The Global Competitiveness of Taiwan's Industrial Technology*

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For more than a decade, Taiwan has been working actively on programs for the localization of technology. Taiwan is not only ranked the world's third largest supplier of information and technology (IT) products, but it is also ranked fourth in technology and third in innovation according to the 2001 World Economic Forum (WEF) "Global Competitiveness Report." Overall, the competitiveness of Taiwan's technology has been very impressive. Taiwan is not a member of the Organization for Economic Cooperation and Development (OECD). With respect to Taiwan's technological innovation capability and national competitiveness of each individual industry, the indices to make direct comparison with OECD are still under construction. In consideration of data comparability and availability, this research aims to establish a set of indicators that can be used to compare the competitiveness of Taiwan's industrial technology with other countries, so as to understand the technological performance of Taiwan's industrial technology and its international status. These assessment indices include indicators representing current competitiveness and output (such as patents, licensing fees and royalties, added value, and export indicators), as well as indicators to represent the input competitiveness index (research and development (R&D) investment and researcher). The method of analysis includes comparing of individual indicators, as well as using patents and market share for cross-analysis, in order to study changes in Taiwan and its competitors. The results of comparison and analysis show that Taiwan experienced a slow downturn on inputs in 2000. In both hi-tech industry and industry as a whole the R&D expenditure growth rate and R&D density were lower than in 1999. Because R&D and innovation are significantly related to Taiwan's future competitiveness, causes for the slack in R&D investment growth need to be confirmed in order for the government to make the industrial policy. As to the performance on output, patent performance has been outstanding despite the number of granted patents, patent strength, or impact. It reflects the fact that Taiwan has become an important player on the international innovation stage. However, Taiwan's industrial structure is highly concentrated in the information and communication technology (ICT) sector, and the weak demand in the ICT market following the September 11th terrorist attacks in the United States had a serious impact on the export competitiveness of Taiwan's hi-tech industries in 2001. In the future, enhancing the density of industrial technology R&D investment future risks will be Taiwan's next challenge.

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I. FOREWORD¹

Investment in R&D and the spread of new technologies allow constant accumulation and progress of technology and innovation. Moreover, it enhances international competitiveness, and drives national economic growth. The collection of information about inputs, application and outputs in scientific technology has become an important task for all nations. If detailed information is offered, scientific resources will be rationally distributed and managed, and thus create the optima for economy and society, no matter who the national policy-maker or corporate decision-makers are.

Science & Technology Indicators were the first indicators, developed by the OECD in the 1970s. They were used to measure the technology level of developed nations. "Frascati Manual" later served as a handbook for the collection of national technology data and the production of related surveys and statistics. The OECD subsequently produced the "Technology Balance of Payment (TBP) Manual," relating to technology trade revenue and expenditure statistics, and the "Patent Manual," relating to the collection of data on patents. In the early 1990s, the OECD produced the "Oslo Manual," to serve as a handbook for innovation measurement. This was the most important milestone in the development of technology indicators in the 1990s. By 1995, the OECD, the EU and the United States had realized that traditional technology indicators were no longer adequate in reflecting the development of knowledge economy, and in 1996 work on a new generation of technology indicators (such as the OECD's "Blue-Sky Project") began. The OECD members undertook collaborative research, development, surveys, and analysis, while also holding many international conferences to share their experience in the development of new indicators and results of empirical research that they had undertaken. After many meetings and conferences, a clearer framework and measurement methods for "common technology and innovation indicators" were developed.

The main function of technology and innovation indicators is to represent the current state of a nation's technology and innovation activity on inputs, processes and outputs, or to measure the performance achieved in the development of knowledge economy. The main types of indicators are as follows:

1. Input indicators: These cover R&D expenditure, innovation expenditure, number of researchers, quality and quantity of human resources, knowledge investment², venture capital, etc.
2. Process indicators: These cover knowledge extension indicators (such as ICT facilities and their use status, and the number of documents and patents cited

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² The OECD uses a combined measure of R&D expenditure, ICT investment, and expenditure on education to measure knowledge investment.

or applied) and R&D collaboration models (such as the number of technology-related strategic alliances, and the state of collaboration between corporations, universities and research institutes).

3. **Output indicators:** These include direct indicators such as the number of patents produced, the number of scientific papers published and the volume of trade in technology, as well as hi-tech industry's added value, export value and share of the total manufacturing industry exports.

Both the traditional and new innovation indicators for the measurement of technological change and innovative activities have their limitations. The R&D expenditure is the most obtainable, reliable and popular S&T indicator, however, R&D is not the only input indicator of innovative activities. Such activities as design, production, market research, and education and training are also important inputs influencing the innovative process. Felder et al. (1996) argued that the expenditures of non-R&D innovation made up a large part of the expenditures of German manufacturing innovation. Similarly, the survey and research of the expenditures of Italian manufacturing innovation conducted by Sterlacchini (1996) revealed the same viewpoint. However, the ratios of R&D expenditures in the total innovation expenditure vary in different countries; the ratio of R&D in the total innovation expenditure in some countries can reach up to one-third, while some only take one-fourth (such as Netherlands' CIS I, 1992). In addition, some studies also showed that in accordance with the R&D expenditure in the OECD "Frascati-Manual," the R&D expenditures of R&D and non-R&D activities of small enterprises are often under-estimated (Kleinknecht 1987; Sterlacchini 1990).

With respect to the patent indicator, although it is considered as the closest measurement proxy variable to the "innovation output" (Griliches 1984), many limitations and arguments still existed (Jaffe, Trajtenberg and Henderson 1993). Different enterprises or industries will be different in the tendency or preference of patent application. For example, to the automobile industry, a patent is not a very important key factor for success; but to the pharmaceutical industry, it is very important (Arundel et al. 1995; Levin et al. 1987; Berrin & Wyatt 1988). Therefore, it may be biased if the number of patents is only one single indicator used to measure the innovation or R&D output. Additionally, the number of patents cannot completely reflect software innovation activities, as the protection of software innovation still takes the copyright as the most important form. Furthermore, the number of patents does not represent the economic value, because while most patent indicators reflect the "dynamic feature of the invention," they can not reflect the economic value and impact of commercialization (Schankerman & Pakes 1986).

As for the bibliometric indicator, such as the number of papers in Science Citation Index (SCI), it generally reflects the output of basic research, not innovation. Therefore, it is normally used for the measurement of the output of national science or basic research, rather than in the output of industrial R&D and innovation.

With respect to the measurement of technology activities, there are two different kinds of methods that can be used to measure these. One is the traditional input-output approach. With this method, technology activities are viewed as a process of input and output, and the relationship between inputs and outputs is used to analyze the technology level, productivity, etc. The second type is the utilization and impact approach. Here, several important impact indicators are established, and these quantitative or qualitative indicators are used to analyze the impact of technology activities on the economy or society as a whole.

Over the last ten years or so, Taiwan has been making many efforts to achieve the localization of technology. Thanks to the combined devotion of government and industry, impressive achievements have been made in this area. Not only is Taiwan now the world's third largest producer of IT products, but it also leads the world in semiconductor manufacturing technology. In the WEF's global competitiveness report in 2001, Taiwan ranked fourth in technology and third in innovation.

Since Taiwan is not a member of the OECD, and has yet to establish parallel indicators to those used by the OECD³, direct comparison is not possible. It is therefore, an important responsibility and task for the government to establish as soon as possible an internationally compatible system of S&T indicators for regularly monitoring Taiwan's industrial technology competitiveness.

This paper attempts to establish a set of measurement indicators suitable for the assessment and comparison of Taiwan and other countries' industrial R&D and innovation capability, based on the consideration of the availability of current data regarding Science and Technology (S&T) in Taiwan. The organization of the paper is as follows: section II proposes the methodology; section III conducts an international comparison of industrial technology competitiveness indicators. Section IV analyzes the state of competition among the selected countries in the hi-tech sector in the United States. Finally section V presents the conclusions.

II. METHODS

1. Conceptual Framework

There are various ways of approaching the measurement of competitiveness. The competitiveness measured by the Technological Achievement Index (TAI) introduced by the UN in 2001 is the level already achieved. In the bulk of the literature, the two kinds of competitiveness measured are current competitiveness and future develop-

³ In 2002 Taiwan did announce technology indicators which were compatible with the OECD indicators. However, because for some indicators Taiwan does not collect the necessary data or undertake the necessary surveys, it is still not possible to use these indicators for comparisons with the OECD member nations. Such data that can be used for direct international comparisons is mainly basic information on technology activity. Although work has begun on innovation surveys, it has yet to be completed, and the data is not yet available for use.

ment potential.

What current competitiveness shows is the output level that has been reached by industrial technology. Future development potential is measured by the current level of inputs in industrial technology innovation; because of the time lag in technology R&D and innovation, the greater the inputs today, the greater the output (or competitiveness) in the future. Of course, besides the inputs and outputs, competitiveness relates also to the process conversion efficiency and the common environment, including the efficiency of knowledge transmission, innovation environment, innovation social capital, etc. For example, the Institute for Management Development (IMD) defines competitiveness as assets multiplied by process conversion capability, and the development of the knowledge economy emphasizes the importance of knowledge flow and extension, the innovation environment, and systems and mechanisms for interaction (OECD 1996). When measuring the competitiveness of a country's industrial technology, one has to take into consideration the current level of industrial competitiveness, future development potential and process competitiveness. If these three kinds of competitiveness are all growing together, the competitiveness of the nation or industry can continue to grow.

At present, however, the competitiveness indicators relating to processes and environment rely mainly on questionnaire surveys to obtain data (for example, the IMD and WEF indicators). Relatively little has been made of the measurement values and statistics in terms of widespread international use. In order to maintain objectivity in this study, process and environment indicators are not taken into consideration. They will be left for future research.

On the basis of the above, this study will develop a conceptual framework for the measurement of industrial technology competitiveness based on the two aspects of current competitiveness and future potential competitiveness (see Figure 1).

FIGURE 1. CONCEPTUAL FRAMEWORK FOR THE ANALYSIS OF INDUSTRIAL TECHNOLOGY COMPETITIVENESS

2. Measurement Variables

On the basis of the industrial technology competitiveness conceptual framework described above, indicators and variables have been selected, which are suitable for measuring the two aspects covered. These are collected as in Table 1. Most indicators used here followed those in OECD Science & Technology Scoreboard (2000), but also a modified patent-related indicator named "Subsequent Impact

Index" from the "Current Impact Index" developed by CHI Research Inc. The individual measurement variables are discussed below:

(1) Input Indicators

The input indicators for technology innovation inputs should include not only R&D expenditure but also experimental design and marketing research, education and training, etc. However, the results of the innovation surveys that have been conducted in Taiwan have yet to be announced. For the purpose of this survey, R&D expenditure and researcher have been selected to serve as the indicators for measuring technology input competitiveness. Comparison is undertaken in terms of both absolute size and relative size, with further analysis of structural changes, so as to examine the changes in the technology input competitiveness of Taiwan and its main competitors.

(2) Output Indicators

- Patent Indicators

Patents have always been viewed as the indicator best able to represent technology and innovation output. The accumulation of patent capability reflects a nation's vitality and competitiveness in the area of technology and innovation activities. Particularly today, when so much emphasis is being placed on intellectual property rights, patents are important weapons for strengthening an enterprise's competitiveness. For the purposes of measuring patent performance, in this study, we examine the number of utility patents granted to each country by the U.S. Patent and Trademark Office (USPTO), ignoring the number of patents granted within each country. This is because different countries have different patent review systems that affect the number of patents granted. The variables used include quantitative indicators (the absolute number and relative quantity, of patents granted in industry as a whole and in the hi-tech sector), qualitative indicator (citation frequency), as well as patent strength, which have both quantitative and qualitative characteristics; these variables are used to measure individual countries' technology performance (NSF 1998; Narin, Albert and Hicks 2001).

- License Fee and Royalty Income

The patent indicators noted above are related to the quantity and quality of patents. Technology revenue and expenditure directly reflect the value of technology; the higher technology revenue is, the more competitive that country's technology is. For the purposes of this study, "payments for the use of patents, trademarks, etc.," was used as a variable for measuring the value of patent rights. Although payments for trademark use are not closely related to industry technology competitiveness, it was not possible to obtain separate data for patents alone. The combined data for patents

and trademarks therefore had to be used as the variable for the market value of R&D and innovation output. In this paper, revenue divided by expenditure is used for measurement; the higher the ratio, the more competitiveness the R&D and innovation output has.

TABLE 1. MEASUREMENT INDICATORS AND VARIABLES FOR INDUSTRIAL TECHNOLOGY COMPETITIVENESS

Competitiveness Aspect	Indicator	Measurement Variables
1. Future Development Potential	<ul style="list-style-type: none"> • R&D expenditure indicator • Researcher indicator 	<ul style="list-style-type: none"> • Gross expenditure of R&D (GERD), and R&D expenditure as percentage of GDP (GERD/GDP) • Business expenditure of R&D (BERD), and Business R&D expenditure as percentage of GDP or DPI (Domestic Production of Industry) • Changes in the structure of industry's R&D expenditure • Total Researcher • Total number of Researcher employed in Business Enterprise • Changes in the structure of Researcher numbers in industry
2. Current Competitiveness	<ul style="list-style-type: none"> • Patent strength indicator • Licensing fee and royalty indicator • Added value indicator • Export indicator 	<ul style="list-style-type: none"> • Hi-tech industry and industry as a whole <ul style="list-style-type: none"> - Number of patents granted - Patent impact - Patent strength - Patent Intensity • Licensing fee and royalty revenue and expenditure • Added value in manufacturing industry • Added value in hi-tech industry • Changes in industry's added value structure • Hi-tech industry export value • Hi-tech industry export value as percentage of the export value of manufacturing industry as a whole • Changes in manufacturing industry export structure

• Added Value Indicator

Not only does the utilization of new technology create new products with high added value, it can also help manufacturing industry as a whole to increase the added value of its products, and achieve the goal of industrial upgrading. The stronger a country's industrial technology R&D capability, the higher the level of added value will be in its hi-tech industry and its manufacturing industry as a whole. In this study, the added value of the hi-tech industry and manufacturing industry as a whole is used as an indicator of technology output, along with further observation of the changes in added value structure in different countries.

- Hi-tech Industry Export Indicator

Export indicators are often used to measure the international competitiveness of a country's industry. However, as enterprises have become more internationalized, in order to reduce the distortion that could result from this internationalization, exports of technology-intensive products are usually used as a measurement variable. For example, the OECD uses the term "hi-tech industry" (including the pharmaceuticals industry, computer and OA equipment, electronics and communications equipment, and the aerospace industry) to represent technology-intensive industry. This study uses the same definition of hi-tech industry as used by the OECD to compare hi-tech industry exports and changes in export structure.

3. Data Processing, and Methods of Comparison and Analysis

(1) Data Processing and Data Sources

As international comparisons are being made, it is necessary to achieve uniformity in terms of data classification and definitions. For OECD member nations, data are available which is based on a uniform standard; the published data can be cited directly. In the case of Taiwan, however, because Taiwan is not a member of the OECD, the data have to be adjusted to bring it into line with the OECD data before international comparison can be attempted. The data sources are shown in Table 2. The data adjustment and processing methods used are described below:

- Comparison by Industry

The Taiwanese data were adjusted according to the international standard industrial classification (ISIC) used by the OECD (see appendix Table 1). The data that had to be adjusted included the number of employees, added value, etc. The data for industry sub-categories were estimated by taking the Ministry of Economic Affairs survey data covering the number of employees, added value, etc., comparing it with the percentage of the industry sector accounted for by that sub-category, and multiplying by the figure for number of employees and added value given for that sector by the Directorate General of Budget, Accounting and Statistics, to obtain estimates for the sub-category.

- Comparison of Industry Classification Codes With Patent Codes and Customs Codes

Patent classification with respect to industries may be one-to-one or one-to-many. For this study, the USPC and SIC handbooks published by the USPTO (1997) were used for the classification and calculation of patent data. For the comparison of industry classification codes and customs import/export codes, the OECD's instructions for comparison of the ISIC (rev. 3.0 edition) and the HS code were used to classify and calculate Taiwanese import and export data by industry.

TABLE 2. DATA SOURCES FOR INDUSTRIAL TECHNOLOGY COMPETITIVENESS INDICATORS MEASUREMENT VARIABLE

Measurement Variable	Data Source-Comparison Countries	Data Source-Taiwan
1. R&D Expenditure <ul style="list-style-type: none"> - GERD (Total R&D Expenditure), BERD (Enterprise R&D Expenditure) - GERD/GDP, BERD/DPI - BERD Structure 	<ul style="list-style-type: none"> • OECD, MSTI database • OECD, STAN database • OECD, BSTS database 	<ul style="list-style-type: none"> • Indicators of Science and Technology of the R.O.C. • The Human Resource Statistics Yearbook of the R.O.C. • The National Income Yearbook of the R.O.C.
2. Researcher <ul style="list-style-type: none"> - Total R&D Researchers - Business Enterprise Sector RSE (Researcher of Scientist & Engineering) - Business Enterprise Sector RSE Structure 		
3. Patent Strength Indicator <ul style="list-style-type: none"> - All Industry & Hi-tech Industry - Granted Patent Numbers - Subsequent Impact Index(SII) - Patent Strength(PS) - Patent Intensity(PI) 	USPTO, Patent CD-ROM IMF, IFS	USPTO, Patent CD-ROM Quarterly National Economic Trends
4. Licensing Fee and Royalty Income and Expenditure	OECD, International Trade in Services	The Balance of Payments of the R.O.C.
5. Added Value Indicator <ul style="list-style-type: none"> - Value Added of Manufacturing - Value Added of Hi-tech Industries 	<ul style="list-style-type: none"> • OECD, STAN database 	<ul style="list-style-type: none"> • The National Income Yearbook of the R.O.C. • The Industrial Statistical Survey Report of R.O.C.
6. Export Indicator <ul style="list-style-type: none"> - Exports of Hi-tech Industries - Hi-tech Exports as a Percentage of Total Manufacturing Exports 	<ul style="list-style-type: none"> • OECD, STAN database • The commodity trade tape of Japan • The commodity trade tape of China 	<ul style="list-style-type: none"> • The commodity trade tape of the R.O.C.

(2) Comparison Methods

The most common methods for measuring R&D and innovation competitiveness include direct comparison with other nation's technical capabilities in terms of specifications, and using the "Techno-economy" method (Stoneman 1995), to collect and calculate relevant measurement indicators so as to perform international comparison. In this study, the latter method is used, making use of quantitative indicators that can reflect technological change and innovation. The method employed combines individual comparison of single indicators and cross-tabulation analysis with export and patent indicators, to undertake comparison with the industrial technology competitiveness of the

leading countries and examine the changes that have taken place. In order to avoid the possible bias of applying a single indicator, in this paper, we use the share of patents granted in the United States as a proxy of technological capability and the market share of commodities exported to the United States as a proxy of manufacturing capability so that different features of competitiveness can be distinguished.

III. INDUSTRIAL TECHNOLOGY COMPETITIVENESS INDICATOR COMPARISON

In this section, we will undertake international comparison and analysis with respect to the various indicators of industrial technology competitiveness. Cross-analysis will then be undertaken using the export and patent indicators, and finally an attempt to examine the changes in technology and manufacturing competitiveness in the U.S. market will be made.

1. Analysis of Input Competitiveness

While it is emphasized that individual corporations are the most important element in innovation, the state's activities in terms of the establishment of R&D infrastructure and the provision of funding for universities and research institutes to undertake R&D work (what can be called the "innovation support system") also have an impact on the capabilities of the national innovation system. They can also have either a direct or indirect impact on the strengthening of industrial technology capability. The authors believe that only when the R&D investment of all the players in the national innovation system is increasing simultaneously can enterprises' international competitiveness be strengthened. Thus, besides comparing enterprises' R&D investment, we also undertake international comparison of national R&D investment.

(1) International Comparison Using Gross Domestic Expenditure on R&D as a Percentage of GDP

- Gross Domestic Expenditure on R&D (GERD)

If we compare gross domestic expenditure on R&D (GERD) in 2000 (using purchasing power parity data⁴), it can be seen that the United States is far ahead of any other country. They are followed by Japan, Germany, China, France, the U.K., South Korea, Canada, Italy and Taiwan (see Table 3). If one calculates R&D expenditure on a purchasing power parity basis, then Taiwan's R&D expenditure in 2000 reached US\$ 10.3 billion; US\$ 700 million higher than the figure for 1999, which was US\$ 9.6

⁴ In 2001 technology data for Taiwan, Singapore, China and Israel was included in the OECD's MSTI report in the "non-member nation" section. This means that, for the first time, it is possible to compare Taiwan with other nations using purchasing power parity R&D data.

billion, putting it in the tenth place globally (the same ranking as in 1999).

One point worth noting is that the USA's total expenditure on R&D in 2000 reached US\$ 265.3 billion (in purchasing power parity terms); once again, this was higher than in any previous year. However, following the September 11 terrorist attacks and the war in Afghanistan, the amount of money available to be spent on technology was significantly increased (by a higher percentage than at any time in the previous 20 years). The increase was particularly great in the areas of national defense and medicine.⁵ The terrorist attacks cast a pall over the global economy, which continued to go downhill, affecting business performance. It is still unclear whether this had a negative impact (either direct or indirect) on R&D expenditure by companies in the United States or elsewhere in the world, because the results of most surveys on R&D expenditure in 2001 have yet to be announced. However, it seems likely that it did.

• GERD/GDP

If one wishes to measure the efforts that a country has made to transform itself into a knowledge economy, one can gain a rough idea of this by looking at the expenditure on innovation. The R&D density indicator is one of the most commonly used indicators here. If one looks at GERD as a percentage of GDP in 2000, Israel had the highest figure, at 4.40%, followed by Sweden with 3.78% (1999), Finland with 3.37%, Japan with 2.98%, the United States with 2.70%, Switzerland with 2.64%, and South Korea with 2.55%. The second group, where the percentage was under 2.5% but higher than 2%, included Germany with 2.38%, France with 2.18%, and Taiwan with 2.05%. Countries with GERD higher than Taiwan's but where GERD as a percentage of GDP was lower than Taiwan included China with 1.0%, the U.K. with 1.83%, Canada with 1.84% and Italy with 1.04% (1999) (see Table 3). If one compares R&D density in 1999 and 2000, it can be seen that the density rose in the United States and Japan but fell in most of the Western European nations. In particular, the figure for Germany fell from 2.44% to 2.38%. As Germany's GERD increased, it can be deduced that the rate of increase in GERD was not as great as the rate of increase in added value. Taiwan's R&D density was 2.05% in both 1999 and 2000. Whereas during the period 1996–1998, Taiwan's R&D density was increasing rapidly, in the last few years it has been stagnating. This is mainly due to the slow R&D growth in the last two years.

(2) *Comparison of Business Enterprise R&D Expenditure as a Percentage of GDP and DPI*

If one looks at business enterprise expenditure on R&D (BERD) in 2002, it can be seen that the United States and Japan were the biggest spenders. In the United States, BERD totaled US\$ 199.9 billion, 1.9% (nominal) up from the figure for 1999.

⁵ *Science & Technology in Congress*, January 2002.

This figure was almost as large as the total of all the other G7 member countries combined. It was a far higher level of investment than can be found in any other country in the world. Germany, China, France, the U.K. and South Korea all fell into the second group; Canada, Italy, Taiwan, Sweden, the Netherlands, Sweden, Israel, Australia and Finland were in the third group (see Table 3). In 2000, Taiwan had BERD⁶ of approximately US\$ 6.6 billion (PPP), 6.5% (nominal) up from the 1999 figure of US\$ 6.2 billion. Taiwan thus ranked number ten in the world, the same ranking as for GERD.

TABLE 3. INTERNATIONAL COMPARISON OF TOTAL EXPENDITURES ON R&D AND BUSINESS EXPENDITURES ON R&D (1999, 2000)

	GERD US\$ millions		GERD as percentage of GDP (%)		BERD ^b US\$ millions		BERD as percentage of GDP (%)		BERD as percentage of DPI ^c (%)	
	1999	2000	1999	2000	1999	2000	1999	2000	1999	2000
U.S.	244,700	265,322	2.66	2.70	182,823	199,855	1.99	2.04	2.72	-
Japan	92,774	98,222	2.94	2.98	65,604	69,700	2.08	2.11	3.02	3.10
Germany	49,295	52,851	2.44	2.38	34,393	37,398	1.70	1.76	2.44	2.50
China	-	50,286	0.83	1.00	18,731	30,152	0.41	0.60	-	-
France	30,350	31,410	2.19	2.18	19,174	20,113	1.38	1.37	2.05	2.03
U.K.	26,024	27,094	1.88	1.83	17,374	17,787	1.25	1.22	1.83	1.78
Korea	15,793	19,060	2.47	2.55	11,275	14,114	1.76	1.98	2.16	2.44
Canada	14,480	15,839	1.80	1.84	8,247	8,994	1.02	1.04	-	-
Italy	14,355	-	1.04	-	7,080	7,384	0.51	0.51	0.72	0.71
Taiwan	9,617	10,326	2.05	2.05	6,166	6,568	1.31	1.30	1.42	1.40
Netherlands	8,476	-	2.02	-	4,778	-	1.14	-	1.68	-
Sweden	7,865	-	3.78	-	5,908	-	2.84	-	4.35	-
Australia ^d	6,847	-	1.51	-	3,119	-	0.64	-	0.87	-
Switzerland	-	5,727	-	2.64	-	4,225	-	1.95	-	2.07
Israel	4,489	5,598	3.86	4.40	3,093	4,072	2.66	3.20	-	-
Finland	3,893	4,392	3.22	3.37	2,654	3,117	2.19	2.39	3.26	3.49
Denmark	3,071	-	2.09	-	1,947	-	1.32	-	2.14	-
Singapore	1,542	1,776	1.90	1.88	970	1,101	1.19	1.17	-	-

Note: a) 1998.

b) Business Enterprise sector classification of Taiwan is in accordance with Frascati Manual, OECD.

c) DPI is Gross Domestic Product of Industry.

Source: 1. OECD, Main Science and Technology Indicators 2002/1, 2002.

2. National Science Council, Indicators of Science and Technology R.O.C., 2001.

3. National Income in Taiwan Area, DGB, Accounting and Statistics, Executive Yuan, R.O.C.

Turning to BERD as a percentage of GDP, the countries with the highest percentages in 2000 were Israel (3.2%) and Sweden (2.84%). These percentages were far higher than those of any other country. The figures for Finland, Sweden, the United States and Japan were all over 2%. The percentage for Taiwan was 1.30%; lower than

⁶ The statistics for Taiwan's corporate R&D expenditure use the OECD classification; for the basic data, see the *R.O.C. Science and Technology Statistical Yearbook*, 2001 edition, 146-147.

South Korea's 1.98%, Germany's 1.76% and Switzerland's 1.95%, close to France's 1.37%, and higher than the U.K.'s 1.22%, Singapore's 1.17%, the Netherlands' 1.14% (1999), Canada's 1.04% and China's 0.60% (see Table 3). For both GERD and BERD, Taiwan's growth in 2000 was slow. The fact that the growth rate in R&D expenditure was lower than the added value growth rate meant that BERD fell as a percentage of both GDP and DPI. As to why Taiwan's GERD and BERD growth rates fell, further research will be needed to determine whether this was due to slower growth in R&D expenditure on the part of industry as a whole, or because the trend towards globalization has meant that R&D resources are being allocated on a global basis or used to purchase technology from overseas, thereby reducing domestic expenditure on R&D. Another point is that 2000 was a good year for the global economy. Many countries, including Taiwan, saw exports rise to new heights, and it may be that many companies were concentrating their efforts on expanding their production lines, neglecting R&D investment in the process. The authors feel that all of these scenarios are possible, but the shortage of data on which to base an analysis means that this question will have to wait for more in-depth research in the future.

(3) Industry's R&D Expenditure Structure

• R&D Expenditure in the Manufacturing and Service Sectors

As regards the structure of individual countries' R&D expenditure, for all countries the manufacturing sector accounts for the highest percentage of the total R&D expenditure. In the case of Japan, Germany and Taiwan, manufacturing industry R&D accounts for over 90% of the total. Countries where the service sector accounted for a high percentage of the total R&D expenditure in 1999 included the United States, Canada, Australia, the U.K. and the Netherlands. One point worth noting is that during the period 1997-1999 the percentage of the total R&D expenditure accounted for by the manufacturing sector in the United States fell significantly, while the percentage accounted for by the service sector rose. This shows that the United States is moving aggressively into service sector innovation and R&D. In the future, this is likely to stimulate a global trend towards service sector innovation and R&D (see Table 4). In Taiwan, there has been little change in the percentage of the total R&D expenditure accounted for by the service sector. By contrast, in South Korea (one of Taiwan's main competitors), the percentage of the total R&D expenditure accounted for by the service sector has risen significantly. At a time when people in Taiwan are advocating the development of the service sector, the question of how to strengthen service sector R&D investment is an important policy issue.

• The Percentage of R&D Expenditure Accounted for by Hi-tech Industry

In 1999 the country where hi-tech industry accounted for the highest percentage

of the total manufacturing industry R&D expenditure was Canada, where the percentage was 75.91%, followed by Taiwan with 63.33%, Finland with 61.13% and South Korea with 58.37%. It is clear from Table 4 that in these four countries there was a high concentration of R&D expenditure in the hi-tech industries, particularly the electronics and communications industries. It is worth noting that during the period 1998–1999 the percentage of the total R&D expenditure accounted for by hi-tech industry rose significantly in both Finland and South Korea, increasing by 6.21 and 11.18 percentage points respectively. In both countries, there has been a significant increase in the percentage of R&D expenditure accounted for by the pharmaceuticals and electronics and communication industries. The achievements of this R&D work were reflected in the marked increase in the number of biotechnology and communications patents which Finland and South Korea secured in the United States in 2001 (Lin and Lin 2002). In Taiwan, the percentage of the total R&D expenditure accounted for by hi-tech industry was significantly higher in 2000 than in 1998. The increase was highest in the computer and OA industry, where there was an increase of 4.44 percentage points; this was probably related to the ICT boom. By contrast, in the United States the percentage of the total R&D expenditure accounted for by hi-tech industry fell dramatically, by 5.97 percentage points. Most of this fall was accounted for by an increase in R&D expenditure in the medium-tech sector, particularly in the scientific and specialist instruments industry (Lin 2001).

TABLE 4. MANUFACTURING AND SERVICE INDUSTRIES R&D EXPENDITURES AS PERCENTAGE OF BERD OF MAJOR COUNTRIES

(unit: %)

	1997				1999			
	Industry	Manufacturing	Service	Others	Industry	Manufacturing	Service	Others
U.S.	100.00	79.92	19.65	0.43	100.00	67.04	31.21	1.75
Japan	100.00	94.82	1.76	3.42	100.00	94.01	2.74	3.24
Germany	100.00	95.47	5.42	1.12	100.00	95.65	5.42	0.93
France	100.00	85.34	9.09	5.57	100.00	85.72	9.06	5.22
U.K.	100.00	79.88	17.08	3.05	100.00	79.59	17.44	2.97
Canada	100.00	65.21	29.54	5.25	100.00	68.27	27.84	3.89
Italy	100.00	84.68	13.52	1.80	100.00	85.96	12.19	1.85
Australia	100.00	57.39	25.47	17.14	100.00	50.73	40.33	8.94
Netherlands	100.00	75.71	18.52	5.77	100.00	76.05	17.97	5.98
Sweden	100.00	85.92	11.58	2.50	100.00	85.46	12.83	1.82
Finland	100.00	86.61	9.99	3.40	100.00	85.06	11.68	3.26
Korea	100.00	85.34	9.25	7.41	100.00	81.60	13.33	5.07
Taiwan	100.00	91.18a	7.28a	1.55a	100.00	91.68	7.29	1.03
Taiwan					100.00	91.95b	7.50b	0.55b

Note: 1. a) 1998; b) 2000.

2. Business Enterprise sector classification of Taiwan is in accordance with Frascati Manual, OECD.

Source: 1. OECD, Main Science and Technology Indicators 2002/1, 2002.

2. National Science Council, Indicators of Science and Technology R.O.C., 2001.

TABLE 5. THE HI-TECH INDUSTRY'S R&D EXPENDITURES AS PERCENTAGE OF MANUFACTURING'S R&D EXPENDITURES OF MAJOR COUNTRIES

(unit: %)

	1998					1999				
	Hi-Tech	Pharmaceuti- cals	Office, Account & Computing Machine	Electro. Equip. (Radio, TV & Commun.)	Aerospace	Hi-Tech	Pharmaceuti- cals	Office, Account & Computing Machine	Electro. Equip. (Radio, TV & Commun.)	Aerospace
U.S.	49.87	11.52	11.24	10.10	17.00	43.90	11.77	7.67	10.04	14.42
Japan	36.21	1.02	10.63	6.72	17.84	38.36	1.03	11.40	6.90	19.03
Germany	29.26	7.85	2.44	7.12	11.85	27.32	7.08	2.29	6.79	11.16
France	46.35	14.93	2.77	15.06	13.59	45.90	15.37	2.21	14.60	13.72
U.K.	50.47	27.06	1.51	9.33	12.56	52.81	28.18	1.23	9.64	13.75
Canada	75.37	8.72	6.56	42.05	18.04	75.91	9.21	7.31	43.16	16.23
Italy	46.52	9.69	2.13	23.19	11.51	47.46	10.35	1.98	23.93	11.19
Sweden	49.26	18.55	0.80	26.53	3.38	50.90	19.32	0.79	27.39	3.41
Finland	54.92	3.85	0.80	49.98	0.29	61.13	4.83	0.37	55.88	0.06
Korea	47.19	1.76	1.73	43.25	0.45	58.37	2.87	6.77	48.73	0.00
Taiwan	60.59	1.33	15.89	42.25	1.12	63.33	1.53	17.61	43.04	1.15
Taiwan	(67.36)	(1.49)	(20.33)	(44.27)	(1.27)					

Note: 1. Figures in bracket are the data of 2000 for Taiwan.

2. Business Enterprise sector classification of Taiwan is in accordance with Frascati Manual, OECD.

Source: 1. OECD, Main Science and Technology Indicators 2002/1, 2002.

2. National Science Council, Indicators of Science and Technology R.O.C., 2001.

Looking at the leading nation's hi-tech R&D investment structure, it can be seen that, although in most countries it is the electronics and communications industries which account for the highest percentage of the R&D expenditure, in the U.K. it is pharmaceuticals which ranks the highest, and in France pharmaceuticals, electronics and communications and aerospace are all roughly on a par with each other. In Taiwanese manufacturing industry, R&D investment is largely concentrated in the ICT industry. The percentage of the R&D expenditure going on pharmaceuticals and aerospace (Taiwan's emerging industries) is significantly lower than that going on Taiwan's other core hi-tech industries. It is also lower than in the other advanced nations. Although R&D expenditure has been increasing steadily, the rate of the increase has been rather low. This is an area to which the authorities in Taiwan should pay more attention.

(4) Comparison of the Intensities of Business Enterprise R&D

• The Intensities of Technology-intensive Manufacturing R&D

This article defines that "the R&D intensities are R&D divided by added value." In the year 1999, the performance of R&D intensities for the leading countries

manufacturing are Japan 8.65% (year 1998), Finland 8.61%, Sweden 8.24% (year 1998), United States 8.17%, Germany 7.45%, France 6.97%, and the U.K. 6.09%. In the years 1999 and 2000, Taiwan's ratios were both 4.53%, which was a little behind the developed countries, but was higher than South Korea 4.51% (year 1999). (Please see Table 6).

TABLE 6. R&D INTENSITY BY TYPE OF MANUFACTURING

(unit: %)

	Period	by R&D-Intensive Sectors					Hi-Tech Industries				
		Manufac- turing	Hi- Tech	Medium- High-Tech	Medium- Low-Tech	Low- Tech	Knowledg e-based	Pharma- ceuticals	Office, Account & Computing Machine	Electro. Equip. (Radio, TV & Commun.)	Aerospace
U.S.	1998	8.74	24.86	10.88	2.30	1.35	15.83	24.32	35.03	19.01	30.70
	1999	8.17	20.53	11.87	1.77	1.19	14.90	22.32	19.75	15.77	30.45
Japan	1997	7.68	19.48	11.98	3.26	1.43	14.23	19.11	27.16	16.61	28.38
	1998	8.65	22.05	12.41	3.33	1.65	15.27	21.45	37.36	17.65	29.93
Germany	1998	6.99	35.25	9.58	1.51	0.55	12.44	27.17	16.18	41.49	59.53
	1999	7.45	33.99	-	-	-	-	28.74	17.04	36.87	50.34
France	1998	7.01	30.91	9.17	2.51	0.79	14.73	29.33	14.23	31.70	42.34
	1999	6.97	30.73	-	-	-	-	27.56	13.31	34.14	40.09
U.K.	1998	5.47	22.08	6.86	1.78	0.67	11.38	48.01	3.48	12.10	24.28
	1999	6.00	25.00	7.48	1.59	0.66	12.70	54.17	3.12	13.72	27.82
Italy	1998	2.37	19.86	3.27	0.83	0.17	5.92	10.89	16.24	25.24	28.53
	1999	2.50	21.44	3.34	0.85	0.18	6.19	12.06	16.92	27.73	29.90
Sweden	1997	8.19	32.40	10.08	1.52	1.46	15.86	33.62	13.15	35.04	33.91
	1998	8.24	34.81	9.75	1.47	1.33	15.99	32.29	9.34	43.55	33.17
Finland	1998	7.63	26.58	9.14	2.97	1.59	16.06	27.69	18.12	27.49	4.45
	1999	8.61	27.73	8.88	3.21	1.70	17.41	37.33	26.70	27.80	1.15
Korea	1998	4.69	13.17	8.74	1.25	0.59	10.69	2.97	3.86	17.38	8.64
	1999	4.51	13.36	5.80	1.18	0.70	9.33	4.59	6.97	17.89	0.07
Taiwan	1998	4.22	12.03	3.74	1.42	1.28	7.58	9.24	9.80	13.45	8.69
	1999	4.53	12.32	4.11	1.23	1.43	8.17	11.60	10.40	13.53	8.44
	2000	4.53	11.63	4.04	0.95	1.25	8.03	10.10	11.93	11.52	13.00

Note: Business Enterprise sector classification of Taiwan is in accordance with Frascati Manual, OECD.

Source: 1. OECD, STAN on-line database, 2002.

2. OECD, Basic Science and Technology Statistics, 2001.

3. OECD, ANBERD database, 2001.

4. National Science Council, Indicators of Science and Technology R.O.C., 2001.

5. National Income in Taiwan Area, DGB, Accounting and Statistics, Executive Yuan, R.O.C.

For intensities of high-tech industrial R&D, in the year 1999, Sweden had the highest ratio of 34.81% (year 1998) followed by Germany 33.99%, France 30.73%,

Finland 27.73%, the U.K. 25.00%, Japan 22% (year 1998), Italy 21.44% and the United States 20.53%. The intensities of Taiwan and South Korea's high-tech industrial R&D in 1999 were 12.32% and 13.36%, respectively, which were behind those of the developed countries and Northern Europe. Please see table 6. However, in 2000, Taiwan's intensities of high-tech industrial R&D decreased from 12.32% to 11.63%. The same situation happened to the intensities of high-and-medium, medium-and-low and low technology industries. The reason was also because the growth rate of R&D investment was lower than the growth rate of added value. Compared to other countries, US's intensities of high-tech industrial R&D decreases even more, which is from 24.86% to 20.53%. The reason is mainly because, during 1997-1999, the U.S.'s high-tech industrial R&D investment decreased, and investment moved to service industry's R&D which had high added value.

With respect to the intensities of the R&D investment in four large high-tech industries, the United States, Germany, France and Italy have the highest intensities in Aerospace industry. Japan has the highest in computer and OA equipment industries. The U.K. and Finland have the highest in pharmaceuticals. Sweden, South Korea and Taiwan (year 1999) have the highest in electronics and communication industries. With regard to the intensities of electronics and communication industries, Taiwan has higher ratios than South Korea in the other three high-tech industries.

Based on the R&D investment intensities of different technology industries, manufacturing R&D intensity is still relatively low in Taiwan, which indicates that the scale of R&D investment is relatively smaller than other countries although Taiwan has outstanding performance in manufacturing and management. R&D is the base for technology innovation. The intensities of R&D investment are highly related to industry's future competitive advantage. If Taiwan wants to be globally competitive, the scale of R&D investment has to be enlarged.

(5) *The Comparison of R&D Researcher*

• Comparison of National and Industrial R&D Researcher

Comparing the number of R&D researcher (based on Full Time Equivalent, FTE) in every country (see Table 7), Taiwan's R&D FTE⁷ was 55,460 man/year, (year 2000), which was lower than the number in the United States (year 1997), China, Japan, Germany, France (year 1999), the U.K. (year 1998), South Korea, Canada (year 1999), Italy (year 1999) and Austria (year 1998). Taiwan is eleventh in the world. In the year 1997, Taiwan's R&D (FTE) was 47,573 man/year. In the year 1998, the number rapidly increased to 53,492 man/year. However, between 1999 and 2000, the increasing scale is smaller. Regarding the enterprise R&D researcher (FTE), in the year 2000, Taiwan had 31,975 man/year (year 1999 was 31,474 man/year). As for the national R&D (FTE), Taiwan was eleventh in the

⁷ Taiwan R&D(FTE) is based on the OECD's definition, the FTE of researcher above college.

world. (Please see Table 7.) Taiwan's enterprise R&D (FTE) only increased 500 man/year in the year 2000, which reflects that the growth of Taiwan's S&T human resource (HR) stopped. It may be related to the HR movement to China.

TABLE 7. COMPARISON OF NATIONAL & BUSINESS ENTERPRISE (2000)

	Total National Researcher (FTE) ^a	Business Enterprise Researcher(FTE)	National Researcher per Thousand Employed Persons	Business Enterprise Researcher per Thousand Employed Persons of Industries
U.S.	1,114,100 ^c	1,015,700 ^a	7.9 ^c	10.1 ^a
China	695,062	353,843	1.00	0.50
Japan	647,572	421,363	9.70	9.80
Germany	259,214 ^d	153,210	6.70	5.50
France	160,424	75,390 ^d	6.8 ^d	4.8 ^d
U.K.	157,662	85,755	5.5 ^a	4.20
Korea	108,370	71,894	5.20	4.10
Canada	90,810 ^e	49,500 ^e	6.1 ^e	4.6 ^e
Italy	64,886 ^a	26,192 ^a	2.9 ^e	1.6 ^e
Australia	62,790 ^e	15,283 ^a	7.2 ^b	2.3 ^a
Taiwan ^e	55,460	31,975 ^f	5.80	3.37 ^f
Netherlands	40,623 ^a	19,359 ^a	5.1 ^e	3.5 ^a
Sweden	39,921 ^a	22,822 ^a	9.6 ^e	9.0 ^e
Finland	26,162	11,285	11.40	7.30
Singapore	16,633	8,632	7.90	4.39

Note: a: 1999; b: 1998; c: 1997.

d: The number of Researcher are full-time equivalents.

e: Researchers (FTE) of Taiwan are those who have a university degree or above.

f: Business Enterprise sector classification of Taiwan is in accordance with Frascati Manual, OECD.

Source: 1. OECD, Main Science and Technology Indicators 2/2000, 2001.

2. Labour Force Survey, June 2002, Manpower Research and Statistics Department, Singapore.

3. The Human Resource Yearbook of R.O.C., 2000, DGB, Accounting and Statistics, Executive Yuan, R.O.C.

• The Researcher per Thousand Employment Persons in Manufacturing Industries

The R&D researcher per thousand employment persons in manufacturing industries is used as the index for HR intensities. Comparing Taiwan with other countries in the OECD, in the year 2000, Taiwan's R&D researcher per thousand labor force in manufacturing industries was 5.8, only lower than Finland's 11.40, Japan's 9.7, Sweden's 9.6, and Singapore and the U.S.'s 7.9. The number was higher than U.K.'s 5.5 (year 1998), Holland's 5.1 (year 1999), South Korea's 5.2, Italy's 2.9, (year 1999) and China's 1.0. Regarding the enterprise R&D researcher per thousand employment persons in manufacturing industries, in the year 2000, Taiwan's number was 3.37, only higher than Austria, Italy and China.

Regarding the number of R&D researchers, Taiwan is about 11th in the world

on an absolute scale, but the ranking is little lower on a relative scale. Besides, in terms of the growth rate, the R&D HR has a tendency to stop growing. Further investigation and analysis has to be done to see whether it is due to brain drain or the decrease of demand for R&D researcher. However, in the future knowledge-based economic age with HR as the mainstream, Taiwan must emphasize S&T education and the problem of brain drain in order to cope with the challenges of knowledge and globalization.

TABLE 8. RESEARCHERS OF HI-TECH AND AS A PERCENTAGE OF MANUFACTURING'S RESEARCHERS

unit: %

	Period	by R&D- intensive sectors						Hi-Tech Industries					
		Manufac- turing	Hi- Tech	Pharma- ceuticals	Office, Account & Computing (Radio, TV Machine & Commun.)	Electro. Equip.	Aero- space	Manufac- turing	Hi- Tech	Pharma- ceuticals	Office, Account & Computing (Radio, TV Machine & Commun.)	Electro. Equip.	Aero- space
U.S.	1997	682,100	525,400	45,300	66,100	157,000	77,000	100.000	47.71	6.64	9.69	20.09	11.29
	1998	659,000	308,900	56,000	45,600	146,900	66,400	100.000	46.87	7.59	9.92	22.29	10.08
	1999	599,900	223,100	41,300	21,300	105,200	55,300	100.000	37.19	6.88	3.55	17.54	9.22
Germany	1997	120,368	40,015	5,221	5,158	22,059	7,577	100.000	33.24	4.34	4.29	18.35	6.29
	1998	129,912	40,998	5,340	4,630	22,697	8,331	100.000	31.56	4.11	3.56	17.47	6.41
	1999	58,287	24,159	6,206	2,885	9,151	5,917	100.000	41.45	10.65	4.95	15.70	10.15
France	1997	58,686	26,330	6,291	2,794	11,120	6,125	100.000	44.87	10.72	4.76	18.95	10.44
	1998	59,978	25,954	6,517	2,023	11,436	5,938	100.000	43.27	10.87	3.37	19.13	9.90
	1999	59,978	25,954	6,517	2,023	11,476	5,938	100.000	27.49	6.10	2.96	17.88	0.55
Japan	1997	367,382	124,868	18,080	-	106,686a	102	100.000	33.99	4.92	-	29.04 ^a	0.03
	1998	382,761	132,328	18,733	-	113,478a	117	100.000	34.57	4.89	-	29.65 ^a	0.03
	1999	389,104	139,052	18,815	-	120,78a	159	100.000	35.74	4.84	-	30.86 ^a	0.01
Korea	1997	59,741	29,047	1,491	1,805	24,846	915	100.000	48.62	2.50	3.02	41.57	1.53
	1999	51,418	23,363	992	1,365	20,771	235	100.000	45.44	1.93	2.65	40.40	0.46
Taiwan	1998	25,300	17,268	582	4,830	11,471	385	100.000	68.25	2.30	19.09	45.34	1.52
	1999	26,917	18,299	564	5,432	12,062	241	100.000	67.98	2.10	20.18	44.81	0.90
	2000	27,789	20,401	567	7,285	12,348	261	100.000	73.41	2.04	26.22	44.43	0.72
Australia	1999	7,930	2,205	619	162	1,390	34	100.000	27.80	7.81	2.04	17.53	0.42

Note: a: Japan's RSE of office, account. & computing machine. Industry are included in the RSE of Electro. equip.

Source: 1. OECD, STAN On-line database.

2. OECD, Basic Science and Technology Statistics, 2001.

3. National Science Council, Indicators of Science and Technology R.O.C., 2001.

• High-tech Industry Researcher

In the year 1999, the number of Taiwan's high-tech industry R&D researchers were about 18,299, which was lower than developed countries and South Korea. In the year 2000, the number kept increasing to 20,401, which was about 70%

in manufacturing. The main industry R&D researcher was in ICT industry, which was also 70%. Taiwan's R&D researchers are in the high-tech industry. Compared with the other evaluated countries, the number is much higher. The percentage of South Korea's high-tech R&D researcher in the manufacturing industry is only 45%, which again indicates Taiwan's high concentration in R&D resource.

2. The Evaluation of Patent Performance

Patents are considered the closest proxy variables for the measurement of technology innovation outputs, which are normally used to measure the performance of invention and innovation. Utilizing the USPTO data and taking the utility patent as the basis⁸, this study makes an international comparison of all industrial utility, numbers of granted patent, subsequent Impact Index (SII), patent strength (TS) and patent intensity (PI).

Regarding the information process, every patent will be classified to a main original classification. At the same time, it is also possible to be classified to other parent classification, which is usually called cross-reference classification. This research uses cross-reference classification in the patent classification process. Besides, for the U.S. patent code and industry classification code, this research uses the handbook published by the U.S. patent bureau to compare the patent code and industry. Because every patent may be classified to different industries, for the total calculation, the research will deduct the part that repeats. Some patents cannot be classified to a specific industry, so the total number of industrial utility patents will be a little lower than all the utility patents.

(1) All Industrial Utility Patents

• Numbers of Granted Patents

The study chooses year 1991 and 1996-2000 as the period to analyze the performance of whole industrial utility patents that are granted (see Table 9). We find that Taiwan and South Korea's industrial patents granted largely grew from year 1991 to 1996. Taiwan's number doubled, and South Korea increased 2.7 times. These were the most outstanding countries among all of the evaluated countries. At the same period, Japan's number and the U.S. have gradually increased, while Western Europe has decreased. Analyzing granted patents in the year 2000, as for the industrial utility patents, Taiwan ranked the fourth, only behind the United States, Japan and Germany. In 1991, Taiwan was far behind western European countries. However, now, Taiwan is ahead of most of the countries. It indicates Taiwan's enthusiasm in industrial invention and innovation.

⁸ The U.S. patent includes utility patent, design patent and plant patent. In which, the utility patent is the closest to technology innovation.

TABLE 9. COMPARISON OF THE TOTAL INDUSTRY UTILITY PATENT'S PERFORMANCE OF MAJOR COUNTRIES IN USPTO

	Number of Granted Patents (PN)						Subsequent Impact Index (SII)					
	1991	1996	1997	1998	1999	2000	1991	1996	1997	1998	1999	2000
U.S.	51,689	60,879	61,425	79,678	83,258	84,552	1.02	1.03	1.03	1.04	1.05	1.05
Japan	20,787	22,925	23,061	30,604	30,893	31,142	1.01	1.00	1.02	1.03	1.04	1.05
Germany	7,611	6,800	7,003	9,090	9,331	10,211	0.95	0.90	0.88	0.86	0.81	0.74
Taiwan	903	1,895	2,040	3,063	3,670	4,636	0.99	1.02	1.04	1.08	1.12	1.29
Korea	396	1,484	1,886	3,239	3,540	3,284	0.98	0.99	0.99	0.98	0.98	1.05
Canada	2,008	2,198	2,349	2,951	3,176	3,377	1.01	1.00	0.99	0.98	0.95	0.91
U.K.	2,786	2,459	2,676	3,448	3,553	3,654	0.97	0.95	0.91	0.89	0.85	0.82
France	2,996	2,785	2,947	3,660	3,816	3,808	0.95	0.91	0.88	0.84	0.80	0.72
Sweden	715	853	865	1,228	1,398	1,567	0.93	0.94	0.92	0.89	0.87	0.83
Italy	1,197	1,197	1,248	1,579	1,497	1,711	0.90	0.90	0.87	0.82	0.79	0.68
Netherlands	986	802	806	1,218	1,243	1,240	0.95	0.95	0.95	0.87	0.81	0.73
Switzerland	1,332	1,115	1,089	1,275	1,277	1,324	0.93	0.88	0.84	0.85	0.77	0.66
Israel	302	482	528	748	733	776	1.01	0.98	1.00	0.97	0.96	0.88
Finland	326	443	450	593	648	616	0.98	0.91	0.87	0.93	0.97	0.90
Australia	458	473	476	717	699	698	0.95	0.98	0.93	0.82	0.88	0.74
Singapore	-	-	-	122	141	218	-	-	-	1.14	1.29	1.67
China	-	-	-	-	-	136	-	-	-	-	-	0.80

	Patent Strength (TS)						Patent Intensity (PI)					
	1991	1996	1997	1998	1999	2000	1991	1996	1997	1998	1999	2000
U.S.	52,622	62,549	63,435	82,602	87,015	89,024	208	235	237	305	319	316
Japan	20,941	23,006	23,417	31,373	32,005	32,782	169	183	186	248	253	258
Germany	7,241	6,141	6,155	7,780	7,534	7,521	91	75	75	95	92	92
Taiwan	898	1,938	2,116	3,317	4,105	5,962	44	90	98	152	186	268
Korea	389	1,467	1,862	3,172	3,482	3,447	9	32	40	68	74	73
Canada	2,024	2,191	2,326	2,882	3,008	3,079	70	74	78	95	99	100
U.K.	2,695	2,342	2,444	3,084	3,002	2,999	47	40	41	52	50	50
France	2,832	2,539	2,600	3,058	3,043	2,756	50	43	44	52	51	47
Sweden	665	798	797	1,087	1,210	1,299	77	90	90	123	137	146
Italy	1,081	1,081	1,086	1,288	1,186	1,155	19	19	19	22	21	20
Netherlands	937	760	762	1,066	1,013	906	62	49	49	68	64	57
Switzerland	1,241	979	916	1,082	989	867	183	139	129	152	139	121
Israel	304	473	526	729	701	685	61	83	90	122	115	113
Finland	320	402	390	553	630	557	64	78	76	107	122	108
Australia	437	464	441	588	615	518	25	25	24	31	32	27
Singapore	-	-	-	139	183	365	-	-	-	35	46	91
China	-	-	-	-	-	109	-	-	-	-	-	0

Notes: 1. The numbers of industry patent are calculated based on "Concordance between SIC and USPC system" publishes by USPTO TAF Branch, 2001.

2. Patent Counts Based on Cross-reference Classification.

3. Patent Intensity is Patent Strength divided by populations (per millions).

4. SII measure is biased upward when the number of patents on which it is based is small, so we calculated the SII if the patent numbers are larger than 100 for lowering biases.

Source: USPTO CD-ROM, TIER.

• Subsequent Impact Index, SII, and Patent Strength, PS

This paper utilizes the concept of "Current Impact Index" of CHI Corporation in the United States to establish the patent impact index, and build a subsequent impact index, SII. For example, the patent impact index in the year of t in country A , is the frequency of the patent in the year of t cited by years $t, t+1, t+2, t+3, \dots, t+n$ ⁹ as the prior art, divided by the average cited frequency of all patents. In general, the patents of a country are more important if the relative average cited frequency of all patents is higher. Patent strength can be obtained by multiplying the patent impact index by the granted number of patents.

$$SII_{a,t} = \frac{\sum_{s=t}^{2001} CN_{a,t,s} / PN_{a,t}}{\sum_{s=t}^{2001} CN_{all,t,s} / PN_{all,t}}$$

$$PS_{a,t} = PN_{a,t} \times SII_{a,t}$$

In which $SII_{a,t}$ represents the patent impact index of country A in the year t .

$PS_{a,t}$ represents the patent strength of country A in the year t .

$CN_{a,t,s}$ & $CN_{all,t,s}$ are the cited times in country A and all countries in the year of t ($Y = t, t+1, \dots, 2001$);

$PN_{a,t,s}$ & $PN_{all,t,s}$ are the granted number of patents in country A and all countries in the year of t ;

Generally speaking, every patent will cite the patents in the past, which are the patents within 4-5 years. Thus, the research will analyze the patent impact index based on the patents granted in 1991 and during the period 1996 to 2000. At the same time, in order to avoid a low number of patents, which may lead to the high value of SII, the research only chooses the numbers of granted patents that are over one hundred. In all industrial utility patents' SII, we can find that in the past few year, Singapore and Taiwan have been very outstanding, and the SII was 1.12 and 1.29 respectively, in the year 1999. The number is increasing, which indicates that the importance of the patent in that country is increasing. (see Table 9). If we further analyze, we can find that besides the reason of leading technology, it is possibly related to the patent information, which has technological field effect (Jaffe, Trajtenberg and Henderson, 1993). Some technology tends to be cited more than others. For example, ICT's life cycle is shorter, and the technology updates are faster. Thus, the frequency of citing or being cited is higher. Singapore and Taiwan highly concentrate on ICT and therefore, SII are relatively higher. Other countries that have relatively higher SII include the United States and Japan.

Patent strength can be obtained by multiplying SII and PN. According to the

⁹ the research will be accumulated to year 2001

calculation, it indicates that the United States and Japan are still in the technologically leading position; the patent strength of the U.S. is three times more than that of Japan. Germany and Taiwan belong to the second group, followed by the third group consisting of South Korea, Canada, the U.K. and France, which indicates that Taiwan has become one of the countries that are globally influential in the field.

• Patent Intensity

With respect to the patent intensity, it is obtained by the patent strength of each year divided by the population in millions of each country, and the influence of the scale of each country is eliminated. From Table 9, we can find that the growth of patent intensity in Taiwan is very drastic. In the year 1991, it is only 44, which is in the group that was behind most of the other countries. However, in the year 1998, the number increased to 152, which ranked the 3rd in the world. In the year 2000, the number increased to 268 exceeding Japan and just behind the United States. Taiwan became the 2nd highest ranked country in industrial patent intensity country, which reflects Taiwan's enthusiasm in technology innovation.

(2) *Utility Patents of High-Technology Industries*

• Numbers of Granted Patents

Regarding the numbers of the granted patents in high-tech industries, in the year 1999, Taiwan and South Korea still fell behind other developed countries. However, in the year 2000, they became the 4th and the 5th ranked country in terms of the global high-tech industrial patents granted. During the period from 1991 to 1999, South Korea's number of high-tech industrial patents granted was higher than that of Taiwan. Until 2000, Taiwan exceeded South Korea. Other countries' changes were relatively smaller, which indicates that Taiwan and South Korea are quite developed in high-tech industrial technology. (Please see Table 10.) Taiwan has advantages in semiconductor technology, and South Korea has advantages in air-conditioning equipment and communication technology.

• Patent Impact Index and Patent Strength

The performances of Taiwan and Singapore's patent SII in high-tech industry are the best. Taiwan's SII in high-tech industrial patents is higher than the number of all industrial utility patents. The numbers in the year 1999 and 2000 were 1.16 and 1.30, respectively, representing a frequency of citing higher than the average of 16% and 30%. Please see Table 10. The reason is that Taiwan's patents are highly concentrated in ICT industry. Thus, under the influence of patent's "technological field effect," SII is relatively higher. However, there is no doubt that Taiwan has been in the leading position of semiconductor technology, and therefore, the importance and influence of patent technology are great.

TABLE 10. COMPARISON OF THE HI-TECH INDUSTRY UTILITY PATENT'S PERFORMANCE OF MAJOR COUNTRIES IN USPTO

	Number of Granted Patents (PN)						Subsequent Impact Index (SII)					
	1991	1996	1997	1998	1999	2000	1991	1996	1997	1998	1999	2000
U.S.	16,871	24,041	25,973	35,818	38,040	39,236	1.01	1.02	1.02	1.04	1.01	1.05
Japan	9,966	12,660	12,600	17,320	17,623	17,573	1.01	1.00	1.02	1.02	1.01	1.01
Germany	2,174	2,131	2,319	3,082	3,216	3,623	0.94	0.92	0.88	0.85	0.80	0.72
Taiwan	210	715	851	1,358	1,733	2,501	0.99	1.05	1.07	1.09	1.16	1.30
France	1,120	1,224	1,338	1,646	1,665	1,688	0.94	0.90	0.85	0.82	0.75	0.66
U.K.	1,128	1,093	1,229	1,625	1,738	1,728	0.95	0.96	0.89	0.89	0.85	0.82
Canada	490	711	749	1,079	1,253	1,301	0.99	1.02	1.00	0.98	0.97	0.91
Korea	259	1,005	1,257	2,191	2,387	2,336	1.01	0.99	0.99	0.97	0.99	1.01
Sweden	159	335	346	478	575	700	0.91	1.00	0.92	0.96	0.92	0.93
Italy	335	400	449	550	515	563	0.89	0.90	0.87	0.80	0.78	0.58
Switzerland	336	312	355	402	397	378	0.95	0.89	0.86	0.75	0.74	0.66
Netherlands	409	389	378	590	596	554	0.97	0.98	0.95	0.86	0.77	0.69
Israel	94	260	266	405	432	428	0.99	1.00	1.01	0.99	0.93	0.85
Australia	109	129	147	259	243	224	0.94	0.90	0.93	0.81	0.81	0.68
Finland	74	163	151	275	316	291	0.96	1.01	0.95	1.02	1.11	1.20
Singapore		53	74	86	108	157		1.05	1.12	1.12	1.29	1.60
China	-	-	-	-	-	-	-	-	-	-	-	-
	Patent Strength (TS)						Patent Intensity (PI)					
	1991	1996	1997	1998	1999	2000	1991	1996	1997	1998	1999	2000
U.S.	17,109	24,512	26,615	36,947	39,639	41,342	68	92	99	137	145	147
Japan	10,108	12,662	12,859	17,658	17,844	17,733	82	101	102	140	141	140
Germany	2,048	1,960	2,040	2,631	2,571	2,596	26	24	25	32	31	32
Taiwan	208	751	914	1,476	2,019	3,259	10	35	42	67	92	146
France	1,058	1,106	1,141	1,356	1,251	1,113	19	19	19	23	21	19
U.K.	1,073	1,044	1,098	1,442	1,478	1,422	19	18	19	24	25	24
Canada	485	727	746	1,056	1,213	1,185	17	25	25	35	40	39
Korea	261	993	1,238	2,134	2,361	2,356	6	22	27	46	50	50
Sweden	145	334	320	460	529	652	17	38	36	52	60	73
Italy	317	359	391	443	400	326	6	6	7	8	7	6
Switzerland	320	277	305	300	292	249	47	39	43	42	41	35
Netherlands	396	380	359	505	458	381	26	24	23	32	29	24
Israel	93	260	270	402	400	362	19	46	46	67	66	60
Australia	103	117	136	209	197	152	6	6	7	11	10	8
Finland	71	164	144	280	350	348	14	32	28	54	68	67
Singapore	0	55	83	96	139	251	0	15	22	25	35	63
China	-	-	-	-	-	-	-	-	-	-	-	-

Notes: 1. The numbers of Industry patent are calculated based on "Concordance between SIC and USPC system" publishes by USPTO TAF Branch, 2001.

2. Patent Counts Based on Cross-reference Classification

3. Patent Intensity is Patent Strength divided by populations (per millions).

4. SII measure is biased upward when the number of patents on which it is based is small, so we calculated the SII if the patent numbers are larger than 100 for lowering biases.

Source: USPTO CD-ROM, TIER.

Based on the calculation, the United States and Japan still sit comfortably on the top of global high-tech industries in terms of patent strength. Taiwan's patents mainly concentrate on the ICT area, which is categorized as high-tech industry. Taiwan's high-tech patent strength exceeded Germany in the year 2000 and became 3rd in the world. However, Germany's technology advantages are in heavy industries, which are classified as "medium-high technology" industries by the OECD. Thus, Germany's patent performance in medium-high technology is better than in the high-tech area.

• Patent intensity

From Table 10, we can find that Taiwan's performance in a relative scale is very good in terms of high-tech patent intensity. Not only was the growth of patent intensity very fast, but also exceeded Japan's 140 in 2000, which was very close to the U.S.'s 147. Other countries do not change much, except for Singapore which keeps increasing in relative scale.

In general, from the number of patents granted, patent strength, and patent intensity, it can be inferred that Taiwan has become an active innovator instead of copier in the area of high-tech industry invention and innovation.

FIGURE 2. THE RATIO OF RECEIPTS AND PAYMENTS OF ROYALTIES AND LICENSE FEE (1999)

Resource: 1. OECD, International Trade Statistics in Service, 2001.

2. The Balance of payment of R.O.C., The Central Bank, 2002, May.

3. Ratios of Royalties

According to the information on royalties in every country's income statements, we can find that only the United States, the U.K., and Sweden have a positive number; in other words, their ratios are bigger than one. For income, the United States is the biggest exporting country for intangible assets followed by Japan and the U.K.

For expenses, those three countries are the biggest buyers followed by Germany, France and South Korea. Taiwan, in this aspect, is a buyer of intellectual capital. The sale is about 20% of the expenses. The amount in the year 1999 was the lowest, which was 15%. The deficit of intangible assets was the highest in 1999 and 2000, reaching 1.463 billion U.S. dollars. Then, the number was reduced to 1.16 billion U.S. dollars in 2001. Those royalties are mainly for electronic products such as CD-ROM, and TFT LCD. When intellectual capital becomes important to a corporation's income, Taiwan should increase its competitiveness ability by speeding up development of key technology and decreasing its dependence on technology. Also, Taiwan should enhance the rights of intellectual assets and create added value of intellectual capital. By doing so, it can cut down the royalty deficit problem.

4. Production Performance

Production performance mainly includes the comparison of industrial value added and exporting index.

(1) *Industrial Value Added*

• The Industrial Value added of Different Technology-Intensive Industries

With regard to the value added in the industries of each country in the year 1999, in the manufacturing industry, the United States, Japan, Germany, France, the U.K., Italy, South Korea and Canada were the leading countries. The value added in Taiwan's manufacturing was US\$ 76.6 billion, but in year 2000, it is increased to US\$ 81.6 billion. For absolute value, Taiwan is still behind the leading group. With respect to the value added in high-tech industries, in the year 1999, Taiwan's amount was US\$ 17.9 billion, which fell behind the United States, Japan, the U.K., Germany and France, but still ahead of the other countries under comparison. Especially in the year 2000, Taiwan's value added in high-tech industries increased by 25% compared to the year 1999 (calculated by US\$). (Please see Table 11.)

In the value-added structure of manufacturing in each country, Taiwan, South Korea and Finland's high-tech industries take the higher ratios in the manufacturing GDP. Taiwan's ratios in years 1999 and 2000 were 23.31% and 26.24% respectively. These ratios keep increasing, and the ratios of medium-low industry are decreasing.

With respect to the ratio of knowledge-based manufacturing, which represents the development progress of the knowledge-based economy of a nation (high-tech and medium-high technology in total), in year 1999, Germany had the highest with 54.26%; followed by the United States 48.99%, Japan 47.82%, Taiwan 47.13%, the U.K. 43.18% and South Korea. For Taiwan, in the year 2000, the ratio kept increasing to 49.87%, but still did not reach the average of the OECD countries.

TABLE 11. INDUSTRIAL VALUE ADDED OF VARIOUS TECHNOLOGY-INTENSIVE INDUSTRIES OF MAJOR COUNTRIES

(unit: US\$ millions, %)

	U.S.			Japan		Germany		U.K.	
	1996	1999	2000	1996	1998	1996	1999	1996	1999
Hi-Tech	217,909	268,885	285,548	132,942	127,192	27,960	27,961	25,120	30,738
Medium-Hi-Tech	416,893	464,421	494,967	326,170	301,646	227,742	201,611	67,703	72,446
Medium-Low-Tech	307,229	350,952	364,615	275,623	252,008	131,758	96,952	58,315	59,663
Low-Tech	374,018	412,528	421,449	221,332	215,910	110,068	94,360	72,700	76,110
KI-Manufacturing	634,802	733,306	780,515	459,112	428,838	255,702	228,572	92,823	103,184
Manufacturing	1,316,049	1,496,786	1,566,579	1,126,373	895,425	497,528	419,884	223,838	238,957
Percentage (%)									
Hi-Tech	16.56	17.96	18.23	11.80	14.20	5.62	6.42	11.22	12.86
Medium-Hi-Tech	31.68	31.03	31.60	28.96	33.69	45.77	48.02	30.25	30.32
Medium-Low-Tech	23.34	23.45	23.27	24.47	28.14	26.48	23.09	26.05	24.97
Low-Tech	28.42	27.56	26.90	19.65	24.11	22.12	22.47	32.48	31.85
KI-Manufacturing	48.24	48.99	49.82	40.76	47.89	51.39	54.44	41.47	43.18
Manufacturing	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
	France		Italy		Canada		Taiwan		
	1996	1998	1996	2000	1996	1997	1996	1999	2000
Hi-Tech	24,004	25,128	13,494	11,015	8,449	9,550	14,606	17,866	21,422
Medium-Hi-Tech	78,529	73,046	70,762	62,061	26,845	29,185	20,139	18,253	19,283
Medium-Low-Tech	79,345	70,439	79,549	62,557	25,637	27,071	27,477	27,649	27,404
Low-Tech	80,109	70,778	83,691	70,093	38,597	38,406	15,843	12,862	13,520
KI-Manufacturing	102,533	98,174	84,256	73,076	35,294	38,735	34,745	36,119	40,706
Manufacturing	261,987	239,390	247,496	205,725	99,547	104,212	78,065	76,630	81,629
Percentage (%)									
Hi-Tech	9.16	10.50	6.37	5.81	8.49	9.16	18.71	23.31	26.24
Medium-Hi-Tech	29.97	30.51	27.98	29.61	26.97	28.01	25.80	23.82	23.62
Medium-Low-Tech	30.29	29.42	30.68	30.78	25.77	25.98	35.20	36.08	33.57
Low-Tech	30.58	29.57	34.97	34.09	38.77	36.85	20.29	16.78	16.56
KI-Manufacturing	39.14	41.01	34.35	35.43	35.45	37.17	44.51	47.13	49.87
Manufacturing	100.00	100.00	100.00	100.29	100.00	100.00	100.00	100.00	100.00
	Korea		Finland		Denmark		Sweden		
	1996	1999	1996	2000	1996	2000	1996	1998	
Hi-Tech	24,246	25,527	2,812	5,898	2,044	2,495	6,218	5,471	
Medium-Hi-Tech	40,923	29,180	7,229	5,967	7,698	6,852	17,866	16,488	
Medium-Low-Tech	49,695	49,987	6,426	6,245	7,694	6,484	11,929	11,281	
Low-Tech	35,249	24,725	10,795	10,023	9,215	7,324	15,406	13,679	
KI-Manufacturing	65,169	54,707	10,040	11,865	9,742	9,347	17,608	19,983	
Manufacturing	150,114	129,418	27,261	28,133	26,650	23,156	51,419	46,920	
Percentage(%)									
Hi-Tech	16.15	19.72	10.31	20.97	7.67	10.78	12.09	11.66	
Medium-Hi-Tech	27.26	22.55	26.52	21.21	28.88	29.59	34.75	35.14	
Medium-Low-Tech	33.11	38.62	23.57	22.20	28.87	28.00	23.20	24.04	
Low-Tech	23.48	19.10	39.60	35.63	34.58	31.63	29.96	29.15	
KI-Manufacturing	43.41	42.27	36.85	42.18	36.55	40.37	34.24	42.59	
Manufacturing	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	

Sources: 1. OECD, STAN On-line database, 2002.

2. National Income Yearbook 2001, The DGBAS of Taiwan.

3. Industry Statistic and Survey Yearbook, MOEA, R.O.C.

TABLE 12. INDUSTRIAL VALUE ADDED OF VARIOUS HI-TECH INDUSTRIES OF MAJOR COUNTRIES

(unit: US\$ millions, %)

	U.S.			Japan		Germany		U.K.	
	1996	1999	2000	1996	1998	1996	1999	1996	1999
Hi-Tech	217,909	268,885	285,548	161,468	127,192	27,960	26,961	25,120	30,738
Pharmaceuticals	47,234	58,541	64,995	31,706	24,262	9,559	7,747	6,650	7,571
Office, Account & Computing Machine	32,076	36,931	39,861	29,560	22,058	4,645	3,960	5,261	5,748
Electro. Equip. (Radio, TV & Commun.)	98,426	121,828	131,495	97,134	78,243	9,390	10,524	8,226	10,225
Aerospace	40,173	50,585	49,196	3,068	2,649	4,366	4,730	5,004	7,194
Manufacturing	1,316,049	1,496,784	1,566,579	1,126,373	895,425	497,528	436,679	223,838	248,956
Percentage (%)									
Hi-Tech	16.56	17.96	18.23	14.34	14.20	5.62	6.17	11.22	12.86
Pharmaceuticals	3.59	3.98	4.15	2.81	2.71	1.92	1.77	2.96	3.17
Office, Account & Computing Machine	2.44	2.47	2.54	2.62	2.46	0.93	0.91	2.35	2.41
Electro. Equip. (Radio, TV & Commun.)	7.48	8.14	8.39	8.62	8.74	1.89	2.41	3.67	4.28
Aerospace	3.05	3.38	3.14	0.27	0.30	0.88	1.08	2.24	3.01
Manufacturing	100.00	100.00	100.00	100.00	100.30	100.00	100.00	100.00	100.00
	France		Italy		Canada		Taiwan		
	1996	1998	1996	2000	1996	1997	1996	1999	2000
Hi-Tech	24,004	25,128	13,494	11,015	8,449	9,550	14,606	17,866	21,422
Pharmaceuticals	9,199	6,531	5,138	4,368	1,713	1,484	483	458	545
Office, Account & Computing Machine	3,384	3,259	781	622	255	573	4,418	5,882	6,361
Electro. Equip. (Radio, TV & Commun.)	7,795	7,961	5,749	4,139	3,485	4,128	9,564	11,354	14,714
Aerospace	3,626	5,377	1,827	1,885	2,956	3,365	141	473	362
Manufacturing	261,987	239,390	247,496	205,725	99,517	134,311	78,065	76,640	81,269
Percentage (%)									
Hi-Tech	9.16	10.50	5.45	5.35	8.49	9.16	18.71	23.31	26.24
Pharmaceuticals	3.51	2.56	2.08	2.12	1.72	1.42	0.62	0.60	0.67
Office, Account & Computing Machine	1.29	1.36	0.32	0.30	0.40	0.55	5.66	7.68	7.72
Electro. Equip. (Radio, TV & Commun.)	2.98	3.33	2.32	2.01	3.50	3.96	12.25	14.43	17.41
Aerospace	1.38	2.25	0.74	0.92	2.97	3.23	0.18	0.62	0.44
Manufacturing	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
	Korea		Finland		Denmark		Sweden		
	1996	1999	1996	2000	1996	2000	1996	1998	
Hi-Tech	24,246	25,527	2,812	5,898	2,044	2,495	6,718	5,471	
Pharmaceuticals	4,941	3,650	302	250	1,189	1,795	2,101	2,221	
Office, Account & Computing Machine	1,421	5,675	185	2	175	101	297	351	
Electro. Equip. (Radio, TV & Commun.)	17,593	15,915	2,174	5,549	681	600	3,242	2,355	
Aerospace	291	287	151	102	0	0	588	564	
Manufacturing	152,114	129,418	26,946	27,857	26,650	23,156	51,415	46,920	
Percentage (%)									
Hi-Tech	16.15	19.72	10.44	21.19	7.67	10.78	12.09	11.66	
Pharmaceuticals	3.29	2.82	1.12	0.90	4.46	7.75	4.09	4.75	
Office, Account & Computing Machine	0.95	4.38	0.65	0.01	0.65	0.44	0.58	0.71	
Electro. Equip. (Radio, TV & Commun.)	11.72	12.30	8.07	19.93	2.55	2.59	5.29	5.02	
Aerospace	0.19	0.22	0.56	0.36	0.00	0.00	1.14	1.20	
Manufacturing	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	

Sources: 1. OECD, STAN On-line database, 2002.
 2. National Income Yearbook 2001, The DGBAS of Taiwan.
 3. Industry Statistic and Survey Yearbook, MOEA, R.O.C.

• The Value Added of High-tech Industries

Taiwan, South Korea and Finland had the highest ratios in high-tech industry manufacturing, especially in the area of electronic and communication industries. The U.K., France, Denmark and Sweden's ratios in pharmaceutical industries were higher than the other comparison countries, which all exceeded 3%, especially Denmark's ratio in the year 2000 was 7.5%. For aerospace industry, the United States and the U.K.'s ratios were above 3%, which were higher than other countries. For computer and OA equipment industries' value added ratios, Taiwan's 7.72%, Canada's 5.66% and South Korea's 4.38% were higher. (Please see Table 12.)

In view of each country's high-tech industry structure, Taiwan and Finland are similar in terms of manufacturing value added. The ratio of the both countries increased in high-tech industries, and the ratio in medium-high, medium-low, and low technology decreased. It illustrates two factors: one is that Taiwan and Finland's manufacturing has adjusted the structure very quickly in the last ten years, and the high-tech industry has become an essential sector playing an important role in supporting their economic growth; second is that Taiwan and Finland's industries concentrate too much on high-tech industries, especially electronic and communication industries. For Taiwan's industry development, this phenomenon could lead to crisis. Taiwan is a medium-small country. If the industry is too concentrated, it will be affected more easily by the fluctuation of the global economy, compared to big countries. For example, Taiwan's ICT industry was deeply hurt as a result of terrorist attack on the United States.

Thus, to speed moving information and electronic industries towards the development of high value added products to keep up the economic growth and developing high value added and high growth new industry and service industry is vital for improving Taiwan's economic growth.

(2) *Value of Export*

In terms of high-tech industry export value in the major countries in 2000, the United States had the highest value of US\$ 227.8 billion, followed by the second leading group; Japan US\$ 123.1 billion, the U.K. US\$ 84 billion, Germany US\$ 81.5 billion; and the third leading group, France US\$ 63.8 billion, South Korea US\$ 69.5 and Taiwan US\$ 62.7 billion. See Table 13. In 2001, the global economy was not good. Most of the leading countries' high-tech export was affected by the economy and decreases. The European countries and South Korea were less affected. However, Taiwan was more affected because it is highly dependent on the U.S. market and also because the high-tech industries in Taiwan moved to China. The high-tech export value (by US\$) decreased to 21.5%. The high-tech industry export value of Finland, whose industry structure is similar to Taiwan, has also decreased to 19.17%. On the other hand, China's high-tech production value increased from US\$ 48.7 billion in 2000 to US\$ 57.7 billion in 2001, exceeding Taiwan's high-tech export value. (See Table 13.)

TABLE 13. THE EXPORTS OF VARIOUS TECHNOLOGY-INTENSIVE INDUSTRIES OF MAJOR COUNTRIES

(unit: US\$ millions, %)

	U.S.		Japan		U.K.		Germany	
	2000	2001	2000	2001	2000	2001	1999	2000
Hi-Tech	227,832	204,704	123,655	94,673	84,043	81,251	74,900	81,385
Medium-Hi-Tech	410,524	291,065	263,230	226,413	99,958	91,727	190,215	183,245
Medium-Low-Tech	94,277	87,895	62,182	53,772	37,401	35,338	85,572	83,194
Low-Tech	81,148	77,106	12,295	11,609	31,145	28,884	64,345	59,564
KI-Manufacturing	558,356	496,769	386,285	321,086	184,007	172,978	342,708	335,873
Manufacturing	713,781	661,770	460,762	386,467	252,548	237,301	513,431	507,476
Percentage (%)								
Hi-Tech	31.92	31.08	26.71	24.50	33.28	34.25	14.59	16.06
Medium-Hi-Tech	43.50	43.98	57.13	58.59	39.58	38.67	55.52	55.81
Medium-Low-Tech	13.21	13.28	13.50	13.91	14.81	14.90	16.28	16.39
Low-Tech	11.37	11.65	2.67	3.00	12.33	12.18	12.61	11.74
KI-Manufacturing	75.42	75.07	83.84	83.08	72.86	72.92	66.75	78.01
Manufacturing	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
	France		Canada		Korea		Taiwan	
	2000	2001	1999	2000	2000	2001	2000	2001
Hi-Tech	63,838	61,632	33,613	45,959	65,514	60,022	62,691	49,197
Medium-Hi-Tech	117,738	118,138	138,859	145,843	53,865	59,676	38,678	43,081
Medium-Low-Tech	47,907	45,685	52,514	61,561	43,624	47,278	26,856	22,588
Low-Tech	49,846	48,669	66,272	71,006	26,491	26,532	18,752	15,790
KI-Manufacturing	181,576	179,771	172,432	191,802	123,379	119,097	101,569	85,249
Manufacturing	278,430	274,125	291,258	324,369	193,494	192,907	146,978	131,656
Percentage (%)								
Hi-Tech	22.93	22.48	11.54	14.17	35.93	31.11	42.65	30.41
Medium-Hi-Tech	42.29	43.10	47.68	44.96	27.84	30.62	26.32	28.04
Medium-Low-Tech	16.88	16.67	18.03	18.98	22.55	24.51	18.27	18.57
Low-Tech	17.90	17.75	22.75	21.89	13.69	13.75	12.76	12.98
KI-Manufacturing	65.21	65.58	59.22	59.13	63.76	61.74	68.97	68.45
Manufacturing	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
	China		Italy		Sweden		Finland	
	2000	2001	2000	2001	1999	2000	2000	2001
Hi-Tech	48,732	57,656	21,787	22,059	19,463	20,812	11,186	9,013
Medium-Hi-Tech	55,874	60,012	95,414	96,127	30,266	29,918	11,664	11,755
Medium-Low-Tech	52,587	53,323	58,515	57,602	15,797	15,362	8,192	8,273
Low-Tech	82,111	85,332	55,130	57,406	14,894	14,974	15,680	13,727
KI-Manufacturing	104,606	117,668	117,196	118,186	49,722	50,730	22,850	20,797
Manufacturing	239,605	256,323	230,841	233,195	78,414	80,866	44,722	41,796
Percentage (%)								
Hi-Tech	20.34	22.49	9.44	9.46	24.82	25.74	25.01	21.63
Medium-Hi-Tech	23.41	23.32	41.33	41.22	38.59	37.00	26.08	28.12
Medium-Low-Tech	20.80	21.95	25.35	24.70	17.60	18.75	18.32	19.79
Low-Tech	34.29	34.39	23.88	24.62	18.99	18.52	30.59	30.45
KI-Manufacturing	45.91	43.66	50.77	50.68	63.41	62.73	51.09	49.76
Manufacturing	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Note: The exports by sector are in accordance with The Concordance between ISIC and HS code that OECD DSTI provided.

Source: 1. OECD, STAN On-line database, 2002.

2. The export/import data rate of R.O.C., 2000-2001, TIER calculated.

3. The export/import data rate of China, 2000-2001, TIER calculated.

4. The export/import data rate of Japan, 2001, TIER calculated.

TABLE 14. THE EXPORTS OF VARIOUS HI-TECH INDUSTRIES OF MAJOR COUNTRIES
(unit: US\$ millions, %)

	U.S.		Japan		U.K.		Germany	
	2000	2001	2000	2001	2000	2001	1999	2000
Hi-Tech	227,832	205,704	123,055	94,673	84,045	81,251	74,900	81,483
Pharmaceuticals	14,920	17,642	3,675	3,553	11,708	13,778	16,583	14,459
Office, Account & Computing Machine	57,523	49,404	35,216	28,516	21,966	19,300	14,467	16,332
Electro. Equip. (Radio, TV & Commun.)	102,455	81,076	81,956	59,945	29,664	29,054	25,281	30,344
Aerospace	52,934	57,582	2,209	2,659	20,705	19,119	18,569	20,248
Manufacturing	713,781	661,770	460,762	386,467	252,548	237,201	513,431	507,476
Percentage (%)								
Hi-Tech	31.92	31.08	26.71	24.50	33.28	34.25	14.59	16.06
Pharmaceuticals	2.09	2.67	0.80	0.92	4.64	5.81	3.23	2.85
Office, Account & Computing Machine	8.06	7.47	7.64	7.38	8.70	8.14	2.82	3.22
Electro. Equip. (Radio, TV & Commun.)	14.35	12.25	17.79	15.51	11.75	12.25	4.92	6.00
Aerospace	7.42	8.70	0.48	0.69	8.20	8.06	3.62	3.99
Manufacturing	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
	France		Canada		Korea		Taiwan	
	2000	2001	1999	2000	2000	2001	2000	2001
Hi-Tech	63,838	61,632	33,613	45,959	65,514	60,022	62,691	49,197
Pharmaceuticals	11,857	13,711	1,737	1,890	721	792	170	154
Office, Account & Computing Machine	9,850	8,336	7,118	8,198	22,210	17,440	29,190	23,970
Electro. Equip. (Radio, TV & Commun.)	22,123	18,105	14,065	22,935	45,707	40,981	33,211	24,938
Aerospace	20,008	21,481	10,693	12,936	876	808	119	136
Manufacturing	278,430	274,125	291,258	324,369	193,494	192,907	146,978	121,656
Percentage (%)								
Hi-Tech	22.93	22.48	11.54	14.17	35.93	31.11	42.65	40.44
Pharmaceuticals	4.26	5.00	0.60	0.58	0.37	0.41	0.12	0.13
Office, Account & Computing Machine	3.54	3.04	2.44	2.53	11.48	9.04	19.86	19.70
Electro. Equip. (Radio, TV & Commun.)	7.95	6.60	4.83	7.07	23.62	21.24	22.60	20.50
Aerospace	7.19	7.84	3.67	3.99	0.45	0.42	0.08	0.11
Manufacturing	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
	China		Italy		Sweden		Finland	
	2000	2001	2000	2001	1999	2000	2000	2001
Hi-Tech	48,732	57,656	21,781	22,059	19,462	20,812	11,186	9,042
Pharmaceuticals	2,256	2,541	7,000	7,946	4,062	3,943	325	351
Office, Account & Computing Machine	18,638	23,575	3,209	2,944	786	751	423	346
Electro. Equip. (Radio, TV & Commun.)	27,232	31,029	7,473	7,718	13,398	14,823	10,333	8,170
Aerospace	606	512	4,098	3,451	1,217	1,294	105	175
Manufacturing	146,978	121,656	230,841	233,195	78,414	80,866	44,722	41,796
Percentage (%)								
Hi-Tech	33.16	47.39	9.44	9.46	24.82	25.74	25.01	21.63
Pharmaceuticals	1.53	2.09	3.03	3.41	5.18	4.88	0.73	0.84
Office, Account & Computing Machine	12.68	19.38	1.39	1.26	1.00	0.93	0.95	0.83
Electro. Equip. (Radio, TV & Commun.)	18.53	25.51	3.24	3.31	17.09	18.33	23.10	19.55
Aerospace	0.41	0.42	1.78	1.48	1.55	1.60	0.23	0.42
Manufacturing	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Note: The export by sector are in accordance with The Concordance between ISIC and HS code that OECD DSTI provided.

Source: 1. OECD, STAN On-line database, 2002.

2. The export/import data tape of R.O.C., 2000-2001, TIER calculated.

3. The export/import data tape of China, 2000-2001, TIER calculated.

4. The export/import data tape of Japan, 2001, TIER calculated.

In terms of the export ratio in manufacturing in each country in the year 2000, Taiwan had the highest ratio in its high-tech industry, up to 42.69% (in 2001 it decreased to 40.44%), followed by the United States 31.92%, South Korea 35.93%, and the U.K. 33.28%. The United States, Japan, Germany, France and Canada are mainly aiming for medium-high technology export. The ratios are more than 40%, which are cars and chemical products. China's high-tech product export ratio is going up, and medium-low and low technology product export ratios are going down, which indicates that China's market share of traditional industry in the international market is above 50%. Since the demand is saturated, the growth space is limited. Thus, China faces the problem of adjusting the product structure. It has to develop intensive technology products to bring economic growth, which is also one of the reasons that China's high-tech product export has largely increased. Another reason is the contribution of Taiwanese business.

Regarding the export of four high-tech industries of each country, as shown in Table 14, in 2000, Taiwan's computer and OA equipment industry's export value was US\$ 29.2 billion dollars, making it the 3rd largest export country in the world, next to the United States and Japan. Furthermore, the electronic and communication industry export value was US\$ 33.2 billion, next to the United States, Japan and South Korea. However, in 2001, as the U.S. economy declined, Taiwan's computer and OA equipment industry exports decreased from US\$ 29.2 billion to US\$ 24 billion. The ratio decreased to 18%. The electronic industry was affected the most. The export value decreased from US\$ 24.9 billion to US\$ 33.2 billion; a decrease to 25%. South Korea's computer and OA equipment industry's export value decreased to 21.5%. Electronic and communication products decreased to 10.34%. Compared to Taiwan, the effect was relatively smaller.

In the changes of export structure, from 2000 to 2001, most countries' ratios of high-tech export decreased. For example, Japan's ratio decreased from 26.71% to 24.50%, South Korea from 35.93% to 31.11%, Taiwan from 42.65% to 40.44% and Finland from 25.01% to 21.63%. European countries' high-tech export ratios have slightly increased, not affected by the U.S.'s economy. Regarding the four high-tech industry ratios, most countries' manufacturing and aerospace industry export ratios have slightly increased, and the ICT has decreased. It was mainly because of the unstable economy, which caused the decrease of the ICT product demands, but only China was an exception. Most of the four high-tech ratios have increased, which indicates that China's export structure is changing toward intensive technology products.

IV. ANALYSIS OF COMPETITION POSTURE OF HIGH-TECH INDUSTRIES IN THE U.S. MARKET

This research divides the competition posture of high-tech industries into the following groups with the hi-technology industrial patent share in the USPTO as the Y-axis

and hi-technology product demand market share¹⁰ as the X-axis. Due to the constraint of data availability, the analysis is conducted using the US market as basis.

- Group I: high technological capability and high manufacturing capability ("super leader" countries)
- Group II: high technological capability and low manufacturing capability ("technology-based" countries)
- Group III: high manufacturing capability and low technological capability ("manufacturing-based" countries)
- Group IV: low technological capability and low manufacturing capability ("laggard" countries)
- Group V: the dynamic changes in both technological capability and manufacturing capability are large, and this condition can't be classified in any group above.

Countries that have strong performance in high-tech exports and patents in the U.S. market are selected to evaluate the competition posture of high-tech industries across country. In particular, years 1996 and 2000 are chosen to observe the movement of their positions on the technological performance ladder and competitiveness in world high-tech industries vis--vis other counterparts.

In Figure 3, the United States and Japan are in group I and take the lead in both technological and manufacture capabilities. Germany, France and the U.K. belong to group II (high technological and low manufacturing capability). Their patent share is second in the world, but their market share in the U.S. import market is not as strong as technology performance. The competitive advantage of this country grouping lies in high-tech industries such as aerospace and pharmaceuticals and medium-high-tech electrical industries. For example, the U.K. is number one in the U.S. pharmaceutical product import market. France is number one in the U.S. aerospace import market. Since aerospace and pharmaceutical industries have much more smaller market scale compared to information and electronics industry, countries like Germany, France and the U.K. all have a smaller high-tech market share in the United States than the Asian countries that are specialized in the original equipment manufacturing (OEM) of information and electronics products. However, in the year 2000 and 2001, the changes in export competition among the European countries were very large. The market share of US high-tech products has especially improved. If we trace the competitive situation of those countries in the U.S. market during the period from 1991 to 2000, as shown in Figure 4, we can find that the market share of patents of Germany, the U.K. and France in group II "technology-based

¹⁰ The Total Demand Market of the United States = Production Export + Import, the market share of the United States is the ratio of production value minus export value to total demand market; other country's market share in the United States is the ratio of import value to total demand market.

countries" is going down, and the share of market of goods is going up. Market share of patents decreases because in recent years, the number of U.S. patents granted has stopped or decreased, and Taiwan and South Korea's market share of patent increased. Regarding the increasing market share of goods, it may be because of the stable growth of the European Unit's economy in the last two years and the technology of new industry and the leading ability of commercialization.

FIGURE 3. THE DYNAMIC COMPETITION OF HI-TECH INDUSTRIES IN THE U.S.

Source: Taiwan Institute of Economic Research (2002).

Countries in group III (high manufacturing and low technological capability) are Singapore, Malaysia, and China. These three countries are in the top 5 countries in terms of the import market share of information, and electronics and telecommunications equipment in the United States. Group III countries are characterized by the local presence of many overseas subsidiary companies of giant trans-national corporations (TNCs) as production bases. These countries tend to have better manufacturing capability than technological capability because technology is directly imported from the parent companies of the TNCs. Group IV is comprised of many less industrial developed countries with low manufacturing and technological capability. However, due to policies encouraging foreign direct investment and the opening up of markets, an increasing number of foreign enterprises are helping to catch up with the export performance of the industrial advanced countries. China is a noteworthy example. In 1991, China's market share of the U.S. high-tech industries was less than 0.5%, but surpassed Korea, Taiwan and Singapore in 1999, becoming the third biggest supplier to the United States. The competitive posture transforms group VI to group III. Because of China's economic development and the competitive advantage of cheap labor, Singapore's market share of high-tech products in the United States is obviously affected. The market share decreased from 3.27% in 1996 to 2.07% in 2000. On the other hand, China's market share of high-tech products increased from 1.68% to 3.11% in the same year.

South Korean and Taiwan constitute a distinct group in transition regarding competition posture. These countries still lag some distance behind the super leader league. However, unlike group II or III, they have a solid foundation of technological and manufacturing capabilities. South Korea and Taiwan, in particular, have been clearly moving from the manufacturing-based group III toward group I. If we look at the two countries' competition in the U.S. market during the period 1991-2000, (see Figure 5), we see that it is almost parallel. Before 1999, South Korea's high-tech industry had a higher competitiveness than Taiwan's, but Taiwan exceeded South Korea in 2000. However, for the market share of high-tech products, the situation was reversed. Taiwan's market share has been higher than that of South Korea's until 2000. This was due to the factories that moved to China for production.

From the evolution of competition posture of the U.S. high-tech industries in the period 1991-2000, group II countries are moving downward to a dimension of decreasing patent shares, but increasing market shares. Group III countries increased significantly in product market share. Group V countries had both technological and manufacturing capabilities on the rise. However, Singapore's competitive advantage decrease in product market is very obvious. China and Malaysia's market share of products kept increasing. The super leader group with the increasing competition of other groups in high-tech industries has, on the contrary, seen both patent share and market share decrease.

Moreover, the research focuses on the important new developed industry in the U.S. market share of importing goods and the number of patents granted for a

cross analysis. Observe the changes in competing countries for the three years from 1999 to 2001. (See Appendix Table 2.) We can find that Japan's competition in technology and products has decreased. In 2001, the European countries have improved their market share of products and technology. Although Taiwan has increased its competitiveness in technology, only the market share of information and semi-conductors kept increasing. The competitiveness of consuming electronic and communication products declined. Singapore had its market share of patents slightly increased, but the competitiveness of importing electronic and information products in the United States obviously declines.

FIGURE 5. THE DYNAMIC COMPETITION OF HI-TECH INDUSTRIES IN THE UNITED STATES-TAIWAN, KOREA

Source: Taiwan Institute of Economic Research (2002).

Generally speaking, the competition changes of importing goods in the U.S. market do not fully reflect the advantages of each country. They partly reflect the result of dividing work globally. Thus, as the concept of globalization, using the term, "country" as the research subject for competitiveness is not really going to reflect the real technology competition of a country.

V. CONCLUSION

The research considers the ability to obtain objective index information. It also uses the index accepted internationally to adjust and calculate Taiwan's information to be compiled internationally. Taiwan can compare its competitiveness in terms of technology with the OECD member countries and part of Asian countries. From the result of the international comparison, the research raises several points:

1. Taiwan's investment in technology industry has slowed down, and the reason needs to be discussed further.

In 2000, Taiwan's whole or corporation R&D investment growth rate was the lowest. At the same time, the growth rate of high-tech industry R&D researcher (above college) almost stopped. We need to pay attention. In 2000, Taiwan's growth rate of value added was not bad, but it couldn't attract industry to invest in R&D. What is the problem? Is it related to corporation's Global R&D distribution. Is it because new technology is not coming out and the future of industry is not clear, so that investors are afraid of investing? Is it just because corporations were hoping to see a new economic miracle during the years 1999 and 2000 and invested too much in equipment, and no money could be used for R&D? Since there is no real case to prove, we can't directly judge the situation. However, because R&D and innovation is the power behind knowledge-based economic development, we have to find the problems so that the government can offer suitable policies to encourage corporations to invest in R&D.

2. Taiwan's investment intensity in manufacturing R&D is comparatively lower than other industrial countries, which is at disadvantage for improving international competitive ability.

Comparing different technology intensive industries' R&D investment, Taiwan's R&D investment intensity in manufacturing is comparatively lower than other developed countries. It indicates that although Taiwan has outstanding performance in manufacturing and management, the R&D investment scale is obviously smaller than other countries. If Taiwan wants to keep its international competitiveness, it has to enhance the scale of R&D investment.

3. Maintaining Taiwan's manufacturing advantages, and developing new industry and service industry are important goals for future industry technology development.

The service industry is the main power of a country's economy, and the service industry's innovation is getting attention. Form the year 1999, the U.S.'s service industry's R&D investment ratio has largely increased, and it will be the international trend in the future. However, Taiwan's R&D resources are highly concentrated on ICT industry, and the R&D ratio for service industry does not even reach 10%. The goals and challenges of the future industry technology development policy are to develop service industry, and at the same time, to keep the original manufacturing advantages. Creating high value added industry development is also the challenge that Taiwan has to face.

4. Patent is the defensive weapon or money-making capital?

In recent years, no matter the number of patent granted, patent strength, patent intensity, Taiwan's performance has been very outstanding, which indicates that Taiwan is very active in invention and innovation. However, in terms of royalty performance, we can see Taiwan's trade deficit problem of technology is getting worse. When intellectual capital becomes a corporation's important income, Taiwan's patents will not have their economic value. However, we still have to think about where the patent's economic value comes from. Taiwan's patents are mostly in manufacturing, and those patents consolidates Taiwan's role of global manufacturing, which, we can say, is a defensive weapon. The value should be embodied in the production value. The policy of selling or transferring technology involves a corporation's strategic consideration; whether to accept royalties or use the right of intellectual assets as the defensive weapon for manufacturing in order to make money. Corporations also have to see if they can keep making break through in technology and maintain a certain leading distance before transferring or authorizing it to other countries. Thus, Taiwan only has advantages in "D" of the R&D, and a lot of "D" is manufacturing, which has low value added. Taiwan still has to enhance the "R" part, which has high value added, in hopes that intangible intellectual capital will create high value added for Taiwan.

5. The structure of industry is seriously sloping, and the corporations are moving out. How can Taiwan avoid the impact of bad economy and maximize the benefit of limited resource distribution?

Taiwan's industry concentrates too much on the information and electronic industry, and highly depends on the U.S. market. In 2001, when the global economy was declining, Taiwan's exports were more seriously affected comparing to Europe and

South Korea. Currently, because of the pressure of cost, Taiwan's industry distributes the business globally. Full planning is needed to check which industry is suitable to stay in Taiwan, and which industry needs to be developed or created. Only by doing so, can business be successful under the factors of limited resources and chances. At this moment, clearly describing future industrial development is the key to disperse concentrated industry and effectively use resources.

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APPENDIX

TABLE 1. THE CONCORDANCE BETWEEN ISIC AND SIC OF TAIWAN

OECD's classifications of industries	ISIC Rev.3	Taiwan's SIC Rev.7
TOTAL MANUFACTURING	15-37	08~31+84-8492
Food products, Beverages & Tobacco	15-16	08+09
Food Products and Beverages	15	8
Tobacco Products	16	9
Textile, Fur & Leather	17-19	10+11+12
Textiles	17	10+112+1141+119
Wearing apparel & fur	18	11-112-1141-119
Leather Products & Footwear	19	12
Wood, Paper, Printing, Publishing	20-22	13+15+16+84
Wood & Cork (not Furniture)	20	13
Pulp, Paper, Paper Pro., Printing and Publ.	21+22	15+16
Pulp, Paper and Paper Products	21	15
Printing and Publishing	22	16
Coke, Petrol., Nucl. Fuel, Chem., Rub. Plas.	23-25	17+18+19+20+21
Coke, Ref. Petrol. Prod. & Nuclear Fuel	23	19
Chemicals and Chemical Products	24	17+18
Chemicals Excluding Pharmaceuticals	24e×2423	17
Pharmaceuticals	2423	182
Rubber and Plastics Products	25	20+21
Non-metallic Mineral Products	26	22
Basic Metal	27	23-2314-2315
Iron and Steel	271+2731	231-2314-2315
Non-ferrous Metals	72+2732	232+233+234+239
Fabricated Metal Products	28	24+2314-2492
Machinery EQ., Instrument & Trans. Equip.	29-35	25+26+27+28+29+30+ 2492
Machinery N.E.C.	29	25-256+282+2492
Office, Accounting and Computing Machinery	30	256+261+264
Electrical Machinery	31	281+283+284+289
Electro. Equip.(Radio, TV & Commun.)	32	26+27-261-264
Electro. Comp. (Inc. semi-conduc.)	321	27
TV, Radio & Communication Equip.		

OECD's classifications of industries	ISIC Rev.3	Taiwan's SIC Rev.7
Instruments, Watches & Clocks	32-321	262+263
Motor Vehicles,	33	30
Other Transport Equipment	34	293
Ships	35	29-293
Aerospace	351	291
Other Transport Equip. Nec.	353	296
Furniture, Other Manufg. Nec.	352+359	292+294+295+299
Furniture	36	14+31
Other Manufacturing, Nec.	361	14
Recycling	369	31
	37	2315
Electricity, Gas & Water Supply	40+41	33~36
Construction	45	38~42
		44~48+50~51+53~60+62~
Total Service	50-99	64+66~67+69~77+79+81~
		82+84~90+92~96+98~99-84
Wholesale, Ret. Trade, Mot. Veh. Repair, Etc.	50-52	44~45+46~48+95
Hotels & Restaurants	55	50+51
Transport & Storage	60-63	53+54+55+56+57+58+964
Post and Telecom	64	59+60
Post	641	59
Telecommunications	642	60
Financ. Intermedation (inc. insur.)	65-67	62+63+64
Real Estate, Renting & Busin. Activ.	70-74	66~67+69~77-7322-7704+849
		2+875+92+9691
Computer & Related Activities	72	72+73-7322+8492
Software Consultancy	722	7201+8492
Other Computer Services, Nec.	72-722	72+73-7201-7322
Research & Development	73	75
Other Business Activities, Nec.	74	66~67-72-73-75-7704+875+
		92+9691
Comm., Soc. & Pers. Serv. Activ., Etc.	75-99	79+81~82+84~90+92~96+1
TOTAL BUSINESS ENTERPRISE SECTOR		98~99+7322+7704-84-
		875-92-95-964-9691

Source: Indicators of S&T, National Science Council, R.O.C., 2002.

TABLE 2. THE SHARE OF COMMODITIES IMPORT VALUE OF U.S. AND PATENTS GRANTED IN USPTO (1999, 2000)

(unit: %)

		Semiconductor		Consumer Electron. (Radio, TV)		Aerospace		Communication		Office, Account & Computing		Pharmaceuticals		Biotechnology	
		Commodity	Patent	Commodity	Patent	Commodity	Patent	Commodity	Patent	Commodity	Patent	Commodity	Patent	Commodity	Patent
Germany	1999	1.53	2.87	0.60	2.66	11.3	6.1	1.11	2.65	0.95	2.36	23.3	6.3	8.2	3.92
	2000	1.48	2.76	0.64	2.57	12.7	6.5	0.86	2.93	0.78	2.56	14.9	7.3	9.6	4.02
	2001	2.70	2.58	0.72	3.06	12.3	6.8	1.00	3.42	0.82	2.36	13.3	7.2	9.8	4.38
U.K.	1999	0.73	0.83	1.11	1.75	9.17	2.3	1.85	2.81	2.23	2.05	14.7	5.2	7.0	3.58
	2000	0.55	0.70	0.99	1.93	7.61	2.3	2.10	2.92	2.32	1.95	16.8	5.5	7.6	3.58
	2001	0.58	0.65	0.88	2.12	6.10	2.3	2.16	3.01	2.05	2.06	15.4	5.2	8.1	3.78
France	1999	1.38	1.05	0.43	2.00	24.1	2.5	0.90	2.52	0.41	1.36	4.6	5.4	10.3	2.81
	2000	1.11	1.06	0.42	1.62	28.6	2.4	1.11	2.53	0.49	1.19	5.7	5.3	11.2	2.99
	2001	1.61	1.06	0.27	1.61	26.9	2.4	0.84	2.32	0.31	1.33	8.2	5.7	10.8	3.01
Sweden	1999	0.14	0.35	0.55	1.15	0.26	0.9	1.06	2.62	0.11	0.38	3.5	1.0	0.7	0.95
	2000	0.11	0.54	0.58	1.21	0.14	1.0	1.39	3.04	0.10	0.51	4.3	1.2	0.7	0.89
	2001	0.06	0.49	0.39	1.18	0.16	1.0	1.25	2.74	0.06	0.63	3.1	0.9	0.7	1.04
Finland	1999	0.01	0.07	0.22	0.89	0.01	0.4	0.28	2.42	0.10	0.23	0.2	0.2	0.2	0.47
	2000	0.01	0.09	0.24	0.85	0.01	0.3	0.18	2.18	0.04	0.24	0.2	0.2	0.2	0.36
	2001	0.01	0.06	0.13	1.11	0.00	0.4	0.95	2.35	0.02	0.26	0.4	0.2	0.2	0.35
Denmark	1999	0.03	0.03	0.16	0.08	0.08	0.3	0.26	0.16	0.04	0.09	0.5	0.9	1.6	1.28
	2000	0.05	0.03	0.19	0.13	0.05	0.2	0.36	0.15	0.04	0.05	0.6	0.9	2.2	1.45
	2001	0.09	0.01	0.12	0.07	0.04	0.2	0.39	0.12	0.05	0.07	1.0	1.0	2.6	1.40
Australia	1999	0.01	0.04	0.05	0.21	0.91	0.4	0.36	0.16	0.09	0.26	0.4	0.9	0.3	1.10
	2000	0.02	0.04	0.08	0.23	0.57	0.4	0.25	0.11	0.05	0.34	0.3	0.7	0.3	0.92
	2001	0.03	0.17	0.07	0.27	0.62	0.5	0.22	0.15	0.05	0.71	0.8	1.0	0.3	1.35
Japan	1999	16.0	31.1	27.9	39.6	9.43	20.2	9.97	18.6	17.0	22.8	10.4	8.5	4.7	7.11
	2000	15.8	27.8	25.4	36.4	6.86	19.8	8.07	17.7	16.4	26.76	11.2	8.3	4.6	6.95
	2001	13.5	26.5	24.6	35.6	7.25	20.0	5.94	17.1	13.9	26.2	9.4	9.2	3.6	6.89
Taiwan	1999	10.4	9.34	2.97	1.04	0.11	2.4	7.94	0.84	11.9	1.17	0.1	0.3	0.0	0.19
	2000	11.4	11.4	3.34	1.24	0.14	2.9	6.36	1.01	11.9	1.16	0.1	0.2	0.1	0.21
	2001	12.3	12.0	2.73	1.23	0.14	3.2	5.61	1.02	12.0	1.30	0.1	0.3	0.1	0.47
Korea	1999	19.6	6.73	3.96	5.96	0.84	2.3	9.09	4.26	6.84	2.97	0.3	0.5	0.0	0.53
	2000	17.4	5.63	4.46	5.05	0.73	2.1	10.2	3.59	8.80	2.90	0.3	0.6	0.0	0.33
	2001	13.1	5.82	4.35	5.19	0.90	2.1	16.3	3.81	6.33	2.44	0.2	0.6	0.0	0.82
Singapore	1999	5.80	0.48	0.95	0.11	0.38	0.0	1.53	0.07	14.0	0.13	2.1	0.0	0.0	0.08
	2000	5.70	0.76	1.05	0.28	0.32	0.1	1.15	0.15	11.4	0.13	2.8	0.0	0.0	0.07
	2001	6.43	1.02	1.19	0.38	0.34	0.1	1.00	0.15	10.7	0.19	2.7	0.0	0.0	0.06
China	1999	1.43	0.04	16.7	0.06	0.18	0.0	13.4	0.04	9.02	0.03	2.3	0.1	2.0	0.05
	2000	1.14	0.02	19.0	0.08	0.19	0.0	10.1	0.01	11.3	0.06	2.0	0.1	2.2	0.10
	2001	1.54	0.05	19.9	0.07	0.28	0.1	12.1	0.01	13.6	0.07	1.7	0.2	0.7	0.20
Malaysia	1999	13.0	0.05	7.63	0.05	0.01	0.0	6.19	0.04	9.39	0.01	0.0	0.0	0.0	0.00
	2000	12.8	0.04	7.68	0.05	0.01	0.0	7.30	0.03	9.25	0.02	0.0	0.0	0.0	0.01
	2001	15.4	0.12	7.77	0.05	0.01	0.0	8.06	0.03	10.0	0.0	0.0	0.0	0.0	0.00
Israel	1999	0.18	0.18	0.38	0.37	1.86	0.4	1.98	0.78	0.25	0.78	1.6	1.1	0.5	1.05
	2000	1.14	0.23	0.50	0.47	1.81	0.5	1.72	0.77	0.42	0.78	2.0	0.9	0.2	0.90
	2001	0.82	0.23	0.34	0.56	1.75	0.5	1.90	0.95	0.35	0.85	2.8	0.7	0.2	0.81

Note: 1. The HS codes of above industries are according with "The Study on the Development Dynamics and Strategies of Emerging Industries," IADB of R.O.C. (2001).

2. The numbers of Industry patent are calculated based on "Concordance between SIC and USPC System" publishes by USPTO TAF Branch, 2001.

Source: 1. The export/import data rate of the U.S., 1992-2001, TIER calculated.

2. USPTO CD-ROM, TIER calculated.