Development Bank of Japan Research Report No. 1

Corporate Strategies in Japan's Semiconductor Industry: Implications of Development in Other Asian Countries

October 1999

Economic and Industrial Research Department
Development Bank of Japan

Contents

Corporate Strategies in Japan's Semiconductor Industry:

Implications of Development in Other Asian Countries

Summary

1. The production value of Japan's semiconductor industry at the peak of the personal computer market in 1995 was ¥4.8 trillion, accounting for 15% of the entire electrical industry. But after 1996 the industry went into worldwide recession, driven by a sharp plunge in the DRAM market. Considering the condition of the semiconductor divisions of the five integrated electrical equipment manufacturers, which in the aggregate account for more than 60% of Japan's production, we see that in FY 1998 they were not immune from consolidated operating losses, leading inevitably to a reduction of nearly 40% in capital investment.

   The silicon cycle, however, oscillates wavelike between boom and bust, with poor earnings environments repeating themselves. Still, as the background to a current semiconductor recession viewed as particularly bad in Japan, we may cite the sense of crisis generated by delays in accommodating to the trend toward an international division of labor, as well as by expansion of the semiconductor production scale, which had a major impact on profit margins and exacerbated the instability of the earnings structures of the integrated electrical manufacturers.

   The noteworthy characteristic of the 1990s is the decline in Japan's share of world semiconductor production, while those of other Asian countries rose. The driving forces in the latter have been Korea, second to Japan in the region, Taiwan, and Singapore. Although China's production scale is still small, expectations about the potential of its market are high and it has in recent years been growing at a stable annual rate of about 20%, even as the rest of the world semiconductor industry languishes.

2. Going into the 1980s, **Korea**'s conglomerate-led semiconductor industry, of which Samsung Electronics is representative, invested management resources heavily in the DRAM business, whose market was then large. The industry's sharp growth was supported also by government technological development and import customs policy. Now Korea leads world DRAM production in terms of both technology and scale. Entering the industry recession after 1996, there has appeared the risk associated with specialization in DRAM continuous production, but going forward there is no change in the strategy of concentrating on DRAMs. If progress in structural reform of "*Zaibatsu*" (the business conglomerates) corrects the inefficiencies of their management, it can be expected that Korea will become the clear leader as the world's DRAM production base.

   Taiwan's semiconductor industry is led by such foundries as TSMC, a government R&D agency spinout that showed noteworthy growth going into the 1990s. Within the trend toward an international division-of-labor system, foundries have cemented their position as core logic manufacturers on contract, and the post-1996 recessionary impact has been

comparatively small for them. Looking ahead, and against a background of increasing numbers of corporations without fabrication capabilities, mainly in the U.S., and outsourcing by Japanese and other continuous producers, the need for foundries is expected to grow yet further. In addition, considering the strength of the production base itself, it is highly probable that the Taiwanese industry will increase its power comprehensively.

Spurred by the start of business of the Chartered Semiconductor Manufacturing local foundry, **Singapore**'s industry also grew sharply in the 1990s. But its growth lagged that of Taiwan, and competitive gaps opened up in respect of technological development as well. It can be thought that the cause of this lay in differences in the strength of the industrial bases, in particular the degree of dependence on government. Because of excessive dependence on the pervasive influence of the Singapore government and its projectionist industrial policies, there was insufficient cultivation of unprotected fields and private-sector enterprises. In Singapore, support and the like continue to play an important role based on the government's "Industry 21" plan. Also, it is indispensable for corporations and the people to develop a competitive consciousness and seek to graduate from dependence on the government.

China's semiconductor industry got its start to meet military demand, and therefore the civilian sector lags far behind. In 1990, the government designated it a critical industry and bolstered its support; this has at last enabled a base to firm up. Currently, however, the Chinese industry is characterized by back-end processing by Japanese and other foreign affiliates, and it must be said that both the production and market aspects are immature. Still, government support of the "909 Project," the first large-scale national project aimed at cultivating the industry, is underway full-scale, the potential market is being supported, and prospects are that the industry will move forward steadily on an intermediate-term perspective.

3. In line with the foregoing, we see the world semiconductor industry constructing an international division of labor that embraces Asia, the U.S., and Europe. What is required here of the integrated electrical equipment makers that dominate Japan's industry is to break out of the old pattern whereby they respond chiefly to internal and other limited customers' needs, and look to join the international division of labor system.

   The preferable future corporate strategies for them are "Business predicated on 'coexistence'" and "Management reform with 'competition' in mind." The former involves identifying strategic businesses, adding higher value by reinforcing design and service, and confirming their own place in the world, while making aggressive use of foundries and others for inefficient and uncompetitive fields, and moving forward on the premise of coexistence among foreign, mainly Asian, and domestic enterprises. The latter strategy does not stop at accelerating decision-making and so on; more serious issues are breaking into restructuring hitherto preserved divisions and locations, and carrying out radical management reform.

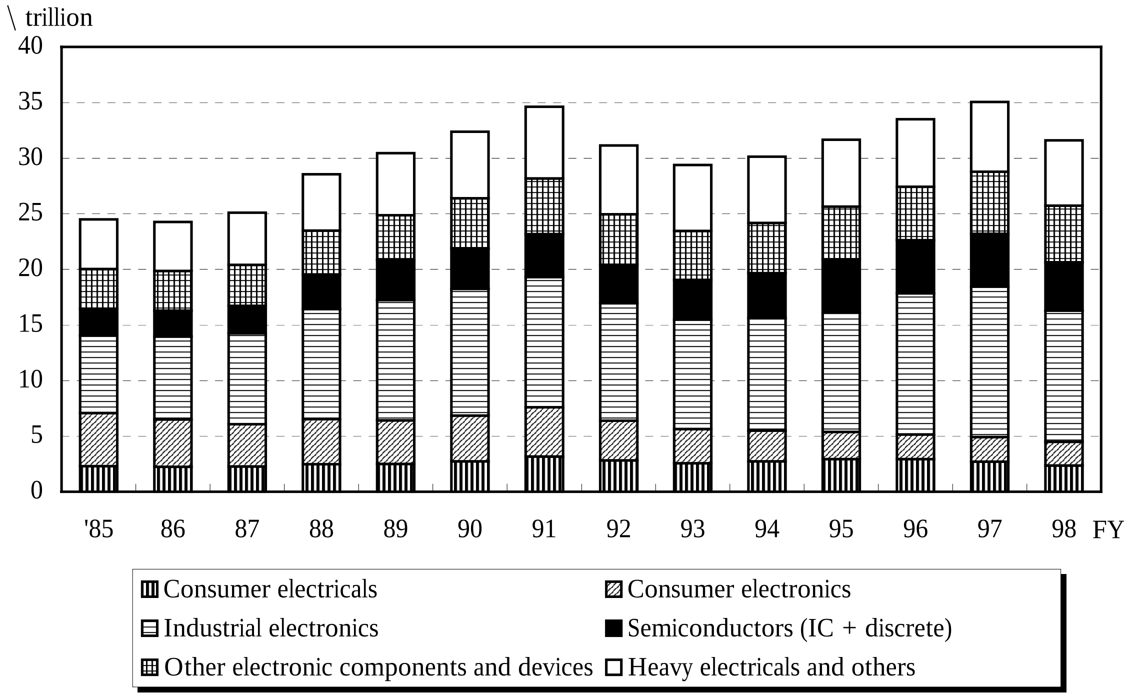
   In addition to this kind of corporate self-help, the government must prepare the environment for the information infrastructure and other sources of semiconductor demand, support technological development and remove all obstacles to overall industrial revival, including the legal framework relating to corporate partition and provide effective support from a new perspective.

I Direction of Japan's Semiconductor Industry

1. Increasing Weight in the Electrical Equipment Industry

Figure 1-1 shows the movements of production value by sector within Japan's electrical equipment industry. We observe that the 1985 semiconductor figure of ¥2.4 trillion had doubled to ¥4.8 trillion in the following decade. Of the computers and peripherals that accounted for half of semiconductor demand in 1995, the leading product was personal computers (PCs), whose market jumped worldwide in that year on the Windows95 effect. The year also marked the peak of Japan's semiconductor production by value. As a result, the weight of semiconductors in the production value of the industry as a whole, including home appliances and heavy electricals, rose from 8.5% in 1985 to 15.1% in 1995.

Figure 1-1. Production Value by Sector in Japan's Electrical Industry



(Unit: ¥trillion)

Division / year	'85	86	87	88	89	90	91	92	93	94	95	96	97	98
Consumer electricals	2.3	2.3	2.3	2.5	2.5	2.7	3.2	2.8	2.6	2.7	2.9	2.9	2.7	2.4
Consumer electronics	4.8	4.3	3.8	4.0	3.9	4.1	4.4	3.6	3.1	2.8	2.4	2.2	2.2	2.1
Industrial electronics	7.0	7.4	8.2	9.9	10.8	11.4	11.7	10.6	9.9	10.1	10.7	12.7	13.5	11.8
Semiconductors	2.4	2.3	2.5	3.1	3.6	3.6	3.9	3.4	3.5	4.0	4.8	4.8	4.8	4.4
(Weight within electricals as a whole)	9.8%	9.6%	9.9%	10.9%	11.8%	11.2%	11.2%	11.0%	12.1%	13.4%	15.1%	14.2%	13.6%	13.8%
Other electronic components and devices	3.6	3.6	3.7	3.9	4.0	4.5	5.0	4.6	4.4	4.5	4.7	4.8	5.6	5.1
Heavy electricals, others	4.5	4.4	4.7	5.0	5.6	6.0	6.4	6.2	5.9	5.9	6.0	6.1	6.3	5.9
Totals	24.5	24.3	25.1	28.5	30.5	32.4	34.6	31.1	29.4	30.1	31.6	33.5	35.1	31.6

Note: Due to rounding, totals may not necessarily match those of each division
Source: MITI, "Production Dynamic Statistics"

Semiconductors embrace a wide range of industrial fields, from processing and assembly industries like the raw materials segment that provides silicon and the like, and the precision machinery and other industries that furnish manufacturing and testing devices, to the software industries, including those concerned with design, whose importance has recently come to be recognized. Already semiconductors are being more appropriately regarded not as just another division of the electrical industry but as an independent industry in its own right.

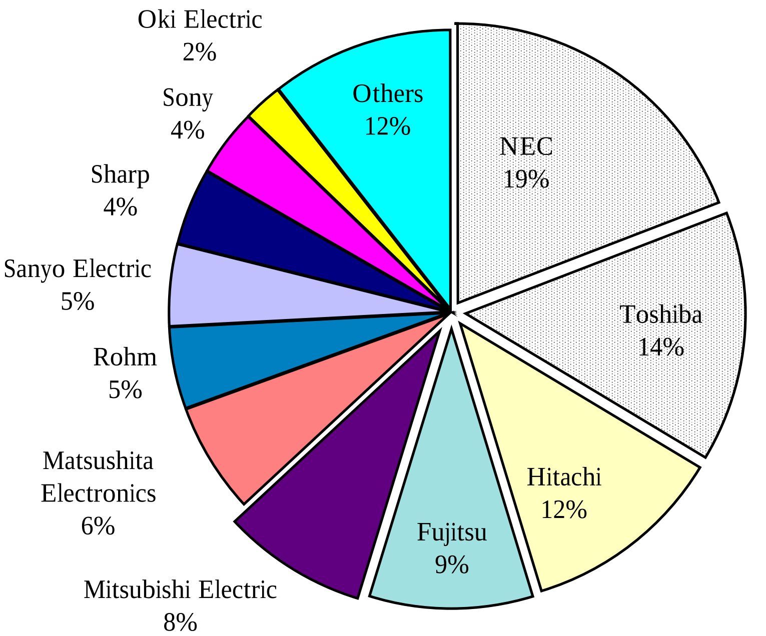
But from 1996 to 1998, the production value of semiconductors followed a declining trend in parallel with the market plunge. It reached ¥4.4 trillion in the latter year, and on that basis its weight in the overall electrical industry fell to 13.8%.

2. Characteristics of Japan's Semiconductor Industry

2.1. Integrated Electrical Manufacturers Account for the Bulk of Production Value

The industry comprises more than 30 manufacturers, but the production shares of the top 5, as shown in Figure 1-2, account for over 60% in the aggregate. NEC, Toshiba, Hitachi, Fujitsu and Mitsubishi Electric are all integrated electrical equipment manufacturers.

Figure 1-2. Production Value Shares of Japan's Principal Semiconductor Makers (FY 1997)

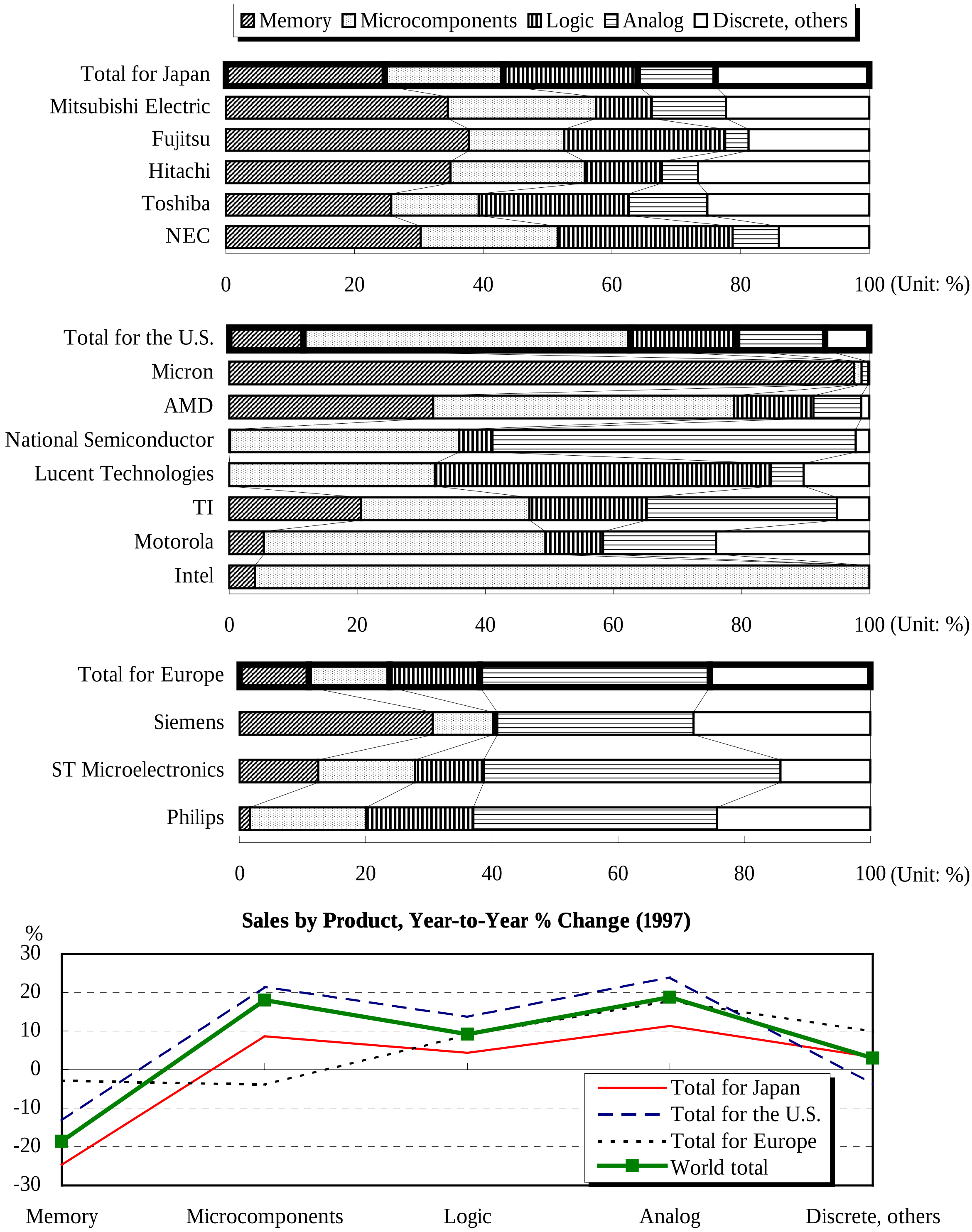


Source: Handotai Sangyo Keikaku Soran, FY 1998 edition, Sangyo Times Inc.

2.2. Diversified Product Composition with DRAMs as Core

Figure 1-3 shows the product composition of the principal semiconductor makers by country/area.

Figure 1-3. Product Composition of the Principal Semiconductor Makers (1997)



Source: IDC Japan, others

Looking at the product composition of the aforementioned 5 integrated companies that are Japan's leading manufacturers, we observe that each handles diversified products across a wide range of fields, including memory, microcomponents (computation elements), logic, analog (linear), discrete (semiconductor elements) and others, in what is called "department store style." The background to this characteristic is that historically semiconductors were developed by these manufacturers mainly for internal consumption in their other products designed for more precise accommodation of customer needs. Here, a common thread is high dependence on DRAM memories. The share of memory in overall semiconductor production was around 30% in 1997. But this share declined when the DRAM market sank in and after 1996, with the result that the manufacturers themselves are looking to break out of this dependence on general-purpose DRAMs.

Turning our attention to U.S. firms, we note that many are narrowing their focus to their leading products, as can be seen in "Micron's DRAM specialization," "Intel's MPU" and "TI's stress on DSP." Historically, when in the 1970s U.S. firms led the world in both the scale and technology of semiconductor production, Intel and others were naturally in the DRAM business. Now the situation is different. In the semiconductor recession of the early 1980s, Intel's withdrawal from DRAMs represented the onset of large-scale business concentration. U.S. companies have been quick to deal with the current industry recession that started in 1996, with Motorola pulling out of DRAMs in 1997 and TI moving toward full concentration of management resources in DSP in and after the same year, and selling off its DRAM business to Micron in 1998. Micron, for its part, seeking the benefits of later entry and thorough cost-cutting derived from making the most of its superiority in microtechnology, boosted 16M DRAM production substantially in 1997, and is expected to strengthen production of 64M DRAMs yet further in 1999.

The three major European firms have not pursued specialization in designated fields to the same extreme as the American manufacturers, and instead handle products in all fields. Yet they differ from their Japanese counterparts in focusing on analog and discrete ICs in which demand is seen as relatively stable and competition limited, and in differences in the weighting each company gives to memories. And each stresses designated-use products in which it has an advantage, and thereby avoids the risk of excessive competition. For example, Philips in effect withdrew from the memory business in 1991 and is now a leader in AV home electricals, communications and computers, and in particular has more than half the world market for television LSIs. The company is looking to reinforce its semiconductors for digital TV and other digital household electricals, and also aims at the world's top slot in semiconductors for electric power controls and for high-output transistors in the discrete field. And ST Microelectronics (formerly SGS-Thomson) plans on further growth in such products for home appliances, communications equipment, autos, smart cards and other designated applications; the company has the world's top market share in these products. It aggressively pursues tie-ups with companies leading their fields, as in, for example, auto parts, and designated application products account for 70% of total production. Siemens (known as Infineon Technologies after April 1999), meanwhile, continues to move forward in development of the DRAM business, centering on 256M DRAMs and other next-generation products, and is placing yet greater emphasis on power discrete ICs and others for optical devices and auto safety devices.

2.3. Domestic Orientation as Seen in Business Development

Japan’s major manufacturers focus their attention on domestic businesses in terms of both production and sales.

In Table 1-1's comparison of the numbers of production bases for the world's principal semiconductor manufacturers, we can see that most of Japan's bases are domestic; the average is slightly more than 10 per Japanese firm the highest of all the other manufacturers at more than 70% of all production locations. Except for other (non-Japanese) Asian firms that have heretofore not sought geographical diversification due to their business configurations, this ratio is much higher than those for U.S. and European companies. Moreover, in the moves of the Japanese companies to concentrate their bases in and after 1998, there has been a broad tendency to close or slim down the overseas locations in favor of more intensive utilization of the domestic ones. The importance of domestic production is thus increasing yet further.

Table 1-1. Numbers of Production Bases of the Principal Semiconductor Makers

	Production bases				Totals	Foundries or overseas production cooperation companies
	Japan	U.S.	Europe	Asia		
Japan						
NEC	12	1	2	5	20	2
Toshiba	17	2	1	3	23	3
Hitachi	11	0	1	4	16	1
Fujitsu	9	1	1	2	13	3
Mitsubishi Electric	7	1	1	1	10	1
Totals	56	5	6	15	82	10
U.S.						
IBM	1	3	4	0	8	0
Intel	0	8	1	4	13	2
Lucent Technologies	0	4	1	3	8	0
Micron	1	1	1	2	5	0
Motorola	3	11	4	8	26	0
Totals	5	27	11	17	60	2
Europe						
Philips	0	3	8	5	16	3
ST Microelectronics	0	3	10	4	17	0
Siemens	0	0	6	3	9	2
Totals	0	6	24	12	42	5
Asia						
Korea						
Samsung Electronics	0	1	0	3	4	0
Hyundai Electronics	0	1	1	2	4	0
LG Semiconductor	0	0	1	2	3	0
Totals	0	2	2	7	11	0
Taiwan						
TSMC	0	1	0	3	4	—
UMC	1	0	0	5	6	—
Winbond	0	0	0	4	4	0
Totals	1	1	0	12	14	0

Note: Shaded areas highlight figures for domestic area and total numbers of production bases
Source: Electronic Journal, *Semiconductor Data Book 1999*

Table 1-2 shows the weight of sales, by geographical area, of the world's principal manufacturers. Again, we observe that in Japan's case dependence on domestic sales is high except for Fujitsu, over 50%, led by Hitachi's 60%. Among U.S. and European firms, by contrast, the domestic sales weighting was mostly in the 40% range. Moreover, the numbers for Samsung Electronics and other Asian companies that have advanced aggressively into world markets by narrowing down their product range and business content show a sales weight for the Asian markets (ex-Japan) only in the 20% range, and a marked preference for North America. Thus we find confirmation here also of Japanese enterprises' domestic orientation.

Table 1-2. Weight of Principal Manufacturers' Sales by Geographical Area (FY 1998 estimates)

(Unit: %)

<table>
<tr><th></th><th></th><th>North America</th><th>Europe</th><th>Asia</th><th>Japan</th></tr>
<tr><td>North America</td><td>Intel</td><td>45</td><td>28</td><td>19</td><td>8</td></tr>
<tr><td></td><td>Motorola</td><td>45</td><td>25</td><td>20</td><td>10</td></tr>
<tr><td></td><td>TI</td><td>55</td><td>15</td><td>10</td><td>20</td></tr>
<tr><td>Europe</td><td>Philips</td><td>24</td><td>41</td><td>30</td><td>5</td></tr>
<tr><td></td><td>ST Microelectronics</td><td>22</td><td>42</td><td>32</td><td>4</td></tr>
<tr><td></td><td>Siemens</td><td>19</td><td>59</td><td colspan="2">< 23 ></td></tr>
<tr><td>Asia</td><td>Samsung Electronics</td><td>40</td><td>24</td><td>24</td><td>12</td></tr>
<tr><td></td><td>TSMC</td><td>57</td><td>11</td><td>27</td><td>5</td></tr>
<tr><td></td><td>Chartered Semiconductor Manufacturing</td><td>65</td><td>10</td><td>20</td><td>5</td></tr>
<tr><td>Japan</td><td>NEC</td><td colspan="3">< 44 ></td><td>56</td></tr>
<tr><td></td><td>Toshiba</td><td>26</td><td>9</td><td>16</td><td>50</td></tr>
<tr><td></td><td>Hitachi</td><td>12</td><td>12</td><td>16</td><td>60</td></tr>
<tr><td></td><td>Fujitsu</td><td>24</td><td>16</td><td>14</td><td>46</td></tr>
<tr><td></td><td>Mitsubishi Electric</td><td>20</td><td>13</td><td>16</td><td>51</td></tr>
</table>

Note: Because of rounding-off, weights may not necessarily total 100. Figures in shaded areas show domestic area weightings within total sales.

Source: Electronic Journal, *Semiconductor Data Book 1999*

3. Japan's Semiconductor Industry in Crisis

3.1. Recent Situation of the Principal Manufacturers

1) Earnings and capital investment

After 1996's plunge in the world DRAM market, the semiconductor industry has continued in a poor condition. This is illustrated in Table 1-3's consolidated numbers for the semiconductor divisions of the 5 integrated electrical makers that lead Japan's industry.

Table 1-3. Situation of the Integrated Electricals' Semiconductor Divisions (Consolidated)

(¥ billion, %)

	Production amount		Operating profit/loss		Capital investment		Memory ratio	
	FY 97	FY 98	FY 97	FY 98	FY 97	FY 98	FY 97	FY 98
NEC	1,150	1,020	52.8	-51.9	180	150	29	24
Toshiba	870	760	25	-50	170	120	24	24
Hitachi	710	600	-40~-50	-100	120	67	35	28
Fujitsu	570	480	-32.5	-83.3	175.3	80.4	37	32
Mitsubishi Electric	510	480	-60	-40~-50	90	45	34	27

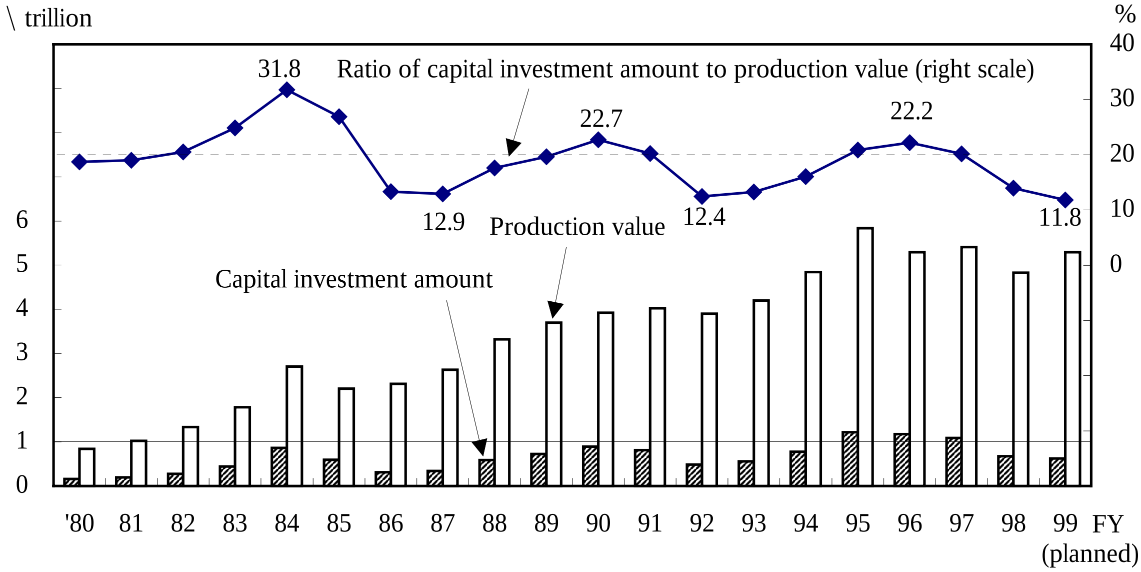
Note: The operating profit/loss figures for NEC and Fujitsu are for their electronic device divisions, which include semiconductors.

Source: Electronic Journal, *Semiconductor Data Book 1999*, Denpa Shimbun (May 31, 1999), home pages, others

FY 1998 production values for all five companies fell below year-earlier levels. The semiconductor divisions' business results at the operating level had already, in the prior year, fallen about ¥50 billion into the red for three of the five firms (Hitachi, Fujitsu, Mitsubishi Electric), and they were joined in FY 1998 by NEC and Toshiba. The total operating loss expanded to more than ¥300 billion, and the situation worsened yet further.

It is a situation wherein Japan's manufacturers have become ever more cautious about capital investment. Figure 1-4 shows how the investments of the 11 principal manufacturers peaked at over ¥1.2 trillion in FY 1995 and have declined continuously for the three succeeding years. The margin of year-to-year decline in that FY 1996~1998 period also expanded from minus 3.5% to minus 7.2% to minus 38.1%. As a ratio of capital investment amount to production value the figure declined from around 20% in FY 1995~1997 to 14.0% in FY 1998, a level far below the 20% standard for judging the adequacy of supply in the following period.

Figure 1-4. Principal Japanese Manufacturers' Semiconductor Production and Capital Investment Values (11 companies, consolidated, some parent-only)

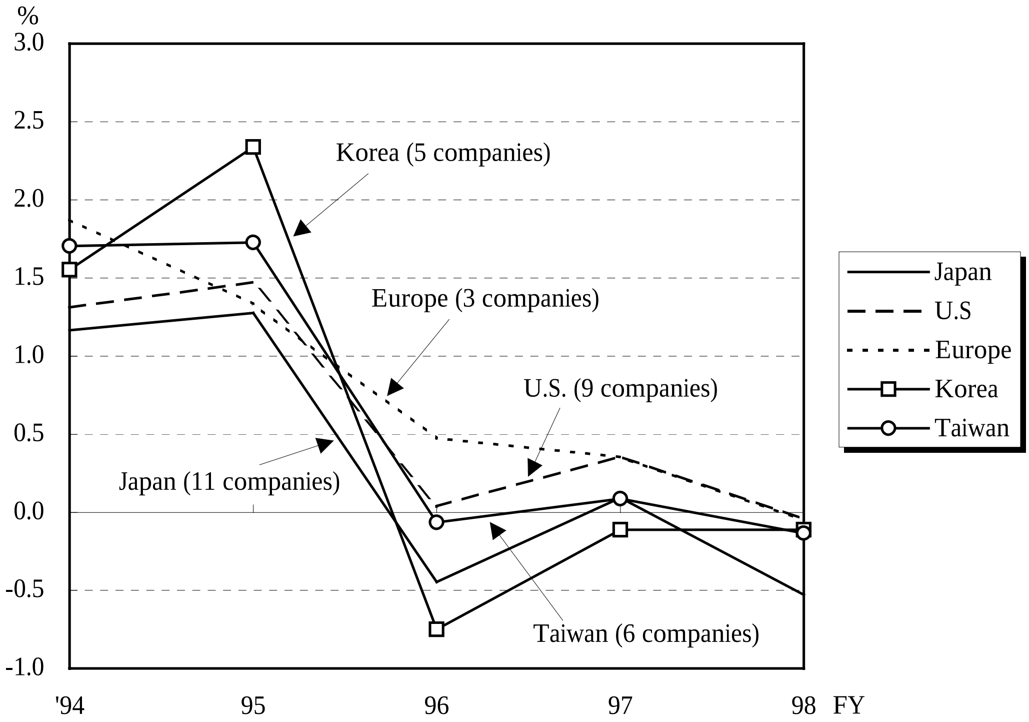


Note: The 11 Japanese companies: NEC, Toshiba, Hitachi, Fujitsu, Mitsubishi Electric, Matsushita Electronics, Rohm, Sanyo Electric, Sharp, Sony, Oki Electric

Sources: *Handotai Sangyo Keikaku Soran*, annual editions, Sangyo Times Inc.; *Denpa Shimbun* (May 31, 1999)

FY 1999 semiconductor capital investment is planned to contract yet further from the already-low FY 1998 levels. In the background to this is the extreme decline in the capital investment efficiency (the ratio of this fiscal year's increase in production value to last fiscal year's capital investment value) of Japanese corporations. Figure 1-5 shows the principal semiconductor makers' capital investment efficiency by country/area; in it we see that Japan's efficiency is broadly lower than those of other countries/areas, and had its greatest decline in FY 1998.

Figure 1-5. Capital Investment Efficiency of the Principal Manufacturers by Country/Area



Notes: Some FY 1998 figures are estimates.
Capital investment efficiency = current fiscal year's production increase amount/previous fiscal year's capital investment amount

The 11 Japanese companies:	NEC, Toshiba, Hitachi, Fujitsu, Mitsubishi Electric, Matsushita Electronics, Rohm, Sanyo Electric, Sharp, Sony, Oki Electric
The 9 U.S. companies:	Intel, TI, Motorola, IBM, National Semiconductor, AMD, Micron, Lucent Technologies, LSI Logic
The 3 European companies:	Philips, ST Microelectronics, Siemens
The 5 Korean companies:	Samsung Electronics, LG Semiconductor, Hyundai Electronics, Anam Semiconductor, Korea Electronics
The 6 Taiwanese companies:	TSMC, UMC, Winbond, Mosel Vitelic, Macronix International, Hualon Microelectronics

Sources: For Japan: *Handotai Sangyo Keikaku Soran*, FY 1998 edition, Sangyo Times Inc.; *Denpa Shimbun* (May 31, 1999)
Ex-Japan: *Semiconductor Data Book* annual editions, Electronic Journal; *Semiconductor Almanac*, 1997

2) World position

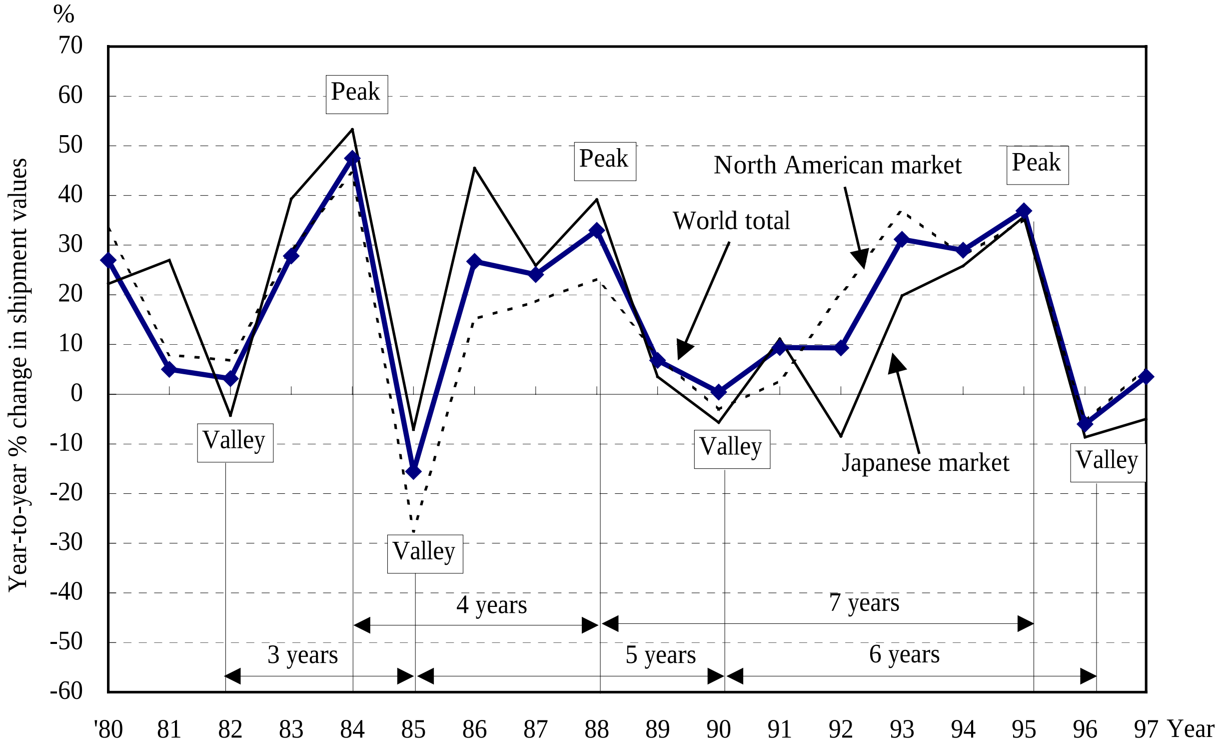
In the sales rankings of the world's top 10 manufacturers announced by Dataquest Corp., we can also glimpse the poor situation of the Japanese firms. Back in 1991 NEC led the world, and 6 of the top 10 in sales were Japanese (the 5 integrated electricals plus Matsushita Electronics). But in 1992 the Intel onslaught secured it the top slot, and the following year Samsung Electronics elbowed its way into the top 10. After around 1996 European companies raised their profile, and the Japanese presence shrank to 4 (NEC, Toshiba, Hitachi, Fujitsu).

In 1998, moreover, while the industry recession still persisted, we saw a more pronounced tendency for Intel and the European firms to flourish and the Japanese and some others to languish. The sales of Intel at the top were almost threefold those of No. 2 NEC, and for the first time Philips, ST Microelectronics and Siemens in Europe came simultaneously into the top 10. The Europeans had previously lagged behind American and Japanese companies in both production scale and technology, but they were successful with a product lineup centering on designated applications, and the growth in the European market of such electronic equipment as portable telephones gave them a boost. Sales of their Japanese counterparts and some others, in contrast, were all forced down at double-digit rates.

3.2. A Changing Industry Environment

At the same time, however, as we see in Figure 1-6, there are ups and downs in the semiconductor industry that follow the so-called "silicon cycle," whereby the earnings environment worsens repeatedly. Yet the current industry recession is regarded not simply as another valley in the cycle but something much deeper. We believe this derives from the following changes in the environment.

Figure 1-6. The Semiconductor Silicon Cycle

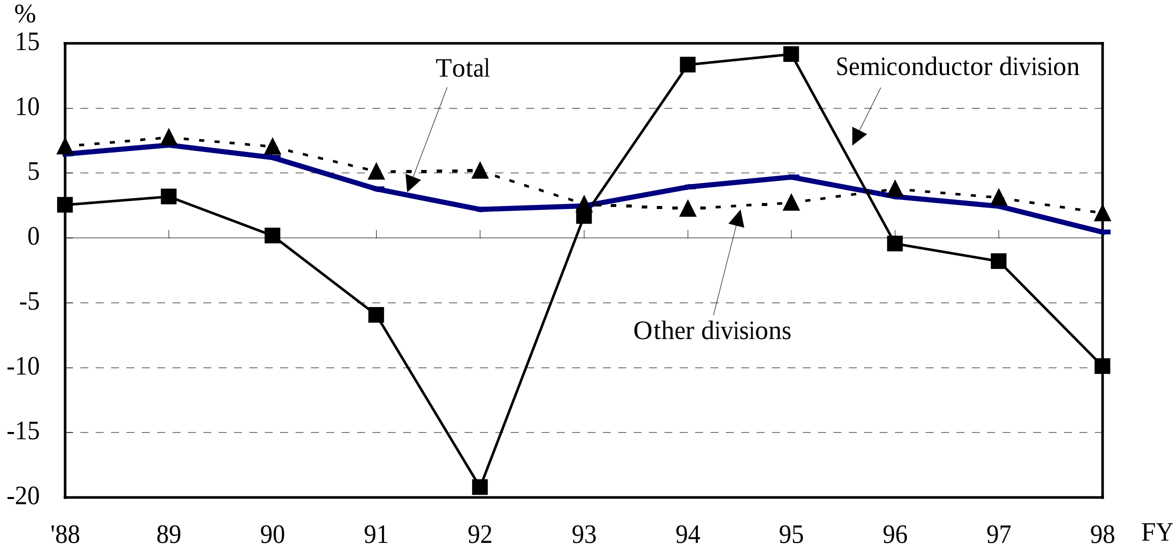


Source: Dataquest

1) Growing instability in the integrated electrical makers' earnings structures

Figure 1-7 shows the operating profit margin rates of the 5 Japanese major integrated electrical firms. The trial calculations are divided into those for the semiconductor divisions and non-semiconductor divisions.

Figure 1-7. Operating Profit Margin Rates of the 5 Integrated Electrical Firms



Notes: Consolidated accounts of the 5 integrated electricals (NEC, Toshiba, Hitachi, Fujitsu, Mitsubishi Electric)
Estimates by JDB
The trial calculation method for the FY 1988~1997 period was as shown below.
For FY 1998, calculations are based on rough estimates of divisional operating profit/loss when accounts were announced.

FY 1988~1997 Trial Calculations

The integrated electrical makers have recently made accounting year information available for each division. But for historical operating profit margins we have used the calculations shown below to ascertain separate data for the semiconductor and non-semiconductor divisions.

1. Among the big electrical makers, Oki Electric can break the business down into two classifications: "Industrial communications equipment" and "Semiconductors." This enables us to estimate its semiconductor operating profit margin using published data from the 24 industrial communications equipment makers (such as Anritsu and Ikegami, but not including Oki).
2. Considering Oki Electric's memory ratio and the like, we can apply the profit semiconductor profit margins of the 5 majors.
3. The production values of the 5 majors ascertained from the FY 1998 edition of the Sangyo Times Inc's *Handotai Sangyo Keikaku Soran* (partially updated in newspaper articles) are considered as approximations of their sales values (as in the case of Oki Electric, above). Operating profit values are calculated using the already obtained operating profit margins for their semiconductor divisions.
4. By subtracting these from the 5 majors' aggregate operating profit/loss, the non-semiconductor divisions' operating profit/loss is calculated.

As verification, if we compare FY 1997's semiconductor operating profit/loss (the aggregate for the 5 companies) for our trial calculation values and each firm's publicly-disclosed values, we come up with minus ¥68.6 billion for the former and minus about ¥60 billion for the latter.

Source: Trial calculations based on Sangyo Times Inc., *Handotai Sangyo Keikaku Soran*, 1998 edition, and Electronic Journal, *Semiconductor Data Book 1999*

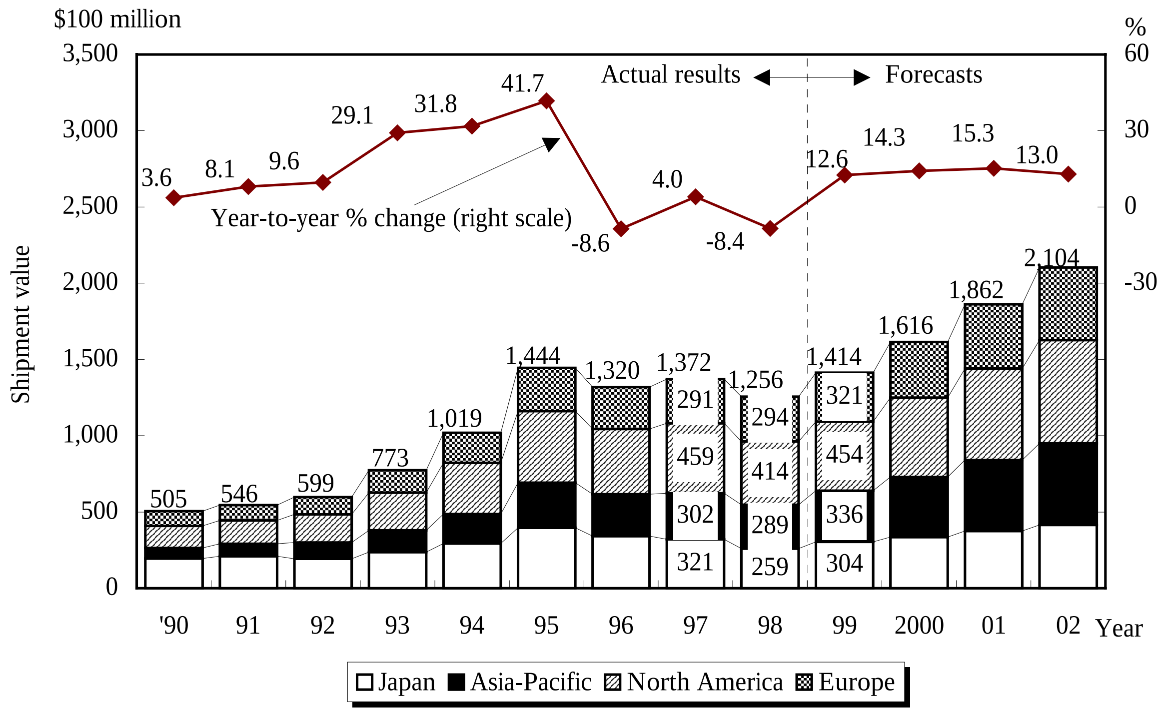
As we see in Figure 1-7, margin rates for the semiconductor divisions are characterized by extreme volatility. We noted previously that sharp accelerations in production scale brought incremental gains in contributions to corporate earnings as a whole. Other divisions' margins have also declined continuously, from the 7% range in the late 1980s to slightly over 5% in the early 1990s to slightly less than 2% in FY 1998. In other words, the old dispensation whereby the other divisions compensated when the semiconductor division languished has disappeared, and instability has increased in corporate earnings structures as a whole. FY 1998 saw a record-low operating profit margin of barely 0.4% for all divisions.

2) The shrinking Japanese market

Looking at the world semiconductor market since 1990, it is apparent, as shown in Figure 1-8, that its scale expanded in the decade's first half and peaked at $144.4 billion in 1995. By region, however, in this period the growth rate of Japan's market was generally lower than those of other regions after holding top share among the four areas up to 1992, it switched places with North America in 1993.

In and after 1996, growth in the world market as a whole decelerated, with a negative 8.4% year-to-year rate in 1998. By area, only Europe was up, albeit just slightly, while the others contracted. Japan's decline was particularly large, and its scale was finally the smallest of all.

Figure 1-8. World Semiconductor Market Scales

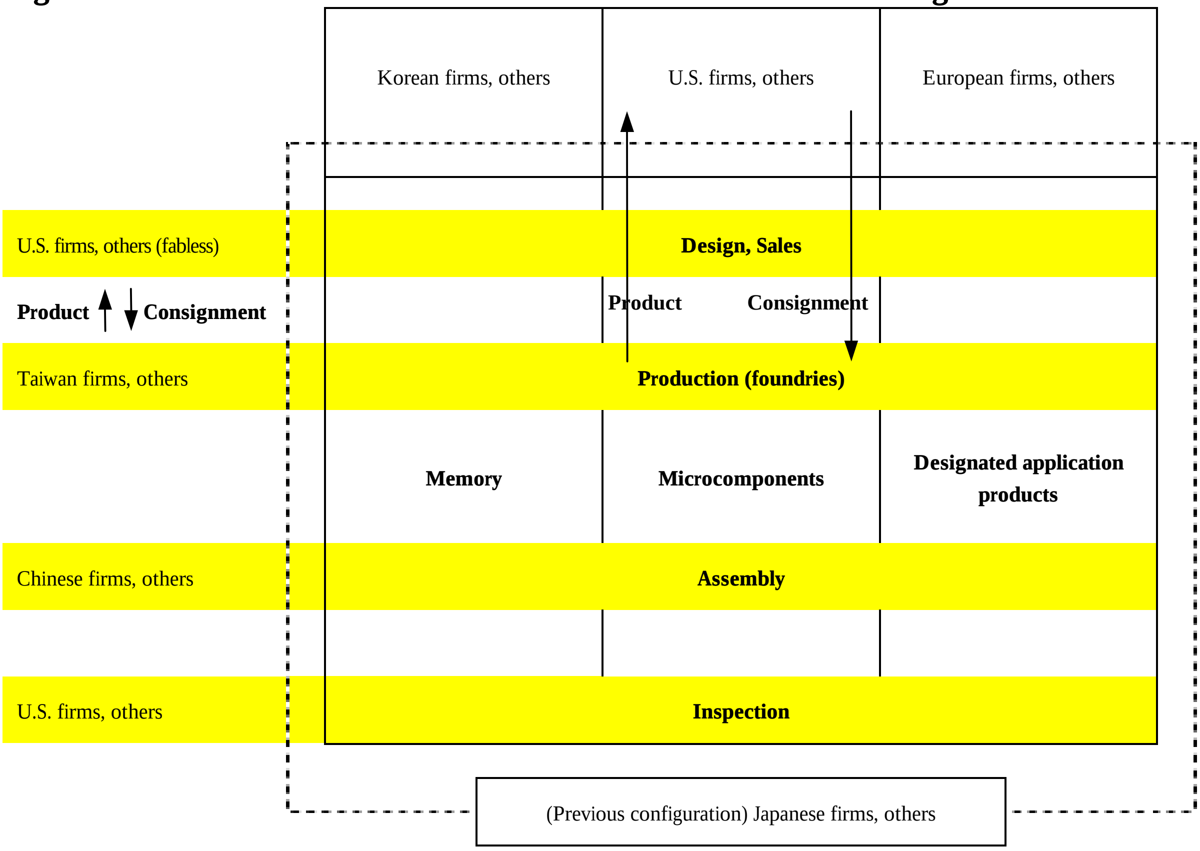


Source: WSTS, *Spring 1999 Semiconductor Market Forecast*

3) International division of labor and Asian competitors

What cannot be ignored in the world semiconductor market in recent years is the structural change in the production organization: a division of labor that transcends national boundaries. Figure 1-9 illustrates the pattern.

Figure 1-9. Pattern of the World Semiconductor Division of Labor Organization



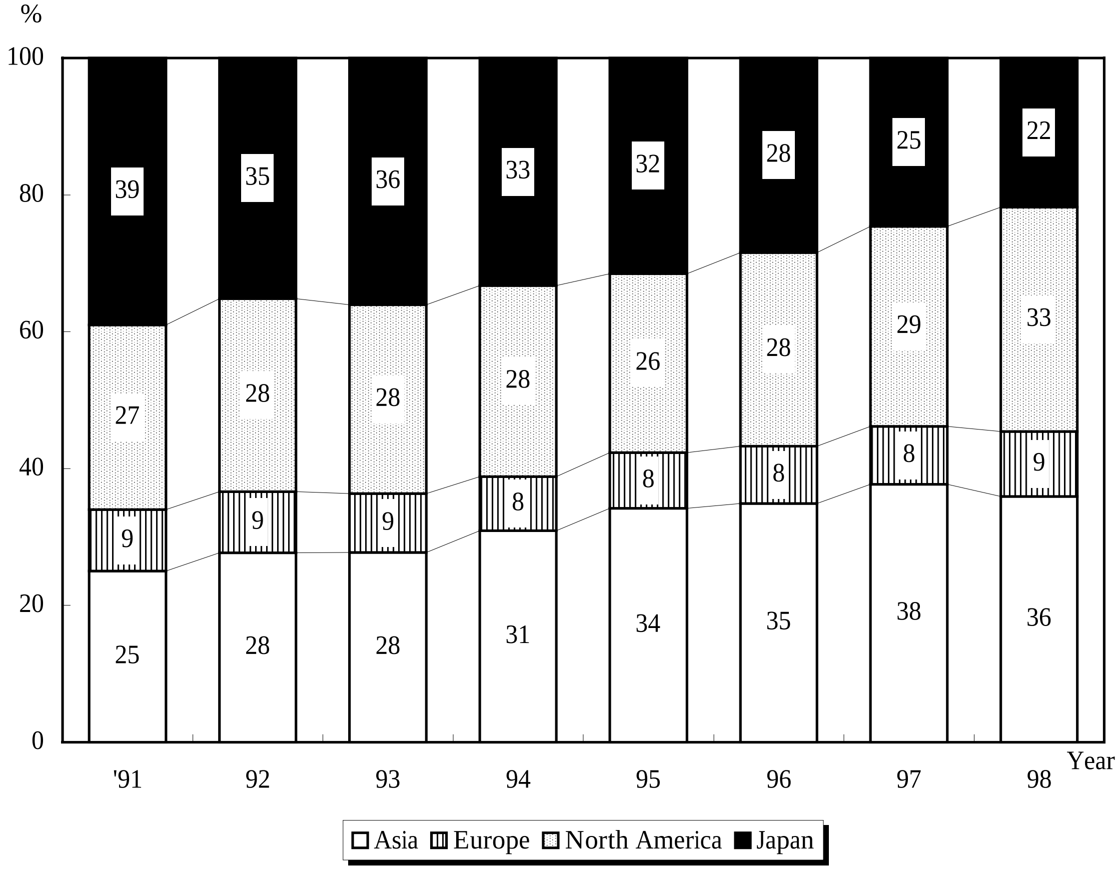
Source: JDB

There are two types of this corporate separation. One is narrowing the product composition to specialized products like DRAMs and MPUs, and processing them continuously from design to production to assembly to inspection, and finally to sales. The other is specialization, or separate businesses for each design, production and other process so-called horizontal separation.

U.S. and European firms, and those in Korea, Taiwan and elsewhere in Asia, are all putting one or the other of these separation strategies into practice. Among these firms there is already being constructed a cross-border division of labor organization. Their Japanese counterparts, on the other hand, as represented by the integrated electricals, have retained their customary comprehensive approach and not responded sufficiently to the international trend just described. Of course, for Japanese companies this configuration is a "product of history," and the comprehensive approach by one's own company was strong at one time. Or else there was at least no pursuit of the necessity of such separation.

With the higher density and wider diversification of semiconductor products, however, it is more difficult for Japanese manufacturers to secure competitiveness as they continue maintaining the comprehensive business configurations they always have. As shown in Figure 1-10, in the world of the 1990s the characteristic of production share by country/area saw a decline in Japan's and a corresponding increase in those of Asia. Japan's and Asia's shares of total world production value in 1991 were 39% and 25%, respectively; by 1998 they were reversed to 22% and 36%. On a four-area comparison as well, after 1995 Asia's production share rose substantially, and was in fact noteworthy throughout the 1990s.

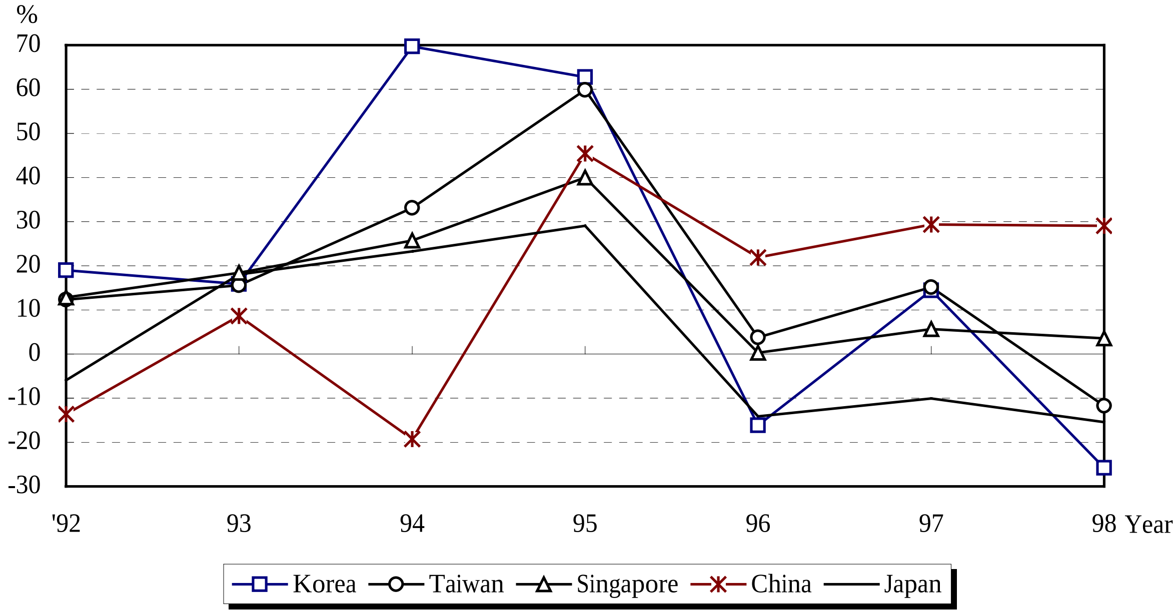
Figure 1-10. World Semiconductor Production Shares by Country / Area



Note: Due to rounding, the share totals will not necessarily equal 100%.
Source: Electronic Journal, *Semiconductor Data Book*, annual editions

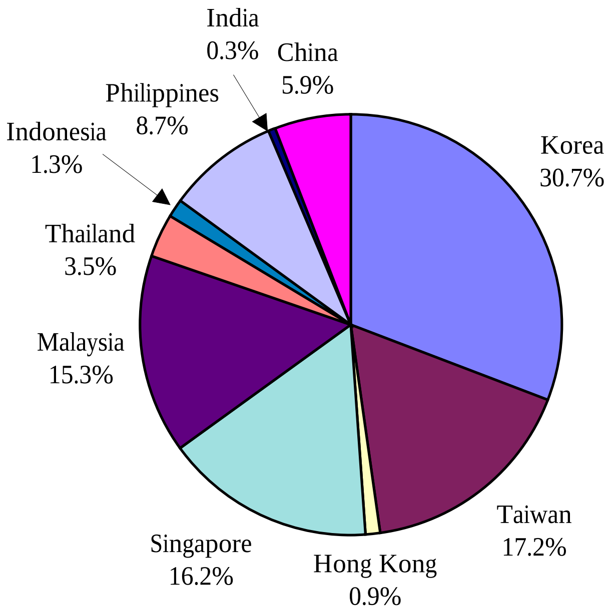
As we see in Figures 1-11 and 1-12, Asia's production growth in the 1990s has been led by Korea, followed by Taiwan and Singapore. Although China's production scale is still small, the potential of its market is huge and amid the worldwide semiconductor recession it has been showing a stable average annual growth rate on the order of 20%. In the next chapter, we will examine the industry's historical development in these four countries, its recent situation, and the future outlook.

Figure 1-11. Year-to-Year % Change in Semiconductor Production Values for the Principal Asian Countries and Japan



Source: Electronic Journal, *Semiconductor Data Book*, annual editions

Figure 1-12. Semiconductor Production Shares by Asian Country (ex-Japan) in 1998



Source: Electronic Journal, *Semiconductor Data Book 1999*

II The Semiconductor Industries of Other Asian Countries

1. Korea: Specialization in DRAM Continuous Production

1.1. The Course of Development and the Recent Situation

Going into the 1980s, the Korean business conglomerates, of which Samsung Electronics is representative, concentrated management resources on investment in the DRAM business, whose market scale was then large. Accelerated development was the result. The government laid emphasis on cultivating the semiconductor industry as part of its policy of promoting an export-driven economy. But the early development stages coincided at that time with moves toward international trade liberalization, and that placed limits on direct financial support for the industry. Instead, support went into improving semiconductor technology for the business conglomerates that had always been cash-rich, to reducing customs duties on imports of semiconductor manufacturing equipment and the like, and to shortening depreciation periods. This policy had the effect of fattening Korea's business conglomerate and weakening its medium/small enterprises.

Korea's semiconductor makers first imported technology from their U.S. counterparts, and moved into continuous production of DRAMs. Initially they were mainly outsourcers for IBM, TI and Intel, and some 70% of exports were OEM products. Thereafter, however, Samsung Electronics, which had accelerated improvement of its technological power, developed its own 4M DRAM in 1988. By 1990 it had developed a 16M DRAM and reached world levels in technology, established itself as a world DRAM production base, and confirmed the status of Korea. In addition, the strong yen and the collapse of the Bubble economy caused the Japanese manufacturers, theretofore the world's leaders in production, to slow their investments in the early 1990s. Those of Korea continued aggressively, and the scale of the country's production grew dramatically. Accordingly, its production value soared from $6.1 billion and an 8% world share in 1991, equivalent to less than a quarter of Japan's, to $23.7 billion and a 15% share at the 1995 peak, equal to slightly less than half of Japan's.

In 1996 the Korean firms entered upon difficult times as the DRAM market plummeted. This was exacerbated by the Asian economic crisis in and after 1997's second half. After June 1998, the three leading manufacturers (Samsung Electronics, Hyundai Electronics and LG Semiconductors) took steps to rebuild the market by cutting production more than 20% from initial plans; this brought Korea's production value down to $16.9 billion, and its world share to 11% from the prior year's 14%.

These production cuts and other factors stabilized the DRAM market from around the fall of 1998 and maintained that tone into the new year. But growth in the U.S. PC market slowed, and on preparations for mainstream 64M DRAM mass production organizations, Micron and the Korean firms eased up on the production cutbacks, so that after March 1999 the DRAM market has again languished.

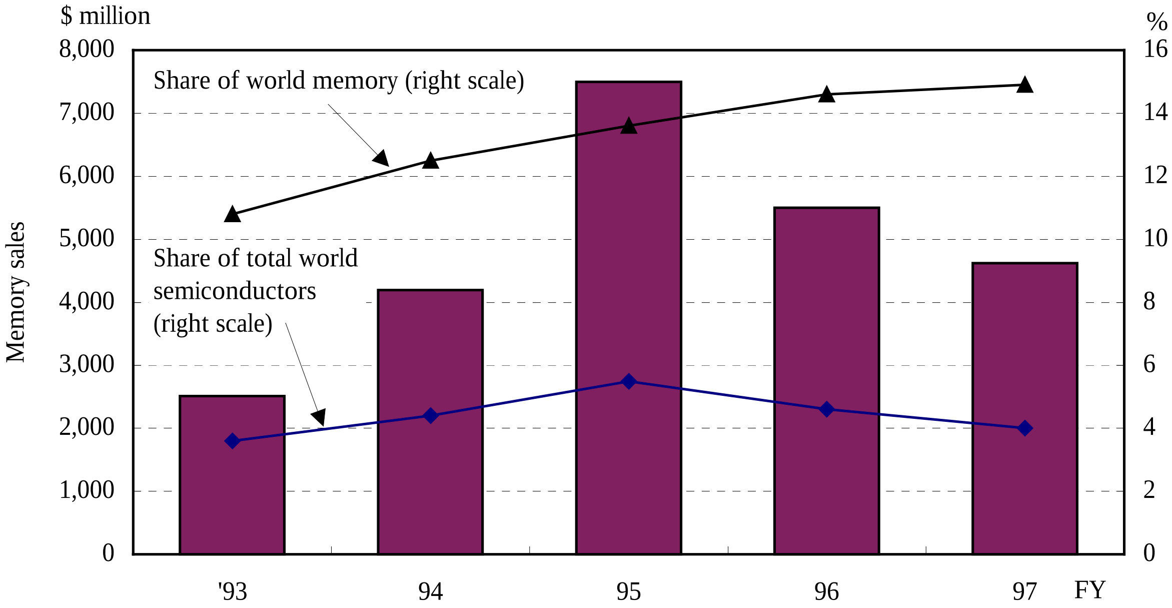
1.2. Outlook and Issues

The DRAM business risk has grown because of the market plunge incident to a looser supply-demand relationship and the increase in capital investment. But the Korean companies are nevertheless maintaining their strategy of DRAMs as core products. This stems from the following factors.

The first is that the Korean semiconductor industry for historical reasons has a product line that is overwhelmingly dependent on DRAMs. In the 1998 production weightings, memory accounts for 84% of the total (and most of the memory is DRAM). The second reason is that Korea has already firmed up its standing as the world's DRAM production base: its share of world DRAM production in 1998 was slightly less than 40%. Thirdly, DRAM demand is expected to grow as the markets for PCs and other electronic equipment expand, and in line with technological development to meet ongoing requirements for yet further compactness and higher speeds. Finally, if companies that cannot hold up under the current severe industry situation withdraw, the competitive environment will likely improve and with it the position of the Korean firms as DRAM makers.

More specifically, Samsung Electronics has made clear its policy of maintaining its place as the world's top DRAM maker. Actually, as seen in Figure 2-1, even as the company's sales contracted for two straight years during the industry recession after 1996, its world memory share continued to rise.

Figure 2-1. Memory Sales and World Share of Samsung Electronics



Source: Samsung Electronics

Japanese firms have begun to withdraw from or reduce their exposure to the DRAM business, or are maintaining a wait-and-see posture. Samsung, in contrast, expects demand to expand on the back of greater computer functionality, looks for shortages ahead, centering on high-speed products, and is again aggressive about capital investment. Last January it was announced that Intel would invest $100 million, and this and other fund procurement have fueled plans for a FY 1999 capital investment amount of $1.2 billion, up 20% year-to-year. Although this represents an absolute level barely half the peak $2.3 billion, it is the first increase in four years. A new production line for 0.18μm wire processing is slated for the fall of 1999; another goal is early preparation of a mass production organization for such high-speed products as advanced DRAMs over 128M and direct Rambus DRAMs. Hyundai Electronics and LG Semiconductors have also re-adopted aggressive policies toward capital investment.

It is nevertheless a fact that many issues remain for the Korean semiconductor industry. In DRAM specialization, and in design and production technology for high added-value products, it still lags and is dependent on imports for the bulk of this. It is for this reason that imports account for nearly 80% of the value of overall shipments. Moreover, the country's accumulation of peripheral industries in raw materials (silicon wafers) and precision machinery (semiconductor manufacturing equipment) is thin, with 1998 self-supply ratios of 56% for the former and only 18% for the latter. In addition, we may point out the inefficiency of the business conglomerates that dominate the industry.

There have been some partial moves to address these problems. Korean firms have, for example, learned from this DRAM recession that risk diversification should be planned for, and have put forward policies to lessen DRAM dependence and strengthen non-memory sectors. More specifically, through tie-ups with Silicon Valley venture enterprises and others, and in collaboration among industry, government and academia, they are coming to grips with improving their system LSI design capabilities and the like. Yet this is still limited to the level of "expanding into non-DRAM (non-memory) fields with DRAM process technology as the base," or "reducing the present 80%-plus memory ratio to around 70% by 2000." And the objective of bolstering the semiconductor peripheral industries is for Korea a matter of greater cooperation with the Japanese companies that are an important source of imports. In this regard the government, through the aforementioned "Media Valley Project," shows a posture of wide support for the cultivation of the information communication industry, including semiconductors. In addition, as a link in its economic renovation program, the government is moving aggressively forward in structural reform of the business conglomerates, including the semiconductor makers, with the aim of improving their efficiency.

1.3. The Principal Manufacturers and Government-Related Projects

1) Samsung Electronics in comparison with the 3 major manufacturers

In the semiconductor division operating profits of the three majors Samsung Electronics, Hyundai Electronics, LG Semiconductors in 1998's first half, only Samsung was in the black, with the other two estimated to be in deficit. As DRAM makers, Samsung led the world with a 1998 share of 19%, with Hyundai trailing in third place with 11% and LG in fifth place with 8%. Table 2-1 assembles the principal factors behind Samsung's strength.

Table 2-1. Principal Reasons for the Strength of Samsung Electronics

Timing of business entry	Because it was an early entrant into the business (the 1970s, with the other two in the 1980s and 1990s), Samsung was able to secure a fixed market share in advance of competitors.
Technology development power	Samsung always leads others by 6~12 months in technology development (improving yields) and product commercialization, gaining the benefits of leading the pack.
Dependability	Based on dependability of high quality (yield), Samsung can conclude contracts with large customers (IBM, HP, others) that are profitable in terms of unit price and duration.
Personnel	Because of its brand image, the elite aspire to join. Thorough training after entry assures superiority in personnel quality.
Financial condition	No dependence on excessive borrowing and active use of overseas securities markets reduce fund procurement costs, enabling a relatively good financial condition. (The debt-to-equity ratio declined from 296% in 1997 to 245% in the first half of 1998, vs. advances from 688% to 935% for Hyundai and from 487% to 617% for LG over the same period.)
Collaboration with Europe and the U.S.	Together with expanding capital investment, Samsung is aggressive about cooperation with the U.S. and European manufacturers possessing high technology, as a means of cost reduction (the company is currently studying joint ventures and other arrangements with the overseas manufacturers for next-generation development investment).

Source: On-site visits and interviews

Samsung's operating profit in 1998's first half is owed mainly to the company's early start in 64M DRAM mass production. It also leads the others in 256M DRAMs, targeting the start of mass production in March 1999.

Going forward, it will be important to watch carefully what changes will be wrought in the current DRAM maker power relationships, owing to the merger of the semiconductor divisions of Hyundai and LG, as described below.

2) Structural reform of the business conglomerates

Following the Korean War, the country adopted a protectionist industrial policy to build up the national capital. The business conglomerates, which already had a certain amount of financial power, were mainly cultivated as the core forces of the export industries by the government, and they became more powerful and diversified. But their management inefficiency had long been pointed out, and when they came under IMF management in December 1997 in the wake of the Asian economic crisis the opportunity arose for the government to exercise guidance again this time in the direction of structural reform of the conglomerates.

In our context, this reform involves a merger of the semiconductor divisions of Hyundai and LG, the world's third- and fifth-largest DRAM makers. They have already agreed on setting up the merger that will vault them to the top of the rankings, alongside Samsung.

Although the agreement was reached in September 1998, the following December a U.S. research firm published a report to the effect that "after the merger, it is appropriate that Hyundai be the management core." LG objected on the grounds that its financial condition and technology level outshine Hyundai's, and for the time being negotiations stalled. The impasse seemed resolved when in early 1999 LG accepted transfer to Hyundai of 100% of its equity. But later in January the LG employees staged a strike that stopped all production lines that had operated at full capacity for a decade. The strike was over after about 15 days, but during that period LG sustained losses of ¥1 billion a day and in a continuous process both firms lost credibility overseas; the departure of customers and superior personnel diminished sales and created problems of serious concern. Eventually agreement was reached in late April, and as expected Hyundai absorbed LG to unite both firms' semiconductor divisions. If all goes well, the new company will come into being on October 1 this year.

As the beneficial results of the merger, we can cite lower costs derived from avoidance of overlapping investment, and market dominance (price-setting power) through share expansion. In the technology aspect, many believe that synergy effects are unlikely between DRAM makers. Negatively, there is concern about disposition of the combined total of 18 trillion won in liabilities, an effective diminution in production incident to risk diversification by major customers, and the losses arising from the time and costs required for the merger procedure and for fusion of technologies. These and other negative results have been pointed out.

So it has to be said that the post-merger road will be a thorny one. The merger's effects will not be actually apparent in the market until after 2000 at the earliest, and in fact some believe it will cause a temporary DRAM shortage. But if it sparks a radical rationalization, competitiveness will improve over the intermediate and long terms, and Korea can be expected to reaffirm anew its position as the world's DRAM production base.

3) Overview of the "Media Valley Project"

About one hour west of Seoul by train lies the city of Inchon , where there are plans to establish a concentration of leading-edge knowledge industries, as in the U.S.'s Silicon Valley. The Media Valley Project is one of the 100 issues selected by the administration of President Kim, and Inchon City and Media Valley are the main foci of this project. Centering on semiconductors and other export industries, Korea has heretofore concentrated on cultivating only a small number of fields; now it is moving full-scale to raise the industrial level, conscious of the rising importance of the information transmission industries, including hardware and software.

More specifically, in addition to corporations concerned with the contents, software, communications, semiconductor and other industries, Korea is targeting attraction of domestic and overseas venture capital and the like (with a goal of 2,055 such firms by 2005), construction of academic institutions and residence facilities, and building the world's largest information communications industry base on a 42.9 million m^2 area by 2010. The area will be divided into six parts, each comprising one of the following important installations.

"Media Valley Academia"	Graduate school of information communication, university, education center
"Technopark"	Research institute, production technology research institute, advanced industry exhibition hall
"Information Culture Hall"	Software museum, conference rooms, library
"Softbank"	Major firms, medium/small enterprises, overseas corporations
"Venture Building"	Enterprise startup support center, marketing center, venture business space
"Ecofriendly Village"	Residence facilities, commercial installations, recreation facilities, park, schools

Construction began in 1998, and this year will see the start of foundation laying and distribution of lots. Companies will construct installations in and after 2000, and from 2001's second half are expected to begin business operations. The cost of this project, however, is said to exceed ¥1.2 trillion, and there are fears that a Korea under IMF management may not be able to raise sufficient funds.

2. Taiwan: Strengthening Logic Core Foundries in Liaison with U.S. and European Countries

2.1. The Course of Development and the Recent Situation

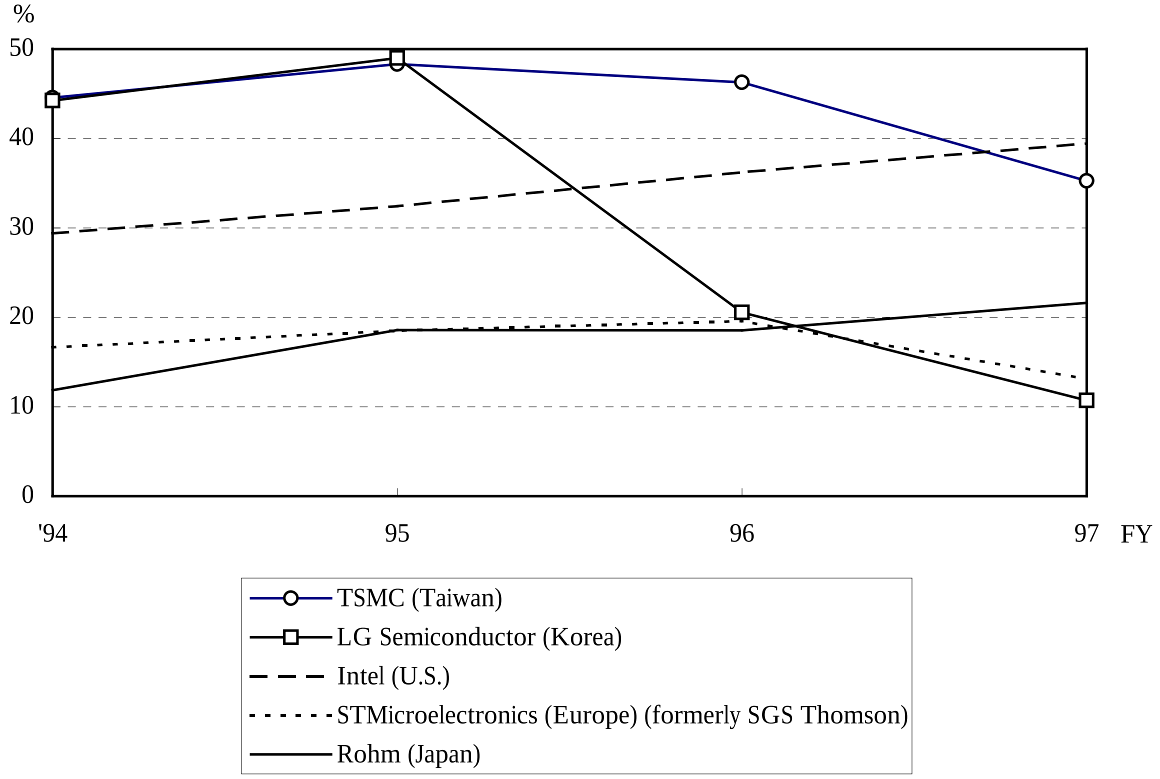
The history of Taiwan's semiconductor industry begins in 1974 with the establishment of the predecessor to the ERSO government research institution. In the late 1970s DRAM designs and manufacturing technology were introduced from the U.S.'s RCA, and R&D commenced. After that, ERSO embarked on a number of technology development projects aimed at fostering the semiconductor industry. Based on that technology, many companies were established in "spin-out" mode from ERSO. There are "official" and "unofficial" spin-outs. The former are those wherein the importance to the government of the technology it fostered is recognized, and its financial and other support enables commercialization. The latter comprise those cases wherein no government support is received and commercialization is accomplished independently. A specific example of an official spin-out is UMC, the oldest and now the world's second-largest foundry (accepting consignment orders for unbranded products), established in 1980. In addition to financial and technological support, ERSO provided personnel and employee training. Initially, UMC produced telephone and PC chips under its own brand name, then switched to its present foundry incarnation in 1994. And in 1987, TSMC was established as the world's first foundry, with capital from the government (48.3%), Philips (27.5%) and local private enterprises (24.2%). Now it is the world's top foundry.

The role of the foundries has been changing over time. There appeared in the late 1980s, mainly in the U.S., specialized design companies that had no plants of their own; the foundries accommodated their requirements and accepted orders for contracted production. The initial evaluation was something along the lines of "Taiwan, a late entrant in the semiconductor industry and with scant technology, has extended its power as a subcontractor by accepting the favor of automated production equipment." No one expected growth on the order the foundries have shown. But gradually opportunities increased to accommodate the continuous-production manufacturers looking to reduce the burdens of their giant investments, and as their needs mounted the evaluation has changed: the view that the foundries have "an indispensable role in the industry" began to take hold.

Taiwan's semiconductor industry showed startling growth on into the 1990s, revolving around the foundries as new contracted production businesses. When the worldwide industry went into recession in 1996, they secured growth amid deceleration and in 1997 production by value exceeded $10 billion for the first time; Taiwan's world production share rose from 1991's 2.3% to 6.7% in 1997. Moreover, the number of foundry production lines accounted for less than 9% of Taiwan's domestic semiconductor lines in 1991; by 1997 this proportion had jumped to 55%, highlighting the major contribution the foundries were making to the country's industry. But in another important business, the ratio of the number of DRAM production lines to the total, the proportion of 29% in 1991 was far higher than the above foundry line proportion; by 1997, when the DRAM ratios stopped at 38%, it was far less. On a comparative basis, then, a large gap had opened up.

Figure 2-2 shows the operating profit margin rates of the major manufacturers. As we see in the case of TSMC's approximately 40% margin, those of the foundries far exceed those of other semiconductor manufacturers. This is one of the sources of their special characteristics, as seen in Table 2-2.

Figure 2-2. Operating Profit Margin Rates of the Major Semiconductor Makers



Source: TSMC: Annual Report, 1997
LG Semiconductor: Daewoo Securities, "Kankoku Jojo Kaisha Survey Toshi Guide," spring 1998
Intel, Micron, STMicroelectronics: home pages
Rohm: Nihon Keizai Shimbun, *Nikkei Kaisha Joho*, 99-I, New Year

Table 2-2. Special Characteristics of the Foundry Business

Costs	No direct involvement in design and sales, contracted production and minimum necessary process technology R&D mean much lower personnel, advertising and R&D expenses.
Technology	Other than self-developed technology, the information and technology necessary come (based on trust related to protecting secrets) from continuous manufacturers and those without fabrication plants that recognize the importance of foundries as contracted producers.
Product composition	In handling of mainly ASIC and logic elements, little effect from market variations, compared to DRAMs.
Markets	Most orders come from U.S. and European manufacturers. Small impact from Asian economic crisis.
Operating rates	On parallel orders from multiple customer companies, high operating rates can be maintained.
Profitability	No exclusive contracts with any particular company. After study of the commercial viability of each product, only contracts that meet profitability criteria are accepted. In meeting customer needs quickly and flexibly, emergency requests are accepted at higher margins.

Source: On-site visits and interviews

Other factors supporting the foundries' high profit margins are the straight-line depreciation method and incentive stock bonuses.

In Taiwan, moreover, there has been a major contribution to the semiconductor industry's growth from the strength of the industrial base itself. Even in comparison to Japan, Taiwan has sufficiently filled out its infrastructure and educational system, electricity costs are about half, and in other cost aspects it enjoys advantages. In Table 2-3, these and other strengths are assembled together and compared to Singapore's.

Table 2-3. Taiwan's Industrial Base (Compared to Singapore's)

	Taiwan	Singapore
Industrial concentration	The industrial structure based on manufacturing supports heavy concentration of raw materials, semiconductor production equipment and other peripheral industries, as well as PC and other user industries.	The industrial structure centers on tertiary industries, so concentration of semiconductor peripheral industries is thin.
Corporate composition	Reflecting a national character respectful of legendary business founders, the principal elements are medium/small enterprises. Quick decision-making enables effective turnaround.	No reverence for industry founders, difficult to foster local medium/small enterprises.
Management capabilities	No dependence on borrowings, use of own cash to the utmost, pursuit of high earnings the so-called Chinese-style management (high management capabilities).	Superior to Taiwan in consideration of safety and high levels of dependability, but weaker awareness of efficiency, profit and competition.
Relations with U.S.	Many cases of return home after study in the U.S. and working experience in high-tech Silicon Valley firms. Personnel fostered this way later stimulate business.	Few seek work in U.S. after studying there. Many cases of employment with government after returning home.
Labor	Abundant high-quality labor, including that from mainland China, can be secured at low cost.	Small population, insufficient labor.
Government support	Funding support: low interest rate loans, tax incentives (low rates on the part of profits allocated for capital investment, 5-year tax holiday after company establishment in the Hsin-chu Science-Based Industrial Park), others Personnel support: fostering human resources, calling home good-quality personnel living abroad, others Technology development support: preparing and equipping the Hsin-chu Science-Based Industrial Park, others Others: with market research and the like, government extends positive support. Companies make use of these and develop business efficiently.	Adequate funding support (tax incentives, others), but no consistent support organization, including technology development and others. Strong tendency for companies to depend on this government support, no aggressive do-it-yourself approach to improving competitiveness.

Source: On-site visits and interviews

Taiwan's semiconductor industry grew continuously to 1997, then turned to negative growth in 1998, with production again dropping below $10 billion (6.2% world share). But that decline owed much to the impact on the DRAM makers of a languishing market, one which sent about half of them into the red.

In this situation, one DRAM maker after another sought to convert to the foundry business, centering on logic chips. Nanya Technology, for example, in 1998 entered the business, and Powerchip Semiconductor, the DRAM production base of Mitsubishi Electric, decided in the same year to switch the locus of its business in that direction. The Acer Semiconductor specialized joint venture between Acer and TI for DRAM production (formerly TI Acer) was switched to the foundry business when TI withdrew from DRAMs in 1998. More recently, Mosel Vitelic has been studying new participation in the foundry field. Reflecting these moves, the ratio of foundry production lines to the total for semiconductors rose to 55% in 1997, as aforementioned, and rose further to 58% in 1998; over the same period, the DRAM line proportion sank from 38% to 28%.

But in 1998, not only DRAM makers but the foundries themselves lost momentum. The leader TSMC was no exception: at the beginning of the year the operating rate of its core 200mm wafer line was almost 100%. But the supply-demand balance collapsed because of large increases in production capacity and slowing demand brought about by PC inventory adjustment; the operating rate therefore declined to 60% in the second quarter and 50% in the fourth.

Going into 1999, however, the U.S. and Japanese chip makers cut back their own lines and once again increased their outsourcing orders to the Taiwanese and other foundries, prompting an industry revival. The TSMC 200mm wafer line's operating rate exceeded 70% in the first quarter, and as of May the average rate for all its plants is back up to 90%. This has made the company rethink its capital investment stance: where in 1998 it spent slightly less than $800 million (a more than 30% downward revision in initial plans), it has revised up the initial 1999 plan of slightly over $700 million, and as of May is targeting $1,265 million, mainly for 0.18μm process technology.

2.2. Outlook and Issues

The need for the foundries that have driven the sharp growth of Taiwan's chip industry is expected to increase yet further in the period ahead, as the international division of labor organization is constructed, companies without fabrication facilities proliferate mainly in the U.S. and Japanese and other companies seek to reduce investment risks by outsourcing. The ratio of foundry production to the world total remains at about 10%, so there is plenty of room to expand. Further, as seen in the growth of the design field, if there is an aggressive approach to system LSIs, it is highly probable that Taiwan's chip industry will increase its overall strength.

Yet the outlook is not wholly rosy. There is a shortage of capable managers and engineers, R&D is lacking, there is excessive dependence on the U.S., and there are limits to the stock bonus system as an incentive, among other factors. A further point of concern is the stiffer competition attendant upon new entrants into the foundry business. As has been seen heretofore, the foundry market certainly has potential and Taiwanese companies in particular do possess good international competitiveness. Perhaps the major problem is excessive competition among the Taiwan’s foundries that can destabilize the business environment. We have recently seen a number of new entrants, with WSMC, third in scale after TSMC and UMC, starting up full-bore in January this year.

The issues related to foundry survival in this situation are "securing competitive power in respect of costs and technology" and "business differentiation by providing higher added-value services." Specifically, this would involve avoiding a posture of regarding foundry work as an adjunct or something done when there is spare time, and instead exclusivising consignment production, undertaking concentrated investment in advanced process technology as the core, and securing competitiveness in both the cost and technology aspects. In addition, it is necessary to plan for differentiation from others through improvement of product composition segregation and services and build firm customer relationships. Already some companies are offering services whereby orders can be given over the Internet and searches performed regarding the outsourced product situation, and are preparing specialized factories with capital jointly supplied my major customers, in order to capture customers within a web of services.

Foundry industry leader TSMC sees a bright overall future, based on its track record and the relations of trust built up with customers. As a foundry, it has come out with a clear policy of business specialization all around, and of bolstering its IP (intellectual property) related content in the system LSI era. The U.S. and European IP providers and continuous manufacturers are aggressively furnishing information to the foundries to promote IP use, and the latter are aware of its importance in the service and other aspects; already tie-ups exist between sides.

What is worthy of special mention are the moves of the foundries, led by TSMC, to expand the Japanese market, starting full-scale from around 1998. TSMC currently has about 8% of the Japanese chip makers' orders, and is looking to grow that to 28% within the next year or two. As we will note in more detail later, UMC also is firming up a Japanese base with its purchase of Nippon Steel Semiconductor.

Semiconductor capital investment by the Taiwanese companies has remained at a high level since 1997, when the Korean firms had to cut way back. Japan and Korea led in this respect from the 1980s to the mid-1990s, but now Taiwan plays the leading role in Asia. The momentum is being maintained with aggressive plans for the future: TSMC is targeting $14.5 billion in investments over the next decade and UMC an even higher $18.8 billion for the same period. Including these, the 10 leading Taiwanese manufacturers are looking to spend $79.2 billion in intermediate/long-term capital investments.

2.3. The Principal Manufacturers and Government-Related Projects

1) UMC's purchase of Nippon Steel Semiconductor

In September 1998, UMC decided to buy Nippon Steel Semiconductor out from under Nippon Steel. UMC moved quickly: from receipt of the initial approach to decision, it took only six months. This reflects the contrast between the Japanese chip makers mired in recession and trying to restructure themselves out of it, and the Taiwanese firms expanding on the back of good business results; it is symbolic of the recent power relationships in the world industry. Nippon Steel has pulled completely out of the domestic chip industry, and Nippon Steel Semiconductor has been reborn in January 1999 as the "Nippon foundry" of UMC.

With this acquisition, UMC became the first Taiwanese chip maker to establish a production base in Japan. Its principal objectives are to "create the infrastructure for expanding the foundry business in Japan (securing a sales network and collecting information)," "complementing our DRAM production capabilities (it is cheaper and faster than constructing a new plant)," and "introduction of technology, including quality control and distribution systems." It was for these reasons, as well as the good locations of Nippon Steel Semiconductor's facilities and plants and the high quality of its personnel, that the decision was made. Plans call for investment of some ¥25 billion for facilities renewal to make it a future production base, mainly of logic chips.

2) Overview of the "Taiwan Semiconductor Research Consortium (provisional name) "

Centering on the ERSO research group, TSMC, UMC and 12 other leading firms are participating in a research organization for new semiconductor technology that got underway in

July 1999 and plans studies for as long as 10 years. Major projects aimed at developing process technology for 0.1μm and smaller, cost cutting and developing new materials are targeted, with a likely research budget of NT$1 billion (provided equally by government and industry). U.S. and European chip makers, the U.S.'s Sematech and others have been invited to participate, toward a goal of guiding joint international development of next-generation technology. The Taiwanese chip makers that have seen high growth heretofore, centering on foundries, can confirm new world positions through promotion of these projects, and the organization's direction deserves careful attention.

3. Singapore: Foundry Business Development Under Government Protection

3.1. The Course of Development and the Recent Situation

The history of Singapore's semiconductor industry goes back an unexpectedly long way. It began when U.S. and European firms moved in around the end of the 1960s. For those manufacturers at that time, it was a matter of urgency to move labor-intensive back-end processes (assembly, inspection) to Asia, where labor costs were low. Singapore had the merits of a good infrastructure, a high English-speaking proportion of the population, and tax incentives and other government support to entice in foreign firms. Many responded.

With the large advances in Singapore's personnel costs of the 1980s, the advantages of back-end operations there began to wane. Companies therefore betook themselves to neighboring countries where assembly costs were lower, leaving only inspection processes in Singapore. This marked the onset of a period of stagnation in the city-state's semiconductor history, when in the 1981~89 time frame its production value grew by an annual average of only 4.9%, as against a world figure of 16.0%.

In the latter half of the 1980s, a fresh start was enabled by a shift to high added value front-end processing (wafer processing). In 1986, STMicroelectronics began the first continuous production in Singapore, and in 1987 established Chartered Semiconductor Manufacturing, the country's representative chip maker. In 1989, the company began operations as a foundry.

The Singaporean industry grew sharply on into the 1990s, maintaining double-digit advances in production value in the 1992~95 period, in particular. The reasons: Japanese firms hit hard by the stronger yen expanded production there, and the environment improved as needs mounted for a chip production base geographically close to Asian regions where home appliance, PC and other manufacturing was getting underway full-scale, and the foundries, centering on Chartered, were able to contribute. In 1996 the world semiconductor recession's impact made Singapore's industry decelerate sharply, with production almost flat on a year-to-year comparison; yet Chartered managed to maintain growth of nearly 20%.

Comparing the industries of Singapore and Taiwan, we can surmise from the fact that their representative firms, Chartered and TSMC, were both established in 1987, that they developed almost in parallel with the history of foundry growth. But in terms of level, Singapore's growth fell below Taiwan's with the result that Chartered's world position was No. 3 while TSMC's was No. 1, and in terms of their schedules for process technology development a 6-month time gap has opened up. These highlight a divergence in the competitiveness of their chip industries.

As shown in Table 2-3 above, this divergence may be thought of as stemming from the degrees of strength in the industrial bases. The decisive difference arises from the national character or the degree of dependence on the government. In other words, in Singapore there is excessive dependence on the protectionist policies of a strong government, leading to appropriate development of a handful of industries and companies under it while other fields and private companies were neglected.

Singapore's industrial base is of course supported by a full infrastructure and a high educational level, in common with Taiwan's. The latter is superior in terms of a thoroughly legalized body politic, safety and fidelity to contracts. It is a fact that Taiwan's foundry production has been hindered by plant fires in the past, while Chartered has remained a stable supplier without incident.

In respect of government support, sufficient cash facilities have been created and the results manifested. Specifically, based on the "Manufacturing 2000" project that aims at raising the industrial level centering on manufacturing, the government-itself is taking part in front-end chip processing via Chartered, which is under the government-related Singapore Technologies Group. As with TECH Semiconductor and Hitachi Nippon Steel Semiconductor, there are cases wherein the government seeks to reduce investment risks for the chip makers through joint capital participation. In addition, the government has been successful in luring in many foreign firms companies in such advanced businesses as front-end chip processing, by means of such measures as granting "Pioneer Status" corporate tax holidays of up to 10 years (whereby, if a new plant is constructed, earnings arising from it are tax-free for that period from the time it begins full operation), and allowing back-end processing business on condition that this period is shortened to about five years.

Chartered has grown in parallel with the foundry market, meaning that it too suffered when the Asian economic crisis hit in late 1997 and had to defer some of its capital investment. But with the chip market's recovery, it appears that the company had already started up off the bottom in October 1998. Singapore's chip industry as a whole never plunged to the same extent as did those of Japan and Korea in the world semiconductor recession, and has instead remained relatively stable, albeit at low levels.

In the country's chip production, front-end processing accounted for no more than about a quarter in 1996 and even now low added value back-end processing is still central. But steady progress is being made toward shifting to front-end processing, with the support of the government. Especially from around 1997, there were successive announcements of the start of front-end processing plant operations and construction plans. Up to early 1999, there were 13 locations with either existing, under construction or planned domestic plants for this purpose. Table 2-4 refers.

Table 2-4. Development of Front-End Processing Plants in Singapore (some planned)

Company	Government support configuration	Principal business	Monthly wafer processing capability (1,000 units)	Wafer size (inches)	Design rule (μm)	Total investment amount (S$ billion)	Start of operations
Chartered Semiconductor Fab1	All under aegis of a government related corporation	Foundry	26	6	1.2/0.6	0.3	1989
Chartered Fab2	〃	Foundry	45	8	0.6/0.2	1.3	1995
Chartered Fab3	〃	Foundry	20	8	0. 35/0.18	1.8	1997
Silicon Manufacturing Partners JV1, Fab3B	Capital participation by Chartered	Foundry	26	8	0. 35/0.18	1.7	1999
Chartered Silicon Partners JV2, Fab4	Capital participation by EDB (Economic Development Board)	Foundry	30	8	0. 35/0.18	2.0	2000
Chartered JV3 (planned)	–	–	–	–	–	–	–
Chartered JV4 (planned)	–	–	–	–	–	–	–
Hitachi Nippon Steel Semi-conductor	Capital participation by EDB (Economic Development Board)	64M DRAM production	20～30	8	0.25	1.3	1998
ST Microelectronics Fab1	–	Logic and linear chip production	128	5	0.50	0.5	1986
ST Microelectronics Fab2	–	–	20	8	0.50	1.0	1999
TECH Semiconductor Fab1	Capital participation by EDB (Economic Development Board)	16/64M DRAM production	11	8	0.35	0.5	1993
TECH Semiconductor Fab2	〃	〃	25	8	0.35	0.6	1997
Philips-TSMC	Capital participation by EDB (Economic Development Board)	Foundry	30	8	0. 25/0.18	2.0	2000

Note: S$1 = US$1.6755 = ¥77.6 (1997 rates, BOJ, "Comparative Economic and Financial Statistics"
Source: Chartered Semiconductor Manufacturing, others

3.2. Outlook and Issues

Driven by expansion in neighboring country markets for home appliances and other electronic equipment and by mounting needs for foundries, Singapore's chip industry returned to vitality in 1999 and promises to show double-digit growth again from 2000. But there is concern over its lower cost-competitiveness and excessive competition in the foundry market.

The government, conscious of the industrial base strengthening seen as Singapore's major issue, has already renewed the old "Manufacturing 2000" project as "Industry 21," effective in July 1998, and is pursuing it vigorously. The principal point of change lies in expansion of the scope of government support: where "Manufacturing 2000" stressed bringing up the level of manufacturing, especially electronics and chemicals, "Industry 21" embraces both manufacturers and related industries. For the semiconductor industry this means concentrating on such peripheral fields as raw materials and production equipment, accumulation of design technology and the like, all aimed at fortifying the general industrial base. Hewlett Packard has taken advantage of the time differences between the U.S. and Asia to switch its design activity to Singapore, with the objectives of greater work efficiency and ascertaining demand in the region. This has yielded results, and there is every likelihood that other manufacturers will follow its example. The government is also stressing a shift to higher added value front-end processing: as the preceding Figure 2-4 indicates, the target is to boost the number of such domestic plants from the present 13 to 25 by 2000.

Although it may be thought that such dependence on government support is a mistake, it also has to be said that its content is still insufficient for Singapore to overtake its competitor Taiwan. For Singapore to boost its international competitiveness further, it is indispensable that a competitive spirit take root in its corporations and private sector and that they break away from excessive reliance on the government. Amid poor management results in the government-related enterprises, the government itself is beginning to have misgivings; the invitation to the Philips-TSMC joint venture to come to Singapore may be said in the present circumstances to be the first step in a shift of consciousness about competition.

Looking at individual companies, we note that while Chartered Semiconductor Manufacturing follows the previous policy of foundry specialization based on concentrated investment in process technology development and a product lineup centering on logic chips, it also plans to differentiate itself from other firms by efficient technology improvement and providing high added value services. In respect of the former, it is bolstering collaboration with universities and research institutes, and on a recent tie-up with Motorola is seeking early introduction of mass production technology for the 0.15μm and smaller necessary for copper distribution wiring and other applications. In respect of high added value services, the company has set up the independent "Chartered Express" service, whereby it can respond regularly to the supply needs of multiple customers for the same product; this enables reductions in costs and time. Attention is also being given to strengthening the way it deals with IP matters, as a means of dealing with system LSIs. Specifically, through inspection of various IP categories, information is accumulated and put to practical use to improve the company's production efficiency. When necessary the information is provided to customers, with the company in the role of "IP broker" linked to indirect business expansion. The number of tie-ups with U.S. and European IP providers and EDA (electronic design automation) vendors has risen sharply from zero in 1995 to 25 in 1998. The company also became a member of the Virtual Component Exchange (VCX) in March 1999 which was established for IP trading. All this points to the increasing seriousness of the company's IP strategy.

3.3. The Principal Manufacturers and Government-Related Projects

1) The Philips-TSMC joint venture

In September 1998 it was announced that the Philips, TSMC and EDB (the Economic Development Board) joint venture planned new plant construction that would start in early 1999 for full-scale production in 2000's second half of 0.25μm and smaller logic chips. The investment amount would be $1.2 billion, and at full operation the plant would employ some 900 persons.

This project has garnered a great deal of attention as the first advance into Singapore of Taiwan's foundries. But for TSMC, setting up this new base is no more than a matter of long-term necessity, and it is being guided by Philips and the Singapore government. To maintain its lead in logic chips for the home appliance and communications equipment market, Philips wanted the base as part of its global strategy, which is congruent with the government's objective of pursuing higher technology. It is said that initially, TSMC would rather have established a new base in Taiwan. But a move into Singapore by the world's largest foundry would be a clear threat to the dominant Chartered, and would operate to improve the latter's all-around competitiveness.

2) Overview of the "Science Hub"

As part of its policy fostering high added value high-tech industries, the government announced in September 1998 a project to construct a "Science Hub" on the island's west coast, where there would be a concentration of high-tech venture enterprises, research institutes, universities and the like. Expectations are for preparation of a Science Park, incubator installations for venture businesses and a Business Park, among others, in an area of about 8.1 km^2. Construction will take some 15 years, and the total investment is budgeted at over ¥300 billion. The U.S.'s Silicon Valley is the model, and the Hub is to rank alongside Taiwan's Hsin-chu (an area of semiconductor and other concentration) and India's Bangalore (a center for software, etc.) as an Asian high-tech base.

Kent Ridge Digital Labs (KRDL) is positioned at the core of the project. It has independently introduced a business startup promotion system for researchers, which is being closely watched as a "Singapore-style venture cultivation method." Its special characteristics are not only that it offers various incentives to stimulate researchers' commercialization, but also that it enables them to return to research in the event of failure. This thorough support organization is believed likely to yield results in future.

4. China: Full-Scale Government Support Fuels High Growth Expectations

4.1. The Course of Development and the Recent Situation

China's semiconductor industry has a long history. It began in the late 1960s with military applications as its core. Civilian uses thus lagged far behind. In the 1980s local corporations brought in second-hand facilities from the U.S. to acquire the technology, but this did not yield sufficient results.

When at last China began to build a base for its chip industry, it was because the government designated it as a priority industry and augmented its support after 1990. In the Eighth Five-Year Plan (the "908 Plan" for the years 1991~95), investment of funds was concentrated in five core priority enterprises (Hua Jing Electronics, Hua Yue Microelectronics, Shanghai Bei Ling, Shanghai Advanced Semiconductors, Shougang NEC Electronics). In the following Five-Year Plan, the "909 Plan" (1996~2000), there is the clear objective of domestic production of leading-edge chips (200mm wafers, mass production of processing thicknesses at the 0.5μm level, and so on). After 1990 the chip market expanded sharply, driven by home appliance growth and others, with an average annual growth rate of 25% in the 1990~95 time frame.

China's semiconductor industry lacks a sufficient accumulation of production technology and domestic demand is still small in consideration of its potential market, although it has expanded sharply. In both the production and market aspects, it must be said that it is still immature. Its world production share was a little over 2% in 1998, and as of 1997 its self-sufficiency ratio was slightly below 20%. Content-wise, it centers on the more labor-intensive back-end processing performed by more than 210 of its approximate 250 enterprises. Domestic production technology has at last achieved the 1μm level, indicating a lag of almost 10 years behind world advanced technology. Looking at the market direction, we see that in 1998 China's share of the world market at last reached 5%. The average unit price in China's market is about one-sixth that of the world average roughly ¥50 and in important components the concentration is on low-end products like transistors and diodes.

Examining semiconductor sales in China in 1998's first half, shown in Table 2-5, we see that of the top 10 firms most are foreign wholly-owned firms or joint ventures with foreign capital. Only two local companies made it into the ranking in that period. Moreover, the leading local firm, Hua Jing Electronics, sank from third place in 1996 to fourth in 1997 to sixth in 1998. Thus, the industry's immaturity is structured to depend on foreign capital, and its local firms do not possess sufficient international competitive power.

Table 2-5. Top 10 in Sales of China's Chip Makers (As of first half 1998)

(Unit: 1,000 RMB)

	Company	Sales	Configuration
1	Motorola	1,252,055	Parent company capital (Motorola)
2	Shougang NEC Electronics	334,274	Joint venture (NEC)
3	Shanghai Advanced Semiconductors	274,058	Parent company capital (Canada's Northern Electronics)
4	Shanghai Bei Ling	186,413	Joint venture (Bei Ling)
5	Nantong Fujitsu Microelectronics	117,578	Joint venture (Fujitsu)
6	Hua Jing Electronics	97,571	Government-run
7	Wuxi Huazhi Electronics	84,854	Joint venture (Toshiba)
8	Jiangsu Changjing Electronics	73,667	Changed from government-run to partnership
9	Shanghai Matsushita Electronics Semiconductor	52,795	Joint venture (Matsushita)
10	Alphatech Electronics of Shanghai	51,145	Joint venture (Alphatech)
-	Mitsubishi Stone Semiconductor	-	Joint venture (Mitsubishi Electric)
-	Hitachi Semiconductor	-	Parent company capital (Hitachi)

Notes: 1 RMB = US$8.280 = ¥15.7 (1997 rates, BOJ, "Comparative Economic and Financial Statistics")
Shaded area: Local firm
Sources: Nantong Fujitsu Microelectronics, others

In the autumn of 1998, however, Shanghai Bei Ling decided on full-scale foundry participation in order to accommodate to the increase on domestic design and other companies without fabrication capabilities and to production line insufficiencies. The company differs from its Taiwanese and Singaporean counterparts in that it will for the time being cater to domestic needs, but this movement is being closely followed as a new business development in China. While semiconductor plummeted in every other country after 1996, China's continued to grow more than 20% every year on the back of memory chips for home appliances and computers. Taking into account these indications of local enterprise growth and the potential market scale, there is a high probability that the country's industry will move forward substantially in the period ahead.

As a result of the advantages outlined in Table 2-6, many Japanese semiconductor manufacturers have already begun production in China.

Table 2-6. Advantages of China for Japanese Firms

Costs	Real estate, personnel and other costs all lower
Personnel	Quality personnel and abundant labor can be stably secured
Production capability	Providing for insufficient chip production capabilities
Geographical balance	Establishing Asian production bases as part of global strategy
Future market	Securing a route to a promising market (including equipment as well as chips) and a clue to ascertaining local needs
Relations with government	Constructing a good relationship with the Chinese government to smooth business negotiations

Source: On-site visits and interviews

In Table 2-5's display of the top 10 in sales, we see four Japan-linked companies. Two more are coming into the production arena, and in March 1999 Shanghai Hua Hong NEC Electronics completed China's largest semiconductor plant.

But the business results of these companies are not necessarily favorable. Among them we find some that failed to investigate commercial possibilities in China, and went in just because others were doing so; they cannot switch to full operation and are fighting a desperate battle. Yet for most of them the government's fickle policy is the main reason they find it hard to formulate business strategy. For example, the government previously took positive measures to entice them into back-end chip processing, but now the objective is accumulation of continuous production technology and the priority has shifted to design and front-end processing. For this reason, other than NEC's two continuous production bases, the Japan-related firms that have remained as back-end processing specialists in consideration of costs and demand now find themselves getting less government support than before, and many complain of a poorer business environment.

There are nevertheless examples of companies that have accurately ascertained local demand and other factors, taken measures for development and successfully expanded business in this situation. Nantong Fujitsu Microelectronics is one of them. Most Japanese firms that have gone into China have taken over back-end processing of DRAMs and other parent-company products, and almost their entire output is bought back by the parents. Nantong Fujitsu accepts back-end production on contract orders from firms other than its parent, including Chinese domestic enterprises, in a role not dissimilar to a back-end processing foundry. The products handled are low-end, centering on logic chips. Differentiating itself from the Thai and Philippine companies doing the same business, Nantong Fujitsu increases added value all the way through inspection. In addition, the company has thoroughly cut costs by converting a former school building to a plant, making aggressive use of old facilities, and other measures.

4.2. Outlook and Issues

According to the Chinese government, the country's semiconductor market in the decade ahead will maintain growth at an average annual rate of around 15%. Based on this potential scale and all-out government support, China's chip industry seems poised for accelerated development over the intermediate and long terms.

Via its "909 Plan," the government aims at accumulating continuous production technology for the most advanced semiconductors, including design. In parallel, its policy calls for making foundries take root and quickly raising the chip industry accumulation. To these ends, it is studying multi-faceted support, including supply of funds on an unprecedented scale, constructing industrial parks and otherwise readying the R&D environment, and promoting industry-academic ties.

But to bring about the chip industry development desired by the government, many peripheral problems must be solved. They include upgrading technology, increasing demand, fostering peripheral industries, preparing the social infrastructure, cultivating engineers and managers, and smoothing negotiations with the government. The largest of them all is perhaps the product demand necessary for higher technology, and which is presently non-existent domestically. In development of China's chip industry, boosting this domestic demand is also an urgent issue.

For joint ventures in China, another point of concern is the lowering of employee motivation arising from the system of paying the "same wages for the same jobs" as those in the locality this means that local staff and partner company employees can secure the same income for the same types of jobs. It will be important to revise this system in order to improve workforce quality.

4.3. The Principal Manufacturers and Government-Related Projects

1) Overview of the "909 Plan"

This is the first large-scale national project aimed at fostering the semiconductor industry, and the most important segment of the Ninth Five-Year Plan.

NEC was among the forerunners in cementing close relations with the government and local enterprises to build business aggressively. The government, recognizing the achievements of Shougang NEC Electronics, requested its participation in the project. As will be seen later, both Shanghai Hua Hong NEC Electronics and Beijing Hua Hong NEC IC Design were established as part of this. Motorola is also presently constructing a line with the same level of technology but whose production capacity is expected to exceed that of Shanghai Hua Hong NEC Electronics. And the Philips joint venture Advanced Semiconductors is augmenting its Shanghai plant in this connection.

2) NEC's new bases (Shanghai, Beijing)

Shanghai Hua Hong NEC Electronics is a joint venture established in July 1997 by NEC and the China Shanghai Hua Hong Group Corporation. In March 1999 it completed a new plant in Shanghai and began continuous production. In the joint venture, the government's objective is to bring in leading-edge technology; this is congruent with NEC's needs for a new front-end processing base in Asia as part of its own global strategy. NEC, however, is believed to have taken a broad view of multifaceted business development in China as a hypothesis within the joint venture's intermediate/long term strategy. The total investment amount is about $1 billion, of which capital is $700 million. But the share breakdown is about 70-30 in favor of the Chinese side, whose group includes the city of Shanghai. This ratio shows serious government support of the chip industry. Using the most advanced 0.35μm process technology, initial production capacity will be 5,000 200mm wafers per month; by the end of 2000 this is to go to 20,000 per month, making it the country's largest semiconductor plant. For the time being, production will center on 64M DRAMs for the Japan market. After 2000, output of logic chips and others for AV home appliances and computers will begin. Target markets for the future include not only China but the ASEAN countries, Japan, Europe and the U.S. A wide range of business development is under study, including foundry work.

Beijing Hua Hong NEC IC Design was established in July 1998 to support Shanghai Hua Hong NEC Electronics in design and marketing, and began operations in January 1999. Of the total $30 million invested capital is $20 million, with an approximate breakdown of 40% by the Chinese side (a new company created for the purpose of investing in the joint venture) and 60% by NEC. The JV is positioned as the country's first full-scale design firm, and is intended to improve the design technology of both partners.

Table 2-7. Currency Conversion Rates (per US$, as of calendar yearends)

	Korea won	New Taiwan dollar	Singapore dollar	China RMB	Japan yen
1995	774.70	27.265	1.4143	8.317	102.83
1996	844.20	27.491	1.3998	8.298	116.00
1997	1,695.80	32.638	1.6755	8.280	129.95

Source: Bank of Japan, "Comparative Economic and Financial Statistics"

III Corporate Strategies in Japan's Semiconductor Industry

1. Adjustment of Problems

The countries that have led Asian semiconductor growth in recent years Korea, Taiwan, Singapore and China, expected to show high growth in future, all possess such problem areas as fostering peripheral industries, adding value, breaking away from government dependence, and improving technology. But they must at least assure their own positions within the international division of labor that is the industry trend, and in China's case strengthen a market environment pregnant with potential, and bolster full government support. In Japan, a chip industry dominated by integrated electrical manufacturers that principally service internal divisions and a limited number of other customers has not yet sufficiently broken away from its old business pattern.

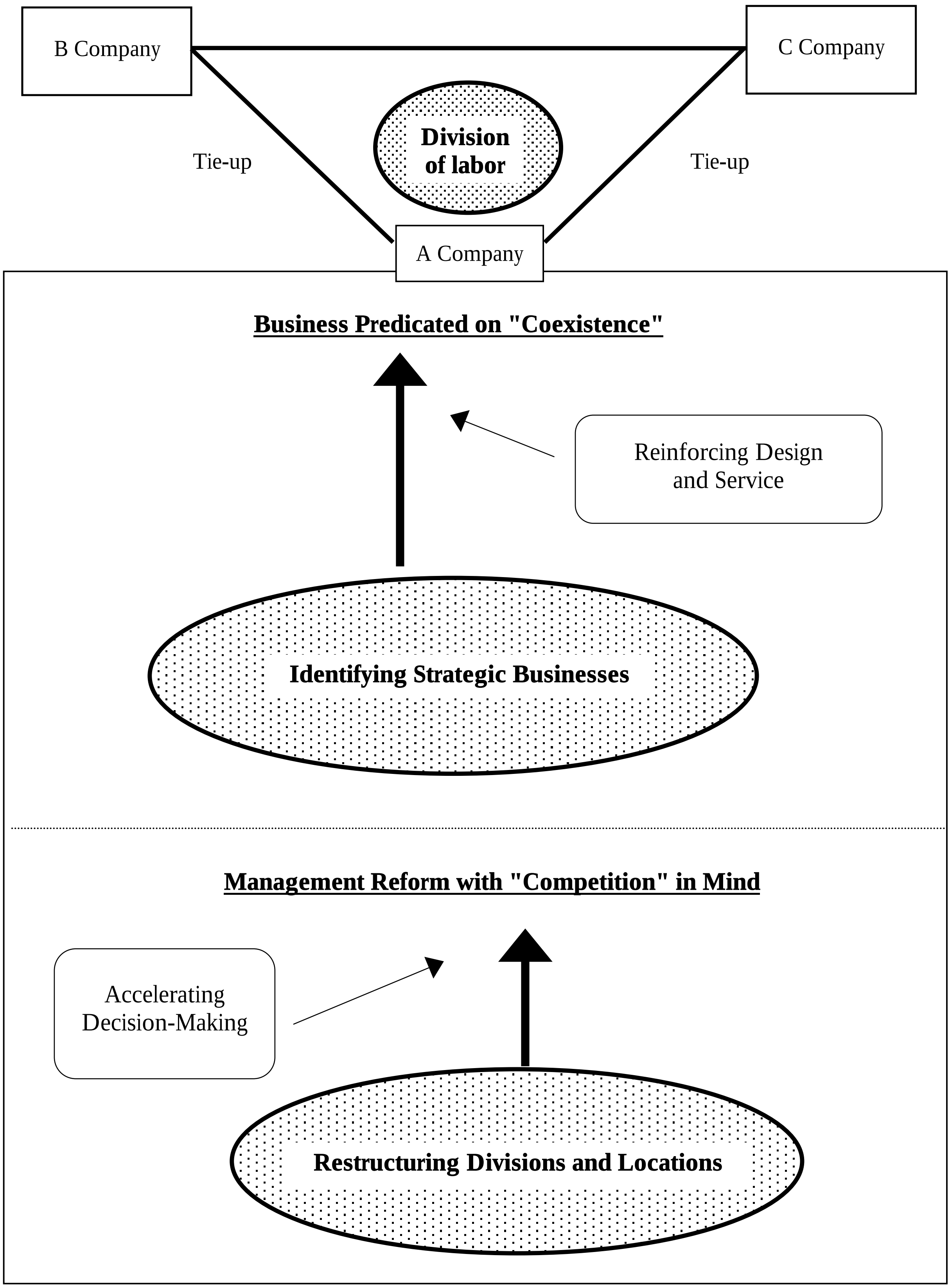
Of course, this traditional business pattern did not emerge as a problem because the mix of product classes, generations and production processes were not as complex as today. It has rather been a source of strength, since needs can be efficiently addressed if the sources of demand are internal or affiliated companies. But with diversification of the electronic equipment market have come a multiplication of product types, small-lot production and high integration, and it has become equally difficult for every company to arrange its product lineup. This has made it necessary for the Japanese firms to change radically their ways of doing business, by narrowing their fields to those wherein they have competitive advantages, or by seeking aggressively new markets outside their internal divisions and external affiliates. Then they must stimulate the sagging domestic market and work to maintain expansion, while promoting development of overseas markets even more aggressively with an ever-greater consciousness of the necessity of international competition.

In the world chip industry we are seeing steady progress toward an international division of labor, including the U.S., Europe and Asia. Japan is presently lagging this trend, to the point where it can be said to have lost its position. Japan has arrived at a time when it must plan for swift revision of its business and organization, and create clear corporate strategies for coping with a new era.

2. Corporate Strategies for the International Division of Labor

The key phrases for Japan's corporate strategies in the era ahead are "Business predicated on 'coexistence'" and "Management reform with 'competition' in mind." Figure 3-1 shows these concepts in graphical form.

Figure 3-1. Corporate Strategies Required in the New Era



Source: JDB

2.1. Business Predicated on "Coexistence"

The tendency among Japanese chip makers has heretofore been to regard the Korean, Taiwanese and other Asian firms as rivals following in their wake. Nor have the Japanese been particularly aggressive about tie-ups with U.S. and European companies. Going forward, however, it will be advantageous to develop strategic businesses efficiently on the premise of "coexistence" with the domestic and overseas enterprises that have enhanced their competitive power. Toward that end, each Japanese firm must first identify its strategic businesses and make intensive investments of management resources in them. In addition, it must fortify the design and service aspects, add value, and secure its position in the world.

1) Identifying strategic businesses

Upon identification of strategic businesses, the chip products must address specific electronic equipment needs and be matched with each company's technological strengths at the same time. Heretofore, the semiconductor divisions of the integrated electricals gave priority to technology improvement and keeping up with each other, and if they did not necessarily or always address those specific needs, deficiencies could be handled internally somehow. But in fair international competition, those who are earliest in offering products to meet needs can capture the market.

Transistors for radios in the 1950s, ICs for pocket calculators in the 1960s, LSIs for large computers in the 1980s history shows that there must first be demand for electronic products, then the market for the necessary semiconductors grows. Demand for each of these products arose within Japan and drove the domestic industry to accommodate it. The 1990s, however, have seen the locus of the electronic equipment market shift to the U.S. with the advent of the personal computer era. This has meant that Japan's chip makers could not accurately ascertain needs, and the market was snatched away by the U.S. and others. But with digital home appliances Japan's specialty field booming large on the horizon, there is an excellent opportunity ahead for the integrated electricals' semiconductor divisions to ascertain needs in liaison with their equipment divisions and assure international competitiveness.

2) Reinforcing design and service

The digital home appliances and others for which there are high hopes are mounted with system LSIs, whose world market scale was slightly below $1.6 billion in 1997 and is expected to jump to $13.5 billion in 2001. For Japan's semiconductor makers that are strong in those appliances, it will be essential that they respond to this opportunity going forward.

System LSIs are ICs that combine multiple functions. Design is an important element in production. But design is the specialty of U.S. companies, and it has to be said that in Japan there is an extremely thin accumulation of this technology. Accordingly, for the country's chip makers it is desirable to acquire combining technology through reinforcing design, to make proposals as systems congruent with their strategic businesses, and thereby to increase added value yet further. And because the diversification of electronic gear requires an increase in types of LSI functions, no single company can make them all; it is therefore natural that the trend in the design field runs toward IP use. Looking ahead, cultivating design technicians to cope with IP should be more aggressively pursued.

In addition, much is being said lately about raising the level of hardware technology, now mismatched with demand. For the Japanese firms heretofore increasingly dependent on technology, offering high added value services is effective in boosting competitiveness outside that aspect. Singapore's Chartered Semiconductor Manufacturing provides its own "Chartered Express" service, whereby it seeks differentiation from other companies; if it can tighten relations with customers, a more stable business development will be possible.

2.2. Management Reform with "Competition" in Mind

In planning for conversion to corporate organizations with sufficient international competitiveness, Japan's chip makers face urgent issues not only those of accelerating the decision-making process and the like, but also the restructuring of existing divisions and locations in order to carry out radical management reform.

1) Restructuring divisions and locations

As their description implies, the integrated electrical makers have multiple divisions (and their associated locations). At any given time, some may be in deficit while the others that are doing well compensate, so there has been little sense of risk and no felt need for radical restructuring. Or else it was extremely difficult to implement reforms even if attempted, because of the priority given to preserving employment. In future, however, gaining international competitive power mandates attaching importance to the profitability of divisions or locations, pursuing restructuring of unprofitable activities even at the cost of reducing hitherto sacrosanct employment, and improving the management efficiency of the enterprise as a whole. It can even be further said that if the mindset of interdivisional compensation were wiped away, there would be a contribution to improved efficiency.

The Korean business conglomerates are often compared to Japan's integrated electricals and other major enterprises, in that their management has long been inefficient. But on the opportunities presented by current structural reform of the conglomerates, restructuring of their divisions is also going ahead full steam. Among them, Samsung Electronics has transferred to Hewlett Packard all its stock in the 45-55 joint venture company formed in May 1998 with HP for sales of PCs and others, and has withdrawn from the business. And in January 1999 Samsung announced the sale of its wholly-owned U.S. subsidiary AST Research. In the semiconductor field as well, April 1999 saw completion of the sale to the U.S.'s Fairchild Semiconductor of the non-core power device segment, and complete withdrawal from that business as well. In employment, Samsung in 1998 cut 15,000 employees from the payroll through voluntary retirements and formation of internal companies. As a result of this restructuring policy, the company in that year saw its first profit increase in three years, with net up 153% year-to-year, and going into 1999 appeared to be positioned for further growth.

2) Accelerating decision-making

The integrated electricals have historically had complex organizations in which responsibilities were unclear; one of their weak points was that they therefore lagged in the speed of decision-making and other management aspects. The foundries that have grown so sharply are the reverse of this, and some say that is the reason the Japanese companies can never be converted to foundries. The slowness of their management may be directly connected to loss of business opportunities, and it must be said that this is lethal. Not only that the inefficiency of slow decision-making impacts adversely on employee motivation, with a consequent indirect effect on work quality and efficiency. At the same time that the Japanese firms physically adjust unprofitable divisions and employment, it is important to improve this longtime, deep-rooted corporate culture and management system. What must be addressed most urgently is the speed of decision-making.

An example of success in management reform is the U.S.'s highly-rated GE, which in the 1980s already recognized the importance of improving management speed. Toward this end, it promulgated a strategy of simplifying and accelerating the decision-making process. Since then, the management efficiency of the corporation as a whole has moved forward, through administration of multiple indicators across the design and development, manufacturing and organizational administrative divisions.

For Japan's chip makers to confirm anew their positions in an industry moving into the international division of labor era, they must convert from the old paradigm of diversified business and ever-larger investment costs to efficient businesses based on "coexistence" and "competition." Moreover, they must in future pursue diversified collaboration not only among themselves but with the direct and indirect users of semiconductors. In other words, while expanding substantially the uses of semiconductors, to address wider needs they must recognize the importance of exchanging information with such other industries as games (contents), autos and auto parts.

3. Moves of the Principal Manufacturers

Taking their cues from the position of Japan's industry in this difficult situation, companies are already undertaking various studies of future projects, restructuring policies and the like. Table 3-1 summarizes, as representative examples, some of the moves being made by the five integrated electricals.

The general tendency shared by all is encounters with stiffer competition from Korean and other firms in their principal traditional businesses, forcing rationalization and concentration in the DRAM sector. Strategic businesses are, within the DRAM field, gravitating from general-use to high-speed products, or from DRAMs to flash memory, logic chips, system LSIs and other products. Reflecting these trends, the development of bases or locations is moving in the direction of closing down U.S. and European DRAM plants, as has been seen since 1998 in the cases of Hitachi, Fujitsu and Mitsubishi Electric. But NEC's policy is one of "balance" and "integrated capabilities," wherein the company continues its aggressive involvement in such next-generation leading products as high-speed Rambus DRAMs and high-speed VCMs (virtual channel memories) within the DRAM field. In contrast to the shutdowns of overseas DRAM production facilities carried out by others, NEC in February 1999 started operations at its new large-scale DRAM plant in China, underlining its commitment to "balance" in business development.

Including the DRAM field as aforementioned, three major trends can be discerned in respect of tie-ups. To bring down DRAM R&D costs, the Japanese manufacturers are all moving in this direction. December 1998 saw Toshiba link up with Fujitsu for development of next-generation DRAMs, and in June 1999 NEC and Hitachi announced a tie-up that would initially concentrate on joint development and later extend to production and sales. The second major trend involves outsourcing of production to Taiwanese foundries and others, against a background of mounting investment costs for DRAM manufacture. Toshiba and Fujitsu in particular have expanded the scope of such outsourcing, and are providing technology predicated on consignment production carried out heretofore. The third and final trend relates to system LSIs, seen as an important future field and in which the semiconductor makers are teaming up with those of equipment and other user products. In December 1998, Mitsubishi Electric announced joint development with Matsushita Electric and Matsushita Electronics of system LSIs for information home appliances and next-generation process technology. Toshiba also tied up with Sony Computer Entertainment for Sony's next-generation home game machines. Amid ongoing conservatism by Japan's chip makers about capital investment there are still plans to invest more than ¥100 billion in this business, and as an unusually bullish theme in these times it is attracting great attention.

Aside from the foregoing, there are special factors at work in each company. In a first for Japan's chip makers, for example, NEC has switched from purchase of facilities to leasing.

Toshiba has sold its ATM business to Oki Electric and withdrawn from the unprofitable division, in a move intended to boost its overall competitiveness. Hitachi has pulled out of semiconductor production in the U.S. and strengthened its production base in Singapore. Fujitsu is stressing the software and service field, including design of IP and other chips. And Mitsubishi Electric has narrowed its strategic fields to system LSIs whose core technology is its mixed DRAM-mounted eRAM.

In the management realm there are moves toward organizational revision, including employment adjustment. Toshiba's 1998 adoption of the executive officer system has brought down the number of officers, and from FY 1999 introduction of an internal company system has been doing the same for other employees; this management reform aims at speeding up decision-making and other benefits. Hitachi has introduced both systems starting in FY 1999, with the same objectives. And both NEC and Mitsubishi Electric are planning personnel cuts, including some at subsidiaries.

Table 3-1. Examples of Coping by the 5 Integrated Electrical Makers

(1/2)

	NEC	Toshiba	Hitachi	Fujitsu	Mitsubishi Electric
Identifying strategic businesses	• Bolstering system LSIs • Continuing stress on DRAM business (especially 128M and next-generation high speed DRAMs) • Independently-developed PC memory (virtual channel memories) business	• Fortifying ASIC and non-memory business • Strengthening screen image processing field, a company specialty	• Shifting from memory chips to system LSIs • Stressing "SH" series high function microcomponents, moving into digital information home appliances and others	• Shifting locus from hardware to software and services • Shifting locus from DRAMs to flash memory • Shifting from general-use DRAMs to high speed DRAMs • In logic chips, stressing communications ICs	• With specialty microcomponents and eRAM technology as core, boosting system LSIs (shifting from general memory dependence to IP-driven systems) • Fortifying flash memory • Strengthening high frequency, optical medium and power device fields
Restructuring divisions and locations/bases	• April 99: revised system LSI department from product units to units for each market (consumer, network, PC and peripheral equipment) • Feb. 99: Shanghai Hua Hong NEC Electronics began DRAM production • Chip facility procurement changed from purchase to leasing	• March 99: Closed U.S. plant (ASIC trial production), concentrating this activity domestically • April 99: merged chip business division with independent sales division, strengthened global response to major customers and market-specific sales organization • April 99: sold ATM business to Oki Electric, and dispatched to Oki 300 people from Toshiba parent and affiliates	• March 98: Abolished Twin Star Semiconductor joint venture with U.S.'s TI, closed plant • End-Sept. 98: closed own U.S. plant (4M DRAM production) • Sept. 98: closed Musashi plant • In future, concentration of manufacturing bases to continue, such as that of advanced package assembly in Hitachi Yonezawa Electronics • During FY 99, concentration of 64M and higher DRAMs in Singapore • April 99: transferred silicon wafer business sales to Shinetsu Chemical, withdrew from wafer production • April 99: changed washing machine, vacuum cleaner and lighting divisions to internal companies, and shifted air-conditioner, refrigerator and VTR divisions to existing subsidiaries	• Oct. 1997: Spun off synthetic chemical chip business (concentrated in manufacturing subsidiary Fujitsu Quantum Devices) • Dec. 1998: closed 16M DRAM production plant in Durham, UK • Abolished European JV with U.S.'s TI • Back-end processing line fusion (sold plants in Ireland and Singapore) • Closed Aizu plant (logic chip production)	• Withdrawal from domestic general-use DRAM business • March 98: closed U.S. DRAM production plant • June 98: closed German assembly plant • Nov. 98: Closed U.S. assembly plant • FY 98: overseas restructuring largely complete • Concentration of 180 domestic affiliates into about 140
Employment adjustment	• 15,000 (10%) to be cut on consolidated basis over 3 years from 1999 (by normal attrition and reducing new hires, 9,000 domestically, 6,000 overseas) • 3,000 cuts (50%) in unprofitable overseas Packard Bell NEC subsidiary • For global support of business organization by market, increase LSI designers from 450 to 800 in FY 2000 • Domestically, to strengthen consumer market, double development and design personnel to 400 in 5 years • Study internal company creation, restructuring group companies, absorption by head office	• 6,000 cuts on parent basis in FY 97-98. • 900 cuts in home appliance sales company • Internal company system from FY 99 (chips go to Semiconductor co.), head office staff cuts 50%+ (studying holding company) • Brought in executive officer system from June 98, number of officers cut from 33 to 12	• 4,000 cut in the second half of FY 98 on parent-only basis • About 500 cut from home appliance sales company • Introducing internal company system from FY 99, head office staff to be cut 50%+ (studying business holding company) • Introduction of executive officer system from FY 99, officers cut from 30 to 14 at end of June	• To increase number of system LSI layout design technicians (solution engineers for IP consulting)	• To cut 14,500 on consolidated basis by FY 2001 (8,400 domestic, 6,100 overseas) • To cut 6,000 by FY 2001 on unconsolidated basis • Cut number of officers from 36 to 23 • Add 500 design technicians in FY 98-99 to boost importance of system LSIs • FY 98: cut 2,600 consolidated and 1,000 unconsolidated vs. previous FY

	NEC	Toshiba	Hitachi	Fujitsu	Mitsubishi Electric
Tie-ups	• June 99: comprehensive DRAM business tie-up with Hitachi • Supplying mixed DRAM mounting technology to Rohm • Sept. 98: Tie-up with Lucent Technologies for next-generation communication equipment, system LSIs for information home appliances • Grant of independently-developed memory licenses to Siemens and Hyundai Electronics • Nov. 97: Joint development with Philips of system LSIs using high-function microcompon-ents, and mutual supply • Technology exchange with Samsung Electronics • Oct. 98: tie-up with 3 leading Taiwan manufacturers in high-speed memory field for personal computers	• Dec. 98: Tie-up with Fujitsu for next-generation DRAM development • Established JV firm with Sony Computer Entertainment for 128 bit CPU for next-generation game gear • Tie-up with U.S.'s MIPS Technology for 64 bit RISC microcomponents, year 2001 commercialization target for microcomponents for STB of digital TV • Oct. 98: On tie-up with Motorola, Siemens & others, "Virtual Component Exchange (a group promoting IP trading) " starts • Supplies DRAM technology and outsources some 64M DRAM production to Winbond • Establishes chip assembly JV with Taiwan's Walsin Advanced Electronics • June 97: supplies technology to Chartered Semiconductor Manufacturing	• June 99: comprehensive DRAM business tie-up with NEC • Tie-up with Mitsubishi Electric for flash memory development, work completed on industry's largest (256M) product • Dec. 97: tie-up with ST Microelectronics to develop "SH-5" next-generation microcomponent	• Jan. 98: Tie-up with Sony for development of mixed DRAM-mounted next-generation LSIs • Dec. 98: Tie-up with Toshiba for next-generation DRAM development • JV with AMD for flash memory • Expansion of production outsourced to TSMC • Feb. 99: supply of DRAM manufacturing technology to Acer Semiconductor (and consignment production)	• Dec. 98: Tie-up with Matsushita Electric and Matsushita Electronics for joint development of system LSIs and next-generation process technology • Tie-up with Hitachi for flash memory development, work completed on industry's largest (256M) product • Tie-up with Rohm for eRAM/system integration, full collaboration in Rohm's system LSI development • Tie-up with Motorola in DRAM-mounted system LSI field • Tie-up with Lucent Technologies for joint development of chips for multi-media equipment • Dec. 98: Tie-up with ST Microelectronics for joint development and production of 64M multi-level flash memory • Outsources 64M DRAM production to Power Chip Semiconductor

Source: Electronic Journal, *Semiconductor Data Book 1999*, newspapers and other public information

4. Conclusion: Desirable Policies

As we have seen, Japan's chip makers are at last formulating clear corporate strategies. But they are still only at the beginning stage. Actually, their business policies at the present juncture are generally limited to reducing the risks of the DRAM business, and it is desirable that they define their strategies more precisely and seek to add value. Including the management aspect, whether they can achieve a conversion to radical corporate strategies will depend on how they deal with the situation going forward.

Within Asia, we see swift progress in structural reform of Korea's business conglomerates with results already beginning to appear. In Taiwan and Singapore, foundries are being strengthened centering on U.S. and European collaboration, and signs of renewed growth are visible. In addition, the vast potential of China is catching up in their wake. In a semiconductor industry for the time being subject to swift change and beset by stiff competition, Japan's companies must still devise corporate strategies sensitive to the situation and take additional action based on accelerated decision-making, if they are to secure their positions in the world.

Finally, in this corporate self-help effort the support of the government is still indispensable. When the Japanese chip industry was in its infancy, there was a major contribution from government financial support for equipping corporate production bases. But an industry that has gotten as big as it has cannot expect that kind of contribution from government support on the old model alone.

What is required is a new paradigm for government support. Specifically, we can cite (1) preparation of an environment conducive to semiconductor demand creation, (2) support for technological development, and (3) removal of barriers to revival of the industry as a whole.

For (1) above, we need to see more aggressive and rapid promotion of information communications policy, including infrastructure preparation and deregulation. In Asia, there is already intensifying competition among cities revolving around intensive information facilities; in Singapore and Malaysia there are national projects related to information communications, called "Singapore One" and "Multimedia Super Corridor," respectively, that are beginning to show results. U.S. and European communications firms have not been slow to take part in these projects. Not only in semiconductors but in the information communication field as well, a U.S.-Europe-Asia axis is taking shape. Other important issues are fostering the contents industry in which the U.S. and others are leading, and bolstering network services. Even if the infrastructure is in order and the environment favors the use of communications, if there are no worthwhile contents and services the number of users cannot be increased. This is why support for the industry is necessary from the standpoint of new demand creation.

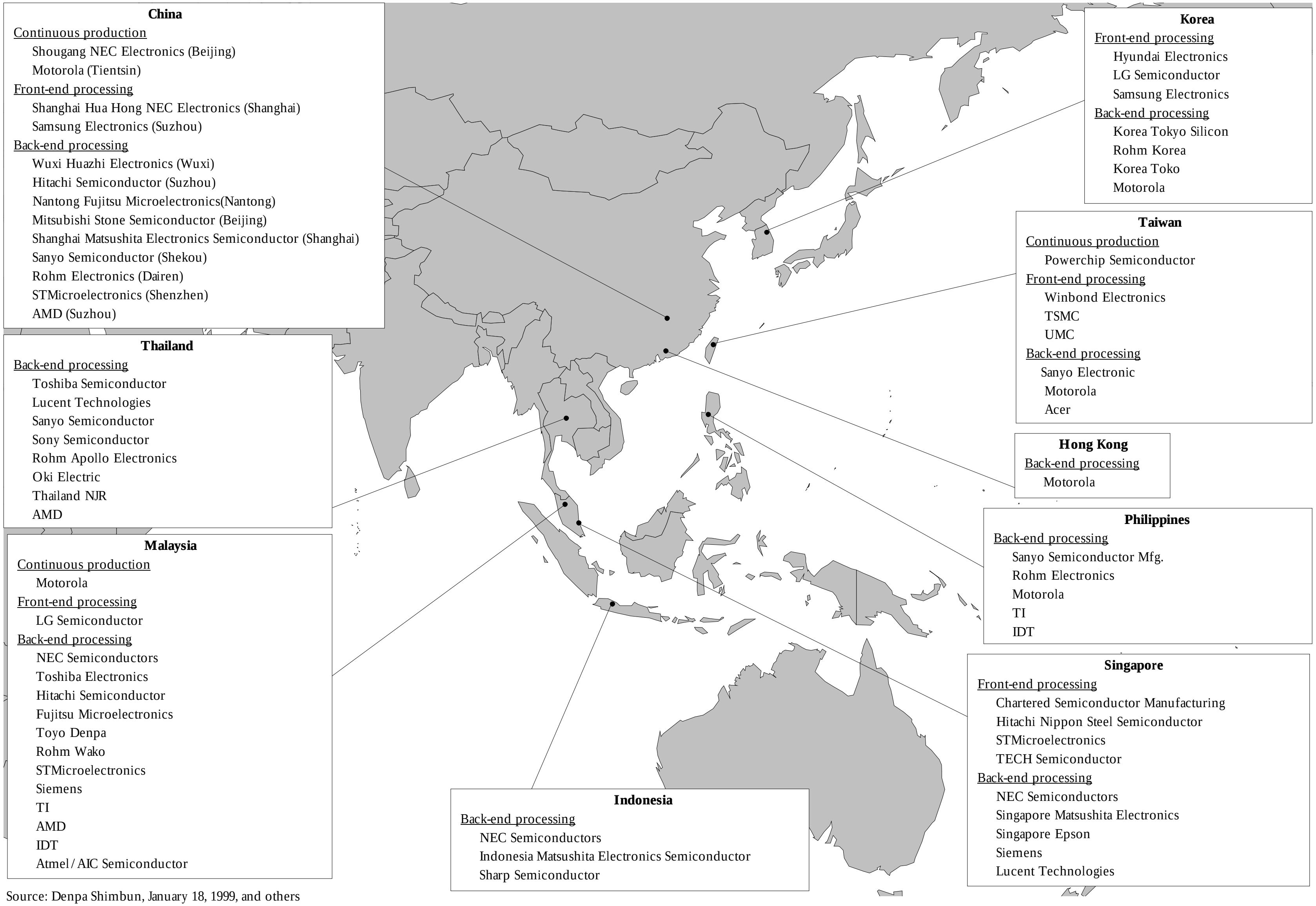
In respect of item (2) above, the erosion of Japan's advantages as a production base makes it essential that it strengthen its position as a technology development base. Here "technology development" does not necessarily mean pursuing the most advanced technology, as in the past. Rather, it refers to mounting requirements for development based on needs, in a hardware subsector that has stabilized at high levels, and to software technology accumulation, including design. A system is necessary whereby academic research and technology development can be efficiently commercialized, and a venue provided wherein researchers and businessmen can exchange information. Such means of support must be widely studied.

Removal of obstacles to industry revival, (3) above, embraces a wide range of content including the legal underpinnings for corporate partition or spin-outs, personnel cultivation and movement, and others. As business diversification moves forward Japanese corporations expand employment, highlighting problems of management inefficiency against a background of stiffening international competition. It has already become a pressing issue of business concentration and personnel reductions. It can be said that the integrated electricals are representative in this regard, but if they are to tread on sacred ground they will need an environment wherein the adverse impact on employment can be minimized. Some examples are preparation of the legal framework for MBOs and the like, retraining of employees looking to move to new occupations, proving appropriate job-finding information, and others within the barrier-removal category.

In tandem with globalization of corporate activity, there should also be a more positive approach to intergovernmental negotiations and above all government support congruent with corporate needs. For the future development of Japan's semiconductor industry, the private and public sectors must merge their separate roles into one.

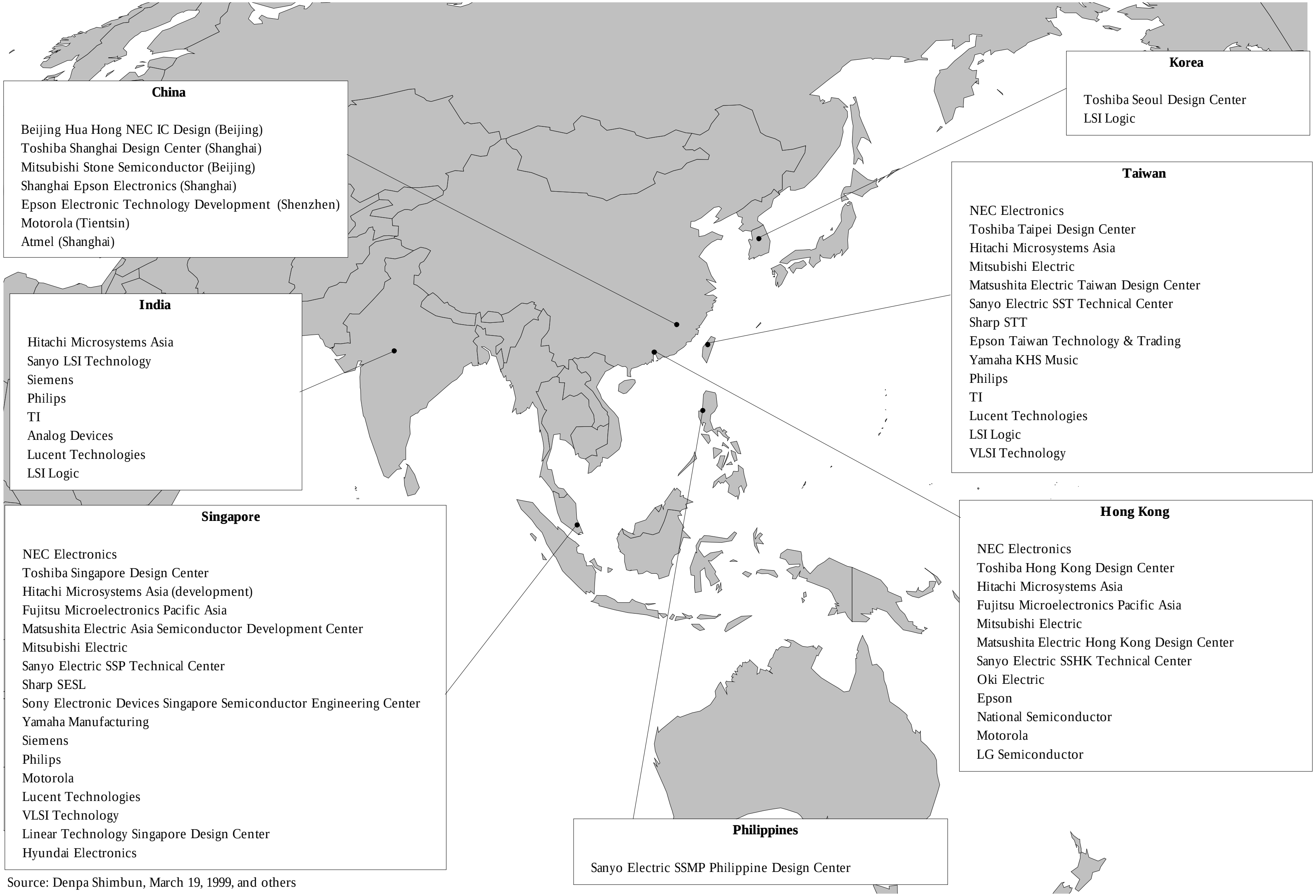
[Kyoko Amano (E-mail: kyamano@dbj.go.jp]

Appendix Figure 1. Asian Production Bases of the Principal Chip Makers



Source: Denpa Shimbun, January 18, 1999, and others

Appendix Figure 2. Asian Design Bases of the Principal Chip Makers



Source: Denpa Shimbun, March 19, 1999, and others

References

Daewoo Securities Co., Ltd. 1998 (Spring). *Kankoku Jojo Kaisha Survey Toshi Guide (Survey of Exchange-listed Korean Corporations: Investment Guide).*

Daiwa Institute of Research. 1998. *Singapore no Electronics Sangyo (Singapore's Electronics Industry)*

Denpa Shimbun. January 18, 1999, March 19, 1999, May 31, 1999.

Electronic Industries Association of Japan. 1998. *Sekai no Denshikiki to Handotai Shijo no Chuchoki Tenbou (Medium- and Long-term Outlook for the World Electronic Equipment and Semiconductor Markets).*

Electronic Journal. *Semiconductor Data Book*. 1999. and other annual editions.

Global Net Corporation. 1997. *Semiconductor Almanac.*

-- and Nikkei Business Publications, Inc. 1999. *Sekai Handotai Kojo Nenkan 1999 (World Semiconductor Plant Yearbook 1999). Nikkei Microdevice separate volume, Nikkei LSI database.*

Japan Development Bank . 1996. "Current Status and Future Perspective of the Japanese Semiconductor Industry," *JDB Research Report* **62** (November).

-- 1998. "Secret of the Taiwanese economy's strength, " *JDB Asia Trend* **9** (September) and other volumes

Nikkei Business Publications, Inc. 1998. "IP 1998, Series I", *Nikkei Microdevice separate volume, LSI design library.*

Nihon Keizai Newspaper Corp. *Nikkei Kaisha Joho*, 99-I (New Year) and 99-II (Spring) editions.

Nikkei Business Publications, Inc. 1998. *Nikkei Microdevice.* (September)

Omichi, Yasunori. 1990. *Handotai Gyokai (The World of Semiconductors).* Kyoikusha new publication.

Press Journal, Inc. 1999. *'99 Handotai Market, Kigyo, SPECIAL SURVEY 26 (The 1999 Semiconductor Market and Corporations).*

Sangyo Times, Inc. 1998. *Handotai Sangyo keikaku Soran (Overview of Semiconductor Industry Projects).* and other annual editions.

Seibundoshinkosha. 1984. *Color ban Saishin Zukai Handotai Guide (Latest Color Diagram, Semiconductor Guide).*

Semiconductor Industry News. 1999. *Kankoku to Taiwan no Handotai Sangyo wa Dounaru? (What Will Happen in the Korean and Taiwanese Semiconductor Industries?).* Forum 21 Documents (March).

-- 1998. *Silicon Foundry Saizensen to Sono Katuyou (The Silicon Foundry Front Line and Their Functions).* Forum 21 Documents (September).

World Markets Research Centre. 1998. *BUSINESS BRIEFING ASEAN: Semiconductor Manufacturing Technology*

WSTS Japan Conference Council. 1999. *Semiconductor Market Forecasts* Spring edition.

Company annual reports, homepages, others.

List of Back Numbers (Including JDB Research Report)

No.1 Corporate Strategies in Japan's Semiconductor Industry: Implications of Development in Other Asian Countries (This Issue)

JDB Research Report

No.96 Recent Trends in the Japanese Economy: Focused on Fixed Investment and Capital Stock, August 1999

No.95 Efforts to Protect the Natural Environment in the United States and Germany: Environmental Mitigation and Biotope Conservation, July 1999

No.94 Survey on Planned Capital Spending for Fiscal Years 1998 and 1999, June 1999

No.93 Towards the realization of 'environmental partnership': A survey of Japan's environmental NPO sector through comparison with Germany, June 1999

No.92 The Impact of Demographic Changes on Consumption and Savings, March 1999

No.91 Recent Research and Development Trends in Japanese Enterprises: Technology Fusion, March 1999

No.90 Recent Trends in the Japanese Economy: Prolonged Balance Sheet Adjustment, January 1999

No.89 Impact of Asset Price Fluctuations on Household and Corporate Behavior: A Comparison between Japan and the U.S., December 1998

No.88 Survey on Planned Capital Spending for Fiscal Years 1997, 1998, and 1999, December 1998

No.87 Foreign Exchange Rate Fluctuations and Changes in the Input-Output Structure, November 1998

No.86 Structural Changes in Unemployment of Japan: An Approach from Labor Flow, November 1998

No.85 Recent Trends in the Japanese Economy: Characteristics of the Current Recession, August 1998

No.84 R&D Stock and Trade Structure in Japan, August 1998

No.83 Survey on Planned Capital Spending for Fiscal Years 1997 and 1998, August 1998

No.82 The Significance, Potential, and Problems of DNA Analysis Research: Establishing Public Acceptance is Essential, May 1998

No.81 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1996, 1997 and 1998 Conducted in August 1997, March 1998

No.80 Recent Trends in the Japanese Economy: Growth Base of the Japanese Economy, January 1998

No.79 Information Appliances: The Strength of Japanese Companies and Tasks for the Future, January 1998

No.78 Challenges and Outlook for the Japanese Machinery Industries: Impact of ISO14000 Series and Environmental Cost, January 1998

No.77 Current Conditions and Issues of Computerization in the Health Care Industry : For the Construction of a Health Care Information Network, January 1998

No.76 Household Consumption and Saving in Japan, December 1997

No.75 The Direction of Japanese Distribution System Reforms: Strengthening the Infrastructure to Support Diverse Consumer Choices, November 1997

No.74 Foreign Direct Investments by Japanese Manufacturing Industries and Their Effects on International Trade, October 1997

No.73 The Impact of the Changing Trade Structure on the Japanese Economy: With Special Focus on the Effects on Productivity and Employment, October 1997

No.72 An Analysis of Foreign Direct Investment and Foreign Affiliates in Japan, August 1997

No.71 Recent Trends in the Japanese Economy: Stock Replacement and New Demand as Aspects of Economic Recovery, August 1997

No. 70 Corporate Fundraising : An International Comparison, June 1997

No. 69 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1996 and 1997 Conducted in February 1997, May 1997

No. 68 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1996 and 1997 Conducted in August 1996, August 1997

No. 67 An International Comparison of Corporate Investment Behavior: Empirical Analysis Using Firm Date from Japan, France and the US, April 1997

No. 66 Housing in the National Capital: Analysis of the Market for Housing using Micro Data, March 1997

No. 65 The Environment for Locating Business Operations in Major East Asian Cities, January 1997

No. 64 Direction of Reconstruction of Business Strategy in the Chemical Industry, January 1997

No. 63 Reflection on Discussions Concerning Regulation of the Electric Power Industry: Deregulation of the Electric Power Industry in Japan and Implication of Experiences in the United States, December 1996

No. 62 Current Status and Future Perspective of the Japanese Semiconductor Industry, November 1996

No. 61 A Breakthrough for the Japanese Software Industry?: Responsiveness to Users' Needs is the key, October 1996

No. 60 Recent Trends in the Japanese Economy Focusing on the Characteristics and Sustainability of the Current Economic Recovery, September 1996

No. 59 Analysis of the Primary Causes and Economic Effects of Information: Related investment in the United States and Trends in Japan, August 1996

No. 58 Selected Summaries of Research Reports: Published in FY 1995, June 1996

No. 57 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1995 and 1996 Conducted in February 1996, May 1996

No. 56 Recent Trends in the Japanese Economy, May 1996

No. 55 Issues Concerning the Competitiveness of the Japanese Steel Industry, February 1996

No. 54 Changes in the Financial Environment and the Real Economy, January 1996

No. 53 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1994, 1995 and 1996 Conducted in August 1995, October 1995

No. 52 Current Economic Trends: Focusing on the Appreciation of the Yen and its Effects, October 1995

No. 51 Problems Concerning the International Competitiveness of the Petrochemical Industry, October 1995

No. 50 An Economic Approach to International Competitiveness, October 1995

No. 49 Selected Summaries of Research Reports Published in FY 1994, July 1995

No. 48 Strategies for Improving the Efficiency of the Japanese Physical Distribution System: Part2, July 1995

No. 47 Issues on International Competitive Strength of the Auto Industry, June 1995

No. 46 Problems Concerning the International Competitiveness of the Electronics and Electric Machinery Industry, June 1995

No. 45 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1994 and 1995 Conducted in March 1995, June 1995

No. 44 Strategies for Improving the Efficiency of the Japanese Physical Distribution System, March 1995

No. 43 Capital Spending Recovery Scenario Cycle and Structure, August 1994

No. 42 Progress of International Joint Development between Industrialized Countries on the Private Level, May 1994

No. 41 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1993, 1994 and 1995 Conducted in August 1994 , November 1994

No. 40 Selected Summaries of Research Reports Published in FY 1993, June 1994

No. 39 Recent Trends in Japan’s Foreign Accounts, April 1994

No. 38 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1993 and 1994 Conducted in March 1994, April 1994

No. 37 Economic Zones and East Asia Prospect for Economic Activity Oriented Market Integration, December 1993

No. 36 Japanese Corporate Responses to Global Environmental Issues, December 1993

No. 35 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1992, 1993 and 1994 Conducted in August 1993, September 1993

No. 34 Structure of Profit to Capital in the Manufacturing Industry, September 1993

No. 33 Comparison of the Japanese and The U.S. Labor Markets, October 1992

No. 32 The Relative Competitiveness of U.S., German, and Japanese Manufacturing, March 1993

No. 31 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1992 and 1993 Conducted in March 1993, April 1993

No. 30 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1991, 1992 and 1993 Conducted in August 1992, December 1992

No. 29 Flow of Funds in the 80s and Future Corporate Finance in Japan, November 1992

No. 28 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1991 and 1992 Conducted in February 1992, April 1992

No. 27 An Analysis of Foreign Direct Investment in Japan, March 1992

No. 26 Projection of Japan's Trade Surplus in 1995: Analysis of Japan's Trade Structure in the 80s, February 1992

No. 25 Intra-Industry Trade and Dynamic Development of The World Economy, November 1991

No. 24 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1990, 1991 and 1992 Conducted in August 1991, September 1991

No. 23 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1990 and 1991 Conducted in February 1991, March 1991

No. 22 Trends of the Petrochemical Industry and its Marketplace in East Asia, March 1991

No. 21 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1989, 1990 and 1991 Conducted in August1990,September 1990

No. 20 Deepening Economic Linkages in The Pacific Basin Region: Trade, Foreign Direct Investment and Technology, September 1990

No. 19 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1989 and 1990 Conducted in February 1990, March 1990

No. 18 Petrochemicals In Japan, The US, and Korea an Assessment of Economic Efficiency, February 1990

No. 17 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1988, 1989 and 1990 Conducted in August 1989, October 1989

No. 16 Impact of the EC Unification on Japan’s Automobile and Electronics Industries, August 1989

No. 15 Industrial and Trade Structures and the International Competitiveness of Asia’s Newly Industrializing Economies, August 1989

No. 14 The Japan Development Bank Reports on Capital Investment Spending: Survey for Fiscal Years 1988 and 1989 Conducted in February 1989, March 1989

No. 13 The Japan Development Bank Reports on Capital Spending: Survey for Fiscal Years 1987, 1988 and 1989 Conducted in August 1988, September 1988

No. 12 Growing Foreign Investors' Activities and the Future of Internationalization, September 1988

No. 11 Futures Tasks and Prospects for the Japanese Machine-Tool Industry, July 1988

No. 10 International Division of Labor in the Machine Industries Among Japan, Asia's NICs and ASEAN Countries, June 1988

No. 9 Trends of the Petrochemical Industry and its Marketplace in East Asia around Japan, May 1988

No. 8 The International Competitiveness of Japan and U.S. in High Technology Industries, April 1988

No. 7 The Japan Development Bank Reports on Private Fixed Investment in Japan, March 1988

No. 6 Economic Projections of the Japan's Economy to the Year 2000, February 1988

No. 5 The Japan Development Bank Reports on Private Fixed Investment in Japan, September 1987

No. 4 Current Trends in the Japanese Auto Parts Industry in Overseas Production, July 1987

No. 3 Current Moves for Foreign Direct Investment into Japan, May 1987

No. 2 Overseas Direct Investments by Japanese Corporations, May 1987

No. 1 Current U.S. Consumption Trends, May 1987