projected to increase to 10 %. That is going to be a shock for the country. Unemployment compensation is now very limited (50 % of the last salary during 6 months), and the problem was so far handled by the family system. The new perspectives are causing a lot of anxiety.

Q. : *What role do you foresee for Chaebols in the future ?*

D. S. : Korean scholars are currently looking at that question. The prevailing opinion is that Chaebols should probably break up and regroup the component companies into networks along the value chains in the different industries. The new President is applying pressure in that direction, but the Chaebols are resisting. They are currently the only reliable source of funds to repay the IMF, so they are in a very strong bargaining position. If they fail, the entire economy may fail.

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