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THE STATUS AND AN EVALUATION OF THE ELECTRONICS INDUSTRY IN TAIWAN

by

Gee San

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RÉSUMÉ

Le secteur des techniques de l'information a connu à Taïwan une croissance exceptionnelle au cours de la dernière décennie, au point qu'on le considère aujourd'hui comme l'un des premiers du monde. Massivement orienté vers l'exportation, il repose sur deux produits principaux - les micro-ordinateurs et les moniteurs d'ordinateurs -, au premier rang en termes de croissance et de parts de production. Eléments et composants électroniques font également l'objet d'une importante production. Ce type d'exportations taïwanaises reste caractérisé par sa faible valeur unitaire moyenne, sauf en ce qui concerne les moniteurs, qui ont rapidement atteint la moyenne mondiale.

La part des exportations des vingt sociétés dominantes a fortement diminué pendant la dernière décennie, témoignant du dynamisme du secteur des petites et moyennes entreprises. De même, la chute, dans ces exportations, de la part des sociétés à capitaux étrangers constitue un bon indicateur de la puissance relative des firmes nationales. Les échanges internationaux ne se concentrent plus uniquement sur le marché des Etats-Unis, grâce à une diversification réussie, notamment en direction de l'Europe.

L'étude de 318 entreprises de l'industrie électronique à Taïwan met en évidence nombre de différences significatives entre sociétés à capitaux nationaux et sociétés à capitaux étrangers. Ces dernières emploient une plus forte proportion de techniciens par rapport à leur main-d'oeuvre totale. Elles investissent davantage dans la formation des dirigeants et des ingénieurs. Elles consacrent aussi plus de moyens à la recherche-développement (R&D) et se tiennent plus volontiers à la pointe technologique de leurs secteurs respectifs que leurs concurrentes taïwanaises. Tandis que les entreprises à capitaux étrangers considèrent que les capacités limitées de conception de nouveaux produits de Taïwan créent d'importants goulets technologiques d'étranglement, les entreprises nationales se consacrent davantage à l'utilisation pratique des équipements techniques.

Les pouvoirs publics ont joué un rôle de catalyseur dans le développement de l'industrie électronique à Taïwan, à l'aide de prêts à faibles taux d'intérêt aux entreprises, dans le cadre du Programme d'aide aux industries stratégiques (Strategic Industry Assistance Program), grâce à des aides financières au bénéfice d'institutions-clés de R&D et d'assistance technique et enfin grâce à la création du Hinchu Science-based Industrial Park, destinée à inverser le "drainage des cerveaux".

SUMMARY

Taiwan's information technology industry has experienced phenomenal growth in the last decade, and it is currently ranked among the largest in the world. The growth has been overwhelmingly export-oriented, with microcomputers and computer monitors leading in terms of both growth and production shares. The island also has a very large production of electronic parts and components. Taiwan's exports of these information technology products still consists of items with low average unit value, though in the case of monitors its exports have rapidly converged to the world average.

The share of exports concentrated in the 20 leading firms has declined steeply over the last decade, reflecting the dynamism of the small- and medium-scale firm sector. Likewise the share of foreign invested firms in exports has fallen significantly, indicating the relative strength of domestic firms. The degree of concentration of information product exports on the US market has also fallen, reflecting successful diversification especially into the European market.

A survey of 318 firms in Taiwan's electronics industry reveals a number of significant differences between domestic and foreign invested firms. The latter employ a significantly higher proportion of technical personnel in relation to their total workforce. A higher proportion of foreign firms invest in training of managers and engineers. They also spend more per employee on research and development (R&D) and are nearer to the technological frontier in their respective fields than local firms. While foreign invested firms see limited product design capabilities in Taiwan as the major technological bottleneck, domestic firms are more concerned with the effective utilisation of tools and machinery.

The government has played a catalytic role in the development of Taiwan's electronics industry. It has provided low-interest loans to electronics firms under the "Strategic Industry Assistance Program", sponsored key R&D and technical support institutions, and established the Hinchu Science-based Industrial Park to promote a "reverse brain drain".

PREFACE

This paper by Gee San provides a most interesting account of the most dynamic industry in one of the most dynamic newly industrialising economies (NIEs). Based on an extensive survey of electronics firms in Taiwan, it presents a detailed view of the technological capabilities of those firms. The more interesting contrasts are those between wholly domestic firms and foreign invested firms. The evidence documented here sheds new light on the longstanding debate in development literature regarding the importance of foreign direct investment as a means of technology transfer. It also raises the question of the extent to which the experience of the electronics industry is representative.

Probably the most important contribution of this paper is that it helps to correct some possible misconceptions about the role which the Taiwanese government played in the development of the electronics industry. Contrary to a widespread belief, the government has played a critical role. Not only has it provided subsidised credit, but government-sponsored research institutes have acted as conduits for the transfer of foreign technology to local firms. Gee San points out that these institutes have played a catalytic role in the development of technological capabilities by small firms. But the paper also shows that nothing is static and that a certain point in the industry's development, the contents of government intervention, may have to be changed substantially. At the same time the balance between public and private sector R&D efforts will have to shift. The results of the author's survey indicate that a high percentage of firms recognise the importance of investing more heavily in their own R&D if they are to upgrade technologically, but Gee San raises the possibility that the government's active involvement in R&D may have retarded the development of R&D within the private sector. This in turn poses interesting questions for other developing countries, where the lack of private sector incentives to undertake R&D is often offered as a justification for government involvement.

Louis Emmerij
President of the OECD Development Centre
October 1990

I. INTRODUCTION

The history of Taiwan's Electronics Industry dates back to 1954 when NCR set up a branch office in Taiwan to engage in computer renting, selling and servicing. By the early 1960s, the Taiwan government had changed its Import Substitution Policies to Export Promotion Policies. Various preferential treatments for the export industry were introduced and export processing zones were also established to promote Taiwan products. Under these good conditions, Taiwan's low cost and highly efficient labor induced many foreign electronics firms to invest in Taiwan.

During this period, foreign electronics firms that invested in Taiwan were mostly engaged in the assembly business. Their main purpose was to take advantage of Taiwan's low cost labor and various preferential treatments, while, on the other hand, due to their participation, Taiwan's electronics industry grew rapidly in terms of employment, export, and GNP contributions. Moreover, foreign production technologies, management techniques, and sales methods were adopted by the local firms either directly or indirectly through technology diffusion. Undoubtedly, foreign firms played an extremely important role in the development of Taiwan's electronics industry.

Initially, during the 1960s and 1970s, the Taiwan government provided only tax deduction incentives to newly established/expanded local firms and foreign direct investment firms (FDI firms). But starting in the mid 1970s, with the rapid worldwide computer and semi-conductor growth and the increasing market competitiveness that compounded Taiwan's electronics industry's transformation problem, namely, increasing labor costs, the Taiwan government adopted a series of moves that enhanced its competitiveness.

These moves included designating the electronics industry as a strategic industry, giving even more preferential treatment, setting up the Industrial Technology Research Institution (ITRI) to engage in electronics research, establishing the Hsinchu Science-based Industrial Park to encourage more high-tech companies to establish branches in Taiwan, offering special incentives for developing new products, providing manpower training, and promoting new management technologies, etc.

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In this paper, we will examine several key problems that are critical to the future development of Taiwan's electronics industry. First, what is the status of Taiwan's information technology industries? Second, what are the roles of FDI firms in Taiwan's electronics, as well as information technology industry? Third, are FDI firms really more effective as a medium for technology transfer than either OEM or technological cooperation? Fourth, what are the major technological bottlenecks faced by Taiwan's electronics industry? And last, what roles and policies should the government adopt to overcome the technological barriers?

We hope this paper will shed some light on the future development of Taiwan's electronics industry and be beneficial to other developing countries as well. There will be five sections in this paper. In Section II, we will discuss the status of Taiwan's electronics industry. In Section III, we will evaluate Taiwan's electronics industry in terms of the current technology level, major development bottlenecks, and the role of foreign firms. After understanding the industry status, in Section IV, we will discuss the government's role and strategy in developing the electronics industry. Finally, in Section V, we will summarize the paper, outlining the future potential of Taiwan's electronics industry.

II. THE CURRENT STATUS OF TAIWAN'S INFORMATION TECHNOLOGY INDUSTRY

Taiwan's information technology industry has progressively played a very important role in Taiwan's exports. Based on Ministry of Finance statistics, Taiwan's information technology industry's export contribution to the country nearly doubled between 1985 and 1987. In 1985, it accounted for only a 3.97 per cent share of Taiwan's total export value or $1 220 million. But, by 1987, with its rapid growth, its contribution reached $3 701 million or 6.91 per cent. Though not projected in Table 2-1, if the volume growth of the information technology industry continues, it is obvious that by 1988 it will displace the shoe industry as a major export industry. Thus it will rank with the electronics and textile industries.

To further understand the current status of Taiwan's information technology industry, a comparison of Taiwan's hardware information technology products' value with those of other countries will be helpful. From Table 2-2, we see that Taiwan's 1987 computer hardware production value ranked seventh in the world at $3.8 billion. But considering its growth rate was the highest at 79 per cent, it can be expected to surpass Italy, France and even Britain to become one of the top five producers of hardware information technology products.

Also shown in Table 2-2 is a great disparity between the growth rates of NIEs (*i.e.*, Taiwan, Singapore, and Korea) and those of the developed economies (*i.e.*, Japan, Europe and the United States). The developed countries' average annual growth rates are all below 10 per cent, with Britain having the highest at 9 per cent. In contrast, the NIEs have annual growth rates of 63 to 79 per cent. As such, if this trend continues, it is expected that within the next three or four years, the three NIEs will be part of the top five producers in the world. These three emerging Asian tigers will replace West Germany, Britain and France.

Table 2-3 lists various of the Taiwan information technology industry's major products together with their respective production values. Throughout 1986 and 1987, parts and components, monitors, microcomputers, and terminals were Taiwan's four major information technology products. They accounted for more than 93 per cent of the industry's total production value. Moreover, considering that the four products are highly related and complementary to each other, their respective shares of total production value were almost evenly distributed.

Taiwan's information technology industry was nurtured to its present state through gradual development. Initially, Taiwan's electronics industry produced mainly home electrical appliances, such as TVs, radios, and other consumer electronics products. Through these early operations, it accumulated excellent manpower resources, experience and technologies. It has set up a good foundation for the industry during this period. As the economy developed, home electrical appliances firms shifted production to the more value-added information technology products. They produced monitors for foreign firms by way of OEM. For them, that was the easiest and the most logical path to move into. Thus, by the early 1980s, monitors became a major product of Taiwan's information technology industry.

However, as accumulated technology improved and the monitor market became competitive, these home electrical appliance firms shifted production again. This time, they shifted to the higher value-added products such as microcomputers. Thus, starting in the mid-1980s, Taiwan's microcomputer production increased rapidly. Its 1986 production value reached $456 million. Although this was still below the monitors' $501 million, by 1987 this value had jumped to $868 million, exceeding the monitors' $849 million, thus making it second only to parts and components. Even in terms of annual growth rates, the microcomputer's 90 per cent was only next to parts' and components' 110 per cent. It is foreseeable that parts and components, microcomputers, and monitors will become the top three information technology products in Taiwan.

Table 2-4 shows a comparison between Taiwan's and the world market's production volume in terms of quantity and value. Based on this table, the share of Taiwan's production value in the world increased from 1 per cent in 1985 to 2.4 per cent in 1987. Moreover, it was projected that, by the end of 1988, the ratio would increase to 3.2 per cent and that Taiwan would become the world's sixth largest information technology product producing country.

Looking at individual products, Table 2-4 shows that, in 1987, Taiwan's microcomputer production quantities accounted for as much as 11.6 per cent of the world's total production. However, its export value accounted for only a mere 2.3 per cent. This was due to the low-end microcomputers being exported by Taiwan. Its exports were mostly for home-use microcomputers that require only a single mother board and no hard disk drives. In addition, since most of these exports are for OEM cu2stomers, these exports were the high-volume, low-priced type of products.

With regard to monitors and terminals, although their ratios were very high both in terms of quantity and value, the growth rate of terminals has been decreasing in recent years while monitors are expected to increase as the demand for microcomputers keeps growing. For peripherals, such as hard disk drives, printers and image scanners, Table 2-4 also indicates that Taiwan's exports of these products will be very limited. They only accounted for less than 2 per cent of the world market. In contrast, scanner exports will be very even in terms of both quantity and value. They presently account for more than 20 per cent of the world market.

With respect to spare parts, aside from the major export item - add-on cards -, Taiwan also exported large quantities of motherboards, graphics cards, memory cards and various controller interface cards. Considering that there is a large after sales market for microcomputers plus the large second generation PC market led by the IBM PS/2, the growth of computer spare parts will be very strong. Likewise, Taiwan has overcome the bottleneck of keyboard production technology. Its production value and quantity have already reached more than 25 and 35 per cent respectively in the world market. It is expected that, with its rapid development, Taiwan will become a major supplier of membrane switching keyboards, graphics cards, facsimile cards and LAN cards in the world market.

From Table 2-5, we see that the export value of information technology products to total electronics export value has increased rapidly from 11 per cent in 1983 to 34.2 per cent in 1987. It is obvious that information technology products will play a greater role in the development of Taiwan's electronics industry. Furthermore, Table 2-5 also shows that during 1984 to 1987, 93 to 96 per cent of production value was exported. This is an indication of the export orientation of Taiwan's information technology industry.

To understand the players inside the industry, an analysis of the concentration and contribution ratios by FDI firms will also be helpful. Taking the top 20 firms' export value to the total export value as a basis for determining concentration level, it is clear from Table 2-5 that the concentration ratios have been decreasing from 83.2 per cent in 1983 to 53.7 in 1987. This resulted mainly because of the fast growing number of small and medium firms joining the information technology product market, thus dispersing concentration while at the same time increasing Taiwan's information technology industry's energy and flexibility.

Undoubtedly, FDI firms had previously played a very important role in the development of Taiwan's information technology industry. However, they are currently decreasing in importance. In 1985, 16 of the top 30 largest information technology product firms were FDI firms; but this number fell to 12 only by 1987. In addition, from 1984's 57 per cent share of total export value, FDI firms' share went down to 39 per cent by 1987. In spite of these declining trends, considering their still dominant share of the export market, they are still critical players in the market.

Another important factor for evaluating the FDI firms' contribution to Taiwan's information technology industry is their OEM procurement ratios. From Table 2-5, we see that FDI firms' OEM procurement ratios were around 40 per cent, equivalent to their production in recent years. By counting these two ratios together, then their ratio to the total export value can be as high as 97 per cent in 1984, and, even until 1987, the ratio can still be around 80 per cent. Apparently, foreign firms and FDI firms are very important in Taiwan's information technology industry's development.

As mentioned above, a great portion of Taiwan's information technology products were for exports, with the United States as the most important export market. In Table 2-5, it can be seen that exports to the United States in 1983 accounted for 73 per cent of total information technology products exported. However, recently, with the depreciation of the US dollar as against the NT dollar and the increasing US trade protectionism, Taiwan's exports of information technology products to the US market have declined to only a 51.3 per cent share. Nonetheless, this decline did not affect Taiwan as it had already diversified its market to Europe and other world markets.

Due to their diversification programs, the European market is becoming so important that it will replace the United States. In 1987, Taiwan's exports to the European market had already accounted for 32.02 per cent of the total information technology products exported; in addition, exports to the Asian Pacific area amounted to 9.91 per cent while the other markets, including Central and South America and Africa, comprised 4.63 per cent of total export value. On a country basis, Holland, West

Germany and Britain are the major export markets in the European area.

Among the items exported to Europe, microcomputers had the highest share -- in 1987, 50.14 per cent of the total microcomputer export value. In contrast, exports to the United States consisted only of 35.56 per cent. In addition, exports of hard disk drives, printers, terminals, and monitors to the European market accounted for about 30 per cent of the total for these products.

With regard to imports, Table 2-6 shows the ratio of information technology product imports to total imports of electronics products. From this table, we can see the increase in the information technology product imports from 9.0 per cent in 1983 to 16.3 per cent in 1986, though there was a slight decline in 1987 to 14.7 per cent. Taiwan's reliance on imported information technology products can be evaluated through the ratio of import value to total domestic demand value. This ratio was about 84 per cent in 1983 and had decreased to 70.2 per cent by 1987. This decline is due to the government's promotion of local production, as against importation, to develop the local industry.

Table 2-6 also shows that imports of spare parts were not significant from 1982 to 1987. They only accounted for 26 to 30 per cent of the total imports of information technology products. As for computer finished goods, the import ratio has declined rapidly from 46 per cent in 1982 to 17 per cent in 1987. This, again, reflected the development of Taiwan's information technology industry, where a great portion of the domestic demand for computer finished goods can be met easily by local firms.

Taiwan's total import value for information technology products has increased from 1982's $138.3 million to $813.5 million in 1987. Furthermore, its ratio to total world production value has increased from 0.16 per cent in 1982 to 0.58 per cent in 1987. As to import sources, the United States and Japan are the major suppliers. In 1982, imports from the United States accounted for 65 per cent of the total imports. However, this ratio decreased to 32.5 per cent in 1987. In contrast, during the same period, imports from Japan increased from 22 per cent in 1982 to 44 per cent in 1987. Apparently, Japan has taken over the United States as Taiwan's most important supplier. It is also noticeable that as Taiwan's reliance on imports of information technology products declines, imports from the United States and Japan have also declined. In 1982, whereas imports from the United States and Japan accounted for 87 per cent of total import value, they had decreased to 76.9 per cent in 1987.

From the above discussion, we can see that foreign and FDI firms have played very important roles in the development of Taiwan's information technology industry. In fact, based on the number of FDI applications and the amount of actual investment approved by the Ministry of Economic Affairs, we can see the magnitude of foreign capital infusion into Taiwan's electronics industry. From 1952 to 1985, there were 423 FDI applications that were approved. The total investment involved reached $1.48 billion. Among the approved applications, 140 or 33.09 per cent of the total were from the United States. The total investments of these US-based FDIs amounted to $80.8 million or 54.56 per cent of the total amount of investments approved. The number of approved applications from Japan amounted to 52 per cent or 220 of the total applications. However, in terms of the amount invested, the Japanese have only

$33.1 million or 22.3 per cent of the total. Another major investment source was Europe. Although the number of approved European applications amounted to only 17, their total investments amounted to $18.4 million.

From the above analysis, if we consider only the absolute number of investments and the amount invested, then the United States and Japan will definitely be the two major foreign capital investors in Taiwan's electronics industry. However, if we consider the average amount of investments per case, then European firms would be the most important. With approximately $10.836 million per investment, the Europeans topped the $6.287 million of the second-ranked United States and the $1.506 million of the Japanese. Actually, the average amount of Japanese investment was even lower than the total average amount of $3.419 million per investment.

III. EVALUATION OF TAIWAN'S ELECTRONICS INDUSTRY

In Section II, we discussed the status of Taiwan's information technology industry. In this section, we will discuss the technology level of Taiwan's electronics industry, its technology bottleneck, and the roles of FDI firms. The source of this discussion is based on a survey of the Taiwan electronics industry in 1987 including 318 samples. Five major product categories were included in the study: electronic parts and components, semi-conductors, computers and peripheral devices, consumer electronic products and telecommunications equipment[1]. A sample survey questionnaire is shown in the Appendix.

1. Electronic Parts and Components

In the survey, there were 77 firms manufacturing electronic parts as their major products. Among them, 58 were domestic and 19 were FDI. Of the 19 FDI firms, 11 had a foreign capital share greater than 50 per cent (called FG50 firms hereafter), while the remaining 8 had a foreign capital share of less than 50 per cent (called FS50 firms hereafter). Although the average export rate of the 77 firms is 63.5 per cent, FDI firms have a higher percentage.

The major export market is the United States followed by Southeast Asia, Europe, and then Japan. However, it should be noted that the 77 firms have different export markets. From Table 3-1, we can see that the Japanese FDI firms have concentrated more on the Japanese markets, the US FG50 firms on the US and Southeast Asian markets. The only one European FG50 firm in the sample has concentrated on the US market too.

In terms of technological intensity, from Table 3-1 we can see that the US and European FG50 firms have a higher percentage of engineers and technicians employed in their work forces. This thus indicates a superior technological orientation than the rest. Comparatively speaking, the domestic firms also have a better technological advantage than the Japanese FG50 firms and the FS50 firms.

As far as the level of technology transfers is concerned, Table 3-1 shows that of the 58 domestic firms, only 3.45 per cent had technological cooperation with foreign firms. In contrast, FDI firms had lots of technological cooperation with either their parent companies or other foreign companies. The FDI firms, aside from introducing new technologies to Taiwan, also provide in-service training for the work force and R&D for technology promotion. However, it should be emphasized that the European FDI firms have placed a higher emphasis on in-service training than the Japanese and US FDI firms. Akin to the FDI firms, 31 per cent of the domestic firms have also conducted in-service training (as shown in Table 3-1).

With regard to R&D engaged in by the various firms, it is clear from Table 3-1 that the Japanese FG50 firms have the lowest investment compared to their US and European counterparts. Domestic firms have also invested a lot of effort in R&D --more than the Japanese FG50 firms, about the same as the US FG50 firms, but much less than the European FG50 firms.

As an index to the various firms' technological capability, the firm's product is compared with the best available similar products in the world. Using this process, Table 3-1 shows that the domestic firms' technological level lagged behind the world's by 1.07 year while the FDI firms' lagged only by 0.47 year. The FDI firms' technology is clearly superior to that of the domestic firms. However, among the FDI firms, the Japanese FG50 firms have lagged behind by as much as 1.60 year, which is even worse than the domestic firms. This is basically due to the low investments made by the Japanese FDI firms in both in-service training and R&D.

Lastly, Table 3-1 shows that most of the firms consider their technological bottlenecks to be: insufficient technology for new product development and inadequate tools and molds for application and design technology. In particular, the Japanese FDI firms consider both to be potential problems while the European FDI firms consider insufficient technology for new product development to be the most serious.

2. Semi-Conductors

Taiwan's semi-conductor industry has enjoyed rapid growth in recent years. In fact, in our survey, there are 45 semi-conductor firms, of which 38 are domestic. Summarized in Table 3-2, the results show that only 47.27 per cent of the semi-conductors produced are for export. The major export markets are the United States and other Southeast Asian countries. As to the percentage of technical employees over the total number of employees, domestic firms have a significantly higher percentage than the FG50 firms.

FDI firms have a higher rate of foreign technological cooperation than domestic firms, while Table 3-2 shows that FDI and domestic firms have devoted about the same degree of effort to in-service training. However, as to in-service training for engineers and technicians, FDI firms have put in more effort than domestic firms. With respect to R&D investments, domestic firms have invested much more than FDI firms. From the above analysis, we can see that domestic firms have played a more aggressive and important role than FDI firms in Taiwan's semi-conductor industry.

In view of technological capability, Table 3-2 shows that FDI firms' technology is lagging behind the world's by 0.67 year while that of domestic firms is even worse at 1.43 year. Basically, the two technological bottlenecks causing this lag are: 1) insufficient technology for new product development, and 2) inadequate tools and molds for application and design technology.

3. Microcomputer and Peripheral Devices

As discussed in Section II, microcomputer and peripheral devices are the most important products of Taiwan's information technology industry. In this study, 45 firms are engaged in the microcomputer and peripheral device business: 24 are domestic firms and 21 are FDI firms. Of the 21 FDI firms, 2 FG50 firms came from Japan, 7 from the United States and 2 from Europe. The survey results are summarized in Table 3-3.

The export rates of microcomputer and peripheral devices are very high, about 76.40 per cent; but domestic firms have even a higher rate of 83.33 per cent. The United States is the major export market, with a 53.3 per cent share of the total export value. The European market is ranked second with a share of 24.4 per cent. It is noticeable that the above export shares are very close to the total export rate mentioned in section II. Therefore, we can conclude that our survey results are in accordance with the survey populations. Observing domestic and FDI firms, our samples show that the major export markets of domestic and FS50 firms are the United States and Europe; for FG50 FDI firms, the major export market is concentrated in the United States; and for Japanese FG50 firms, the major export market is Southeast Asia.

With regard to technical employees hired, Table 3-3 shows that about 18.44 per cent of domestic firms' employees are engineers and technicians. In contrast, FDI firms, except for US FG50 firms, have even higher percentages. Similarly, FDI firms have also devoted more effort to introducing new technologies through technological cooperation. Even in terms of in-service training, FDI firms' investments are higher than those of domestic firms; Japanese FG50 firms' investment in in-service training is much higher than any other firms, while European FG50 firms' investment is ranked second.

Moreover, FDI firms have also invested more in R&D than domestic firms. Table 3-3 shows that in 1986, the average total R&D expenditure of the 24 domestic firms was only NT$2.203 million while the 21 FDI firms had NT$25.004 million or about 12 times that of the domestic firms. However, considering that the scale of domestic firms is usually smaller than that of FDI firms, a comparison based on average R&D investment per employee would be more appropriate. Using this basis, although the result is similar, the gap is smaller. Overall, it can be said that FDI firms are technologically more aggressive than domestic firms.

However, regardless of the FDI firms' aggressiveness, Taiwan's technology is still lagging behind the world's: domestic firms lag by 2 years while FDI firms lag by only 0.05 year. Basically, almost all of the firms agree that insufficient technology for new product development is the main culprit. In addition, Japanese FDI firms also regard the lack of quality inspection and control technologies as major bottlenecks.

4. Consumer Electronic Products

The consumer electronics industry has a very wide range of products. It includes TVs, FM-AM receivers, tuners, amplifiers, speakers, headphones, tape and video tape recorders, turntables, audio and video tapes, calculators, magnetic tape for computers, television picture tubes, electronic watches, video games, remote-control toys, and electronic organs, etc. This study gathered 101 domestic firms and 20 FDI firms for the sample. Among the FDI firms, most of them are Japanese FDI firms.

Table 3-4 shows that both domestic and FDI firms have export rates of more than 60 per cent. The majority of these exports are made for the US, European, and Southeast Asian markets. According to the type of company, domestic firms export 40 per cent of their products to the United States and 20 per cent to Europe; Japanese FG50 firms export theirs to the United States, Japan, and Southeast Asia; US FG50 firms have the United States and Europe. Obviously, the reasons why United States and Japanese FDI firms have invested in Taiwan's consumer electronic products are, first, to increase their competitiveness through Taiwan's low labor costs, and, second, to take advantage of Taiwan's favorable investment environment.

To support their market competitiveness, FDI firms (particularly the US FG50 firms) have invested a lot more in technical manpower resources as compared to domestic firms. Moreover, in terms of R&D, domestic firms' investments lag behind those of the FDI firms. Table 3-4 shows that in 1986, the 20 FDI firms' investments were at least five times those of the 101 domestic firms. In addition, even using the average R&D expenditure per employee as a basis, the 20 FDI firms still had two times more. However, with regard to in-service training, domestic firms provide more than the FG50 firms.

Concerning the technology level, Taiwan's technology, as perceived by the various firms, lagged behind the world's by at least one year, with the US FG50 firms having the most pessimistic opinion at 1.5 years. Again, the reasons cited for this backwardness are mainly: 1) insufficient technology for new product development, 2) inadequate tools and molds for application and design technologies, 3) inferior production technology, and 4) deficient quality inspection and control technology.

5. Telecommunications Equipment

In this research, telecommunications equipment was defined to include the following: telephone sets, automatic switching systems, interphones, television and radio-telephonic transmitters and receivers, and civil brand radios. Thirty firms, 25 domestic and 5 FDI, were gathered for this study. From the 30 firms, it was found that their average export ratio was only 56.17 per cent, with the domestic firms claiming a higher percentage. Through this result, it may be interpreted that the FDI firms have the intention of localizing their market operations. With regard to the export market, again, the United States and Europe are the major market segments.

On technological intensity, FDI firms have a higher percentage of engineers and technicians in their work force than domestic firms. Likewise, the FDI firms also put

more effort into in-service training than their domestic counterparts. However, in this industry, no firm in the survey had ever conducted technological cooperation with foreign or mother companies.

In terms of R&D investments, Table 3-5 shows that, in 1986, the total R&D expenditure of the 5 FDI firms was about 20 times that of the 20 domestic firms. Even when using the average expenditure per employee, the gap was still a large one at four times. Considering this, it can be concluded that Taiwan's telecommunications industry is still very underdeveloped.

Supporting the above conclusion, Taiwan's telecommunications technology lags behind the world's level by at least about 1.2 years. In fact, even when comparing the domestic firms' technology level with that of the FDI firms, the gap is also about 1.2 years (1.38-0.2). This gap is the largest among the five electronics industries discussed in this study. The causes of this industry's lacklustre performance include most of the factors mentioned in the other industries. However, in addition to those mentioned earlier, the telecommunications industry has an additional factor to consider. This factor is the government's tight control over the industry due to national security considerations. The iron-handed regulations with regard to the manufacturing and selling of telecommunications equipment have certainly affected the development of the telecommunications industry. It is not surprising at all to find this industry to be Taiwan's weakest.

6. Summary on Taiwan's Electronics Industry

For the above five industries, a total of 318 samples were gathered. Of this number, 246 are domestic firms and 72 are FDI firms. As for FG50 firms, 16 are from Japan, 15 from the United States and 3 from Europe. Table 3-6 shows the overall statistical results of the survey.

It shows that the average export rate for the five electronics industries is 63.66 per cent; with both domestic and FDI firms' export rates above 60 per cent. As to export areas, the United States, Europe and Southeast Asia are the three major markets; only the Japanese FDI firms are able to penetrate the Japanese market. With regard to technological intensity, it was found that domestic firms have a lower ratio of technical employees than FDI firms. Additionally, they also have less technological co-operation with foreign firms.

In terms of technological promotions, the domestic firms are also much more inferior. They did not place as much emphasis as the FDI firms on in-service training and R&D (Table 3-6). Among the FDI firms, the European and US FG50 firms have the highest rate of labor in-service training. Then concerning R&D expenditure, the European firms have the highest, while the Japanese have the lowest investments. In fact, as shown in Table 3-6, the Japanese FDI firms' investment in R&D expenditure per employee is even worse than that of the domestic firms. Their investment per employee comprise only as much as one-fourth of that of domestic firms.

Comparing Taiwan's electronic products with the best available similar product elsewhere, the result shows that Taiwan trailed the world's level by about 0.88 year, of which, domestic firms lagged by 1.03 year, and FDI firms by 0.34 year. On the other hand, comparing the technology level between domestic and FDI firms, their technology gap is about 0.69 years (1.03-0.34). While the technological gap between domestic and European FDI firms is the highest at 1.03 years, it is the smallest, at only 0.53 years between domestic and Japanese FDI firms. The major technological bottlenecks mentioned are insufficient technology for new product development and inadequate tools and molds for application and design technology.

Furthermore, from Table 3-7, it is clear that among the five electronics industries, the microcomputer and peripheral industry has the highest export rate, while the semi-conductor category has among the lowest export rate. As to the rate of technological intensity, *i.e.*, the number of engineers and technicians to the total number of employees, the microcomputer and peripheral industry also has the highest rate, followed by the telecommunications and semi-conductor industries. In contrast, the consumer electronic products industry has the lowest rate since most of the firms involved utilized only the assembly process. With regard to the degree of technological cooperation with foreign firms, the microcomputer and peripherals industry was ranked first while the semi-conductor industry was ranked last.

Similar to the above, when evaluating the five industries' engagement in labor in-service training and R&D, Table 3-7 shows that the microcomputer and peripherals industry still has the lead. Thus, with its better performance than the rest, it is no wonder that the microcomputer and peripherals industry is the superstar of Taiwan's electronics industry.

IV. TAIWAN'S STRATEGIES IN PROMOTING THE ELECTRONICS INDUSTRY

In the early developmental stage of Taiwan's electronics industry, the Taiwan government did not provide many special privileges. The main support given was only the setting up of the export processing zones to encourage investments from foreign electronics firms. Through this, nonetheless, Taiwan's electronics industry still progressed. In the 1950s and 1960s, various foreign electronics-assembly firms were attracted to Taiwan's cheap but quality labor. Consequently, due to the many foreign investments that came into Taiwan at that time, Taiwan's electronics industry has built up a solid foundation for its future development.

By the end of the 1960s, Taiwan's labor market had reached the level of virtual full employment with an unemployment rate of 2.67 per cent. As a result, labor costs shot up rapidly. In fact, between 1973 to 1983, unit labor costs in the electronics industry increased from NT$2 380 to NT$11 548 per year -- a rate of about 4.85 times.

This provoked a process of transition from traditional electronics-assembly to high-tech value-added electronics production whose success depends on the following factors: manpower, environment, and government-sponsored institutions.

1. Manpower

In the early years, with its fast growth, the electronics industry has not only created job opportunities but also offered handsome wages. In addition, it is common for electronics firms to have a modern, clean and comfortable working environment. These factors have certainly attracted many workers to join the industry. For graduating students, the electronics industry is naturally their first choice for a job. Likewise, for students entering college, an electronics engineering course is their number one priority. Under these kinds of preferences, the electronics industry has no doubt attracted the best brains in the country, thus providing the essentials for establishing a rigid foundation for its development.

In addition, the government's educational strategy has also been stressing the engineering and, especially, the electronics fields. Under the government's limited budget for education at a given time, electronics engineering usually gets a better share. Based on Institute for Information Industry (III) statistics, by July 1987, graduates from electronics and information technology science fields had already totalled 114 628 of which 114 had doctoral degrees, 5 004 had master's degrees, 44 765 had bachelor's degrees, and 64 675 had college diplomas. On the other hand, undergraduates who are taking up electronics and information technology sciences as their majors totalled another 57 942 students; 2 383 in graduate schools, 19 655 in universities, and 35 904 in colleges. As can be seen from the number of undergraduates, for every graduate school student there are 8.25 university students and 15.06 college students.

Although formal schooling is just the beginning of a learning process, after schooling a student's further capability development would depend on how actively and

aggressively his/her company trains him/her. In connection with this training, the government does not impose any particular regulations[2]. All workers' training is conducted by individual firms voluntarily. Many of these firms willingly provide workers' training, but, to guarantee their investments they usually ask employees to sign a contract for assurance of service after training.

In this context, it should not be ignored that more than 90 per cent of firms in Taiwan are small- and medium-sized in scale. Therefore, when conducting in-service training, these firms usually encountered problems such as a lack of instructors, insufficient teaching materials, and inadequate facilities. To solve this problem, the government set up two programs to assist these firms. First, it established public training institutes for the electronics industry's entry and middle level manpower. The training courses provided included maintenance of consumer electronics products for maintenance workers, industrial electronics engineering for technicians, and programming skills for CA/CNC programmers, etc. Presently, of all the courses offered by the public training institutes, electronics and mechanical engineering courses are the most popular items among trainees.

The second program was implemented by the government to meet its ambitious computerization project. It entails the rigorous education of higher-level manpower in the field of computers. Under the government's "five-year manpower promotional plan for the information technology industry", the Institute for Information Industry was directed to train at least one thousand government employees annually in computer-related courses. Of these, 350 will come from the Ministry of Education's pool of school teachers (to teach computer-related education to students); 250 will come from the Ministry of Economic Affairs' pool of employees (to fulfil the manpower needs of office automation projects for public enterprises); 150 will come from the National Youth Commission of the Executive Yuan (to meet the job transfer needs of university and college graduates who have difficulty in finding jobs); and 250 will come from the Executive Yuan's Central Personnel Administration. The above manpower training program has been very successful. During the past four years, more than four thousand students have been trained.

Besides manpower training, the employee's true capability should be identified to further promote the industry's success. This process will not only be beneficial to the employers but will also stimulate workers' willingness to learn. Currently, the Taiwan government has implemented the national certification system for the electronics industry. This system ranks the electrical workers, transformer repairmen, household appliance repairmen, and industrial electronic fitters with A, B, and C types of certification. In addition to this system, starting 1984, the III has began employee-capability testing for the information technology industry. The test has three categories: A, B, and C. Category A is for system analysts, category B is for senior programmers, and category C is for programmers. These tests have been particularly helpful to young individuals who are not information technology science majors but are eager to enter the information technology industry. These tests have also been beneficial to those who have no formal schooling in information technology science but have years of working experience. Through the above test, an employee's ability can be identified by his employers and colleagues. Moreover, this system provides the

flexibility needed to complement the rather rigid educational system in Taiwan.

2. Environment

As discussed in the previous section, today the major feature of Taiwan's electronics industry is its transformation from a pure electronics-assembly industry to an OEM-producing electronics industry and, finally, to a high-tech producing electronics industry. It has metamorphosed itself from a fragile industrial structure into a well-structured and integrated industry.

The gradual development process mentioned above has certainly benefited the development of the electronics industry. According to the 43 OEM electronics businesses surveyed in this study, 70 per cent of the firms believe that production technology can be effectively acquired, 62 per cent believe that management techniques can be adopted, and 69.95 per cent believe that product design and development technology can be introduced. Apparently, most of the OEM firms are very optimistic regarding the effectiveness of technology transfers through OEM production. Moreover, it is noticeable that the 27 domestic firms are more positive to OEM's effect on technological transfers than the 16 FDI firms. Obviously, to the domestic firms, OEM production is one of the major channels for acquiring new technologies from abroad. For detailed statistics, see Table 4-1.

Considering that the effectiveness of new technological transfers is dependent upon the technical capabilities of the host firm, Taiwan's highly-educated and well-trained engineers and technicians will definitely be able to adopt these new technologies. Aside from OEM production, another important factor affecting the effectiveness of technological upgrading is labor mobility. According to the statistics of the Executive Yuan's Directorate-General for Budget Accounting and Statistics (DGBAS), the average separation rate of the electronics industry from 1981 to 1987 was 5.84 per cent while the average accession rate was 5.97 per cent. Taking these two figures into consideration, the average labor turnover rate in the electronics industry would be greater than 11 per cent. Thus, under such a high labor turnover rate, the technological know-how of the workers can be effectively diffused. This diffusion can be even more effective when high ranking managers or engineers change their jobs.

In our research, we also found that 104 out of the 318 electronics firms have high-level managers and engineers who have work experience in foreign electronics firms. Of this number, only 42.61 per cent feel that working experience with foreign firms is helpful to their management skills, 31.48 per cent feel that it is helpful to product design and development, and 29.52 per cent feel that it is helpful to their acquisition of market information. The detailed statistical results are shown in Table 4-2.

It is also interesting to note that among the 104 firms, 71 of them are domestic firms and 33 of them are FDI firms. These two figures are 28.86 and 45.80 per cent of the total domestic and FDI firms in the sample. It is clear that when high-level managers and engineers from foreign firms transfer jobs, most of them will more likely work for another foreign firm than for a domestic firm. Considering such a possibility, domestic and FDI firms' opinions on the effect of technology diffusion through labor

mobility are different. Table 4-2 shows that more FDI firms consider labor mobility to be more helpful in acquiring market information than domestic firms.

It cannot be denied that FDI firms' active involvement in the development of Taiwan's electronics industry is an important environmental factor. From Section II, it was found that the United States, Japan and Europe are the three major foreign capital sources of Taiwan's electronics industry. But considering that these FDI firms were induced to invest in Taiwan by the favorable investment climate provided by the government (low-cost labor, and excellent infrastructure), Taiwan's governmental policies should also be considered as one of the major factors that attract foreign investment.

Among the government's various preferential treatments, the "Statute for the Encouragement of Investment" (SEI) promulgated in the 1960s and the "Assistance Program for Strategic Industries" (APSI) introduced in the 1980s are the two most important policies. Based on the SEI, newly established firms or established firms with additional capital expansion are entitled to enjoy a four-to-five year tax holiday. They may also choose to enjoy accelerated depreciation of invested capital to avoid taxes. This statute is effective with regard to both the domestic and FDI electronics firms.

The APSI was implemented in 1982. The government initially chose 151 products as major items for the APSI program. The products included 64 electronics and information products. By June 1987, the number of items included had increased to 199, with 91 electronics and information products[3]. To implement this program, the government has put aside NT$30 billion in the form of loans to the approved firms. These loans will be used for installing the necessary machinery for the production of the above selected items. Any appropriate firm can apply for a ten-year loan with a maximum loadable amount of as high as 80 per cent of total capital needed or 65 per cent of the total expenditure needed for the investment. Furthermore, a preferential interest charge of 1.75 to 2.5 per cent below the prime rate of the Bank of Communications is also introduced. Due to these favorable conditions, 993 firms have obtained such low interest rate loans from the government, with the total amount reaching NT$21.4 billion. Of this amount, NT$10.6 billion was granted to the electronics and information industry. From Table 4-3, we see that the electronics parts and components industry have obtained the largest share of the loan in the electronics industry, followed by the consumer electronics product industry.

It should be emphasized that the above government-assistance programs are neither the only ones nor the most preferential, others were introduced in the 1980s, such as the "Assistance Program to Promote R&D", the "Program of 600 Million US Dollars Low-Interest Loans to Promote Exports", the "Assistance Program to Small and Medium-Sized Enterprises Under the Sino-American Fund", and the "Assistance Program of Low-Interest Loans for Production Industries to Set up Their Satellite Plants", etc. Furthermore, there are other non-financial assistance programs which mainly aim at providing consultancy with respect to the electronics industry.

To further create a sound environment for the development of Taiwan's electronics industry, one of the important strategies is to stimulate domestic demand.

For example, in the "Development Plan for the Taiwan Information Industry (1980-1989)", it was stressed that one of their most important strategies is to push for the computerization of the various government offices, as well as private enterprises. It actively spreads out the utilization of computers through various computer training courses. Through this computerization drive, the government expects to create additional domestic market demand. Moreover, to support the domestic electronics industry, the government also encourages the various government and private organizations to buy domestically produced information technology products.

As a result, during the past ten years, Taiwan has enjoyed a rapid growth in the installation of computer systems. During 1971, there were only 34 computer systems installed throughout the whole island, these systems belonging mainly to large government organizations, public enterprises, and educational research institutes. In contrast, by 1987, the total number of computer systems installed had increased to 4 544 units, of which private enterprises accounted for 2 377. From Table 4-4, we can see that among the 4 544 units installed, 8 are super-large computer systems, 33 are large computer systems, 705 are medium computer systems, and the remaining 3 798 are mini-computer systems[4]. The users of super large and large-scale systems are concentrated in the various government departments and public enterprises while the users of medium computer systems are mostly in the private sector. From Table 4-5, it can be seen that electrical and electronics industries, finance and insurance businesses, administrative organizations, and educational research institutes are the major users of medium-sized computers while commercial and service businesses, manufacturing businesses, and administrative organizations are the major users of mini-computers.

3. Government Sponsored Institutions

In 1980, to encourage the development of high-tech industry in the country, the Taiwan Government established the Hsinchu Science-based Industrial Park. To encourage potential investors to move into the Park, the government has built up the necessary infrastructure and buildings, and a good living environment; bi-lingual schools, tax waivers, cheap rent, and low-interest loans are also offered to attract long-term investors.

Aside from attracting investments to the country, another objective in establishing the Hsinchu Science-based Industrial Park is to halt the brain-drain from the country. A large number of undergraduate and graduate students never come home after they have finished their schooling abroad. Just as importantly, it hopes to attract experienced and well-established Chinese engineers and technicians back to work for the country.

Taiwan's electronics firms, due to their medium- to small-scale operations and limited capital, do not have the capital resources for essential long-term research. To help solve this problem the government established two institutions to support the electronics industry. The first is the Institute for the Information Industry (III), a non-profit organization established in 1979 at the direction of the Executive Yuan. Its mission includes: introducing and developing software technology, assisting government agencies and public enterprises in their computerization projects, training and educating

information professionals, and supplying market and technology news related to the information technology industry. More critically, its primary function is to promote the development and usage of computer-related technologies.

The second support institution is the Industrial Technology Research Institution (ITRI), a complement to the III. Its function is to promote hardware technologies to the information technology industry. Under the ITRI, there are five support organizations, one of which is the Electronics Research and Service Organization (ERSO). Its major function is to help the government conduct R&D in electronics industrial technology for both the public and private sectors. The ERSO develops and disseminates new technological development in three ways. The first is to be an OEM supplier for private electronics firms. This way, the development costs of the private firms can be reduced, thus encouraging more new product/technology development adoptions. The second is to develop and license new products/technologies to private firms. Again, this will reduce the private firms' investments since they will only be charged royalty fees or will be asked to provide stock option investment to ERSO. The third is to set up joint venture programs with the government and domestic/foreign firms.

Taiwan's development of the VLSI (Very Large-Scale IC) is a typical example of ITRI-conducted ventures. Based on the Taiwan government's five-year "VLSI Plan" announced in 1983, the government will invest NT$2.9 billion to achieve the following goals: 1) to set up an experimental VLSI plant; 2) to further research on various VLSI design methods; 3) to develop new production technology for the 1.25 micron chips; 4) to enforce CAD's software functions; and 5) to integrate the design capability of gate array and standard cell. To accomplish this plan, the government has used the "Middle to Long Term Low Interest Loan for the Development of Strategic and Important Industries" fund to set up the Taiwan Semi-Conductor Manufacturing Company (TSMC). This company rented the experimental VLSI Plan built by ITRI in 1986. ITRI and TSMC have co-operated very closely in operating this venture. The former has concentrated its efforts on R&D for new VLSI design technologies while the TSMC has occupied itself with production.

TSMC's strategy for development is to be an OEM supplier only. It will not involve itself in the whole operating process of designing, manufacturing, packaging, testing, and marketing ICs. This strategy is necessary due to both the high investment risk and low flexibility involved in integrated operations. Moreover, considering that the development of Application Specific Integrated Circuits (ASICs) is becoming more and more important, the risks involved in an integrated operation increase proportionately. ASICs shared only 8.6 per cent or $1.16 billion of the world's total IC market in 1983, but by 1985, its market share had increased to 13 per cent or $2.34 billion. By 1991, its total sales amount will have reached $9.66 billion or an equivalent of a 21 per cent[5] market share. Under this fast growth for custom-designed and semi-custom-designed ICs, OEM operations will have a better chance of survival than integrated operations.

In view of Taiwan's emphasis on future IC development, IC design and ASIC production will be the major directions. Furthermore, Taiwan owns a very good environment for IC design development. It has an ample supply of high-quality and low-cost electronics engineers (their salaries are relatively lower than their US,

Japanese, and European counterparts). In addition, as an IC design firm needs only a small amount of capital, it is very suitable for the small- and medium-sized enterprises. Thus, IC design fits the Taiwan industrial environment excellently. In recent years, the growth of the number of IC design firms in Taiwan has been rapid. Prior to April 1986, there were only 4 professional IC design firms but by June 1987, the number exceeded 40. It is foreseeable that the future development of ICs in Taiwan will be accomplished through cooperation between the private enterprises' IC design capability and ITRI/TSMC's ASIC production technology.

4. Evaluation of The Government Strategies

Table 4-6 summarizes the survey results regarding the various firms' opinions on how to promote Taiwan's electronics industry's technology level. From this table, we can see that due to the different product characteristics, the firms have different opinions on what government strategy should be adopted to upgrade Taiwan's electronic industry's technology level. As to the electronics parts and components industry, they think that the government should assist the firms in acquiring foreign technology. As for the semi-conductors industry, since the industry is characterized by large capital investments and high risk, they consider that the government should: 1) provide more technology transfers through government-sponsored research institutes, 2) coordinate joint research programs among firms, and 3) educate more R&D people. As for the microcomputer and peripheral devices industry, they consider that the government should educate more R&D people, as well as transfer technology. As to the consumer electronic products industry, they suggest that the government should educate more R&D people and coordinate joint research. Lastly, as for the telecommunications equipment industry, they consider that the government should offer joint research and technological transfers through government-sponsored research institutes.

Taking into account the above opinions, the Taiwan government's most important missions are: 1) to educate more R&D people, 2) to provide technological transfers through government-sponsored research institutes, 3) to coordinate joint research among the various firms, and 4) to introduce new technologies. On the other hand, low-interest loans and tax exemptions on R&D expenditures are only secondary factors as most firms do not consider them to be the government's major tasks.

In relation to the methods on how to introduce new technologies, the following discussion details the various firms' opinions. Both the electronic parts and components and semi-conductors industries consider that self-conducted research and development is the most effective method, followed by direct technology purchases. With regard to technological cooperation, these two industries consider that cooperation with European firms would be better than with those from other areas. The microcomputer and peripheral devices industry, in addition to self-conducted research and development, also think that European firms' investment and technological cooperation are very effective. The consumer electronic products industry, besides self-conducted research and development, consider that technological cooperation with Japanese firms would be more effective than cooperating with European and US firms. The telecommunications equipment industry consider that self-conducted research and development, European firms' investment, and OEM production are the more effective

methods.

Almost all of the firms consider that self-conducted research and development are fundamental to technology promotion. Moreover, they also regard direct technology purchases as an effective means. With respect to foreign investments and technological cooperation, all the industries, except the consumer electronics product industry, consider that the European firms' investment and technological cooperation is superior to that of the Japanese.

V. CONCLUSION

The electronics industry is the largest and most important export industry in Taiwan. It has been developed for more than three decades and has established a solid foundation for its further development. As regards its future, we are quite optimistic about the prospects. In this study, we have identified four factors that favorably affect the development of the electronics industry in Taiwan.

First, there is the industry's adaptability, flexibility, and determination to achieve greater heights. From the industry's evolution, we can see that it had gone through different production stages: B/W TV's in the early 1950s and 1960s, color TV's in the 1970s, then monitors, and microcomputers in the 1980s. Through this, the industry has registered an impressive growth record over the past decades. In fact, it is expected that, by 1990, its annual production value will exceed Italy's, and even that of France. It will become one of the world's top five or six information technology products producing countries.

Second, there are Taiwan's ample manpower resources. These resources refer not only to non-skilled laborers but also include well-trained, high-quality technicians and engineers. In addition, and more importantly, these skilled technicians' and engineers' labor costs are lower than those of the European countries, the United States, and Japan. As such, it provides a clear competitive edge in the international electronics arena. In fact, in the past two years, more than 30 semi-conductor designing companies have established operations in Taiwan, thus clearly indicating Taiwan's competitive edge.

Third, there is Taiwan's technological capability. From this study, it was found that the technological gap between Taiwan and the world was not very significant. Actually, domestic firms even performed better than FDI firms in some products. Hence, this indicated a significant improvement in domestic firms' technological capability.

And, fourth, we have the self-motivated emphasis on R&D. The survey done in this study indicates that most of the firms consider R&D to be the basis to upgrade the firm's technological level. They do not consider the government's preferential treatment as necessary to promote R&D effectively.

On the other hand, with regard to problems, this study has also identified three potential problems that may affect the industry's growth.

First, there is the inability to conduct product design and development. This problem is shared by most of the firms regardless of whether they are in parts and components, semi-conductors, or in any other information technology-related businesses. The survey done in this study reflects the insufficiency of senior and well-experienced R&D manpower. In consideration of this problem, the government may have to take the lead in providing higher-level R&D education.

Second, there is an over-dependence on government-sponsored technology transfers. It was found in this study that many firms want the government-sponsored

technological research institutions to further enhance technology-transfer efforts. The above request may have two different interpretations: it may reflect the firms' appreciation of the government's support in technology transfers, or else it may reflect the firms' over-dependence upon the government-sponsored technology transfers such that they become complacent. Thus if the latter interpretation holds, the government should then minimize this dependence by levying R&D development fees and royalty charges. Through these charges, the firms will be encouraged to conduct their own R&D instead of just depending on the government.

Finally, there is the over-protected telecommunications equipment industry. Over the past three decades, the Taiwan government's policies toward the electronics industry have been rather favorable. With minimal restrictions, the electronics industry grew rapidly. However, there is an exception to this growth trend - the telecommunications equipment industry. This industry has been heavily regulated by the government due to national security reasons. Much of the civilian telecommunications equipment is not allowed to be produced or marketed. Consequently, this industry has suffered the largest technological gap among the electronics industries in Taiwan. Thus, to rectify this situation, the Taiwan government should thoroughly re-evaluate regulatory policies in this industry. It should minimize intervention to the least possible so as to make this industry develop as strongly as the other electronics industries in Taiwan.

NOTES AND REFERENCES

1. The parts and components industry includes industries with 4638, 4656, 4657 according to Taiwan's Custom Commodity Classification Coding System (CCC code systems); the computer and peripherals industry includes industries with 46511, 46514, 46519 according to CCC; the semi-conductor industry includes industries with 4654 according to CCC; the consumer electronics product industry includes industries with 4631 to 4634, 4652, 46515, 4655, and 4658 according to CCC; the telecommunications equipment industry includes industries with 4637 according to CCC.

2. The government did not implement any dramatic policies toward private firms' training activities except in 1972. In February 1972, the government promulgated the "Vocational Training Fund Statute" which was passed by the Legislative Yuan. According to the Statute, employers in the assigned industries are subject to make contributions to a Vocational Training Fund which are no less than 1.5 per cent of the total payroll of all workers. But the Statute was suspended indefinitely only 18 months after its implementation. For details on the implementation of the "Vocational Training Fund" System, please refer to San, G., and Chen, C.N., *In-Service Training in Taiwan R.O.C.*, CIER Monograph Series no. 20, Chung-Hua Institution for Economic Research, CIER, Taipei, 1988.

3. There are 91 major electronics products which are listed as being part of strategic industries in Taiwan. For instance, personal computers, word processors, translators, graphic terminals, work stations, ferrite heads, thin-film heads, disks, carriage actuators, optical readers, plotters, VCRs, digital audio and video players, semi-conductors, modems, CNC controllers, application software packages, systems software, and database management systems are all on the list.

4. According to the *Computer Industry Report 1987* published by the International Data Company, computer systems have been divided into 5 categories in terms of their capacities and costs: 1) super computers, including CYBER 205, IBM 3090 or other type of computers with a similar capacity; 2) large-size computers, including computers which are able to support 128 users and have average prices of over 1 million US dollars, *i.e.*, IBM 3080; 3) mid-size computers, including computers capable of supporting 17 to 128 users, and costing between 100 thousand to 1 million US dollars, *i.e.*, IBM 9370, 4300, or VAX 8500; 4) minicomputers, including computers capable of supporting 2 to 16 users and costing between 10 thousand and 100 thousand US dollars, *i.e.*, the IBM 5550. The Institute for Information Industry (III) in Taipei has adopted the above definitions for their statistics and these appear in Table 4-4 and Table 4-5 of this study.

5. Please see Michael Hobday's "Trends in the Diffusion of Application-Specific Integrated Circuits (ASICs) - Implications for Latecomers' Strategies in the Semi-Industrialized Countries", Paper presented at OECD Development Centre, November 1988.

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Table 2-1: Export Values of Taiwan's Major Export Products 1985-1987
Unit: Millions of U.S. Dollars

Products	1985	1986	1987
Electronic Products	4,904	6,888	10,580
Textiles	5,744	6,948	8,552
Shoes and leather	2,386	3,175	3,766
[Information Products]	[1,220]	[2,063]	[3,701]
Toys and Sporting Goods	1,751	2,373	3,265
Metal Products	1,780	2,360	3,227
Plastic and Rubber Products	1,674	2,255	3,178
Electric Machinery and Appliances	1,545	2,020	2,901
Machinery	1,228	1,598	2,374
Transportation Equipment	1,263	1,689	2,295
Wool Products and Furniture	1,262	1,686	2,135
Others	7,186	8,815	11,265
Total	30,723	39,789	53,538

Source : Ministry of Finance

Table 2-2: Product Values of Computer Hardwares and Their Rankings Among Major Hardware Producing Countries in the World

1987 Ranking	1980 Ranking	Countries	1987 Product Value*	1987 Growth Rate (%)
1	1	U.S.A.	45.4	7
2	2	Japan	21.2	8
3	3	W. Germany	8.1	5
4	4	England	5.9	9
5	5	France	5.3	5
6	6	Italy	4.2	4
7	7	R.O.C.	3.8	79
8	10	Singapore	2.3	71
9	8	Ireland	2.0	8
10	9	Netherlands	1.8	5
11	13	Korea	1.5	63
12	11	Canada	1.3	10
13	12	Hong Kong	0.8	15

* in Billions of U.S. Dollars

Sources : Western European Electronics Yearbook 1986
International Electronics Yearbook 1986
Institute for Information Industry, MIC, Taipei

Table 2-3: Product Values of Major Information Industry Products in Taiwan
Unit: Million U.S. Dollars

Product Items	1986	1987
Microcomputers	456 (21%)	868 (23%)
Disk Drives	72 (3%)	99 (3%)
Printers	41 (2%)	48 (1%)
Terminals	318 (15%)	417 (11%)
Monitors	501 (24%)	849 (22%)
Other Peripheries	46 (2%)	85 (2%)
Parts and Components	701 (33%)	1,437 (38%)
Total	2,135 (100%)	3,839 (100%)

Sources: Institute for Information Industry (III), MIC, Taipei

Table 2-4: Guideposts for the Information Industry in Taiwan

	1985	1986	1987	1988*
1) Ratios of Total Product Value of the Taiwan Information Industry to That of the World's Total (%)	1.0	1.5	2.4	3.2
2) Ranking of the Taiwan Information Industry Product Values in the World	9	7	7	6
3) Taiwan's Microcomputer Production to That of the World Total				
In terms of quantity (%)	6.3	7.5	11.6	15.9
In terms of Product Values (%)	1.0	1.4	2.3	3.3
4) Taiwan's Monitor Production to That of the World Total				
In terms of quantity (%)	23.2	34.3	41.1	53.1
In terms of Product Values (%)	15.6	31.3	37.3	46.0
5) Taiwan's Terminal Production to That of the World Total				
In terms of quantity (%)	22.2	29.7	31.6	32.8
In terms of Product Values (%)	3.3	4.1	4.8	5.2
6) Taiwan's Disk Drive Production to That of the World Total				
In terms of quantity (%)	2.1	2.4	1.9	2.0
In terms of Product Values (%)	0.3	0.4	0.5	0.6
7) Taiwan's Printer Production to That of the World Total				
In terms of quantity (%)	3.2	2.4	1.8	1.7
In terms of Product Values (%)	0.4	0.3	0.3	0.3
8) Taiwan's Scanner Production to That of the World Total				
In terms of quantity (%)	17.5	20.0	24.0	27.0
In terms of Product Values (%)	13.0	14.0	15.0	17.0
9) Taiwan's Modem Production to That of the World Total				
In terms of quantity (%)	2.0	3.9	4.7	5.5
In terms of Product Values (%)	0.9	1.2	1.4	1.6
10) Taiwan's Key-Board Production to That of the World Total				
In terms of quantity (%)	-	31.0	35.0	38.0
In terms of Product Values (%)	-	20.0	25.0	29.0

Sources: The same as Table 2-3
* : Projected values for 1988

Table 2-5: Characteristics and Export Trends of Major Information Industry (II) Products in Taiwan

	1983	1984	1985	1986	1987
1) Ratios of II Export Value to Electronics Industry Total Export Value (%)	11	19	25	29	34.2
2) Ratios of II Export Value to Its Total Value of Production (%)	-	93.8	96.6	96.7	96.4
3) Ratios of Total Export Value for Top 20 Firms to Total Value of Export in II (%)	83.2	82.4	74.4	57.4	53.7
4) Number of DFI Firms Among Top 30 Electronic Firms in II	-	-	16	13	12
5) Ratios of DFI Firms' Total Product Value to Taiwan Total II Export Value (%)	-	57	58	44	39
6) Ratios of OEM by Foreign Firms to Total II Export Value (%)	-	40	37	39	41
7) (5)+ (6)		97	95	83	80
8) Ratios of Total Value of Export to U.S. Market to Total Value of Export in II	73.0	69.0	64.0	57.0	51.3

Sources: The same as Table 2-3

Table 2-6: Characteristics and Import Trends of Major Information Industry (II) Products in Taiwan

	1982	1983	1984	1985	1986	1987
1) Ratios of II Import Value to Electronics Industry Total Import Value (%)	-	9.0	13	15	16.3	14.7
2) Ratios of Total Import Value of II Products to Total Domestic Market Demand (%)	-	84.0	77.0	75.0	77.5	70.2
3) Ratios of Part's and Components' Total Import Value to Total Import Value of II (%)	26.0	27.9	30.6	31.1	31.0	26.4
4) Ratios of Total Value of Computer Imported tot Total Import Value of II (%)	46.0	32.0	26.0	29.0	20.0	17.0
5) Ratios of Parts and Components Imported for Microcomputers to Total Import Value in II (%)	-	31.0	34.0	40.0	30.0	31.1
6) Total Import Value in II (in Millions of US Dollars)	138.3	192.3	315.6	374.8	515.5	813.5
7) Ratios of Total Import Value in II to Total World Product Value in II (%)	0.16	0.20	0.28	0.30	0.39	0.58
8) Share of Imports from the US	65.0	60.0	52.0	43.0	33.0	32.5
Share of Imports from the Japan	22.0	26.0	29.0	37.0	46.0	44.4
Share of Imports from the US and Japan	87.0	86.0	81.0	80.0	79.0	79.6

Source: The same as Table 2-3

Table 3-1: Survey Results for Parts and Components in the Electronics Industry in Taiwan

	Average	DOM	DFI	FG50	FS50	FG50 Japan	FG50 U.S.	FG50 Europe
1) Sample size	77	58	19	11	8	5	5	1
2) Export Ratios for Major Product (%)	63.51	58.62	78.42	86.27	67.63	88.40	82.00	97.00
3) Major Export Countries								
U.S.	48.05	48.28	47.37	27.27	75.00	-	40.00	100.00
Japan	9.09	3.45	26.32	45.05	-	100.00	-	-
Europe	10.39	13.79	-	-	-	-	-	-
S.E. Asia	18.18	17.24	21.05	18.18	25.00	-	40.00	-
4) Technological Intensity	14.82	15.03	14.20	16.55	8.70	13.81	19.26	16.70
5) Ratios of having Technologial Cooperation with Foreign Firms (%)	9.09	3.45	26.32	36.36	12.50	40.00	20.00	100.00
6) Had Conducted Training (%)	32.47	31.03	36.84	45.45	25.00	40.00	40.00	100.00
Managers' training Ratios (%)	19.44	19.69	20.20	18.14	25.00	7.25	0.00	100.00
Engineers' Training Ratios (%)	13.43	10.27	22.92	21.05	27.29	9.26	8.33	94.50
7) Total R&D Expenditures in 1986 (Thousand NT Dollars)	2,029	927	5,393	6,245	4,221	280	1,460	60,000
R&D Expenditure Per Employee (NT Dollars)	14,533	15,919	10,374	13,776	2,437	2,697	17,333	36,342
8) Technological Gap (Lag) for Sampled Firms (in Years)	0.93	1.07	0.47	0.73	0.00	1.60	0.00	0.00
9) Technological Gap (lag) for Industry as a Whole (in Years)	0.63	0.82	0.29	0.45	0.00	1.00	0.00	0.00
10) Major Technological Bottleneck:								
(1)Product Design Techno.(%)	65.28	64.81	66.67	60.00	75.00	50.00	60.00	100.00
(2)Utilization of Tools and	22.22	22.22	22.22	30.00	12.50	50.00	20.00	-
Machinery (%)	6.94	9.26	-	-	-	-	-	-
(3)Manufacturing Techno.(%)	1.39	1.85	-	-	-	-	-	-
(4)Quality Control (%)	4.17	-	11.11	10.00	12.50	-	20.00	-
(5)Others (%)								

Sources : This study

Note : DOM for domestic firms: DFI for Direct Foreing Investment Firms; FG50 for DFI firms with foreigners' or overseas Chinese share greater than 50 percent; FS50 for DFI firms with foreigners' or overseas Chinese share less thant 50 percent; FG50 Japan for Japanese FG50.

Table 3-2: Survey Results for Semi-Conductors in the Electronics Industry in Taiwan

	Average	DOM	DFI	FG50	FS50	FG50 Japan	FG50 U.S.
1) Sample size	45	38	7	4	3	3	1
2) Export Ratios for Major Product (%)	47.27	42.95	70.71	64.00	79.67	52.00	100.00
3) Major Export Countries							
U.S.	44.40	39.47	71.43	75.27	66.67	66.67	100.00
Japan	-	-	-	-	-	-	-
Europe	-	-	-	-	-	-	-
S.E. Asia	15.56	13.16	28.57	25.00	33.33	33.33	-
4) Technological Intensity	17.89	18.64	12.42	7.20	22.86	10.95	3.45
5) Ratios of having Technologial Cooperation with Foreign Firms (%)	4.44	2.63	14.29	25.00	0.00	33.33	0.00
6) Had Conducted Training (%)	42.22	42.11	42.86	50.00	33.33	33.33	100.00
Managers' training Ratios (%)	16.95	17.31	14.29	0.00	42.86	0.00	0.00
Engineers' Training Ratios (%)	17.42	14.22	40.83	48.75	25.00	60.00	37.50
7) Total R&D Expenditures in 1986 (Thousand NT Dollars)	3,438	3,948	668	1,169	0	1,559	0
R&D Expenditure Per Employee (NT Dollars)	16,531	18,122	4,866	7,299	0	14,599	0
8) Technological Gap (Lag) for Sampled Firms (in Years)	0.67	0.65	0.71	0.00	1.67	0.00	0.00
9) Technological Gap (lag) for Industry as a Whole (in Years)	1.00	0.91	1.43	0.00	3.33	0.00	0.00
10) Major Technological Bottleneck:							
(1)Product Design Techno.(%)	40.48	41.67	33.33	50.00	-	66.67	-
(2)Utilization of Tools and Machinery (%)	28.57	22.22	66.67	50.00	100.00	33.33	100.00
(3)Manufacturing Techno.(%)	16.67	19.44	-	-	-	-	-
(4)Quality Control (%)	9.52	11.11	-	-	-	-	-
(5)Others (%)	4.76	5.56	-	-	-	-	-

Source: This study
Note: Please consult table 3-1 for definitions of DOM, DFI, FG50, FS50, etc.

Table 3-3: Survey Results for Computers in the Electronics Industry in Taiwan

	Average	DOM	DFI	FG50	FS50	FG50 Japan	FG50 U.S.	FG50 Europe
1) Sample size	45	24	21	12	9	2	7	2
2) Export Ratios for Major Product (%)	76.40	83.33	68.48	66.58	71.00	0.00	71.29	100.00
3) Major Export Countries								
U.S.	53.30	50.00	57.10	58.33	55.60	-	71.43	100.00
Japan	-	-	-	-	-	-	-	-
Europe	24.40	33.33	14.30	8.33	22.20	-	-	-
S.E. Asia	4.40	4.17	4.80	8.33	-	100.00	-	-
4) Technological Intensity	25.70	18.44	36.30	32.68	40.60	85.00	7.57	41.20
5) Ratios of having Technologial Cooperation with Foreign Firms (%)	22.20	12.50	33.30	33.30	33.30	50.00	14.29	50.00
6) Had Conducted Training (%)	44.40	37.50	52.40	50.00	55.60	50.00	42.96	100.00
Managers' training Ratios (%)	21.50	16.59	28.70	32.52	24.20	60.67	16.55	47.70
Engineers' Training Ratios (%)	27.90	21.55	37.20	31.92	43.60	88.24	11.41	40.20
7) Total R&D Expenditures in 1986 (Thousand NT Dollars)	12,844	2,203	25,004	9,328	45,906	25,000	5,857	32,968
R&D Expenditure Per Employee (NT Dollars)	24,222	21,589	28,052	20,295	37,362	-	12,394	48,489
8) Technological Gap (Lag) for Sampled Firms (in Years)	0.61	1.29	0.20	0.45	0.11	2.50	0.00	0.00
9) Technological Gap (lag) for Industry as a Whole (in Years)	1.07	1.92	0.05	0.00	0.11	0.00	0.00	0.00
10) Major Technological Bottleneck:								
(1)Product Design Techno.(%)	67.50	57.14	78.95	81.81	66.67	50.00	83.33	100.00
(2)Utilization of Tools and Machinery (%)	7.50	14.29	-	-	-	-	-	-
(3)Manufacturing Techno.(%)	-	-	-	-	-	-	-	-
(4)Quality Control (%)	5.00	9.52	-	-	-	50.00	-	-
(5)Others (%)	20.00	19.04	21.05	18.18	22.22	-	16.67	-

Source: This study
Note: The same as table 3-2

Table 3-4: Survey Results for Consumer Products in the Electronics Industry in Taiwan

	Average	DOM	DFI	FG50	FS50	FG50 Japan	FG50 U.S.
1) Sample size	121	101	20	11	9	6	2
2) Export Ratios for Major Product (%)	66.98	68.17	61.00	62.18	59.56	65.50	50.50
3) Major Export Countries							
U.S.	41.32	39.60	50.00	45.45	55.56	33.33	50.00
Japan	4.13	1.98	15.00	18.20	11.11	33.33	-
Europe	18.18	20.79	5.00	9.10	-	-	50.00
S.E. Asia	9.09	7.92	15.00	9.10	22.22	16.67	-
4) Technological Intensity	13.71	12.80	19.69	23.00	11.86	12.05	36.70
5) Ratios of having Technologial Cooperation with Foreign Firms (%)	12.40	7.92	35.00	45.50	22.22	50.00	50.00
6) Had Conducted Training (%)	37.19	38.61	30.00	54.50	0.00	50.00	50.00
Managers' training Ratios (%)	16.01	16.05	12.80	18.30	0.00	9.52	79.40
Engineers' Training Ratios (%)	22.02	21.74	8.67	12.40	0.00	5.21	50.00
7) Total R&D Expenditures in 1986 (Thousand NT Dollars)	2,246	1,298	7,030	11,567	1,486	5,373	26,500
R&D Expenditure Per Employee (NT Dollars)	16,773	14,432	31,919	24,591	49,020	5,015	91,743
8) Technological Gap (Lag) for Sampled Firms (in Years)	0.94	0.99	0.68	0.80	0.56	0.83	1.50
9) Technological Gap (lag) for Industry as a Whole (in Years)	0.98	1.07	0.53	0.50	0.56	0.33	1.50
10) Major Technological Bottleneck:							
(1)Product Design Techno.(%)	56.78	58.59	47.37	50.00	44.44	40.00	100.00
(2)Utilization of Tools and Machinery (%)	16.10	18.18	5.26	10.00	-	20.00	-
(3)Manufacturing Techno.(%)	10.17	6.06	31.31	20.00	44.44	20.00	-
(4)Quality Control (%)	11.02	10.10	15.78	20.00	11.11	20.00	-
(5)Others (%)	5.93	7.07	-	-	-	-	-

Source: This study
Note: The same as table 3-2

Table 3-5: Survey Results for Telecommunications Equipment in the Electronics Industry in Taiwan

	Average	DOM	DFI	FG50	FS50
1) Sample size	30	25	5	1	4
2) Export Ratios for Major Product (%)	56.17	59.76	38.20	85.00	26.50
3) Major Export Countries					
U.S.	26.67	24.00	40.00	10.00	25.00
Japan	-	-	-	-	-
Europe	23.33	28.00	-	-	-
S.E. Asia	3.33	4.00	-	-	-
4) Technological Intensity	18.26	17.72	20.70	28.00	13.30
5) Ratios of having Technologial Cooperation with Foreign Firms (%)	6.67	0.00	40.00	100.00	25.00
6) Had Conducted Training (%)	16.67	12.00	40.00	100.00	25.00
Managers' training Ratios (%)	13.72	8.15	38.80	10.60	67.00
Engineers' Training Ratios (%)	25.35	9.26	97.80	25.50	70.00
7) Total R&D Expenditures in 1986 (Thousand NT Dollars)	5,194	1,945	21,441	42,208	16,250
R&D Expenditure Per Employee (NT Dollars)	27,686	18,069	70,964	120,594	21,333
8) Technological Gap (Lag) for Sampled Firms (in Years)	1.17	1.38	0.20	0.00	0.25
9) Technological Gap (lag) for Industry as a Whole (in Years)	1.21	1.42	0.20	0.00	0.25
10) Major Technological Bottleneck:					
(1)Product Design Techno.(%)	82.76	79.17	100.00	100.00	100.00
(2)Utilization of Tools and Machinery (%)	6.90	8.33	-	-	-
(3)Manufacturing Techno.(%)	3.45	4.17	-	-	-
(4)Quality Control (%)	6.90	8.33	-	-	-
(5)Others (%)	-	-	-	-	-

Source: This study
Note: The same as table 3-2

Table 3-6: Survey Results for all samples in the electronics industry in Taiwan

	All	DOM	DFI	FG50	FS50	FG50 Japan	FG50 U.S.	FG50 Europe
1) Sample size	318	246	72	39	33	16	15	3
2) Export Ratios for Major Product (%)	63.66	62.65	67.14	71.10	62.46	61.94	62.07	99.00
3) Major Export Countries								
U.S.	43.71	41.06	52.80	48.72	57.60	25.00	60.00	100.00
Japan	3.77	1.63	11.10	17.90	3.00	43.75	-	-
Europe	15.09	17.89	5.60	5.13	6.10	-	6.67	-
S.E. Asia	11.01	10.16	13.90	12.82	15.20	18.75	13.13	-
4) Technological Intensity	16.63	15.11	22.70	22.42	23.20	21.69	16.15	33.00
5) Ratios of having Technologial Cooperation with Foreign Firms (%)	11.32	5.69	30.60	38.46	21.20	43.75	20.00	66.70
6) Had Conducted Training (%)	33.85	34.55	40.30	51.28	27.30	43.75	46.67	100.00
Managers' training Ratios (%)	17.60	16.67	21.30	20.03	23.50	14.62	16.07	66.90
Engineers' Training Ratios (%)	19.71	17.37	29.00	23.85	38.11	23.92	19.33	8.30
7) Total R&D Expenditures in 1986 (Thousand NT Dollars)	4,140	1,774	12,223	9,096	15,918	2,707	6,753	41,979
R&D Expenditure Per Employee (NT Dollars)	18,016	16,341	24,668	22,849	27,886	4,717	24,076	44,440
8) Technological Gap (Lag) for Sampled Firms (in Years)	0.88	1.03	0.34	0.30	0.39	0.50	0.21	0.00
9) Technological Gap (lag) for Industry as a Whole (in Years)	0.95	1.11	0.40	0.27	0.55	0.44	0.21	0.00
10) Major Technological Bottleneck:								
(1)Product Design Techno.(%)	60.47	59.40	64.18	63.89	64.52	50.00	71.43	100.00
(2)Utilization of Tools and Machinery (%)	17.28	18.37	13.43	16.67	9.68	28.57	14.26	-
(3)Manufacturing Techno.(%)	8.31	8.11	8.96	5.56	12.90	7.14	-	-
(4)Quality Control (%)	7.31	8.11	4.48	5.56	3.23	7.14	-	-
(5)Others (%)	6.64	5.98	-	8.33	9.68	7.14	14.26	-

Source: This study
Note: The same as table 3-2

Table 3-7: Comparison Among Different Sectors in the Electronics Industry in Taiwan

	Total Sample					
	All	Parts	Semi-conductor	Computers	Consumer products	Telecommunications Equipment
1) Sample size	318	77	45	45	121	30
2) Export Ratios for Major Product (%)	63.66	63.51	47.27	76.40	66.98	56.17
3) Major Export Countries						
U.S.	43.71	48.05	44.40	53.30	41.32	26.67
Japan	3.77	9.09	-	-	4.13	-
Europe	15.09	10.39	-	24.40	18.18	23.33
S.E. Asia	11.01	18.18	15.56	4.40	9.09	3.33
4) Technological Intensity	16.63	14.82	17.89	25.70	13.71	18.26
5) Ratios of having Technologial Cooperation with Foreign Firms (%)	11.32	9.09	4.44	22.20	12.40	6.67
6) Had Conducted Training (%)	33.85	32.47	42.22	44.40	37.19	16.67
Managers' training Ratios (%)	17.60	19.44	16.95	21.50	16.01	13.72
Engineers' Training Ratios (%)	19.71	13.43	17.42	27.90	22.02	25.35
7) Total R&D Expenditures in 1986 (Thousand NT Dollars)	4,140	2,029	3,438	12,844	2,246	5,194
R&D Expenditure Per Employee (NT Dollars)	18,016	14,533	16,351	24,222	16,773	27,686
8) Technological Gap (Lag) for Sampled Firms (in Years)	0.88	0.93	0.67	0.67	0.94	1.17
9) Technological Gap (lag) for Industry as a Whole (in Years)	0.95	0.63	1.00	1.07	0.98	1.21
10) Major Technological Bottleneck:						
(1)Product Design Techno.(%)	60.47	65.28	40.48	67.50	56.78	82.76
(2)Utilization of Tools and Machinery (%)	17.28	22.22	28.57	7.50	16.10	6.90
(3)Manufacturing Techno.(%)	8.37	6.94	16.67	-	10.17	3.45
(4)Quality Control (%)	7.31	1.39	9.52	5.00	11.02	6.90
(5)Others (%)	6.64	4.17	4.76	20.00	5.93	-

Sources : This study

Table 4-1: Firms' Evaluation of the Technological Transfer Effect of OEM in the Electronics Industry in Taiwan

	Total Sample	DOM	DFI
1) Number of Firms whose Major Products were Produced by OEM	43	27	16
2) Percentage of the OEM Firms which considered OEM can Transfer			
Production Technologies:	70.00	71.13	66.67
Managerial Technologies:	62.11	64.73	54.45
Produc Design Techno.:	69.65	70.15	68.18

Source: This study

Table 4-2 : How Firms whose Senior Managers or Engineers had Worked for Foreign Firms before Evaluate the Technology Diffusion Effect through labor Mobility

	All	DOM	DFI
1) Number of Frims whose Senior managers or Engineers had Worked for Foreign Firms before	104	71	33
2) Percentage of the firms which Considered Such Mobility could Help to Diffuse			
Managerial Technologies:	42.61	42.50	42.86
Production Technologies:	31.48	30.67	33.33
Or to Acquire market information:	29.52	23.61	42.42

Source: This study

Table 4-3: Distribution of the Approved Preferential Low-Interest Loans for Major Electronics Industry Products Which are on the List of the “Strategic Industry Assistance Program”

Industries	Cases	Amount of Loan (‘000 NT Dollars)
(1) Computers	44	1,697,993
(2) Consumer Electronics Products	19	2,335,957
(3) Parts & Components	170	5,595,566
(4) Telecommunications	19	311,552
(5) Industrial Electronics Products	28	489,070
(6) Computer Softwares	11	213,167
(7) Electronics Industries Total	291	10,663,306
(8) Other Industries Total	702	10,785,968
(9) (7) + (8)	993	21,449,274
(10)(7) / (9)	29.3%	49.7%

Source: The same as Table 2-3

Table 4-4: Installation of Computer Systems by Type of Computer and by Sectors

Type	Private Firms		Computer Firms		Government		Public Firms		School*		Total	
	Sets	%	Sets	%	Sets	%	Sets	%	Sets	%	Sets	%
Super	0	0.00	3	37.5	3	37.5	2	25.0	0	0.0	8	100
Large	2	6.1	2	6.1	7	21.2	17	51.5	5	15.1	33	100
Med-size	274	38.9	88	12.4	93	13.4	120	16.9	130	18.4	705	100
Micro	2101	55.3	267	7.0	537	14.1	455	12.0	438	11.6	3798	100
Total	2377	52.3	360	7.9	640	14.1	594	13.1	573	12.6	4544	100

* Including all research and education institutions

Source: The same as Table 2-3

Table 4-5 : Installation of Computer Systems by Trade and by Type of Computer (up to June, 1998)

Type of computer Trade	Super	Large	Med	Micro	Total
Agriculture, Forestry, Fishery, Hunting, Mining	0	0	2	24	26
Textiles, Garments	0	0	15	73	88
Electric & Electronics	0	0	60	120	180
Metal	1	1	21	52	75
Petroleum & Chemicals	0	0	26	53	79
Machinery & Transportation Equipment	0	0	7	57	64
Other Manufacturing	0	0	36	169	205
Water, Gas and Electric	0	2	11	13	26
Construction	0	0	4	19	23
Commerce	0	0	6	207	213
Storage, Transportation and Telecommunications	0	3	26	110	139
Finance & Insurance	1	10	65	118	194
Service Industry in Industry & Commerce	0	0	9	17	26
Computer Services	3	1	51	143	198
Government	1	7	82	172	262
Schools & Research Inst.	0	2	97	142	241
Social Services	0	5	21	49	75
Others	0	0	8	35	43
Unable to Identify	2	2	158	2225	2387
Total	8	33	705	3798	4544

Source: The same as table 2-3

Table 4-6 : Firms' Opinions on the Government's Policies Toward the Development of the Electronics Industry in Taiwan

	All	Parts	Semi-Conductors	Computers	Consumer Elec.	Telecom.
(1) Number of firms	318	77	45	45	121	30
(2) To upgrade the technological level the government should						
(A)	18.24	14.49	21.43	21.43	16.07	24.14
(B)	16.55	14.49	21.43	21.43	17.86	20.69
(C)	16.22	20.29	11.90	13.64	16.96	13.79
(D)	20.27	21.74	19.05	22.73	20.54	13.79
(E)	6.01	1.45	2.38	11.36	8.93	3.45
(F)	8.45	11.59	11.90	4.55	5.36	13.79
(G)	4.05	10.14	2.38	2.27	2.68	-
(H)	9.46	4.34	9.52	13.64	10.71	10.34
(I)	0.68	1.45	-	-	0.89	-
(3) To Upgrade the Firm's Own Technological level, the Firm could						
(I)	10.85	8.45	10.00	21.43	7.89	14.29
(II)	9.46	7.04	12.50	2.38	13.16	7.14
(III)	12.54	12.68	17.50	21.43	7.89	10.71
(IV)	9.15	5.63	5.00	-	15.79	10.71
(V)	8.47	8.45	5.00	9.52	7.89	14.29
(VI)	3.73	4.23	2.50	-	6.14	-
(VII)	32.54	32.39	20.00	35.71	34.21	39.39
(VIII)	12.54	21.13	27.50	7.14	6.14	3.57
(IX)	0.68	-	-	2.38	0.88	-

Source : This study

Where

A : Transfer technology by government-sponsored research institutions
B : Coordinate with firms to do joint research
C : Introduce new technology from abroad
D : Educate more R&D people
E : Help the Firms to establish their own brand names
F : Standardise parts
G : tax credit on R&D expenditure
H : Others

And

I : Induce European or American firms to invest in the ROC
II : Induce Japanese firms to invest in the ROC
III : Promote technological cooperation with European or American firms
IV : Promote technological cooperation with Japanese firms
V : manufacture on an OEM basis for European American firms
VI : Manufacture on an OEM basis for Japanese firms
VII : Engage in its own R&D
VIII : Purchase technology or equipment directly
IX : Others

APPENDIX: SURVEY ON FDI (1987)

Questionnaire concerning the performance and impacts of Direct Foreign Investment Firms in the R.O.C.

Conducted by Chung-Hua Institution for Economic Research (CIER)

Date: February, 1987

I. BASIC INFORMATION

1. Name of the firm:

   Firm's ID number:

   Firm was established in:

   Respondent's name:

   Phone number: _____

2. In 1986, your company's ownership was (based on collected capital)

   Domestic ownership (per cent):

   Overseas Chinese ownership (per cent):

   Foreign ownership (per cent):

   Overseas Chinese capital is from:

   Foreign capital is from:

3. Cost structure

   Labor/Total cost:

   Electricity/Total cost:

   Parts and materials/Total cost:

4. Ratios of domestic purchasing to total purchasing

   Materials:

   Parts:

   Machinery:

5. Composition of employees

   Managerial workers:

   Technicians & engineers:

   Laborers:

II. PRODUCTION TECHNOLOGY

1. What is your major product:

   As for the above product its

   Export Ratio is:

   Major exporting country is:

   Total sales are (NT$):

   Unit price is (NT$):

2. How do you evaluate your company's product, in terms of its technological level, functions, and quality, as compared with another similar product which is ranked number one in the world?

_ a) Better. If it can be measured in terms of a time span, then by approximately how many years does it lead by? _ years.

_ b) About the same.

_ c) Worse. If it can be measured in terms of a time span, then by approximately how years does it lag by? _ years.

3. As for the type of industry your company belongs to, how do you evaluate such an industry's technological level in Taiwan as compared with that for a comparable industry in the developed countries such as the United States, Japan, and European countries?

_ a) Better. If it can be measured in terms of a time span, then by approximately how many years does it lead by? _ years.

_ b) About the same.

_ c) Worse. If it can be measured in terms of a time span, then by approximately how years does it lag by? _ years.

4. 1) Is your company currently engaging in any technological cooperation with any other foreign company?

__ a) No.

__ b) Yes. If so, for how many years has this technological cooperation relationship lasted? From which nation is that foreign firm? __years, ___country.

What is your evaluation of the above technological cooperation relationship?

__ a) Satisfactory.

__ b) Acceptable.

__ c) Not satisfactory, the main reason being:

2) Did your company have any other technological cooperation relationship with any other foreign firms before the one mentioned above?

__ a) No.

__ b) Yes. If so, for how many years has this technological cooperation relationship lasted? From which nation is that foreign firm? __years, ____country.

What is your evaluation of the above technological cooperation relationship?

__ a) Satisfactory.

__ b) Acceptable.

__ c) Not satisfactory, the main reason being:

5. In your opinion, what is the major technological bottleneck facing your company or your industry as a whole in the R.O.C.?

__ a) Product design and development technology.

__ b) Design and utilization of tools and machinery.

_ c) Technology for manufacturing products.

_ d) Quality control.

_ e) Others.

6. Is your company's main product contracted by original equipment manufacturing (OEM)

_ a) No.

_ b) Yes. By which country is it contracted?

7. What is your opinion regarding OEM?

1	2	3	4	5
very effective	effective	acceptable	not effective	useless

1) In terms of introducing

Production technologies:

2) In terms of promoting

Managerial technologies:

3) In terms of promoting product

Design technologies:

8. Has any one of your company's senior managers or engineers ever worked for foreign firms before? Here, the foreign firms are defined as those companies which are specifically utilizing their parent company name such as SONY, RCA, & PHILIPS in the R.O.C..

_ a) No.

_ b) Yes. Companies mainly belonging to which country? ___ Does their work experience in those foreign companies have any value at all?

	very helpful	some help	useless
1) In terms of managerial technology improvement			
2) New product design			

3) Acquisition of marketing information

9. What the most effective method, in your opinion, which can be used to promote your company's technology level?

__ a) To induce European or American firms to invest in the R.O.C.

__ b) To induce Japanese forms to invest in the R.O.C.

__ c) Technological cooperation with European or American firms

__ d) Technological cooperation with Japanese firms

__ e) OEM for European or American firms

__ f) OEM for Japanese firms

__ g) Own R&D

__ h) Purchasing technology or equipment directly

__ i) Others, please indicate:

10. If your company is in the shoe making industry then:

__ a) Has your company ever produced sandals before?

If the answer is yes, then approximately how many years ago?

__ b) Has your company ever produced jogging shoes before?

If the answer is yes, then approximately how many years ago?

__ c) Has your company ever produced leather shoes before?

If the answer is yes, then approximately how many years ago?

III. RESEARCH AND TRAINING

1. How much money did your company spend on R&D in 1986?____Does your company have an R&D department?

__ a) No.

__ b) Yes. It was established in __ (year)

2. To account for technological upgrading, did your company ever conduct any in-service training in 1986?

__ a) No.

__ b) Yes.

1) How many people received training?

Among them,

Managerial staff accounted for __ per cent

Engineers & Technicians for __ per cent

Operators accounted for __ per cent

2) How many people were sent abroad for training?

For how many weeks on average?

3. Topgrade the level of technology, in your opinion, what should we do to improve the quality of in-service training?

__ a) Commission more training to public training centers.

__ b) Commission more training to private training centers.

__ c) Cooperate with vocational high schools.

__ d) Conduct one's own training.

__ e) Hire other workers with experience.

__ f) Others.

IV. POLICY EVALUATION

In your opinion, what is the most effective way in which the government can promote the technological level in the R.O.C.?

_ a) Technology transfer by government-sponsored research institutions.

_ b) Coordinating with firms to do joint research.

_ c) Introducing new technology abroad.

_ d) Educating more R&D people.

_ e) Helping the firms to establish their own brand names.

_ f) Low interest loans on R&D activities.

_ g) Standardization of parts.

_ h) Tax credit on R&D expenditure.

_ i) Others. Please indicate: