



SCIENCE BULLETIN

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1990 Survey of Developments in Science and Technology

The work has been completed on the 1990 Survey of Developments in Science and Technology, a project sponsored by the National Science Council under the Executive Yuan. Following are some excerpts of the survey results.

1. Science and Technology Research and Development Spending

A. Total spending on science and technology R&D was NT\$71.548 billion in 1990, an increase of 30.6 percent over 1989. Looking at growth of R&D spending over several years, 1990 was the first year since 1987 (when the growth rate was 28.1 percent) that the rate of growth exceeded 30 percent. Even after adjusting the rate for inflation, the real value is still an increase of 25.8 percent, showing that there was definitely a large rise in R&D spending in 1990.

B. R&D spending represented 1.65 percent of GNP in 1990, an increase of 0.27 percentage points over 1989's 1.38 percent. Looking at the ratio of R&D spending to GNP over several years, this figure has continued to rise year by year (except for 1986, when it fell under the influence of a weak economy). Both government and the private sector attach great importance to R&D, and coupled with the measures to encourage R&D contained in regulations on industrial upgrading, the effect has been a flourishing growth in spending. It is predicted that by 1996, the ROC can achieve the goal of 2.2 percent of GNP.

C. The distribution of R&D expenditures breaks down as follows: Industry had the highest expenditure of NT\$42.24 billion (59 percent

of the total); next came research agencies, with NT\$19.83 billion (27.7 percent); followed by universities, colleges, institutes and schools with NT\$9.478 billion (13.3 percent). The rates of growth in 1990 were 37.6 for industry, 25.3 percent for research agencies, and 14.6 percent for universities, colleges, institutes and schools.

Growth in industry was the most striking. If we do not consider public enterprises, privately-operated companies had a growth rate of 41.8 percent. If we consider those privately-operated companies with R&D expenditures in excess of NT\$5 million, then the rate of growth in actual R&D spending in 1990 was very high. This proves that the bigger the company, the greater the stress laid on R&D. Among these larger companies, those which spend more than NT\$10 million on research and introducing new technologies made up 56.3 percent of all R&D spending by privately-operated companies.

D. Looking at sources of R&D spending, the ratio of government spending to private spending went from 48:52 in 1989 to 46:54 in 1990. As a means to make science and technology take root and promote industrial upgrading, increasing the amount invested by private industry in R&D is a trend which is stressed in advanced nations.

In 1990, private enterprise spent 97.3 percent of its R&D dollars on in-house research, an increase of 5.1 percentage points over 1989's figure of 92.2 percent. Conversely, private enterprise spent 2.4 percent of its R&D dollars on research performed by outside research agencies, a drop

of 4.7 percentage points over 1989's 7.1 percent. From the direction of growth shown in these figures, it is clear that private enterprise has begun to lay heavy stress on its own R&D capabilities.

E. Under these circumstances, wherein private enterprise is developing its own R&D capabilities, the proportion of operating expenses represented by R&D expenditures went from 0.71 percent in 1989 to 0.95 percent in 1990. Examining this phenomenon in terms of category of industry, in 1990 two types of private companies had R&D expenditures which surpassed NT\$10 for every NT\$1,000 of operating expenses: electrical, electronic, and mechanical manufacturing, parts and repairs, with NT\$22.84; and transportation equipment manufacturing, parts and repairs, with NT\$10.48.

2. Research and Development Manpower in Science and Technology

A. The number of people involved in research in the country as a whole in 1990 was 46,071, an increase of 15.9 percent over 1989. For every 10,000 members of the population there were 22.6 research personnel in 1990, an increase of 2.8 people over the 1989 figure of 19.8 people. Moreover, for every 10,000 members of the work force there were 54.7 research personnel. This figure is an increase of 7.4 people over the 1989 figure of 47.3 people.

B. The number of research personnel in the country as a whole in each of the agencies responsible for implementation in 1990 was as follows: Industry had the greatest

number with 26,440, accounting for 57.4 percent of the total; universities, colleges, institutes and schools had the fewest with 9,623, or 20.9 percent of the total.

If we differentiate on the basis of academic background, the greatest percentage of personnel -- 35.1 percent -- had bachelor's degrees, and the smallest percentage -- 12.9 percent -- had doctorate degrees. If we compare this factor with 1989, the 18.4 percent increase in the number of personnel with master's degrees is the greatest. It is still the case, however, that research personnel with bachelor's degrees formed the principal strength in R&D in 1990.

If we examine this phenomenon from the point of view of the academic backgrounds of research personnel in the different agencies, the mainstream in private industry is research personnel with bachelor's degrees and college diplomas. These two groups together account for 21,892 people, who make up 82.8 percent of all research personnel in industry. Conversely, doctorate and

master's degree holders in universities, colleges, institutes and schools account for 6,607 of their total research personnel, or 68.7 percent of the total.

If we further compare research spending, it is obvious that private industry possesses abundant funds, but lacks high-quality manpower, and thus R&D work is still just getting started. Academia, however, possesses high-quality manpower. Therefore, the question of how to bolster unity, exchanges and cooperation between industry and academia, and thus raise the level of research in industry, is one that we today should be making greater efforts to answer.

3. The Number of Research Papers Published

The number of science and technology papers published in 1990 (including periodical articles, papers presented at seminars, and monographs) was 21,412, an increase of 1,484 over the 1989 figure of 19,928. If we exclude papers pub-

lished in the field of medicine, papers in other fields displayed negative growth.

4. The Number of Patents Applied for and Approved

A total of 36,127 patent applications were submitted in 1991, an increase of 1,784 over the 1990 figure of 34,343. A total of 27,281 patent applications were approved in 1991, an increase of 4,680 over the 1990 figure of 22,601. When we come to patents for new inventions, only 12.6 percent of the total number of applications were submitted by ROC citizens, and the number of approved patents for new inventions by ROC citizens was even lower: 6.6 percent.

The number of inventions is the best indicator of a nation's level of development of science and technology, and the most concrete way to guarantee results. Today the number of ROC inventions is still low. Thus, encouraging research into inventions is the best shortcut to upgrading research and development.

Major Indicators of Research and Development in the Nation as a Whole

| Item | 1988 | 1989 | 1990 |
|--|--------|--------|--------|
| R&D spending (unit: billion NT dollars) | 43.8 | 54.8 | 71.5 |
| R&D spending as percentage of GNP | 1.22 | 1.38 | 1.65 |
| Ratio of government to private industry R&D spending | 57:43 | 48:52 | 46:54 |
| Number of research personnel | 35,437 | 39,742 | 46,071 |
| Number of R&D workers for every 10,000 members of general population | 17.8 | 19.8 | 22.6 |
| Spending per research worker (unit: million NT dollars) | 1.24 | 1.38 | 1.55 |
| Number of approved patents | 12,355 | 19,265 | 22,601 |
| Number of papers | 22,513 | 19,928 | 21,412 |
| Amount of value added in manufacturing (unit: trillion NT dollars) | 1.3217 | 1.38 | 1.45 |
| Value of high-tech products exported (unit: billion NT dollars) | 497.9 | 514.8 | 612.4 |
| Net amount of trade in technology (unit: million US dollars) | -263 | -464 | -421 |
| Percentage of private industry's operating expenses spent on R&D | 0.47 | 0.71 | 0.95 |

Research on the Taiwan Background Atmosphere and Climate and Air Quality: Taiwan Station

The Antarctic hole discovered in the ozone layer and the atmospheric greenhouse effect set forth in various global atmospheric experiments have led scientists further into research into global change. The greatest stumbling block to more advanced research on the effects of man-made pollution on the atmosphere and an evaluation of the degree to which the atmospheric radiation field has affected climate is the uneven distribution of background atmosphere testing stations. There is virtually no scientific data for the western Pacific or subtropical regions. The Taiwan background atmosphere research team has therefore proposed the establishment of a permanent Taiwan station for testing climate and air quality. The establishment of such a station would help Taiwan join the international research team so as to keep up with and assist in research on global change. In addition, the existence of such a station would help in the development of high precision instruments for research into background climate chemistry and would allow for research into local global atmospheric pollution effects.

The establishment of a Climate and Air Quality: Taiwan Station (CATS) was proposed in November 1989 when the National Science Council (NSC) and the National Science Foundation of the United States jointly sponsored a Sino-American Conference on Long-term Air Quality Changes and Effects on the Climate. Through the development of precision instruments to test atmospheric chemistry and radiation fields and through data analysis, a team of domestic sci-tech personnel could be built up and the necessary equipment could be installed. Since Taiwan is located in the subtropics off the coast of the Asian mainland in the Pacific Ocean, it has been on the border of continental and oceanic climatic patterns and therefore demonstrates highly unusual weather systems. As a result, experiments in this region and local background atmospheric data could make up for the deficiency of data on the subtropics. This would create an oppor-

tunity to conduct research into the air current exchanges between the mainland and the ocean.

Atmospheric chemistry and radiation are the main focus of this research proposal. Basically, the definition of "background atmosphere" is "the clean air unaffected by area pollution measured in the atmosphere." Ideally, the permanent station will measure over 90% clean air within a year of operations, and temporary stations can take measurements based on seasonal or regional characteristics.

This research proposal has been officially entitled Research on the Taiwan Background Atmosphere. The project will focus on collecting and analyzing atmospheric chemistry and radiation data for different regions throughout all seasons. Analysis will be carried out on how the air quality and radiation fields locally have been affected by pollution in other regions throughout the world. The purpose of establishing a permanent station is so that this research can be carried out on a long-term basis.

The proposal to develop CATS has been in the works for three years now since its inception in November 1989. The NSC, the Environmental Protection Administration, and the Central Weather Bureau have all offered financial support to the project, which has already completed several projects.

(1) CATS research and development.

(2) Research and analysis of O_3 , NO, and NO_2 in the background atmosphere.

(3) Research and analysis of NMHC, SO_2 , and CO in the background atmosphere.

(4) Analysis of the effects climatic exchanges have on the transfer of particles in the background atmosphere.

(5) Development of a mobile station.

Major research results of interest include the development of the mobile testing station and the research carried out in June and July (1991) when the station was located at the Hsin Wu Experimental Farm in Tao Yuan where it conducted

tests on the background atmosphere carried to Taiwan from the Taiwan Straits by a north-easterly wind. The mobile station is equipped with instruments to measure O_3 , NO, NO_2 , CO, SO_2 , C_2C_6 -HC, and C_6C_{12} -HC; these instruments are all a degree more precise than the ones utilized by the Environmental Protection Administration and can detect extremely small changes in background atmospheric chemistry.

Research results for fiscal year 1991 were presented at an assembly (The Eighth Conference on Air Pollution Control) held by National Chung Hsing University on December 16, 1991.

Some of the projects planned for fiscal year 1992 are listed below. (The NSC has provided financial support for projects (1) through (8), while (9) and (10) have applied to the Environmental Protection Administration.)

(1) CATS Sino-American cooperative research* and development and western Pacific regional observations.

(2) Research and analysis of O_3 , NO, and NO_2 in the background atmosphere.

(3) Testing of high-speed reactive nitrogen species in the background atmosphere.

(4) Research and analysis of C_2 - C_6 , NMHC, and CO in the background atmosphere.

(5) Research and analysis of C_6 - C_8 , NMHC, and SO_2 in the background atmosphere.

(6) Research and analysis of nitrate and carbonate particles suspended in the background atmosphere.

(7) Testing and analysis of CH_4 in the background atmosphere.

(8) Analysis of the effects climatic currents have on the transfer of particles in the background atmosphere.

(9) Research and analysis of PAN in the background atmosphere.

(10) Development of the mobile station and analysis of background air quality.

The most important decision made during fiscal year 1992 was the location of the proposed permanent station in Lan-Yu. Lan-Yu was

chosen because, in the past, it has reliably reflected the special wind current characteristics of both western and southern Taiwan. Electricity supply on the island is quite stable and future industrial development will undoubtedly be very mild. Therefore, a station located here should be able to supply reliable data on the entire region. The research team has already officially requested the Central Weather Bureau to step up planning efforts on the permanent Climate and Air Quality: Taiwan Station in Lan-Yu and to cultivate the necessary manpower and increase available funding.

Air pollution in northern and

western Taiwan is extremely serious making a permanent station unrealistic. Use of the mobile station can be an effective means of collecting data on seasonal background atmospheric characteristics in these regions. This aspect of the project has been listed as a priority for the next three years.

Another important task for fiscal year 1992 was to generate opportunities for international cooperation. During September and October of 1991, an International Western Pacific Research Project was carried out cooperatively. Observations were carried out at the Ken-Ting station and data were analyzed by a

foreign and domestic cooperative team. At the same time, foreign stations and airplanes were gathering observation data which was, in turn, given to the R.O.C. research team. Planning and projects for fiscal year 1993 do not fall within the scope of this paper. It is important to note, however, that research on background atmosphere and climate and air quality is a never-ending task. Research in the ROC in the areas of atmospheric chemistry, atmospheric radiation, and climate is just beginning to sprout and thus requires the guidance of the world scientific community and careful tending to grow and bloom.

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