



STATE OF THE NATION REPORTS

PHILIPPINE SCIENCE AND TECHNOLOGY: Time for Bold Moves

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Number
10



University of the Philippines Press
and the
Center for Integrative and
Development Studies

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PHILIPPINE SCIENCE AND TECHNOLOGY: TIME FOR BOLD MOVES

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UP CENTER FOR INTEGRATIVE AND DEVELOPMENT STUDIES

in cooperation with the

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ISBN No. 971-8797-08-4
September 1993

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FOREWORD

Government's bid for the Philippines to achieve the status of a newly industrializing country (NIC) by the year 2000 may not be realistic given the constraints it is facing at the moment. Nevertheless, if it hopes to ever come as close to this goal as possible in the next seven years, it has to seriously attend to the dismal state of science and technology in the country.

While President Fidel Ramos underscored the need to harness the initiatives made in these fields for economic development when he opened the Science and Technology Week in July 1993, the refinement and execution of the Master Plan for Science and Technology require the openness to correct its inadequacies; the ability to see the links between the underdevelopment of science and technology with the socioeconomic and political structure; and the resolve to see the plans through.

In the light of these imperatives, it may be useful for planners and policy makers to take the reflections of some members of the University of the Philippines (UP) on the state of science and technology in the country into account. Some of these reflections are contained in this tenth volume of the popularized *State of the Nation Report*. The Report evolved from a series of consultations with the UP science community which culminated in a Roundtable Discussion in October 1992.

Taking off from the observation that industrialized countries attained their status because of continuing scientific advances and developments in engineering, industry and management methods, the Report traced the development of science policy in the country. It notes the significant, albeit initial, step taken by the Aquino administration towards developing science and technology. With NIC-hood as a goal, President Corazon Aquino elevated the National Science and Technology and accorded it heavier responsibility. The 1987 Constitution and the Medium-Term Development Plan (1987-1992) likewise stressed the state's role in advancing research and development (R & D). Towards this end, a Presidential Task Force, organized in 1988, drew up a Science and Technology Master Plan (STMP) to set the direction of these fields for the coming years.

Some participants in the Roundtable Discussion on which the Report is based, have criticized the STMP's failure to analyze the root causes of the backwardness of the country's science and technology, and the exclusion of crucial political and social factors in its implementation. There was also no consultation with other sectors regarding the STMP. Moreover, they warned against using the country's gross national product (GNP) as the sole socioeconomic indicator, saying that this does not reflect the true distribution of wealth among the population. Instead, they suggest a bottom-up approach to development planning.

The participants also discussed objective problems in the Philippines' push towards NIC-hood. The nation's economy remains agriculture-based, pre-industrial, and import-oriented. The economy's poor performance is also explained by the neglect suffered by the science and technology (S & T) sector. The Philippines' R & D expenditures as a percentage of GNP, for instance, has been declining since 1979. The participants bewailed the lack of realization on the part of the country's policy makers that one factor to the Asian NICs progress was the dramatic increase in their R & D expenditure, meeting the UNESCO recommended level of one percent of GNP for developing countries.

It is often ignored that these countries also progressed due to the implementation of structural reforms in the political and socioeconomic spheres. Thus, apart from developing science and advancing technology through heavier investment in scientific research, human resource, and infrastructure development, this Report of the Roundtable Discussion argues for radical reforms in policy formulation.

More specifically, the Report proposes the following courses of action:

1. If the strategy of technology transfer must continue, the country should adopt those technologies appropriate to its stage of development and are low-cost and environment-friendly;
2. The current "brain-drain" must be arrested to counter the so-called "reverse technology transfer;"

3. Efforts to develop scientific and technological training must be intensified towards building a stronger human resource base;

4. Government must increase its investment in research and development;

5. Short-term and long-term energy development plans, accompanying a science and technology-led industrialization, must be instituted;

6. The national government must assess the advantages and disadvantages of the country's patent system and intellectual property laws;

7. Better understanding and more cooperation among researchers and scientists, the private sector and the government must be fostered to better coordinate R&D efforts;

8. Private citizens and organizations must band together to create a collective voice that will help the government formulate national science and technology policies and influence the direction of Philippine S & T;

9. A nuclear energy program is advocated by nuclear scientists not only as a solution to the power crisis but to find applications in agriculture, food technology, and industry without harming the government; and

10. The government should lay down accounting and auditing rules that are more responsive to the exigencies of S & T activities of government researches and research institutions.

This *State of the Nation Report* on Science and Technology was integrated from the consultation sessions with the science community of U.P. and the Roundtable Discussion organized in October 1992 by Dr. Virginia S. Cariño, Professor of the Institute of Biology and Director of the Natural Sciences Research Institute, College of Science. Dr. Cariño served as Convenor of the UP Assessments on the State of the Nation (SONAP) Module on Science of Technology. She was assisted by Marqueza Lepana-Reyes and Ma. Catalina M. Tolentino.

A grant from the Ford Foundation to condense and popularize scholarly studies under the SONAP enabled the University of the Philippines-

Center for Integrative Development Studies to publish this report in cooperation with the UP Press. Antoinette Raquiza edited the Report while Joy Aparis and Bella Lucas saw the report through the different stages of publication with the help of Ellen Cometa and Stretch Payawal. The UP-CIDS also acknowledges the editorial comments of Professor Sylvia Ventura of the UP Press. As in all our publications, the assessments and recommendations are those of the author and the group she convened.

Maria Cynthia Rose Banzon Bautista, Ph.D.
General Editor

PHILIPPINE SCIENCE AND TECHNOLOGY: TIME FOR BOLD MOVES

Introduction

While half of the world is making great strides in science and technology, the Philippines continues to lag behind. Philippine officialdom is undoubtedly exerting all efforts in seeking economic and political solutions to uplift the country from impoverishment. Unfortunately, it has relegated to the background an important foundation to progress – science. Certain sectors in Philippine society recognize that science was the key to civilization while technology fuelled industrialization. But these sectors are a minority. This partly explains why science, in particular, and national development, in general, have not grown qualitatively in the Philippines.

This report focuses on the vital role science and technology play in the nation's progress in the hope that the larger society, and Philippine officialdom especially, may put science in its rightful place in the nation's affairs. It traces the beginnings of S & T in the Philippines from the American regime up to the Aquino administration.

This report wishes to emphasize the importance of giving science and technology their due, alongside economic, political and social aspects in order to achieve genuine growth and development.

To advance Philippine science and technology, much needs to be achieved and reformed in the areas of education, policy-making, technology transfer, research and development (R&D), infrastructure and human resource development. Yet, these reforms must be undertaken with extreme caution and with utmost regard to the greater concerns: humankind and the environment.

Science, Technology , and the Economy from a Global Perspective

Science and technology were once two separate and distinct entities. The union of science and technology in recent times has proved a productive and successful enterprise. Scientific discoveries have produced many inventions, paving the way for the development of science-based industries

while technological progress, such as improvements in scientific instruments, has helped develop new scientific theories.¹

Science and technology cover various activities such as basic and applied research, experimental development, and engineering. Science is defined as the dynamic cumulative system seeking to describe, understand, and predict natural phenomena. It is the body of knowledge and activities concerned with a systematic understanding and explanation of the laws of nature. Scientific activity revolves around research aimed at discovering new scientific knowledge.

Research, often symbolized by the letter "R," is usually categorized as basic or applied. Basic research seeks to discover new scientific knowledge for its own sake, without regard to its possible immediate or long-term utility. One example is research in theoretical physics. In contrast, applied research aims to discover new scientific knowledge for practical purposes such as that immediately applicable to a product or process. Research in the agricultural sciences falls under this category.²

On the other hand, technology is the "dynamic, cumulative system of reproducible methods, techniques and processes" derived from empirical know-how or scientific knowledge and used to produce, improve and distribute goods and services, as well as to satisfy society's other material needs.³ Simply put, it is a body of knowledge about techniques. Experimental development, symbolized by the letter "D," is the process in which technologists use research findings to create new or improved products or processes.

In sum, science aims to discover the workings of nature while technology seeks to invent new or improved tools and materials (hardware) or better ways of doing things (software).⁴

Science and technology play vital roles in this modern age, when a nation's progress is often measured in quantitative terms, such as a country's gross national product (GNP). Studies have shown that advances in these fields have fueled growth in industrialized countries. To illustrate, science and technology have contributed 50 to 70 percent to economic growth in industrialized countries, 40 to 50 percent in the newly-industrialized countries such as South Korea, and an average of 30 percent in developing nations.

In fact, the share of science and technology in the industrialized countries' output and trade has been increasing. Between 1973 and 1983, the share of high technology products in the total output of manufacturers in the United States (U.S.) rose from 29.6 percent to 34.4 percent while that in the European countries ranged from 27.7 percent for France to 36.8 percent for the Federal Republic of Germany.⁵ At least half the increase in productivity may also be attributed to technological change – *i.e.*, scientific and engineering advances, improvements in industries and management methods as well as the educational training of labor.⁶

This suggests that capital accumulation is only second to technological change in explaining rising productivity. The US, for one, attributed its 80 percent increase in economic production to technological change and only 20 percent to capital inputs; in Japan, technological progress accounted for 37 percent of growth.⁷ "There is no doubt that quality improvement enhances product acceptability, which in turn leads to increased sales and profit. Technology is the primary factor for quality and productivity improvement."⁸

At the same time, technological innovations have also sustained the increase in labor productivity in the North. Recent studies show that labor quality contributes to economic growth, as shown in the following countries: US, 7.8 percent; Japan, 5.4 percent; West Germany, 2.4 percent; Brazil, 11.1 percent; and Mexico, 16.4 percent.⁹

Finally, the experience of industrialized states shows that science and technology play pivotal roles in socioeconomic progress.¹⁰ For instance, enhanced labor productivity helps improve real wages. In Japan and West Germany then, the sharp growth in real wages was linked to the dramatic rise in labor productivity.¹¹ Hence, industrialized and developing countries have accepted science and technology as a critical ingredient in attaining national development goals.

Science and Technology in the Philippines: Past to Present

Historical background

In the Philippines, historical accounts show how policies of the previous administrations caused the turtle-pace progress of science and technology. It

was during the American colonial period that the pursuit of science was institutionalized, starting with the establishment of the Bureau of Science in 1905. The bureau became the principal government research center until the end of World War II.

Dr. Olivia Caoili, in her paper "Policy Making For Science and Technology in the Philippines," wrote that the American colonial government helped develop Philippine science and technology. However, Caoili also noted that, as early as this period, science "was geared to the needs of agriculture, food processing, forestry, pharmacy, and medicine. The development of industrial technology was neglected by the American colonial authorities. This was because of the adoption of free trade as an economic policy. Free trade fostered a primarily agricultural, export-oriented economy that was largely dependent on the American market for its products and as a source of manufactured goods."¹²

Upon the proclamation of Philippine independence in 1946, the Bureau of Science was reorganized into the Institute of Science. Unfortunately, the newly-proclaimed Republic generally gave little support to scientific work. A report by the US Economic Survey Mission to the Philippines in 1950 noted the lack of basic information needed by the country's industries, neglect of experimental work, and minuscule budget for scientific research including the low salaries of government employed scientists.¹³

The Philippine Congress, during the term of President Carlos P. Garcia, passed the Science Act of 1958 after which the National Science Development Board (NSDB) was created. This was the beginning of policy formulation specifically to advance scientific development and the coordination of scientific activities. Additional institutes and agencies were created.

During the 1970s, the importance of science grew. The 1973 Philippine Constitution, Article XV, Section 1, acknowledged the state's role in promoting scientific research and invention and gave priority to the advancement of science and technology in national development. In 1974, a national science development program was included in the government's Four-Year Development Plan FY 1974-1978. Funding for scientific research and development was increased.

In 1982, by virtue of Executive Order No. 784, the NSDB was reorganized into the National Science and Technology Authority (NSTA), consisting of four sectoral councils, six research and development institutes, three science and technology (S&T) support agencies and two advisory bodies (Please see Appendix A). For the first time, coordination and policy-making were concentrated in one body. The NSTA, therefore, was a more powerful organization than its predecessor. More reorganization took place which helped increase scientific activities. In July 1983, the Scientific Career System in the civil service was instituted.

Science and Technology under the Aquino Administration

Upon assuming power in 1986, President Corazon C. Aquino issued Executive Order No. 128 elevating the NSTA to the Department of Science and Technology (DOST). The DOST was mandated to "provide central direction, leadership, and coordination of scientific and technological efforts"¹⁴ and to formulate and implement policies, plans, programs and projects which would develop and promote science and technology in both public and private sectors.

The DOST's organization and functions have since expanded. The Department is headed by a secretary who is assisted by three undersecretaries and three assistant secretaries. According to Dr. Caoili, the expansion of the NSTA to a regular department has meant that science and technology concerns would now form part of the cabinet policy-making priorities; other government departments would have to take into account DOST policies, thereby facilitating policy implementation.¹⁵

Making up the country's science and technology machinery are five sectoral planning councils, seven research and development institutes, six scientific and technological bodies and two collegial and scientific entities (Please see Appendix B). In addition, the DOST operates twelve regional offices, each headed by a regional director.

The 1987 Constitution gives science and technology greater emphasis in national development. The following sections in Article 14 provide that:

Sec. 10. Science and technology are essential for national development and progress. The State shall give priority to research

and development, invention, innovation, and their utilization; and to science and technology education, training and services. It shall support indigenous, appropriate, and self-reliant scientific and technological capabilities, and their application to the country's productive systems and national life.

Sec. 11 The Congress may provide for incentives, including tax deductions, to encourage private participation in programs of basic and applied scientific research. Scholarships, grants-in-aid, or other forms of incentives shall be provided to deserving science students, researchers, scientists, inventors, technologists, and specially gifted citizens.

Sec. 12 The State shall regulate the transfer and promote the adaptation of technology from all sources for the national benefit. It shall encourage the widest participation of private groups, local governments, and community-based organizations in the generation and utilization of science and technology.

Sec. 13 The State shall protect and secure the exclusive rights of scientists, inventors, artists, and other gifted citizens to their intellectual property and creations, particularly when beneficial to the people, as may be provided by law.¹⁶

The Aquino administration's Medium-Term Philippine Development Plan (1987-1992) further emphasized that "science and technology shall be harnessed fully to achieve the objectives of economic recovery and create conditions for sustained economic growth."¹⁷

In her 1990 State of the Nation Address before Congress, President Aquino stated that science and technological development would be one of the three priorities of the government towards economic recovery. She encouraged scientific and technological discoveries and innovations to support development programs that will enhance the Filipinos' quality of life. Then DOST Secretary Ceferino Follusco reported that the budget allocation during the Aquino administration gradually increased from P464 million in 1986 to P1.054 billion in 1989. While the government was forced to trim down the budget to P920 million in 1990 and P854 million in 1991 due to economic difficulties, it increased S&T allocation to P1.7 billion in 1992.¹⁸

Dr. Roger Posadas, U.P. College of Science dean, commended the DOST under Secretary Follosco's leadership as the "most successful in securing resources for the science and technology community."¹⁹ The budget for grants-in-aid increased and the science and engineering education project was approved, despite resistance from other government agencies. Posadas said these developments could lead to a "substantial improvement of the institutions for advanced education and research and to the development of higher level manpower in science and technology."²⁰

The Aquino administration can also be credited for creating the Presidential Task Force for Science and Technology which drew up the blueprint of the very first Science and Technology Master Plan (STMP). The Plan provided clear signals to both public and private sectors on the desired direction of science and technology (S&T). It has since served as a tool for coherent and sustained efforts in S&T development.

Unfortunately, Congress seemed to lack resoluteness in handling bills on science and technology. The Senate Committee on Science and Technology was one of the committees with the least number of bills for deliberation. Of the 26 bills filed (and another seven as secondary referrals), only two were signed into law, namely those calling for the establishment of provincial science centers, and the conversion of the Philippine National Science Society back to the old National Research Council of the Philippines. Left unattended were bills of greater importance, such as Senate Bill (S.B.) 1757 which aims to strengthen the national program for the development and promotion of non-conventional energy systems, and S.B. 1563 which calls for the creation of a Philippine Science Popularization Program.²¹ Nothing also came of House Bill 33887, a measure designed to constitute the Filipino Inventors Society Inc. into a public corporation.

Policy-makers exert tremendous influence on how the nation is ran. A change in the nation's leadership generally constitutes a change in the general direction of the country. Unfortunately, despite government efforts, the reforms and improvements implemented to boost science and technology have yet to create a substantial impact in the field.

The Science and Technology Master Plan

The Presidential Task Force for Science and Technology was created on 8 August 1988 to formulate an S&T plan that would propel the country to

NIC-hood by the year 2000. The resulting Science and Technology Master Plan (STMP) followed the Medium-Term Philippine Development Plan's development goals as outlined below:

- 1) poverty alleviation;
- 2) generation of more productive employment;
- 3) promotion of equity and social justice;
- 4) attainment of sustainable economic growth; and
- 5) the protection and enhancement of environmental quality.

With the STMP, the aggressive application of S&T was expected to add two percent to the country's growth rate.

As envisioned, the S&T sector's primary objective would be to provide substantial scientific and technological inputs to realize national development objectives. Specifically, the sector would generate, upgrade and utilize technologies needed for countryside development; employ an appropriate mix of locally generated and imported technologies in meeting the requirements for economic recovery and growth; and, build an indigenous capacity for science and technology towards technological self-reliance.

To meet these objectives, the Aquino administration's STMP adopted a three-fold strategy:

- 1) modernize the agricultural and industrial production sectors through massive technology transfer from domestic and foreign sources;
- 2) upgrade research and development capability through intensified activities in high priority sectors; and
- 3) develop S&T infrastructure, including institution building, human resource development and development of an S&T culture.

As contained in the STMP, the vehicles for industrialization and the focal points to becoming a newly-industrializing country would be the "leading edge" technologies in the high priority sectors. The so-called leading

edges refer to sectors providing products and services which can be expected to substantially contribute to GNP and gross domestic product (GDP). In line with a demand-led, market-pull strategy, the STMP selected products and services based on their demand projections up to the year 2000. The priority production and service sectors identified were: agriculture; aquaculture and marine fisheries; forestry and natural resources; metals and engineering; textile industry; mining and minerals; process industry; food and feed industry; energy; transportation; construction industry; information technology; electronics; instrumentation and control; emerging technologies; and pharmaceutical.

The Master Plan, however, has been criticized by some groups. The Scientists' Action Committee (SAC), for instance, said the STMP failed to analyze the root causes of the country's scientific and technological backwardness and assess the country's scientific, technological and industrial state. It also questioned the lack of specific goals for the Plan's short- and medium-range time frame and the viability of some of its implementation strategies.

The SAC further pointed out the failure of the Science and Technology Coordinating Committee (STCC) to link up with other sectors, e.g., farmers organizations and small-scale entrepreneurs in drawing up the STMP. Dr. Fabian Dayrit, a SAC workshop member, said that this approach would restrict industrialization and economic development to a mere "top-down movement."²² The Center for Science and Technology Studies (CSTS) shared this observation, stating that such a technocratic approach overlooked cultural and politico-economic dimensions which the STCC itself adopted.²³ Similarly, the Scientists, Technologists, and Engineers for the People (STEP) said that the STMP was a mere composite of ideas and plans of the various technical panels.

In general, the STMP was a product of a purely top-down approach to planning. This planning approach relies on the "trickle-down" or "spread" effect, from the favored sectors to the rest of the population. However, this approach would make the attainment of genuine economic development and industrialization difficult as these activities would naturally gravitate towards selected growth centers and favored entities. Moreover, national industrialization would not take off if the countryside remained backward and poor.

The STCC could have adopted a more comprehensive and participatory planning process involving those sectors vital to genuine S&T development and national prosperity. An alternative to the top-down or center-down approach is bottom-up planning which would promote development from below. This approach gives equal attention to rural development and modernization.

The STMP has also hinged industrialization to a growth in the country's GNP. Moreover, the country's use of GNP as the socioeconomic indicator can be misleading. GNP does not reflect local development and the true distribution of wealth among the people. Social indicators such as health and nutrition (infant mortality rate, life expectancy, etc.); housing and utilities (housing adequacy, electricity and water availability or accessibility, etc.); social mobility, public safety and justice (e.g., crime rate) as well as education perhaps should also be considered to arrive at a more complete picture of the country's socioeconomic performance.²⁴

To thoroughly assess the nation's scientific, technological and industrial status, a requisite for efficient planning, Dr. Posadas suggested the application of the United Nations-Economic and Social Commission for Asia and the Pacific (UN-ESCAP) Technology Atlas Project as a methodology and framework for evaluation.²⁵

The framework of the Technology Atlas is "based on the premise that technology is a crucial strategic variable for rapid socioeconomic development in today's increasingly competitive international environment." The proposed methodologies are: Technology content analysis, Technology climate analysis, Technology status analysis, Technology capability analysis, and Technology needs analysis. The methodologies were developed "for meaningful integration of technological considerations into the socioeconomic development planning process." The Atlas presents determinants of technological underdevelopment which include: condition of physical facilities, competence of human abilities, usefulness of accumulated facts, effectiveness of organizational frameworks, supportiveness of the national technology climate, and status of national technological transformation stages. (culled from *Technology Atlas: An Overview* UN-ESCAP. February 19, 1988)

Finally, the STMP has been criticized for its "adherence to the so-called market-led, demand-pull strategy that presents the danger of the state subsidizing the technological needs and satisfying the whims of a very conservative private sector."²⁶

The country aspires to join the ranks of the NICs by the year 2000. While this is a laudable goal, seven years would not be enough to attain this. Industrialization based on science and technology cannot be achieved overnight. This early, it is most important that the country chart feasible targets and a realistic deadline.

The STMP is a good starting point, but a plan should be a dynamic guide to achieving development goals. There must likewise be room to incorporate changes, corrections and improvements in the Plan as the country treads its way toward industrialization.

The Philippine Economy, Scientific and Technological Activity, and the Road to NIC-hood

Slow-grinding economy

The Philippine economy has been described as agriculture-based, pre-industrial and import-oriented. The Philippines continues to export low valued, semi-processed or unprocessed agricultural materials like sugar and copra, and import capital goods and technology. In 1982, about 66 percent of the Philippines's total imports were composed of mineral fuels, electric and non-electric machineries and accessories, transport equipment and chemical compounds. From 1983 to 1984, the Philippines imported US\$3.3 billion worth of machineries and transport equipment, US\$526 million worth of organic and inorganic chemicals, and almost a billion dollars worth of steel and iron intermediate products.²⁷

The country's local technology for manufacturing machinery and components is behind those of its Asian neighbors by five to 20 years; local manufacturers supply only 15 to 20 percent of the local demand.²⁸ Moreover, the Philippines's Technological Index stands at negative 0.1 as compared to the US's 100, Japan's 86.3, and South Korea's 5.7.²⁹ The index is a yardstick of the country's technological level and defined as the average of the sum of

the number of patents and registration of new designs, technology trade, the value added in manufacturing and the export of technology-intensive goods.

It is not surprising, therefore, that the Philippines's highest economic growth rate was a mere 6.7 percent, attained in 1988 surpassing only Indonesia which, with 4.8 percent, ranked the lowest among the ASEAN nations (Please refer to Table 1). Per capita has not come close to the US\$1000 mark. In 1990, the total goods and services produced in the country increased by only 3.1 percent, reportedly the lowest since 1987. The drought-stricken agricultural sector grew by 2.2 percent while crop production declined by 3.2 percent. The industrial sector's performance expanded by a meager 1.9 percent from the previous year's 6.9 percent.³⁰ Indeed, a poor showing when pitted against the Asian tiger economies.

In terms of productivity, the Philippines also paled in comparison with its neighbors, generating only an average of US\$1,590 gross domestic product (GDP) per employed person. In current prices, South Korea and Taiwan registered GDP averages of US\$6,670 and US\$9,780, respectively. Singapore had a whopping GDP average of US\$15,830. The "baby tiger" economies of Asia, namely Malaysia and Thailand, fared better than the Philippines, posting a GDP average of \$5,240 and \$1,610, respectively.

In the last decade, some of our Southeast Asian neighbors made giant leaps in their economies. In 1989, Singapore registered US\$10,521 per capita GNP; followed by Taiwan with US\$7,571; South Korea with US\$4,830; Malaysia with US\$2,208; and Thailand with US\$11,194. In contrast, the Philippines posted a dismal \$727 per capita GNP (Please refer to Table 2).

The Asian Tigers' economic success

By any measure, the economic success of the newly industrializing countries of Asia is impressive. However, the Asian NICs owe their present status to structural reforms made in the political and socioeconomic spheres. According to Walden Bello and Stephanie Rosenfeld in *Dragons in Distress*, South Korea and Taiwan, for instance, undertook agrarian reform, thereby strengthening the domestic market, and protected selected national industries before embarking on export-oriented production and the free market road to development.

Analysts opined that the NIC formula was basic to 20th century capitalism which was passed on to the NICs by the US and Japan. A huge amount of foreign aid, in fact, flowed into these countries. The US pumped about US\$1.5 billion in economic aid into Taiwan between 1951 and 1965 and almost US\$6 billion into South Korea between 1945 and 1978. Specializing in the export of labor-intensive manufactures, the NICs tied their fortunes to the US market, which was then vigorously expanding. Japanese assistance, on the other hand, came in the form of technology, machinery and component inputs.³¹ Japanese trading companies also handled international trade for Taiwanese and Korean firms.

Another important factor to NIC-hood is what Bello termed as "command capitalism." Strong interventionist states in Korea, Taiwan and Singapore actively directed the economy as well as "forcefully intervened in the labor market to press down workers' wages below their market value in order to achieve competitiveness for NIC exports in the international market."³²

These factors combined, and not the sole concentration on science and technology, propelled these countries to NIC-hood. As the country proceeds, it must therefore carefully study the strengths and pitfalls of the original NIC model.

Investing in research and development

A highly developed science and an advanced technology can help push the economy into high-speed and optimum production. True enough, South Korea, Singapore and Taiwan significantly increased their expenditures for research and development (R&D) during the eighties, meeting the UNESCO recommended level of one percent of GNP for developing countries.

Furthermore, the bulk of R&D expenditures in these countries originated from the private sector. South Korea and Singapore got most of their R&D funds from private enterprises.³³ Consequently, research results were quickly commercialized and their products' competitiveness in the international market was more easily achieved.³⁴

In stark contrast, the Philippines has not given much attention to scientific and technological activities. Available statistics show that the country's R&D expenditures as a percentage of GNP has been declining

since 1979 (Please see Table 3). At the same time, the private sector undertakes only 15 percent of R&D while government takes responsibility for 85 percent.³⁵

In 1990, only 0.11 percent of GNP was spent on R&D activities. Of that already meager share, only 10 percent went to actual R&D activities such as basic and applied research and experimental development. The bulk or 80 percent went to public services and 10 percent to education.

Scientific manpower and technological resources

Aside from the problem of underinvestment in research and development, the Philippines also suffers from a lack of scientific and engineering personnel. According to the UN Advisory Committee for the Application of Science and Technology, a country must have 380 scientists, technologists and researchers per million population – the critical mass to set the climate for industrialization. These individuals are indispensable in creating indigenous technology and doing research at home, aside from facilitating the use and innovation of imported technology and relevant scientific results from other countries.

In 1984, the Philippines had only 10,185 personnel engaged in R&D or 190 such professionals per million population. Other countries like the US had a ratio of 3,259 per million population; Japan, a ratio of 6,269; South Korea, 2,102; and Singapore, a ratio of 1,931 per million population.³⁶ In 1989, there were only 2,700 scientists and engineers in the Philippines.³⁷

As an offshoot of this situation, the Philippines continues to rely more on foreign know-how as reflected in the statistics from the Bureau of Patents, Trademarks and Technology Transfer. From 1977 to 1988, only six percent of Philippine patents for inventions was Filipino-owned and 94 percent was foreign-owned. From 1983 to 1988, the number of registered technology transfer agreements averaged 70 per year.³⁸

Aside from a few exceptional achievements, local technological capability has remained limited to areas like soap and salt making, food processing, charcoal making, porcelain, pottery, and furniture manufacturing. Local R&D thrusts remain geared towards innovating pre-industrial technology or adapting and replicating industrial technology.³⁹

Time and again, it has been said that in key areas of science and technology, the Philippines is 10 to 15 years behind other ASEAN countries, 20 years behind South Korea, China, India, Taiwan, Brazil and Mexico, and 70 years behind the US and Japan. One Asian scientist had thus concluded that Philippine science and technology are "semi-primitive."⁴⁰

To catch up with other countries, heavier investment in scientific research, human resource development and infrastructure, accompanied by radical reforms in policy formulation, will be needed to reverse such dismal statistical trends. The relationship between the poor state of science and technology and the economy's sluggish performance can no longer be ignored. With a lopsided concern for science and technology, the economy would become a casualty.

Conclusion and Recommendations

Science is clearly one of the country's neglected disciplines due to society's failure to recognize it as an important foundation of development. On the other hand, the minimal gains in the scientific and technological fields explain in part the country's unabated poverty.

Advanced countries give considerable weight to scientific research as a means to discover new knowledge and develop innovative technology. This has benefitted them tremendously. They boast of high-speed production, superior product quality, double digit growth rates; they have also become a dominant force in international trade. Their economic status enables them to exert influence over the rest of the world, much to the detriment of the developing countries.

Experts have prescribed nothing less than a "quantum leap" for the Philippines to approximate the stage reached by Northern countries and the Asian tigers. The Science and Technology Master Plan was first drawn up by the Aquino government to accelerate economic recovery, and to develop the indigenous skills of the Filipino scientists. To achieve these objectives, the DOST has been closely monitoring the so-called "leading edges" or those products and services expected to contribute substantially to GNP and GDP. The Plan, adopted and refined by the Ramos administration, is on its fourth year of implementation.

Former DOST Secretary Follosco had once said that the STMP is a "dynamic" plan, subject to revisions as the implementation programs are assessed and reviewed. In this spirit, it is hoped that the Ramos administration, in evaluating the Master Plan and the overall direction of science and technology, would incorporate the recommendations presented below.

1. If the strategy of technology transfer must continue, the country must adopt technologies appropriate to its stage of development and are low-cost and environment-friendly.

The STMP's first strategy has been to modernize the production sector through massive technology transfer. Transfer of technology is the process of transplanting an operative technology from the country where it was developed into another country.⁴¹ Technology transfer is supposedly an easier and cheaper way to obtain technologies from developed countries since basic R&D needs much capital investment and time.

However, imported technologies are products of profit-oriented, capital-intensive, labor-saving and mass-production economies. Hence they are suited only in the affluent stage reached by industrialized countries; one consequence of this is that only a few in developing countries could afford them.

Past experiences and present conditions show that the country must be discriminating in its use of technologies, choosing only those that are most appropriate to the country's needs and guarding against those which are also detrimental to the ecological balance. The NICs applied science and technology extensively to their industries to maximize production and acquire higher gross national product. But attaining their double digit growth rates came at the expense of the environment.

One example is the infusion of inorganic fertilizers and chemical pesticides, a strategy the International Rice Research Institute adopted to propagate high-yield varieties (HYVs) of rice. Aside from the cost being beyond the reach of the average farmer, such a technology would eventually render the soil unproductive and dysfunctional. Studies have shown that maximum agricultural production cannot be sustained by simply increasing technological inputs such as fertilizers and chemicals which are products of foreign R&D.

Another inappropriate technology is Nestle's milk formulas which are sold as breast milk substitutes. Critics of the huge Swiss food conglomerate say that this discourages breast feeding, which is healthier and accessible to the poor majority. In fact, powdered milk even becomes a health hazard when taken with contaminated local water.⁴²

The country's agricultural and industrial sectors are suffering from low productivity. Yet, this problem can be remedied through the transfer of appropriate, low-cost and environment-friendly technologies. Studies need to be conducted on "middle-range technologies" or techniques which minimize ecological stresses created by certain technologies so as to conserve resources.⁴³ The country needs technologies which maximize resource use while bringing sustained and optimal benefit to the population.

In addition, it would be best to share expertise and technological know-how with other developing or newly-developed countries. Empirical studies indicate that exchanges in technological know-how among countries in similar stages of development are far more useful and relevant than simply importing those from highly industrialized countries.

Technology transfer should likewise be conducted on a government-to-government basis. This scheme would eliminate or at least greatly minimize the exploitative nature of most instances of technology transfer. The conventional practice in which a private global corporation transfers technology through such arrangements as licensing, management contracts, turn-key projects, installation and purchase of equipment has been known to cause conflicts and instances of overcharging.

2. Human resource development and training must be intensified to build a stronger human resource base.

If the country were to continue massive technology transfer as a strategy, it must develop a strong national capability to adapt, repair, maintain and modify the technology, taking into account the local conditions. Only by building such a capability can the country credibly assess which technologies to adopt.⁴⁴

In the same vein, the country needs such a human resource base to build an indigenous science and technology towards attaining technological self-reliance.⁴⁵ The existence of scientific and technical human resources would enhance homegrown technologies and direct it on the right path. Otherwise, due to the country's mere reliance on industrialized countries for its scientific and technological needs, it may become the dumping ground of outmoded technologies.⁴⁶

The DOST, in coordination with the Department of Education, Culture and Sports, leading colleges and universities and the private sector, should continue its Manpower Development Plan (MDP) which seeks to: (a) develop the country's engineering and science education, in general, and high school science and mathematics, in particular; (b) strengthen environmental education; (c) introduce technology management education and training; and (d) develop library networks in science and engineering and management information on human resources. The MDP must be dynamic and be continuously upgraded through the creation of a feedback mechanism that would measure its effectiveness. Moreover, the MDP should contribute towards propagating an S&T culture among Filipinos.

The education sector must regularly be given a bigger budget: educated people make for more productive workers. A positive development is that, since 1992, Congress has acknowledged that education must get the lion's share of the national budget.⁴⁷

The government must also support and increase the number of high standard science schools like the Philippine Science High School. Higher education must also be more attuned to the needs of science and engineering. The Philippine government should study the feasibility of putting up specialized schools similar to the Japan Institute of Science and Technology.

The elementary curricula should be closely studied with an eye towards developing a science culture among future generations. Greater emphasis must be given to science subjects, incorporating necessary changes which would help develop a scientific and inquisitive mind in the young. A new breed of youth with a more scientific inclination would then become the core of future R&D professionals.

To complete the package, textbooks on science and mathematics must be tailored to the needs of the Filipino elementary and high school students. Books and other materials must be written in the native tongue, in keeping with recent studies confirming that the "Filipino language facilitates the teaching of difficult concepts and makes students more responsive in class."⁴⁸

Finally, the country must continue training people in new management techniques in agriculture and industry. The government should continue sending the country's best minds abroad to bring back knowledge on science, engineering and business. But beware of the brain drain: too often the brightest remain in the affluent West!

3. The problem of brain drain must be arrested to counter the so-called "reverse technology transfer."

The Philippines suffers from an acute case of brain drain. It was estimated that the migration of professionals to the US in 1971 and 1972 cost the Philippines US\$98.8 million in educational expenses. Meanwhile, the US reaped US\$266.6 million in educational savings, as represented by these professionals; this was 51.2 percent more than its economic aid to the Philippines for the same period. The brain drain has thus been labelled a "reverse foreign aid" or "reverse transfer of technology."⁴⁹ In 1989 alone, there were 6,700 professionals, technical and related workers who migrated, mostly to the US, Australia and Canada.

At the University of the Philippines, then President Jose Abueva lamented the University's difficulty in attracting and retaining "good and promising young faculty and researchers" due to its inadequate budget.⁵⁰ Often, up and coming recruits end up seeking better opportunities abroad because of the small domestic market for highly skilled technical workers. If they do stay and find jobs, either they are underemployed or grossly underpaid. Thus, instead of pursuing their scientific and technical careers in their own country, they opt to migrate abroad for economic reasons or career growth.

The government intends to correct the brain drain problem through the Scientific Career System which is a way of promoting scientists without burdening them with administrative tasks. The implementation of the merit

system in the Scientific Career System also aims to provide rewards and recognition to attract and retain outstanding scientists. Under this set-up, a scientist is ranked based on his or her educational qualification and training, scientific productivity, significant contributions, practical application of their research findings, discoveries and inventions in commerce, published works, and professional standing in the community.

Nevertheless, all these efforts seem to have forgotten an important segment of the R&D community: the corps of young and promising research associates and assistants who are not quite full-fledged scientists. These budding scientists assist in laboratory and field work to earn their spurs, while working toward a master's or doctoral degree. Their average monthly salary is only about P4,000. The salaries of government scientific research and extension personnel must likewise be increased. Non-wage benefits should also be given such as local and foreign scholarships, short and long-term training programs, subsidized housing in dormitories, and other incentives for them to continue their careers in R&D.

4. Government must increase its investment in research and development.

The rationale of technology transfer is that it is to the developing countries' advantage to draw on and adopt the developed nations' technologies. According to this thinking, technology transfer makes it possible for developing countries to leapfrog the long period of technological evolution which modern industrialized countries underwent and use to the fullest the accumulated stock of knowledge.

However, a developing country cannot simply import foreign technology – a situation which smacks of technological bondage. The Philippines must start widening its technological base now by nourishing indigenous basic and applied R&D. Leapfrogging this pivotal stage would prove counterproductive in the long term.

Basic and applied research must be given equal importance. Although basic research is concerned only with expanding the frontiers of knowledge without any technological or commercial purpose in view, it is the lifeline on which the long-term viability of future R&D must ultimately depend. Basic

scientific breakthroughs often facilitate inventions previously deemed impossible or extremely difficult. It provides fertile ground for fresh ideas and scientific information that qualitatively enhances applied research and development.

Applied research, on the other hand, is where most of inventive activity occurs. It seeks knowledge with specific technical and commercial applications in the form of new products and processes or improvements thereof. It is inventions derived from applied research that combine the fruits of basic research and maintain the stream of technical progress.

Expenditures for research and development must be increased dramatically for the country to catch up with its developing Asian neighbors. The GNP percentage allotment to R&D must be increased from its 1990 value of 0.11 percent. While the Aquino administration allocated P1.7 billion for the DOST, then Secretary Follosco believed the budget should have been raised to P10.19 billion.

The government must also entice the private sector to invest R&D funds in innovative activities to bring the technically feasible and commercially viable inventions to the point where they are ready for the market. In fact, the process of creating, fabricating and producing local technology from pilot scale to mass production requires cooperation between the government and the private sector since applied research and experimental development require massive investments and have a long gestation period.

It is in the R&D arena that the University of the Philippines figures prominently. The national government must appropriate a bigger budget to the University. UP, as a research university, allots 15 percent of its budget to basic and applied research which benefits mostly government agencies. UP spends more than any university in the country to create new knowledge and to contribute to policy making and national problem solving. In fact, the UP System aspires for excellence and national leadership in all areas of science and technology with each autonomous university unit developing its expertise in specific areas: UP Diliman in basic science and engineering; UP Los Baños in agricultural and related sciences; UP Manila in health science; and, UP Visayas in fisheries and marine science.

UP Diliman's College of Science alone contributes much to the country's pursuit of advancing science and technology by expanding and improving its (a) research and development activities, resulting in the increase in the quantity and quality of its research publications, the production of prototypes of products and processes for possible commercialization and the generation of other R&D outputs; and (b) scientific and technological extension services to the public and private sectors, particularly in science teacher's training, laboratory services and science policy advising and advocacy. It has also improved its physical plant and facilities, raising them to almost first-rate levels in some areas through the initial implementation of the UP Diliman Science Complex Project, the acquisition of sophisticated equipment for some of its research laboratories, and the establishment of its own college library system.

Moreover, UP is reputed to have the largest concentration of research scientists and engineers and the only science institution with good quality programs for human resource development in the country. UP helps enhance the country's mathematics and science education through its Science and Mathematics Education Development extension program. If UP is deprived of the full financial support it needs, then UP President Jose Abueva cautioned in 1992 that not only UP but also the whole nation will suffer.⁵¹

UP is also active in the Engineering and Science Education Program (ESEP), which aims to create a pool of scientists, engineers and technicians needed for the country's industrialization. The Program helps develop a close knit network of educational institutions that can supply a steady stream of these professionals.

5. Short-term and long-term energy development plans, accompanying a science and technology-led industrialization, must be instituted.

The recent spate of power failures, with four to 12-hour blackouts, plaguing the entire Philippines illustrates the sad state of the energy sector. This clearly reflects the Aquino administration's failure to consider and foresee the energy sector's role in its Science and Technology Master Plan. Nevertheless, without a reliable, adequate and continuous supply of electricity, an S&T-led industrialization will remain a far-fetched dream.

Clearly, short-term contingency measures must be instituted to tide the country over until long-range energy plans reap results. The country must harness indigenous power sources such as geothermal, hydrothermal, oil and non-conventional energy instead of continuously depending on imported energy. The country is blessed with abundant geothermal reservations due to its unique tectonic setting. This resource must be tapped to its full potential along with the country's potentially rich oil fields. In fact, in 1984, the country produced 44.98 percent of its total power needs from indigenous resources, thereby proving the country's potential to meet at least half of its energy needs.

6. The national government must assess the advantages and disadvantages of the country's patent system and intellectual property laws.

The Philippines acceded to the Paris Convention on Intellectual Property Rights on 27 September 1965. It is also a member of the World Intellectual Property Organization (WIPO). Nevertheless, in light of current international trends, it may be wise for the country to reexamine its membership in such international organizations.

The current global patent system fortifies the economic and technological dualism between the North and the South. Industrial technology is appropriated in the form of patents. Moreover, giant global enterprises or transnational corporations (TNCs) control and owe the bulk of the world's industrial technology. As the international market for technology is imperfect, owners of technology can easily impose one-sided conditions to the buyers of technology, usually the developing countries.

Patents also enable TNCs, particularly Japanese firms, to set up enterprises with incomplete production cycles in various developing countries. This scheme effectively ensures the corporation's complete control over the technology since no single country has access to the complete technological know-how. In fact, this practice could be more accurately described as the transfer of "show-how."

Another controversial issue is that of "life patents." TNCs involved in biotechnology research know that the rich biodiversity of the South is the

resource base of the biotech revolution and Northern biotech companies. The US government, under the previous administration, had rejected UNCED Agenda 21, inked during the Earth Summit in 1992, because it contains strict provisions on methods and ethics biotech companies must follow.

Developing countries are now being pressured to conform to the industrialized world's intellectual property laws. Brazil's experience is one case in point. When the country refused to amend its national patent laws to suit US interests, US ports imposed 100 percent import duties on certain drugs, paper products, and electronic goods of Brazil.

Despite such threats, the government has the duty to protect, first and foremost, the rights and interests of the country and its peoples. Policy-makers should scrutinize the country's existing intellectual property laws and system to safeguard the rights of local scientists and technologists.

Particular to UP, perhaps the creation of a University Patent and Copyright Committee (UPCC) which will formulate patent and copyright policies for R&D activities within its community should be studied. This could be patterned after the University of Hawaii's UPCC.

- 7. Better understanding and more cooperation among researchers and scientists, the private sector and the government must be fostered to better coordinate R&D efforts.**

Closer ties and a good working relationship between the academe and private industry groups towards meeting each other's interests would nurture the growth of R&D in the country. Generating a mutual understanding between scientists and researchers and the end-users in the private sector would increase the possibility that research results would immediately be utilized and applied.

The academe should sponsor talks, conferences and information campaigns to enlighten all concerned sectors as well as to identify the private sector's research needs. For its part, the private sector can set up research endowments and grants and contract universities to undertake research projects. Both the academe and the private sector should also pool their resources to attain common research interests.

Government officials and legislators should also be targets of an information drive to impart the relevance of R&D in national development so that these policy-makers would be more supportive of R&D thrusts in national affairs.

- 8. Private citizens and organizations must band together to create a collective voice that will help the government formulate national science and technology policies and influence the direction of Philippine S&T.**

There are 88 science-based non-government organizations (NGOs) in the country today. Some of these S&T foundations are certified by DOST and enjoy such advantages as grants-in-aid, access to S&T databases and tax incentives. Four such NGOs have already received grants-in-aid worth P693,550 for capability-building and community development projects.

Concerned people must mobilize and form S&T based organizations. Scientists, technologists and scholars must work hand in hand to promote an S&T consciousness among the masses. Some have already begun. The Scientists, Technologists and Engineers for the People (STEP) is one such national organization advocating a genuine industrialization which would also give priority to ecological balance and work for the people's well-being. The Center for Science and Technology Studies (CSTS), on the other hand, aims to collect, disseminate and popularize materials on S&T issues. Another S&T NGO is the Volunteers on Scientific Assistance (VISTA) which has more than a hundred professionals, coming both from government and private institutions, and students providing voluntary technical assistance to marginalized sectors.

Nevertheless, S&T issues must not be confined to these enlightened circles. S&T issues must be disseminated down to the grassroots so that the masses can participate in charting the country's S&T plans and policies. This would also help ensure that S&T programs and policies would benefit the majority. In the same vein, professional organizations and learned societies, with their consortium of prominent experts and established networks, can help frame proactive S&T policies.

- 9. A nuclear energy program is advocated by nuclear scientists not only to solve the power crisis but also to find applications in agriculture, food technology, and industry without harming the environment.**

To contribute to power generation, a nuclear energy program is strongly advocated by Dr. Carlito Aleta, Director of Philippine Nuclear Research Institute (PNRI). Accordingly, nuclear energy power produces electricity without the presence of environmentally harmful gases such as carbon dioxide, sulfur, and nitrogen oxides. Moreover, the radioactive wastes associated with the nuclear power are minimal compared to the wastes that decay with time, unlike the toxic heavy metals that are produced when burning coal.

Nuclear energy can also be applied to other fields such as agriculture. The use of sterile insect technique (SIT) to eradicate selected pests has been successful in some countries. The DOST, thru the PNRI and Guimaras Island experimental station of the Department of Agriculture, is studying the SIT technique to get rid of the fruit fly pestilence in the mangoes of the island.

Other uses of nuclear technology is in food irradiation – to increase the storage life of food and improve quarantine properties in fruits and vegetables, among others. While in industry, radioisotopes can generate data on the residence time of materials.

Dr. Aleta stressed that "The public must be consistently provided with balanced information on nuclear-related issues for only in this way can debate be made less emotional and decisions made more rational."⁵²

- 10. The government should lay down accounting and auditing rules that are more responsive to the exigencies of S & T activities of government researches and research institutions.**

The common complaint of researchers and scientists in the government service is that accounting and auditing rules are too burdensome, bureaucratic, and sometimes downright impediments to scientific pursuits. In other words, there are rules and regulations that implicitly hamper the acceleration of R&D in the public sector.

It is acknowledged that such rules and regulations are necessary on the part of the government to be able to account for public funds. These were not meant to encumber them with unnecessary paperwork and obstruct their productivity with trifling requirements. However, certain rules should be tailor-made to fit the idiosyncracies and distinctions of S & T activities.

Fortunately, the Commission on Audit came out with the 1991 Accounting and Auditing Manual for Research Operations (AAMRO) which is more predisposed to the peculiarities of R&D activities compared to the stifling rules contained in the old Revised Auditing Manual for Research Operations (RAMRO). Hopefully, these rules would be subject to periodic examination by concerned agencies for corrections and revisions to keep them updated with the exigencies of S & T activities. The suggestion is for the Commission on Audit (COA) and the Department of Budget and Management (DBM) to hold regular dialogs with researchers and vice-versa to iron out irritants in auditing rules.

To end, the country still needs to develop a science tradition. There is little social, institutional and financial support and recognition for local science and scientists. It would seem that Filipinos, as a people, are not comfortable with their own S&T, preferring imported technological gadgets instead. Thus, the NSTA observed that the "pervasive sociocultural conditioning of the Filipino, the so-called colonial mentality, stands in the way of the development of national self reliance."⁵³

The time has come for Filipinos to believe that the country can advance to the level of the industrialized world and achieve scientific and technological self-reliance. It is however of utmost urgency that the country starts nurturing the seeds of Philippine science and technology for the next generation to harvest its mature fruits.

Table 1
ECONOMIC GROWTH IN ASIAN COUNTRIES (1981-1988)

COUNTRY	1981	1982	1983	1984	1985	1986	1987	1988
Philippines	3.7	1.6	1.3	5.5	4.0	1.8	5.9	6.7
South Korea	7.4	5.7	10.9	8.6	5.4	11.9	11.1	12.0
Singapore	9.3	5.4	11.1	12.3	0.6	4.5	8.8	11.0
Thailand	4.8	3.6	6.4	5.4	4.4	4.7	7.1	11.0
Hongkong	9.4	2.9	6.5	9.3	0.8	11.8	13.8	7.4
Taiwan	6.1	2.8	7.7	9.6	4.3	10.6	12.4	7.3
Malaysia	6.9	5.9	6.3	7.8	1.0	1.9	4.7	7.5
Indonesia	7.4	0.3	3.3	6.0	2.5	4.0	3.6	4.8

Source: Science and Technology Master Plan, July 1990
Department of Science and Technology

Table 2
PER CAPITA GNP OF ASIAN COUNTRIES (1980-1989)
in US Dollars

COUNTRY	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
PHILIPPINES										
at current price	729	776	773	656	592	584	538	596	665	727
at const. price	255	245	225	170	103	86	76	80	82	
SINGAPORE										
at current price	4680	5461	6007	6915	7566	7093	6956	7241	9351	10521
at const. price	2538	2797	2861	3162	3445	3255	3262	4635	9591	
SOUTH KOREA										
at current price	1590	1719	1774	1914	2045	2048	2321	2861	3721	4830
at const. price	1590	1489	1442	1497	1540	1481	1636	1945	2427	
TAIWAN										
at current price	2305	2632	2607	2746	3056	3137	3753	5087	6051	7571
at const. price	2582	2632	2505	2596	2879	2961	3409	4585	5422	
HONGKONG										
at current price	5444	5694	5834	5334	5892	6196	6765	8418	9600	10950
at const. price	5444	6965	4838	4229	4267	4260	4565	5237	5549	
THAILAND										
at current price	703	734	731	786	801	720	774	878	1044	1194
at const. price	297	286	276	288	289	257	293	319	354	
MALAYSIA										
at current price	1717	1714	1885	1885	2073	1845	1586	1809	1899	2028
at const. price	1441	1423	1425	1451	1495	1354	1273	1366	1380	

Source: Science and Technology Master Plan (July 1990)
Department of Science and Technology

Table 3
R & D EXPENDITURES AS % OF GNP
OF SOME ASIAN COUNTRIES (in million US Dollars)

COUNTRY	GNP AT CURRENT PRICE	R & D EXPENDITURES	% OF GNP
PHILIPPINES			
1979	29552	76.3	0.26
1980	35219	91.9	0.26
1981	38434	33.9	0.17
1982	39278	60.3	0.15
1983	34081	46.3	0.14
1984	31580	36.7	0.12
SRI LANKA			
1974	3656	5.4	0.15
1975	3832	6.4	0.17
1983	4932	9.2	0.19
1984	5659	10.1	0.18
THAILAND			
1980	32840	124.5	0.38
1982	33234	142.2	0.43
1983	35642	92.4	0.26
1984	38025	139.4	0.37
1985	35339	127.9	0.36
INDONESIA			
1978	49495	187.2	0.38
1980	69275	256.0	0.37
1984	81261	271.9	0.33
1985	83190	218.0	0.26
1986	82695	188.5	0.23
SINGAPORE			
1978	7822	16.3	0.21
1981	9677	38.8	0.40
1984	11340	100.5	0.89
SOUTH KOREA			
1970		26.5	
1975	20795	88.1	0.42
1980	60373	348.6	0.58
1985	83733	1327.7	1.59
1986	87961	1728.2	1.96

Source: Science and Technology Master Plan
Department of Science and Technology

Appendix A

NATIONAL SCIENCE AND TECHNOLOGY AUTHORITY

Organizational Structure

A. Science and Technology Sectoral Councils

The science and technology (S&T) councils integrated and coordinated scientific/technological and related activities in their respective sectors. They determined the national research and development priorities and targets, allocated resources for research, assessed the progress of national research programs, established a research information base, built institutional support and strengthened institutional linkages.

The four councils and their areas of responsibility were the following:

1. Philippine Council for Agriculture and Resources Research Land Development (PCARRD) – agriculture, forestry, fisheries and mining.
2. Philippine Council for Health Research and Development (PCHRD) – pharmaceutical development, biotechnical development and health and nutrition services.
3. Philippine Council for Industry and Energy Research and Development (PCIERD) – industry, energy, utilities, and infrastructure.
4. National Research Council of the Philippines (NRCP) – basic researches in the natural sciences, mathematics, social sciences and humanities.

B. Research and Development Institutions

The research and development (R&D) institutions undertook specialized mission-oriented scientific and technological research and development activities. They rendered services such as testing and analysis, calibration, repair, and fabrication of machine and equipment. They also

provided consultation services, human resource training and information assistance.

The R&D institutions and their areas of concern were: .

1. National Institute of Science and Technology (NIST) – food technology, applied food science, industrial chemicals, industrial fermentation, pharmaceutical and cosmetic products, industrial toxicology and pharmacology, and engineering and pilot plant production.
2. Food and Nutrition Research Institute (FNRI) – Philippine foods and food combinations which are good sources of nutrients, community nutrition, and nutrition policies.
3. Forest Products Research and Development Institute (FPRDI) – forest products and allied materials.
4. Philippine Institute of Volcanology and Seismology (PHIVOLCS) – volcanic behavior and eruption prediction, volcanic terrains, utilization of volcanic products, and other related phenomena.
5. Materials Science Research Institute (MSRI) – organic and inorganic materials such as ceramics, metals, plastics, and composites.
6. Philippine Atomic Energy Commission (PAEC) – peaceful application of atomic energy and nuclear regulation.

C. Support Agencies

The support agencies provided vital supplementary services to the R&D effort of government agencies and the private sector.

1. Philippine Invention Development Institute (PIDI) – technical, legal, financial and promotional assistance to inventors and creative researchers for the development and utilization of inventions/creative ideas.
2. Science Promotion Institute (SPI) – promotion of public consciousness in S&T, undergraduate S&T human resource development, and establishment and strengthening of the national S&T information system.

3. Philippine Science High School (PSHS) – quality secondary education with emphasis on mathematics and the sciences for gifted students in preparation for careers in science and technology.

D. Advisory Bodies

The National Academy of Science and Technology (NAST), the National Research Council of the Philippines (NRCP), and the scientific and technological professional organizations and business associations served as advisory bodies to the NSTA on S&T policies and issues of national importance.

Appendix B

DEPARTMENT OF SCIENCE AND TECHNOLOGY

Organizational Structure

The Department of Science and Technology (DOST) consists of five sectoral planning councils, seven research and development institutes, six scientific and technological service institutes and two attached agencies.

A. Sectoral Planning Councils

The sectoral planning councils, within their respective sectors, are responsible for the following tasks: formulating policies, plans, programs, projects and strategies for S&T development; programming and allocating funds; monitoring research and development projects; and generating external funds. These sectoral planning councils are:

1. Philippine Council for Industry and Energy Research and Development (PCIERD);
2. Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD);
3. Philippine Council for Health Research and Development (PCHRD);
4. Philippine Council for Aquatic and Marine Research and Development (PCAMRD); and
5. Philippine Council for Advanced Science and Technology Research and Development (PCASTRD).

B. Research and Development Institutes

1. Industrial Technology Development Institute (ITDI) – undertakes applied research and development to develop technologies and innovations in industrial manufacturing, mineral processing and energy, and transfer of research results directly to end-users or via linkages.

2. Philippine Nuclear Research Institute (PNRI) – conducts research and development on the application of radiation and nuclear materials.
3. Food and Nutrition Research Institute (FNRI) – undertakes research related to problems on food and nutrition.
4. Forest Products Research and Development Institute (FPRDI) conducts applied R&D on processing of forest-based industries.
5. Philippine Textile Research Institute (PTRI) – conducts applied R&D for the textile industry sector.
6. Metal Industry Research and Development Center (MIRDC) – provides relevant, timely and cost effective information, consultative and trade accreditation services and assists in design, testing, production, and repair of metal products.
7. Advanced Science and Technology Institute (ASTI) – conducts research and development in advanced sciences such as biotechnology and microelectronics.

C. Scientific and Technological Service Institutes

1. Science Education Institute (SEI) – undertakes and formulates plans for the development of S&T education and training.
2. Science and Technology Information Institute (STII) – serves as DOST's information arm through the development and maintenance of S&T databank, packaging and dissemination of information.
3. Technology Application and Promotion Institute (TAPI) – undertakes contract research, particularly at the pilot plant and semi-commercial stage; provides technical consultancy including engineering design, patenting and licensing services; and provides grants or venture financing for new or emerging projects.
4. Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) – maintains a nationwide network for observation and forecasting of weather and other climatological conditions.

5. Philippine Institute of Volcanology and Seismology (PHIVOLCS) – predicts volcanic eruptions and earthquakes, their geotectonic phenomena and how they occur.
6. Philippine Science High School (PSHS) – provides S&T education to high school students on scholarship basis, and serves as a training center for science teachers.

D. Attached Agencies

1. National Research Council of the Philippines (NRCP) – promotes cooperation in research at home and abroad and encourages individual initiatives as essentially contributing to the advancement of science.
2. National Academy of Science and Technology (NAST) – provides meaningful incentives and recognition to those engaged in scientific and technological research; serves as an advisory body to the government on S&T through DOST; and establishes linkages with foreign academics and similar bodies.

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