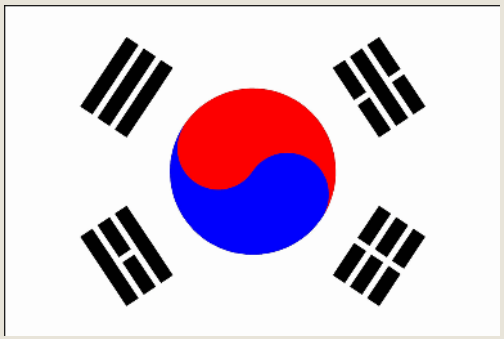
National System of Industrial Innovation:

Dynamics of Capability Building in Korea

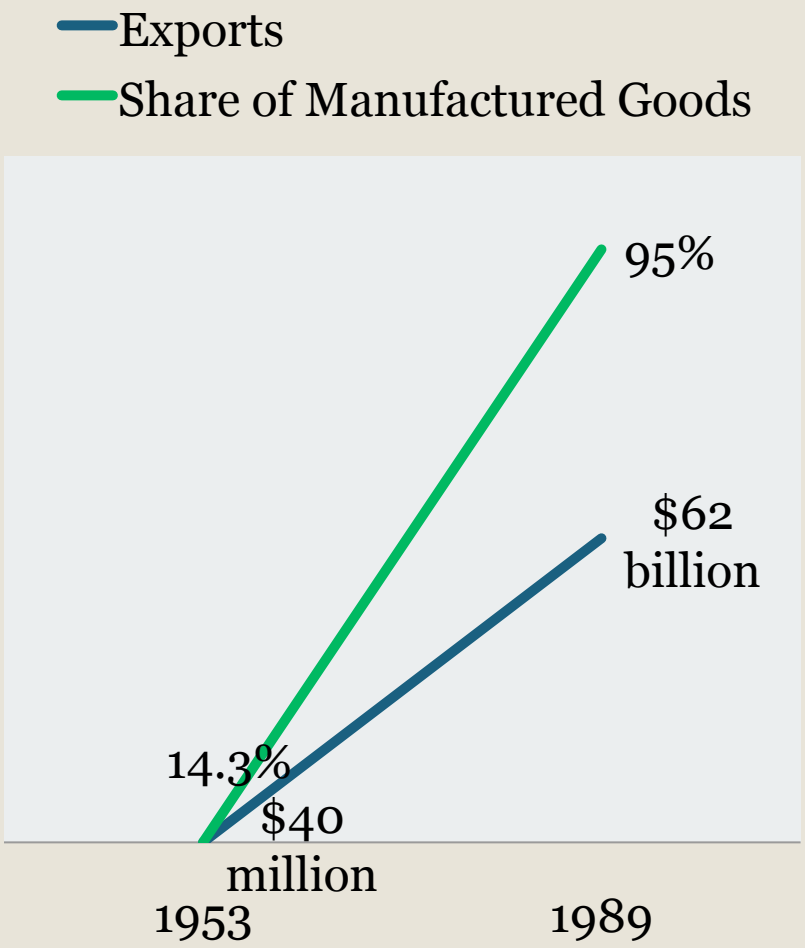
Linsu Kim, 1993

NATIONAL INNOVATION SYSTEMS
A COMPARATIVE ANALYSIS

EDITED BY RICHARD R. NELSON
1993



Introduction



Introduction

	1960s	1970s	1980s
Major Export Items	Textile, apparel, plywood, other labor-intensive products	Ships, steel, construction services	Computers, semiconductor memory chips, video cassette recorders, automobiles

"By the end of the 1980s, Korea's R&D investment as a fraction of GNP, and the number of scientists and engineers as a fraction of the work force were approaching the levels of some of the highly industrialized countries of Europe."

Introduction

- What made it possible for Korea to achieve such a phenomenal growth in industrialization?

- Will Korea be able to sustain the growth in the future?

The article explores the answers to the questions by describing the industrial innovation system as of this new era in Korea's industrial history.

A Little History…

- 1910 – 1945
  - 36 years of Japanese colonialization left some industrial base in the north
- 1945 – 1963
  - Fall of Japanese colonial rule
  - Arbitrary division of the nation into North and South
  - Ensuing civil war
- Impact of Korean War
  - Majority of industrial and infrastructure facilities destroyed
  - 1953: net commodity decreased by 26% compared to 1943
  - Positive impact: transformation of rigid society to a highly mobile one by forcing geographical mobility
- 1953 – 1960
  - Virtually no domestic savings
  - 70% of reconstruction projects financed by foreign aid
  - American aid 10% of Korean GNP
- Early 1960s
  - Korea launched its economic development program

How Korea Got Where It Is Today

- Korea's rapid economic progress can be attributed to
  - Social
  - Economic
  - Technical factors
    - most important
    - Combined outcome of various economic, social & technical inputs
    - Ability to make effective use of technical knowledge in production, investment and innovation
    - "Technological capability enables one to assimilate, use, adapt, change, or create technology and to develop new products and processes in response to a changing economic environment."

9 Macro/General Factors

Factors that influenced the acquisition of technological capabilities:

1. Human resource development
   - Most basic and crucial, as technological capability is embodied in people
2. Hard working habits in long hours
3. Reliance on foreign technology imports
4. Continued relations with USA in the national defense
5. Maintenance of one of the largest military forces in the Free World
   - 36% of annual budget to national defense
6. Korean government designed "strategic" industries for import substitution and export promotion
7. Korean government intentionally created large firms, *chaebols*, as an instrument
8. Korean government set forth exports as something of a life or death struggle to achieve economic growth goals with the small domestic market
9. In contrast to industrial and trade policies, science & technology infrastructure played little role in promoting the development of industries with mature technologies, therefore, the government established in 1966 Korea Institute of Science and Technology (KIST)

Macro/General Factors: 1, 2

1. Human resource development
   - Most basic and crucial, as technological capability is embodied in people
   - Total government budget rose from 2.5% in 1951 to over 22% in the 1980s
   - Govt expenditure was just a third of it, remainder by private sector & parents, evidence of high commitment to education by the Koreans
   - Enrollment in various levels of the formal education system has increased rapidly since 1953
   - The govt planned a well-balanced expansion in all levels of education early enough to support its economic development
   - Table 11.1 shows the changes in Korea's level of human resource development
   - Overseas training and observation also characteristic of human resource development in Korea (1950s historical precedent)
   - "formation of educated human resources…laid an important foundation for the subsequent adaptation of imported technology and development of indigenous technology"

2. Hard working habits in long hours
   - Average working hours per week in manufacturing in 1985 was 53.8hours in Korea compared to 33.1-42.9 in OECD countries (including Japan)

Table 11.1. Indicators of Human Resource Development in Korea

	1953	1960	1970	1980	1987
Literacy rate (%)	22.0	72.1	89.4	[a]	[a]
Enrollment as percentage of corresponding age group					
Elementary school (ages 6–11)	59.6	86.2	102.8	101.0	100.2
Middle School (ages 12–14)	21.1	33.3	53.3	94.6	98.8
High School (ages 15–17)	12.4	19.9	29.3	68.5	82.8
College/university	3.1	6.4	9.3	14.9	25.5
Graduates of vocational training centers (1000)	NA	NA	31.6	104.5	50.9
Number of graduates from tertiary schools (per 10,000 population)	NA	10[b]	11	27	54
Number of scientists and engineers[c]	4,157	16,436	65,687	174,832	361,330

[a]Illiteracy rate after the mid-1970s was so insignificant that the government ceased to collect data on it.

[b]For 1965.

[c]Cumulative number of science and engineering graduates since 1945.

Source: Ministry of Education and McGinn et al. (1980).

Macro/General Factors: 3, 4

3. Reliance on foreign technology imports
   - Korea's policies concerning direct foreign investment (DFI) and foreign licensing (FL) were quite restrictive in the early years of industrailization
   - Therefore, size of DFI & proportion to total borrowing were significantly lower in Korea than in other NICs eg. Proportion of DFI to total external borrowing was 6.1% compared to 91.9% in SG
   - Promoted technology transfer through the procurement of turnkey (off the shelf) plants in the early years
   - "In short, Korea restricted DFI but promoted instead technology transfer through other means such as capital goods imports. Capital was acquired in the form of foreign loans."

4. Continued relations with USA in the national defense
   - The US military procurement program afforded many producers of sectors with occasions for assisted learning by doing to meet exact specifications.
   - Construction contractors, plywood producers, and tire makers, among others, built up their initial capability through the US military contacts

Table 11.2. Foreign Technology Transfer to Korea (US$ Million)

Source	62–66	67–71	72–76	77–81	82–86	Total
1. Direct foreign investment (DFI)						
Japan	8.3	89.7	627.1	300.9	875.2	1,901.2
United States	25.0	95.3	135.0	235.7	581.6	1,072.6
All others	12.1	33.6	117.3	184.0	309.7	658.7
Total	45.4	218.6	879.4	720.6	1,766.5	3,632.5
2. Foreign licensing (FL)						
Japan	—	5.0	58.7	139.8	323.7	527.2
United States	0.6	7.8	21.3	159.2	602.7	791.6
All others	0.2	3.5	16.6	152.4	258.5	431.1
Total	0.8	16.3	96.5	451.4	1,184.9	1,749.9
3. Technical consultancy						
Japan	—	12.1	7.7	20.8	89.2	129.8
United States	—	3.1	6.0	16.7	159.1	184.9
All others	—	1.6	4.8	17.2	84.0	107.6
Total	—	16.8	18.5	54.7	332.3	422.3
4. Capital goods imports						
Japan	148	1,292	4,423	14,269	20,986	41,118
United States	75	472	1,973	6,219	12,394	21,133
All others	93	777	2,445	7,490	53,338	64,143
Total	316	2,541	8,841	27,978	86,718	126,394

Source: Ministry of Finance on DFI and FL; Ministry of Science and Technology for technical consultancy data; and Korean Society for Advancement of Machinery Industry for capital goods data.

Macro/General Factors: 5, 6

5. Maintenance of one of the largest military forces in the Free World
   - 36% of annual budget to national defense
   - Despite strong backup from U.S. Army
   - Impact on development of certain industries to acquire capability for defense production

7. Korean government designed “strategic” industries for import substitution and export promotion
   - To overcome disadvantage of small sized domestic market
   - Take advantage of stable nature of mature technologies on which industrialization strategy was based
   - Industries created in violation of its static comparative advantage
   - Firms had to suffer high costs and “infant industry” growing pains
   - Government used various policy mechanisms to assist these industries
   - Eg. Plywood in the 60s, steel in the 70s, etc.

Macro/General Factors: 7

7. Korean government intentionally created large firms, *chaebols*

- as an instrument to bring about the economy of scale in mature technologies and in turn to develop these "strategic industries" and to lead exports and economy
- Korean govt sold state-owned property to selected local entrepreneurs with a favorable long-term installment payment during the inflationary period = windfall capital gain
- another significant building factor is the allocation of preferential financing, usually at half the real market rate
- state also gave them large import-substitution projects, compensation for foreign debt burdens and other assistance in way of reducing market risks for the chaebols
- chaebols disciplined by penalising poor performance and rewarding only the good ones, no one "too big to fail" and no bailing out
- hence only the strongest lasted decades, e.g Samsung, Lucky-Goldstar (LG) and Ssangyong
- 10 largest chaebols accounted for 48.1% of GNP in 1980
- "Chaebols' rapid growth and diversification have enormously affected industrial structure and market concentration in Korea...total factor productivity as well as output grew faster in Korea's highly concentrated economy than in that of almost any other countries.."

Macro/General Factors: 8

8. Korean government set forth exports as something of a life or death struggle to achieve economic growth goals with the small domestic market

- Govt pushed, pulled with threats and promises
- incentives offered to all exporting firms included unrestricted and tariff-free access to imported intermediate inputs, access to bank loans, all to sustain international competitiveness
- particularly helped large firms (chaebols) grow even larger
- economy primarily export-oriented affected technological capability acquisition in 3 ways
- lump-sum investments forced businesses to acquire tech capability and maximise capacity utilization fast, to achieve international competitiveness
- keen international competition forced producers to invest heavily in technological efforts
- informal technical assistance offered by OEM (original equipment manufacture) buyers to ensure standards provided invaluable help

Macro/General Factors: 9

9. In contrast to industrial and trade policies, science & technology infrastructure played little role in promoting the development of industries with mature technologies, therefore, the government established in 1966 Korea Institute of Science and Technology (KIST)

- KIST as an integrated technical center
- spin-offs to meet industry's technical needs
- however, institutes suffered poor linkages with industry all the way to at least mid-1970s
- most of the staff in the institutes were overseas trained Korean researchers from academic fields or R&D organisations of highly industrializes countries that undertook research
- lacking in manufacturing know-how and development of prototypes
- Korean researchers could not compete with foreign licensors
- unable to assist industry in solving the problems in crucial initial stages

Microeconomic Behavior of Korean Firms

- Strategies developed at microeconomic level to sustain growth by acquiring technological capability fast:

1. Industries using small batch and unit production such as shipbuilding and machinery focus more on developing capability to design and manufacture products than on setting up production processes as they usually produce highly differentiated products.

Microeconomic Behavior of Korean Firms

2. Industries using large batch and mass production systems such as electronics and automobiles produce less differentiated products. The immediate technological task was the implementation of transferred foreign technology for the assembly of imported components and parts, whose final products had been tested and proven elsewhere, requiring only engineering efforts.

Microeconomic Behavior of Korean Firms

3. Industries using continuous processes such as chemicals, cement, paper, and steel produce the least differentiated products in highly-capital-intensive processes. Since the final product and the equipment are relatively well-known, but the proprietary know-how that lies in the details of the production process can make a significant difference in the productivity of these industries, the initial production system of large chemical, cement and steel plants were established on turnkey (off-the-shelf) basis by Western firms.

Microeconomic Behavior of Korean Firms

- Large firms
  - given the large size investment and the lack of experience and capability, resorted heavily to foreign sources in order to ensure quick production and smooth start-up.
- Small firms
  - Underwent long process of imitative reverse engineering, as they lacked financial resources and organizational capability to identify and negotiate with foreign technology suppliers
- Both small & large firms
  - Deployed deliberate, aggressive technological strategies to acquire their own technological capabilities through exerted efforts to assimilate foreign technological from the very outset.

Microeconomic Behavior of Korean Firms

- Acquisition of technology:
  - In piecemeal fashion, as successively more sophisticated capabilities have been acquired and put into practice
  - Process is one of purposive efforts involving a succession of incremental steps, with production capabilities being developed somewhat in advance of engineering and innovation capabilities
  - Import substitution for elements of technology still in place, meaning continued reliance on imports for some elements, but shift of pattern in imports as local capabilities replace foreign ones
  - R&D in formal sense not important to Korea in this stage of imitating foreign, mature technologies
  - Industries started with engineering (E), then evolved into position of undertaking substantial development (D)
  - Research (R) not relevant to Korea's industrialization throughout the 1970s

Microeconomic Behavior of Korean Firms

- Rapid acquisition of capability contributing to rapid growth in the 1970s may be attributed to many factors:
  - Continuous inflow of foreign technology (formal & informal)
  - Formation of highly-trained human resources
  - Entrepreneur's 'can-do' spirit exercised freely under restricted equity participation of MNCs
  - Government's orchestral role in directing *chaebols* and selectively allocating resources to them to achieve ambitious growth objectives under pressure of the competitive international market
    - *Chaebols* played important role as they had quality HR and financial security ("cushioning") that allowed risk-taking
    - By end of 1970s, Korea had largest textile plant, plywood plant, shipyard, cement plant and heavy machinery plant in the world.

Contemporary National System for Industrial Innovation

5 unfavorable environmental factors forcing Korea to change

Since the 1980s …

1. Slow down of the world economy
2. Rising trade imbalance
3. Loss of CA in low wage based labor-intensive industries
4. Reluctance to transfer technology from advanced countries
5. Forced to change its copyright and patent laws

HOW did Korea cope with these problems ??

The Shift of Public Policies

1. Economic Liberalization
   - 'Economic Democratization'
   - Fair Trade Act along with American Antitrust legislation
2. Financial Liberalization
   - Deregulation of non-bank financial intermediaries
   - Denationalization of commercial banks
3. Imports Liberalization
   - ↓ Average tariff rate
4. Technology Transfer Policy Liberalization
   - 999 industrial subsectors open
   - Foreign licensing open

The Shift of Public Policies

5. SMI Promotion
   - The Compulsory Lending Ratio
   - Venture Capital
   - SME Formation Act 1986
6. Shift to Innovation Related Activities
   - Special Incentives
   - Promotion of High Tech Industries
7. Labor Movements Liberalization

Structural Change in R&D Activities

Korean R&D efforts may be reflected in aggregate R&D investment trends

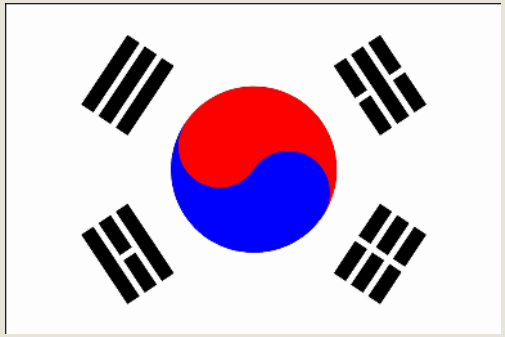


Table 11.3. Major R&D Indicators in Korea (Billion Won)

	1971	1976	1981	1987
R&D expenditures	10.67			1,878.0
Funds from government	7.29			383.0
Funds from private sources	3.38			1,495.0
Government vs. private	68:32			20:80
Manufacturing	NA	16.70	111.77	1,114.7
R&D/sales	NA			1.83
Gross national products	3,376			97,532
R&D/GNP	0.32			1.93
Number of researchers (total)[a]	5,320			52,783
Government/public institutions	2,477			9,184
Universities	1,918			17,495
Private sector	925			26,104
R&D exp/researcher (W. 1000)	4,306			35,580
Researcher/1000 population	0.08			1.27
Number of corporate R&D laboratories	1			455

[a]The figures do not include research assistants, technicians, and other supporting personnel.

Source: MOST, Science and Technology Annals, various years.

Private sector leading role in R&D

R&D rose faster than GNP

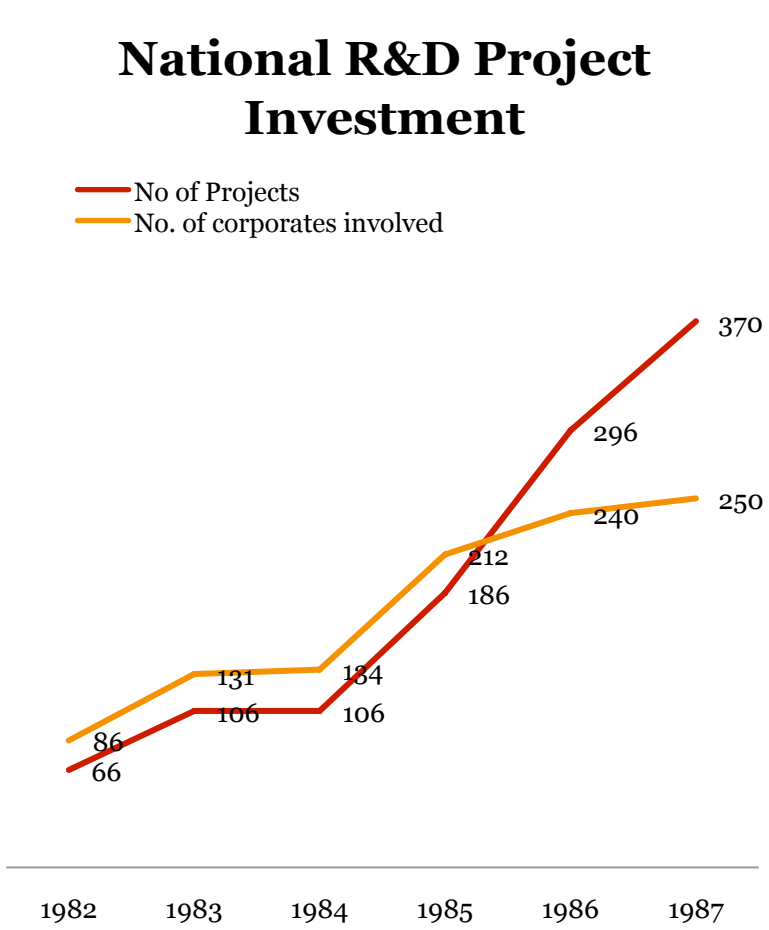
Tax incentives, preferential financing, military exemptions

Sources of Funding for Industrial R&D

1. Direct R&D Subsidy
   - 2 schemes :
     a) NRP by MOST
     b) IBTDP by MTI

2. Preferential Financing
   - Offered by state-controlled banks & public funds

Table 11.4


National R&D Project Investment
No of Projects
No. of corporates involved
370
296
250
240
212
186
184
131
106
106
86
66
1982
1983
1984
1985
1986
1987

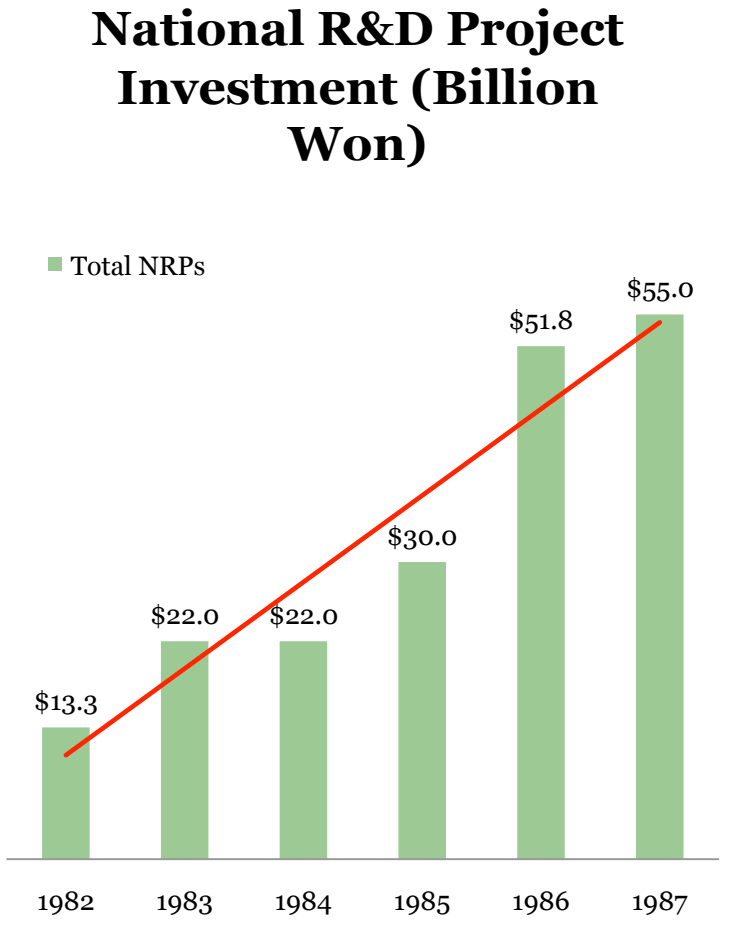

National R&D Project Investment (Billion Won)
Total NRPs
$55.0
$51.8
$30.0
$22.0
$22.0
$13.3
1982
1983
1984
1985
1986
1987

Table 11.5

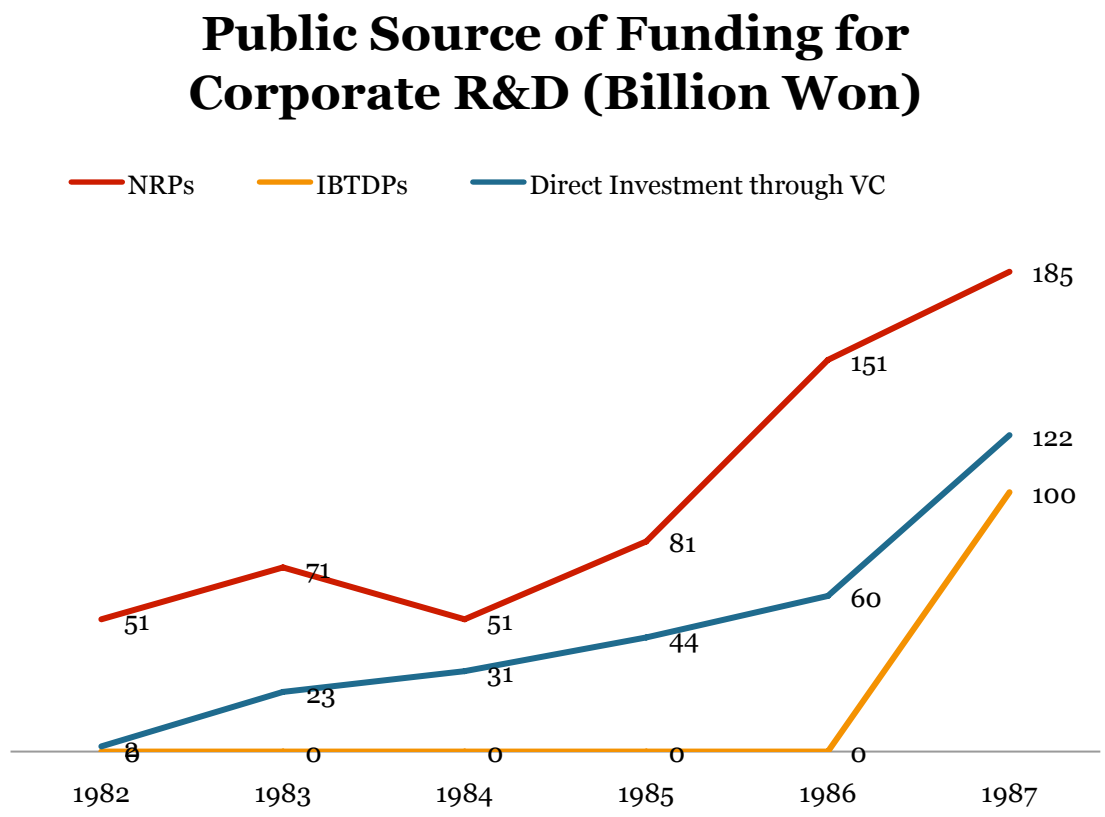

Public Source of Funding for Corporate R&D (Billion Won)
NRPs
IBTDPs
Direct Investment through VC
51
71
51
81
151
185
0
0
0
0
0
100
23
31
44
60
122
1982
1983
1984
1985
1986
1987

Table 11.5. Public Source of Funding for Corporate R&D (W. 100 Million)

	1982	1983	1984	1985	1986	1987
Direct R&D subsidy						
NRPs[a]	51	71	51	81	151	185
IBTDPs[a]	—	—	—	—	—	100
Inventor's prototype development	0.5	0.7	1.0	1.0	1.1	1.2
Subtotal	51.5	71.7	52.0	82.0	152.1	286.2
Direct investment through venture capital firms	2	23	31	44	60	122
Preferential financing						
Venture capital firms	221	499	601	827	905	1,000
State-controlled banks	521	879	920	880	1,352	1,730
National investment funds	—	9	33	4	193	525
Industrial development funds	95	64	91	139	195	307
Industrial technology improvement funds	—	—	—	—	316	2,654
Subtotal	837	1,451	1,717	1,942	3,252	6,716
Total	890	1,545	1,800	2,068	3,464	7,124

[a]NRPs, National R&D Projects administered by MOST in "new" technology areas; IBTDPs, Industrial Base Technology Development Projects administered by MTI in "existing" technology areas.

Source: Science and Technology Annals (1988).

Sources of Funding for Industrial R&D

3. Tax Incentives
   - Aimed at promoting corporate R&D investment
   - Technology Development Fund

Inter-organizational Cooperation

1. Public R&D Institutes-Industry Cooperation

3. University-Industry Cooperation

4. Intercorporate Cooperation

Technological Strategy of the Private Sector

1. Major *chaebols* setup outposts in Silicon Valley
   - Monitor technological changes
   - Acquire advance semiconductor & computer technologies

2. Developed ties with MNCs
   - MNCs from advanced countries looking at Korea to form consortiums

3. Developed ties with local public R&D institutes

4. Invested heavily in developing in-house R&D
   - Absorb, assimilate and adapt imported technologies from their outposts in Silicon Valley & MNC partners

Chaebols

- Took a leading role in moving towards the technological frontier
- From Reverse Engineering to international tieups and to own R&D
- To expedite and cost-minimize in acquiring technological capability in high-tech industries

Conclusion

- Unfavorable environment put pressure on Korea to liberalize its domestic economy
- Government introduced various new policies to develop new National System
- *Chaebols* invested heavily in R&D giving rise to existing capability
- Problem : *Chaebols* focused their efforts in end products with heavy dependence on IMPORTED parts and machinery

"Korea, is indeed, at the crossroad. While the government and private sector exert their efforts to redesign the national system for industrial innovation and in turn to sustain the nation's economic growth by strengthening Korea's technological capabilities, there are several critical signs, as mentioned above, they have led Korea to a serious economic crisis since 1989 and that may impede its future development." (Linsu Kim, 1993)

Korea, 17 years after 1993

- GDP - real growth rate:
  - 0.2% (2009 est.)
  - country comparison to the world: 110
  - 2.3% (2008 est.)
  - 5.1% (2007 est.)
- GDP - per capita (PPP):
  - $28,100 (2009 est.)
  - country comparison to the world: 49
  - $28,100 (2008 est.)
  - $27,600 (2007 est.)
  - note: data are in 2009 US dollars
- GDP - composition by sector:
  - agriculture: 3%
  - industry: 39.4%
  - services: 57.6% (2008 est.)

All information taken from:
https://www.cia.gov/library/publications/the-world-factbook/geos/ks.html

Korea, 17 years after 1993

- Exports:
  - $373.6 billion (2009 est.)
  - country comparison to the world: 9
  - $432.9 billion (2008 est.)
- Exports - commodities:
  - semiconductors, wireless telecommunications equipment, motor vehicles, computers, steel, ships, petrochemicals
- Stock of direct foreign investment - at home:
  - $96.19 billion (31 December 2009 est.)
  - country comparison to the world: 35
  - $94.68 billion (31 December 2008 est.)

All information taken from:
https://www.cia.gov/library/publications/the-world-factbook/geos/ks.html

Further Reading

Do the *Chaebol* Choke Off Innovation?

South Korea's giant family-based conglomerates are thriving, but they may be crushing small companies

By Moon Ihlwan

Seoul - Song Kyu Heon harbors no illusions about the strength of the *chaebol*, the family-controlled conglomerates that dominate South Korea's economy. Nonetheless, as chief executive of tech services company Openbase, Song was confident he could beat *chaebol* -backed rivals to win a multimillion-dollar deal to upgrade the computer systems at a Korean bank. His client roster, after all, includes Citibank (C), LG, heavy equipment maker Doosan, and dozens of other high-profile companies and government ministries. As a longtime contractor with the bank in question, Openbase

THIS ISSUE

December 14, 2009

Dubai: Why It's No Mirage

RELATED ITEMS

How to Play It: South Korea

- http://www.businessweek.com/magazine/content/09_50/b4159058699422.htm