6.4. The Korean Innovation System

Initial conditions

(1) extremely backward, as compared with Japan

(2) little hard currency and little natural resources → export promotion

(3) threat from the North

→ need for heavy industrialisation

(4) political leadership eager to establish "independent economy"

→ imitative (substituting) strategy

The 'enclave' development of the SC industry in the 1960s

- The 'dual structure' of the electronics industry

① import-substituting in final consumer electronics items

: radio, TV set …

② export-promoting items without relation with the domestic market

- electronic calculators, tape recorders, electronic digital watches

  : 51% of consumer electronics products exported in 1972

- electronic parts: 82% exported in 1972
- semiconductors: 100% import & export

  eg. Fairchild's 100% FDI: the first exception to Korea's FDI regulation

Table 4.1. The Share of Export to Production in the Korean Semiconductor Industry

year	1966	1971	1976	1981	1986	1987	1988	1989
%	100	95.9	94.6	96.0	94.1	88.7	86.4	89.4

Source: Yoon (1990: 70, table 1); Kim *et al* (1992: 245, table 4.6)

The enclave development

- MNC's strategy + 'extreme backwardness'
  - utilising low wages without transferring technologies
  - no capacity to force MNCs to transfer technologies or to compete directly with MNCs in this high-tech industry

Transitional period in the 1970s

(1) successful development of consumer electronics

→ need for ‘capital deepening’

(2) Foreign firms retreating, rather than upgrading, in the electronics

cf. Taiwan and Singapore

Transitional period in the 1970s

(3) chaebols

- producing SCs for internal consumption of their consumer electronics divisions
- however, committed to semiconductors even with deficits

Transitional period in the 1970s

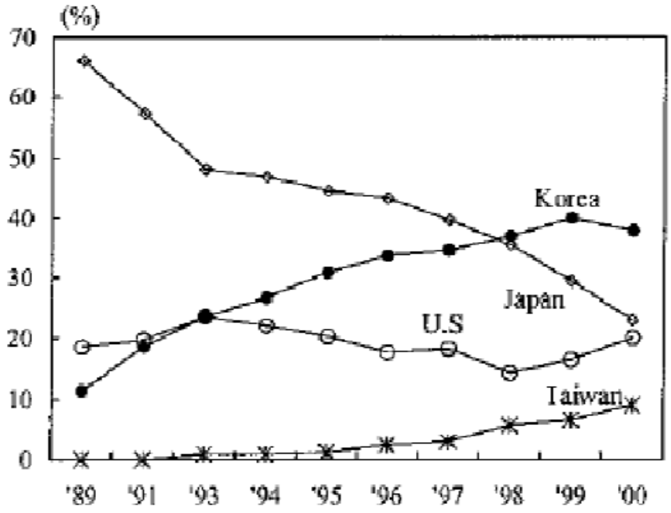
(4) The leading role by the state in developing SC technologies

- KIET (Korea Institute of Electronics Technology)
- maintaining 'pilot production facilities' of semiconductors and computers
- outpost at Silicon Valley

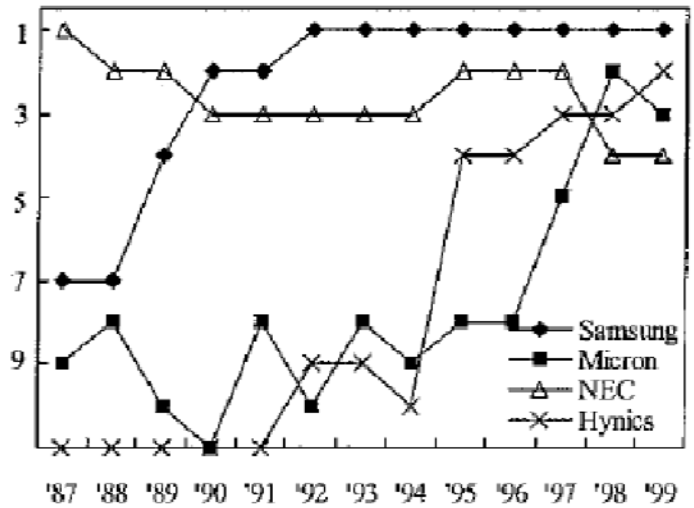
Full-fledged catching-up from the 1980s

- Functional pattern similar to the Japanese catching-up
  - focus on DRAMs
  - utilizing mass production capability developed through consumer electronics

Global market share of DRAM by countries



Global market share of DRAM by firms



Korean Pattern of catching-up

(1) More unbalanced growth

→ concentrating on 'DRAM manufacturing'

"The Japanese producers could reduce the ratio of equipment import from 70-80% in 1976 to around 50% by 1980 with the VLSI Project. But Korea imported 97% of the equipment and 90% of raw materials from abroad even in 1989 when it firmly established itself as a major producer of DRAM in the world market."

"In 1990, the share of DRAM in total semiconductor production of Samsung and Hyundai was 67.0% and 77.6% respectively. In Japan, the degree of specialisation in memories or DRAM was not so high as that in Korea, although it was much higher than that in the U.S. … For instance, the ratio of memories to total semiconductor production was only 26.9% in 1980 when Japan began overtaking the U.S. in production of memories."

(2) the role of the *chaebols*

- centralised coordination system
- concentration of resources at the group level

The Case of Samsung Electronics

- A leading *chaebol* in Korea
- Started from the consumer electronics
- Entered the semiconductor industry by acquiring Korea Semiconductors in 1974
- Entered the VLSI manufacturing in 1983 (64K DRAM)

Samsung Electronics

- Skepticisms from the government and public research institutes

"..would be the first failure of Mr Lee Byung Chul" (a government official)

"A semiconductor industry is possible only when a nation's population numbers over a 100 million, GNP per capita exceeds $10,000, and domestic demand consumes more than 50% of the chip production" (KDI)

Samsung Electronics

- Entrepreneurial vision

"The Korean electronics industry cannot survive in the world market if it only continues assembling parts like today. In order to stabilize the electronics industry, the development of a semiconductor industry is indispensible. Moreover, the semiconductor industry is the basis of the every other industry" (Lee Byung-Chul)

Money-devouring machine in the beginning

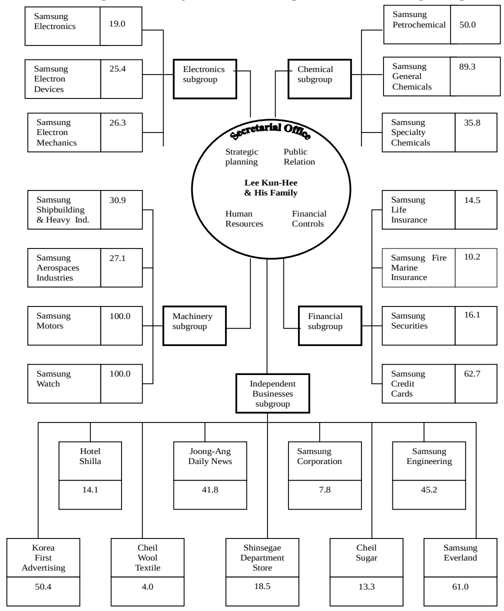
- The cumulative deficit about US$227 million by 1986
  - far more than the whole Samsung Group's profit in 1986, $136million
  - impossible to sustain without intra-group support

Keeping a high level of investment

- Maintained an over 50% investment-to-sales ratio all through the 1980s
- The group-level strategic support

  "the total sales of Samsung group was $21.1 billion in 1987 (Mody 1990: 295, table 3). And those of Hitachi and Toshiba were $23. 6 billion and $20.2 billion respectively (KEIPA 1988: 173; 175, $ = 123.5 at the end of 1987).

Figure 2.10. Major Affiliated Companies of the Samsung Group

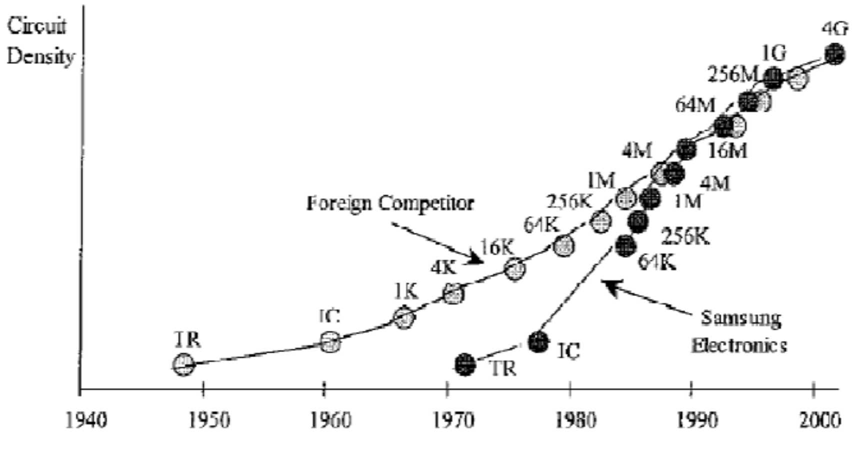


Source: Chang & Hong (1999)
[Note] a: The figures in the boxes represent the percentage of ownership by the Lee family and the cross-shareholding as of 1996.
b: The Secretarial Office is the group-level staff organization, where there are several sub-units, specialized in strategic planning, financial controls, human resource planning, and PR functions.

Learning and developing design capability

- Reducing the development gap

Changes in the Gap between Samsung and Leaders in the Development of DRAM Technology



Source Samsung Electronics

An overtaking strategy

- First, rapid catching-up as soon as possible
- Second, employing the overtaking strategy

  - 1.5 years gap in 4M DRAM (1988)
  - nearly same in 16M DRAM (1989)

An overtaking strategy

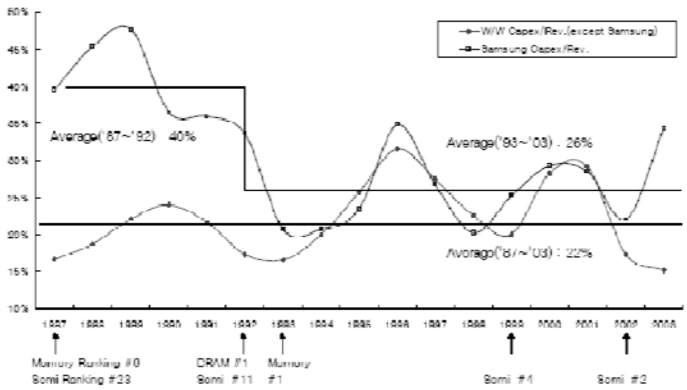
- Investing in the state-of-the-art technologies, though they are not mature and risky
  - 6 inch over 5 inch in 64K DRAM
  - 8 inch over 6 inch in 4M DRAM in 1989

Table 2. Relative Investment Costs and Productivity by Wafer Size
(times)

	8 inch over 6 inch	12 inch over 8 inch
Investment costs per wafer	1.4 (1.2)	1.7 (1.3)
Productivity	1.8	2.3

Source: Samsung Electronics
Note: Numbers in parentheses are based on actual costs Samsung incurred, which were below market prices as the company was the forerunner in mass purchasing the equipment

Figure 1. Trend of Samsung's Capital Expenditure
(%, capital expenditure/revenue)



Source: Samsung Electronics and Dataquest

An overtaking strategy

- Trench vs. stack method
  - inevitable transition from 16M DRAM
  - choosing a difficult technology but with a long-term future

Establishing cost leadership

- "Ramping-up" capability
  - integration between development and production
  - TF system
  - yield rate

6.5. The Taiwanese Innovation System

- Initial conditions

(1) 'extremely backward' + need for export promotion

(2) entrepreneur class migrated from China

"The first textilers were mostly mainlanders." (Wade 1990:79)

(3) threat from China

: the need for heavy industrialisation, but weakened much earlier than in Korea

(4) heterogeneous society

→ social division between mainlander (15%) and local Taiwanese (85%)

→ ruled under martial law until 1986

---

① heavy and chemical industrialisation through public enterprises

② obsession against inflation and big businesses

→ a lesson from Kuomitang's failure in the mainland

③ promotion of SMEs

Semi-internationalist route for catching-up

(1) initially, a hard drive for import substitution

(2) earlier shift to forming alliance with foreign firms

(3) nurturing SMEs

SMEs

(1) Growth through increase in number, rather than in size of firms

cf. Taiwan vs. Korea (Wade 1990: 67)

	# of mfg firms	# of employee (1966-76)
Taiwan	250%	29%
Korea	10%	doubled

(2) highly engaged in exports

eg. In 1985, firms with less than 300 employees accounted for 65% of total exports (Wade 70)

(3) network with overseas Chinese

(4) subcontracting to MNCs

MNCs

- 20% of export (1974-1982), 16% of employed in manufacturing (1975)
- MNCs' role in the electronics sector is more important

  - Philips, RCA, Sanyo ...

  - initially an 'enclave development': a few MNCs dominated the industry and 80% of production was exported in 1976 (Wade 1990: 93)

MNCs

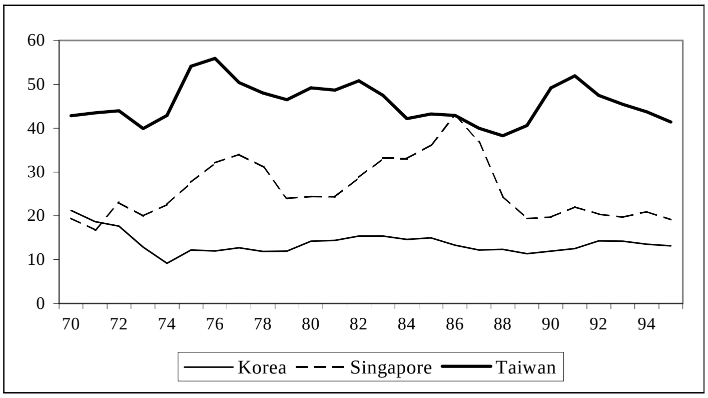
- training ground for local engineers and enterpreneurs
- partners in entering the high-risk industries

The role of public enterprises

- Taking over enterprises established by Japanese companies
- Prime investors during the initial period of industrialisation

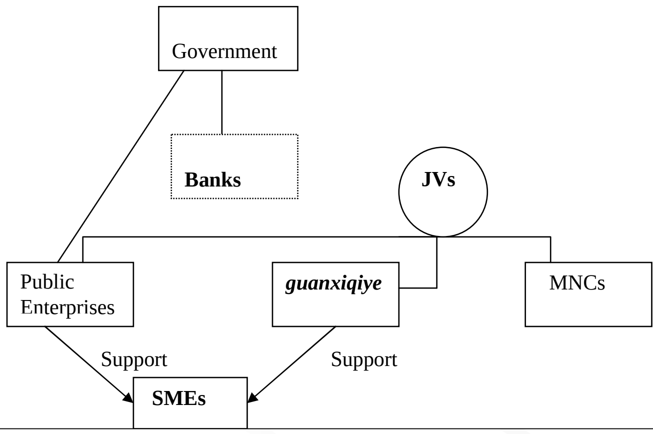
  “Fully half of gross capital formation in the 1958-61 period was carried out by government or public enterprises.” (Wade 1990: 82)
- low cost suppliers for upstream industries like steels, petrochemicals ...

Figure 2. Public Share to Gross Fixed Capital Formation in Korea, Taiwan and Singapore (%)



Source: National Statistical Office (Korea) website
Singapore Department of Statistics website
Bureau of Statistics of Taiwan (2000)

Figure 4. Taiwan's Semi-International Model



The ‘orderly spin-off’ and JVs in the SC industry

(1) the beginning of spill-over and spin-off

- RCA transfers CMOS chip technologies to ERSO (Electronics Research and Service Organisation) in 1976

  → training, design engineering ...:

- ERSO setting up ‘pilot plant’ → later spun off UMC in 1980 (40% govt, 60% private)

(2) arranging joint ventures with MNCs

eg 1. Chung-Hua Picture Tube

- Clinton (1969) and Philips(1971) as fully foreign-owned subsidiaries
- engineering a joint venture between major local TV manufacturers and RCA

eg 2. TSMC

- ERSO (48%) + Philips (27%) + local capital (25%)

(3) Spin-offs and concentration on ASICs and design

* 6 major IC chip companies spun off

: UMC (1982), Advanced (1982), TSMC (1987), Coin Tek (1988), Winbord (1988), Ten Tech (1989)

* the first IC design house: Syntek 1982 → followed by other design houses by MNCs or alliance with MNCs

eg. Vitelic, Mosel allied with Oki ...

(4) Full-fledged catching-up through foundry service

: TSMC, UMC

Table 8
Milestones in IC technology development in Taiwan

* 64K DRAM		1.5 micron
world leaders	:	1980
ERSO in 1980	:	5 micron
Taiwan achieved	1.5	Micron by 1986
Gap	:	6 years
* 256K DRAM		1.2 micron
world leaders	:	1983
ERSO in 1983	:	3.5 micron
Taiwan achieved	1.2	micron by 1988
Gap	:	5 years
* 1M DRAM		1.0 micron
world leaders	:	1986
ERSO in 1986	:	1.5 micron
Taiwan achieved	1.0	micron by 1990
Gap	:	4 years
* 4M DRAM		0.8 micron
world leaders	:	1990
ERSO in 1990	:	1.0 micron
Taiwan achieved	0.8	micron by 1991
Gap	:	1-2 years
* 16M DRAM		0.5 micron
world leaders	:	1992/3
ERSO in 1992	:	0.7 micron
ERSO achieved	0.5	micron in 1994
Gap	:	1 year

Source: Mathews (1995)

Table 12.5. The Division of Labor to Promote Technology Development in Taiwan

Type of Research	Policy Making	The Implementation of the Policies: Schools and Research Institutions	Government-Support Research Institution	Enterprises
Basic Applied research	Academia Sinica Ministry of Education National Science Council	Academia Sinica Universities		MNCs
Technology development Commercialized and applied	Various ministries under the ROC government	Various direct research institutions under the different levels of government	ITRI III Other government-sponsored research institutions that are not directly under the government	Private enterprises Public-owned enterprises

Source: National Science Council, Taiwan, ROC.

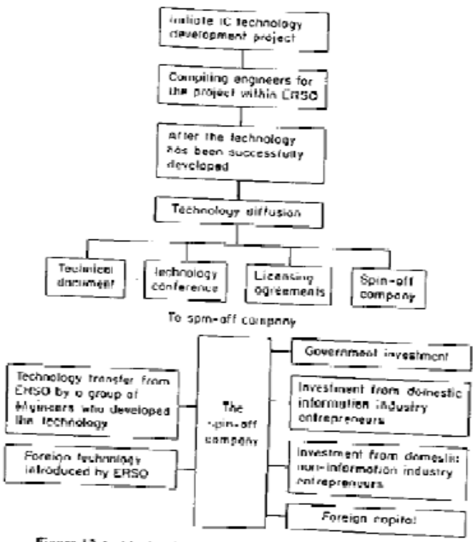


Figure 12.1. Mechanism for ERSO to diffuse its technology.

Hou & Gee (1993)

‘De-coupling’ of design and manufacturing

- A close connection with the U.S. design house

  - by 1996, handling 40% of the output of the US fabless companies

  “Most Taiwanese foundries involve joint ventures with American fables firms (Langlois & Steinmueller 1999: 57)