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An Institutional Analysis of R&D Expenditures in the Public and Private Sectors

Epictetus E. Patalinghug

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For comments, suggestions or further inquiries please contact:
The Research Information Staff, Philippine Institute for Development Studies
3rd Floor, NEDA sa Makati Building, 106 Amorsolo Street, Legaspi Village, Makati City, Philippines
Tel Nos: 8924059 and 8935705; Fax No: 8939589; E-mail: publications@pidsnet.pids.gov.ph
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PHILIPPINE INSTITUTE FOR DEVELOPMENT STUDIES

and

DEPARTMENT OF BUDGET AND MANAGEMENT

AN INSTITUTIONAL ANALYSIS OF R&D EXPENDITURES IN THE PUBLIC AND PRIVATE SECTORS

DR. EPICTETUS E. PATALINGHUG
Professor
College of Business Administration
University of the Philippines
Diliman, Quezon City

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EXECUTIVE SUMMARY

This paper analyzes R & D expenditures in the Philippines and the institutional arrangement for R & D coordination between the government and the private sector.

The proper role of government in the S & T sector is to foster cooperation between government, academe, and industry; establish competitive science research funding mechanisms; promote the development of S & T manpower; and establish a system to monitor, assess, and forecast technology.

There is a need to strengthen S & T education at the elementary and secondary school level to support an expansion of science and engineering enrollment at the tertiary level. This, however, requires an upgrading of laboratory facilities and equipment, as well as the hiring of qualified faculty here and abroad.

To address the incentive problems in the S & T sector, the following are recommended: (1) implement the Scientific Career System initially to target natural scientists and engineers; (2) pool R & D resources from different R & D-related agencies and administer it by an NSF-type agency. This agency is then tasked to undertake a competitive bidding based on merit in the awarding of research grants; (3) design an incentive scheme to encourage private sector R & D, with strict qualifying requirements on what constitutes R & D activities.

To improve the R & D delivery system the following are suggested: (1) reorganize the government-supported R & D institutes into a new corporate structure that gives them flexibility and autonomy; (2) strengthen network of schools or consortia to maximize use of resources and develop core competence; (3) promote the development of S & T culture through awards, TV & radio programs, fairs, plant visits, and apprenticeship; and (4) install a scanning and monitoring system of world technological trends for dissemination to local industries, research institutes, and universities.

And to establish S & T coordination mechanism, the following are recommended: (1) DBM must be involved with DOST in the S & T plan-formulation stage, so that resources are available to implement the plan; (2) a Medium-Term Science and Technology Development Plan must be drafted by DOST at least a year before the drafting by NEDA of the Medium-Term Philippine Development Plan; (3) DOST must establish a Program and Project Monitoring Unit to coordinate the selection of external evaluators and reviewers of the different S & T projects and programs; and (4) STCC must meet more frequently to address the current problems and difficulties in the implementation of the S & T plan.

ABBREVIATIONS AND ACRONYMS

AO	Administrative Order
ASTI	Advanced Science and Technology Institute
CHED	Commission on Higher Education
CRI	Crown Research Institute
CSIR	Council for Scientific and Industrial Research
CTTC	Comprehensive Technology Transfer and Commercialization
DA	Department of Agriculture
DBM	Department of Budget and Management
DFA	Department of Foreign Affairs
DOH	Department of Health
DOST	Department of Science and Technology
DTI	Department of Trade and Industry
EDC	Export Development Council
EMG	Economic Mobilization Group
EO	Executive Order
ESEP	Engineering and Science Education Project
GDP	Gross Domestic Product
GOCC	Government Owned and Controlled Corporation
HRD	Human Resource Development
ICC	Investment Coordination Committee
IDC	Industry Development Council
IDPP	Industrial Development Plan of the Philippines
ITAF	Industrial Technology Assistance Fund
ITDI	Industrial Technology Development Institute
KAIST	Korean Advanced Institute of Science and Technology
KIST	Korean Institute for Science and Technology
KJIST	Kwang-ju Institute of Science and Technology
KORDIC	Korean Research and Development Information Center
MIRDC	Metals Industry Research and Development Council
MOST	Ministry of Science and Technology
MOT	Management of Technology
MSU-IIT	Mindanao State University – Iligan Institute of Technology
MTPDP	Medium Term Philippine Development Plan
NEDA	National Economic and Development Authority
NSDB	National Science and Development Board
NSF	National Science Foundation
NSTA	National Science and Technology Authority
PCASTRD	Philippine Council for Advanced Science and Technology Research and Development
PCAMRD	Philippine Council for Aquatic and Marine Research and Development
PCARRD	Philippine Council for Agriculture, Forestry, Natural Resources Research and Development

PCHRD	Philippine Council for Health Research and Development
PCIERD	Philippine Council for Industry and Energy Research and Development
PEDP	Philippine Export Development Plan
PIDS	Philippine Institute for Development Studies
PTFST	Presidential Task Force on Science and Technology
R & D	Research and Development
RDI	Research and Development Institute
SCS	Scientific Career System
SEI	Science Education Institute
SME	Small and Medium Enterprise
SMEDC	Small and Medium Enterprises Development Council
S & T	Science and Technology
STAND	Science and Technology Agenda for National Development
STCC	Science and Technology Coordinating Council
STII	Science and Technology Information Institute
STMP	Science and Technology Master Plan
SUCs	State Colleges and Universities
TAPI	Technology Application and Promotion Institute
TBG	Technology for Business Growth
TDF	Technology Development Fund
UNDP	United Nations Development Program
UNESCO	United Nations Educational, Scientific and Cultural Organization

An Institutional Analysis of R&D Expenditures in the Public and Private Sectors

Epictetus E. Patalinghug[*]

I. Introduction

A major factor for the success of industrialization is the attainment of confidence and competence in technology. The capacity to use and develop technology through innovation and the management of information will determine the level of competitive industrial development.

For the private firms to acquire technological capability, the role of government in policy formulation, funding, and research generation in the S&T sector is undoubtedly crucial. What is not clear is how to foster closer government and private sector collaboration in the pursuit of building firm-level technological capability. What is the appropriate role of government in R&D activities? And what is the proper institutional and organizational arrangement to encourage R&D activities in the private sector?

This study attempts to address these issues in the Philippine setting. The next section discusses the role of government in technology development. Section III describes technology policy in the Philippines. Section IV explains the relationship between technology and competitiveness. Section V discusses the role of technology in SME development. Section VI elaborates on major policy considerations. Section VII analyzes the patterns of innovations. Section VIII describes the results of both the DOST survey in 1992 and the

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[*] Professor, College of Business Administration, University of the Philippines at Diliman. This is part of a PIDS-DBM study on "Research and Development Expenditures of the Public and Private Sectors." This is a revised version of a paper presented to the consultative workshop on R&D expenditures in the public and private sectors at University of Asia and the Pacific on March 24, 1998.

PIDS survey in 1998. Section IX analyzes the alternative institutional and organizational arrangements for R&D coordination between the government and the private sector. And Section X discusses the recommendations.

II. The Role of Government in Technology Acquisition

Neo-classical economic theory advocates a non-interventionist role for the state. This view argues that the main elements of policy intervention in developing countries should be limited to providing the fundamental conditions such as maintaining a stable macroeconomic environment, limiting price distortions, investing in education and health, investing in infrastructure, and ensuring public order and safety. In few instances, intervention is justified by conventional theory in the presence of market failure or externalities. And if the form of intervention involves incentives, they should have a neutral effect across industries.

However, there are economists who argue for selective intervention in major sectors or industries to make them more competitive through the use of incentives such as subsidies, tariff protection, directed credit, tax exemptions, foreign-exchange allocation and accelerated depreciation allowance. A well-deserved policy intervention to promote technology capability is desired to correct for market failures in developing industrial technology. The dynamic externalities brought about by technology acquisition in terms of higher productivity, appropriate product characteristics, and organizational learning provide a valid case for state intervention.

In the Philippine setting, policy reforms are needed to provide an enabling environment for the S & T sector. The government can take an active part in these efforts by (1) establishing a regulatory framework that encourages private firms to undertake R & D, fosters cooperation between academe and the private sector, and gives firms and research institutes access to the pool of knowledge generated in the international science community; (2) establishing competitive science research funding mechanisms to efficiently allocate research funds and to improve the focus of public financing of research; (3) increasing significantly the pool of qualified S & T personnel at all levels; and (4) establishing a systematic assessment of S & T investments (Holm-Nielsen, et al, 1996).

More specifically, the government can identify the (1) proper tax incentives for R & D, (2) appropriate measures to promote university-industry cooperation, and (3) the legal framework for an effective protection of intellectual property. Thus, the role of government is mainly facilitative. Specific incentives to encourage R & D are transitional in nature and designed to be gradually phased out.

III. Technology Policy

The Department of Science and Technology (DOST) introduced the Science and Technology Master Plan (STMP) in 1990 which set the goals and objectives for the Science and Technology (S&T) sector, and provided a framework for the effective coordination of S&T projects and programs consistent with national development policies. STMP cited the following major problems in the S & T sector: (a) underutilization of S&T for development as reflected in the low quality, and low productivity of the production sector and heavy dependence on imports, (2) underinvestment in S & T development in terms of manpower training, technological services, research and development (R&D) facilities and financial resources, and (3) weak linkages between technology generation, adaptation and utilization.

There has been a general failure to use technology to gain competitive advantage. Resource-based exports (timber, copper) are basically in raw material or unprocessed form. Traditional agricultural exports (coconut, sugar, and banana) are also exported without infusing technology-based processing in the valued-added chain. The shift from primary exports (e.g. coconut, sugar) to manufactured exports (e.g. garments, electronics) has simply reflected the changing factor composition of exports (that is from resource-intensive to labor-intensive). The shift from labor-intensive to skill-intensive or technology-intensive manufactured exports has not yet occurred.

The three main strategies of the STMP are: (1) modernization of the production sector through massive technology transfer from domestic and foreign sources, (2) upgrading of R & D capability through intensive activities in high priority sectors, and (3) development of S & T infrastructure, including institution building, manpower development and development of S&T culture.

The Comprehensive Technology Transfer and Commercialization (CTTC) program was initiated to disseminate and commercialize locally developed technologies. But there was a lack of locally developed commercializable technologies. There was little government-private sector joint research ventures, and government budgetary constraints made it impossible to implement the S & T infrastructure projects.

The Medium-Term Philippine Development Plan, 1993-1998 has targeted an increase in R&D expenditures from 0.24% of GNP in 1992 to one percent of GNP in 1998. However, the priority activities in support of this goal have not been adequately implemented. For instance, activities such as (1) modernization of production facilities in technology-based industries, (2) global technology search to acquire foreign technology in the priority areas, (3) provision of S&T services (e.g. standards, quality control, chemical and physical analysis, etc.), and (4) transfer and commercialization of technologies for the development of competitive industries, are yet to be visibly felt in the industrial sector. One difficulty of satisfying the S&T goal of the MTPDP is the lack of consensus in the Philippine government of what industries qualify in the category of "priority areas" or "competitive industries".

In 1993, DOST came up with the Science and Technology Agenda for National Development (STAND), a successor to STMP. STAND's objective was to help realize the vision of Philippines 2000 by focusing S & T activities on export niches identified by the private sector. While STMP identified fifteen priority sectors (see Appendix 1), STAND identified seven export winners, eleven basic domestic needs, three support industries, and the coconut industry (see Appendix 2). Specific products and processes are being identified for research and development in the STAND through programs coordinated by DOST-approved product managers working in consultation with academe, government and private sector. The assistance of experts from private organizations (local and foreign) has been enlisted by DOST under UNDP funding support. A UNDP-assisted project, "Achieving International Competitiveness Through Technology Development and Transfer" was undertaken for DOST by outside experts in 1995. The most current program for DOST to build scientific and technological capability refers to the Education and Science Education Project (ESEP) which is supported by a program loan from the World Bank. It is envisioned to build and upgrade scientific and engineering expertise and facilities in selected engineering and science institutions. The ESEP includes a Management of Technology (MOT) program which attempts to build and upgrade managerial expertise of scientific and technical decision makers. In addition, it provides assistance for the upgrading of science and mathematics teaching in selected secondary schools in the Philippines.

IV. Technology and Competitiveness

A major factor for the success of industrialization is the attainment of confidence and competence in technology. The capacity to use and develop technology through innovation and the management of information will determine the level of competitive industrial development. For the Philippines, it has to undertake technological catch-up in terms of access to and mastery of the key emerging or leading-edge technologies to prevent future deterioration of its economic growth and international competitiveness.

Recently there have been renewed efforts, particularly by the Department of Trade and Industry (DTI) to formulate industrial policy for the country. In 1991, Republic Act 6977 (Magna Carta for Small Enterprises) created the Small and Medium Enterprises Development Council (SMEDC) which acts as the primary agency responsible for the promotion, growth, and development of small and medium enterprises (SMEs) in the country. In 1994, Republic Act 7844 created the Export Development Council (EDC) which is responsible for monitoring the performance of the country's export winners and for drafting the Philippine Export Development Plan (PEDP). In 1996, Executive Order No. 380 created the Industry

Development Council (IDC) which is tasked to draft the Industrial Development Plan of the Philippines (IDPP). Both councils are composed of government and private sector representatives. Each council has its own priority sectors. In 1998, another body called the Economic Mobilization Group (EMG) was created. Nobody knows the usefulness of EMG, except perhaps that it simply duplicates the functions of the Cabinet-level Tariff and Related Matters (TRM) Committee.

IDC has identified the following factors as adversely affecting the growth and competitiveness of the local industries: technical smuggling, tariffs, power rates, access to technology, skills training, lack of information dissemination on the available government facilities, exchange rate volatility, and restrictive monetary policy.

The disappointing industrial-sector performance in the first quarter of 1997 renewed calls for the adoption of an industrial policy. DTI proposes policy "calibration" in the following areas: (1) tariff review, (2) incentive rationalization, (3) monitoring compliance of trade agreements, (4) liberalizing inputs to industry, (5) plugging leaks from duty-free shops, and (6) rapid development of infrastructure.

The currency crisis that affected the country since July 11, 1997 forced the government to "recalibrate" its tariff reduction program. Instead of the previous 30-20-10-3 tariff structure, a smoothened tariff structure of 30-25-20-15-10-7-5-3 was adopted effective January 22, 1998. This tariff recalibration scheme is intended to serve as a framework that will initially apply to the so-called "Philippine Winning Products." Furthermore, E.O. 63 (issued on January 15, 1999) granted tariff relief for 1999 to six industries: iron and steel; garments and textile; pulp and paper; automotive battery; disposable lighter; and petrochemicals. And A.O. 58 (issued on March 4, 1999) empowered the Petrochemical and Plastics Mobilization Task Force to monitor and regulate the importation of petrochemical and plastic products. The A.O. was later amended that removed the regulatory powers of the task force, and empowered it to simply act as a research and coordinating body responsible for the development of the competitiveness of the petrochemical and plastics industries.

The renewed attempt to formulate industrial policy is a reiteration of the vital role of industrial progress to sustain future economic growth in the country. However, ad-hoc or de-facto industrial policies (as formulated by EDC, IDC, SMEDC and EMG) have not stressed the need for active promotion of technology to build up a strong foundation for industrialization. Identifying "export winners" or "industry/product winners" without technology is like a vehicle without an engine.

Finally, the pole-vaulting strategy implicitly identified at least twelve priority sectors. However, the technologies in support of these "must-do" programs have yet to be identified. On the other hand, the Updated Medium-Term Philippine Development Plan 1996-1998 has indicated that "harmonized S&T efforts of the scientific community and the production sector are essential to strike a balance between the supply of, and demand for, technologies and to focus its activities on technology areas and/or products where the country has comparative advantage." In support of the goal of harnessing science and technology for increasing productivity and attaining competitiveness in the global market the following priority activities are stressed: (1) accelerated implementation of human resources development, utilization and retention programs to improve S&T capability, (2) the institutionalization of S & T forecasting to provide a mechanism for determining technologies which the country should acquire and develop in support of its development vision, (3) global technology search to acquire foreign technology in the priority areas, (4) establishment and strengthening of S & T network and institutions, (5) transfer and commercialization of technologies for the development and production of competitive goods and services, (6) establishment of technology business incubators and science parks, (7) provision of S & T services, and (8) promotion of R & D projects in advanced science and technology.

Technology has become the most profitable commodity in the industrialized countries. The increasing cost of research has led to increasing complexity, selectivity, and specialization in technology The reality in global technology flow is that there can be no natural flow of technology from industrialized countries to developing countries. Business motives rather than welfare considerations dictate its modes of transfer. Technology should not be treated as something which can be acquired and utilized with little effort. More important than the act of acquisition of the physical embodiments of technology is the ability to understand it and to build upon that knowledge. Technology is the key to achieving international competitiveness of Philippine enterprises whose standard of quality will be indicated by the degree of advancement and effectiveness of their technological systems. Thus, an understanding of the nature of technology and its characteristics is important. The catch-up hypothesis has asserted that in comparisons across countries the growth rates of productivity in any long period tend to be inversely related to the initial levels of productivity. Empirical evidence has indicated that the convergence of national productivity levels and per capita income levels has shown itself strongly in industrialized economies, but not in developing economies (Baumol, 1986). The applicability of the technological catch-up or convergence hypothesis in developing countries is being questioned because it assumes that the existence of technological or productivity gap between two countries is enough to guarantee a stronger potential for growth of the laggard country. An adequate social capability is required for a technologically- backward country to absorb advanced technologies. Rapid realization potential requires strengthening the educational, institutional, and organizational components of social capability. These requirements for exploiting the technological opportunity involves higher levels of general and technical education; greater experience with large-scale production, distribution and finance; openness to competition; openness to the establishment and operation of new firms, openness to the sale and purchase of new goods and services, the broad bases of its science, the well established connection of science, technology, and industry; the effectiveness of its legal system, and an effective consensus in favor of development (Abramovitz, 1986).

In analyzing the process of technological change, it is observed that common processes and problems in the production of a wide range of disparate commodities (e.g. firearms, sewing machines, bicycles, and automobiles) occurred. Thus, the technological basis in the production processes of different industries was closely related. This phenomenon called “technological convergence" (Rosenberg, 1963) is important in providing a guide for selecting key emerging technologies which are considered priority areas for R & D.

V. Technology and SMEs

Small and Medium Enterprises (SMEs) play an important role in the Philippine economy. In 1993, SMEs contributed 68.3°/o of total jobs generated by all types of business establishments. More than 90% of the total number of enterprises belong to SMEs accounting for approximately 20% of total output. The government recognizes the importance of SMEs in economic development by providing support in terms of training, credit facility, and marketing assistance. The most popular route of technology transfer from foreign companies to SMEs in the Philippines is through the suppliers of machinery and equipment. This is particularly true among SMEs in the metalworking industry. In the garment industry the most popular mode of technology transfer to SMEs is through subcontracting arrangement where the mother company provides local subcontractors some technical know-how through specific guidelines on the use of sewing machines for a given type of product. In most instances, the mother company in a subcontracting arrangement is simply a provider of raw materials and marketing infrastructure rather than technology. In the food industry, SMEs acquire technology through learning-by-doing approach.

SMEs face several problems to acquire technology or to engage in R&D. Among these problems are: (1) lack of funds, (2) insufficient information, (3) lack of skills in evaluating alternative technologies, (4) lack of technical know-how to shift to more advanced technologies, (5) inadequate mechanism for transfer of technologies, and (6) inertia of entrepreneurs because of no perceived or actual need for technology.

The current policy debate focuses on whether policy intervention employed to demonstrate the feasibility of demand-driven technology acquisition is more relevant compared to a policy of providing seed money for venture finance institutions which aim to assist and promote SMEs in the advanced technology areas. The performance of an existing venture finance company in the country indicates that there are more seed money and no qualified S&T SMEs to avail of it. The experience of other countries has shown that scientists and engineers in major companies that benefit from technology transfer and skill training in these firms are the usual founders and initiators of technology-based SME ventures in emerging and industrial markets. Appreciation of currencies, increasing land rents, and maturity of conventional product markets have transformed the role of SMEs from simply providing new job opportunities and promoting local industries to developing supporting industries which provide effective sources of parts and components to local and foreign final product manufacturers. This is the market that makes technology-based SMEs viable in developing economies. Encouraging or prioritizing SMEs in the advanced technology areas to locate in Science and Technology Parks might support the supply-push strategy, but its viability is not sustainable unless a market for its innovations exists and local firms go through the learning process.

VI. Major Policy Considerations

The major thrust of Philippine S&T policy has been recently subjected to contrasting recommendations. One view recommends that the universities and research institutes focus on the basic sciences and advanced technologies to provide the foundation for sustained technological development. This view is popularly called "supply-push" or "technology-push." The other view argues that it makes more sense for the government to provide the enabling environment for the private sector to purchase technologies that it needs. Choosing "winning technologies" or "winning products" is a costly and arbitrary exercise. This view is called "demand-pull" or "market-pull."

At the firm level, the choice of either innovation-driven or market-driven strategy is determined by the nature of the competitive environment. In market-driven companies, formal marketing research provides the direction of R&D. R&D simply gives advice on what is technically feasible. In an innovation-driven firm, R&D provides the main motivation. The responsibility of marketing is to look for product applications, and to sell the product. The transition from innovation-driven to market-driven can be made successful by effectively linking the R&D and marketing efforts. At the country level, the state of technological development determines the demand for scientific knowledge. Industrial applications of science cannot occur without adequate "social capability" (i.e. higher levels of technical education, greater experience with large-scale production, distribution and finance, and well-established connection of science, technology and industry). A catch-up strategy is possible provided a coherent plan is patiently implemented rather than prematurely pole-vaulted. This strategy requires spending more time to build the country's technological capability. Projects should be carefully chosen so that they require capabilities that can be supported by present resources. Local firms will have to undergo a learning process if the S&T policy is linked to a well-thought development plan that goes through a sequential process (e.g. manufacture of finished consumer goods or import substitute stage, labor-intensive manufactured export stage, intermediate-and-capital-goods manufacturing stage, and technology-intensive manufactured export stage). Investment in science and engineering education is an important component of patiently building the country's technological capability.

The demand-pull view is based on the observation that most R&D is not of a knowledge-creating nature, but of a knowledge-applying one. Some economically valuable knowledge is old, not new, scientific knowledge. Thus, a developing country can undertake an effective technology policy by speeding up the transfer and exploitation of technologies long utilized in industrialized countries. Science can assist in the exploitation of innovations that did not have their origins in recent science. It likewise stresses that the application of scientific knowledge to industrial uses is based on the changing needs of a given country and not in terms of newly emerging scientific knowledge. On the other hand, the supply-push view argues that once exploitation of mature technologies is exhausted, a country that chooses to be a passive participant in the high-technology game will be left behind in a globally-competitive and technologically-driven markets of the 21st century. Advanced technologies provide the insurance to make the economy globally competitive in the future.

VII. Patterns of Innovation

The Japanese historical experience has been suggested to be particularly relevant to many Asian countries because Japanese efforts to bring about a rapid transfer of western technology at the beginning of the Meiji period were undertaken under conditions of scarce capital and natural resources which resembled the conditions faced today by many developing countries (Rosenberg, 1990). The Japanese experience also reinforced the problem faced by innovating firms today; particularly the need to assess alternative technologies available in the market:

> *In the Japanese case, the need to adapt foreign technology to domestic circumstances was not, at first, understood. Dutch water control technology, for instance, was introduced without considering that, in addition to tidal forces, mountain run off was a major source of flooding, Similarly, the Japanese government in 1871 imported a vast mechanized silk reeling plant from France. While it was intended as a model factory, private business discovered that it could not profitably operate such capital-intensive plants (Rosenberg 1990, p.152).*

Nevertheless, the Japanese subsequently learned from its initial mistakes. Another lesson is its recognition of the firm as the focal point, if not the major player, in the process of technology transfer. In many countries trying to embark on a technological catching-up, several research laboratories are set up, but they are not matched by technological capabilities in firms themselves. In India, Rosenberg's (1990) analysis of the failure of CSIR (Council for Scientific and Industrial Research) to make any discernible impact upon the productivity and efficiency of the industrial sector was due to its detachment from the market needs of Indian firms. This Indian case illustrates not simply the importance of building up the educational, scientific and research infrastructure but also the need to improve the effectiveness of adoption and commercialization of new technologies. The capability to commercialize technology is increasingly getting to be a competitive factor for global companies. Leading companies are reported to (1) commercialize two or three times the number of new products and processes as do their competitors of comparable size, (2) incorporate two to three times as many technologies in their products, (3) bring their products to market in less than half the time, and (4) compete in twice as many product and geographic markets (Nevens, Summe and Uttal, 1990). In addition, the objective of encouraging the development of technological capabilities within firms is consistent with the experience of technologically-advanced countries where technology emerges mainly from corporate research and development (although it is highly dependent on academic research). Technology importation is not simply a purchase of production inputs and the licensing of production know-how; it also requires a strong capacity for reverse engineering including some informal tinkering type of R&D in the shop floors of small entrepreneurs and innovators.

The role of private-sector R&D as opposed to public-sector R&D is illustrated in Table 1 in the case of South Korea. Private-sector R&D expenditures are four times those of public sector. In addition, both Japan and South Korea's R&D systems have been changing in response to the changing technological and competitive environment. Table 1 likewise shows South Korea's efforts at achieving a rapid technological catching-up. Its R&D expenditures as a percentage of GNP in 1993 are approaching the levels of R&D investment observed in Japan, Germany, and U.S. The dominant role of corporate R&D in South Korea is shown in Table 2 which indicates that R&D expenditures in national and public institutes are three times the R&D expenditures in universities and colleges. But in Table 3, the dominant role of federal sources in support of basic research in the U.S. is shown. The percentage of government R&D to total in U.S. reached 67% in 1963 (see Mowery and Rosenberg, 1989) and had declined to slightly below 50% thereafter. Thus, South Korea and U.S. assigned different roles to the private sector in their respective R&D systems. Since U.S. R&D is heavily geared towards military purposes, the greater role of the government has been observed. But the declining spillover effects of military R&D to civilian and commercial uses have led analysts (Thurow, 1992) to conclude that U. S. civilian R&D expenditures as percent of GNP are falling behind those of Japan and Europe.

Table 1 indicates that at least 80% of total R&D expenditures is accounted by the private sector. In contrast, Table 4 shows that approximately 67% of total R&D expenditures in the Philippines over the period 1989-1992 is accounted by the public sector. The evolution of the Korean innovation system to its current state is no accident. Ki-Soo (1996) asserted that Korea's S & T development went through different phases: (a) technology importation (1960s), (b) absorption of imported technology (1970s), (c) localization of key strategic high technologies, development of high-caliber S & T manpower, and promotion of private-sector R & D capability (1980s), and (d) globalization of R & D systems and improvement of information networks (1990s). Kodama (1995) has concluded that the evolution of the Japanese manufacturing companies into knowledge-creating organizations followed a trajectory that lasted a quarter of a century covering three distinct periods: (a) technology importation (1961-1975), (b) technology development for economic growth (1975-1985), and (c) transition toward knowledge creation (1985-present). The pattern of S & T development in Korea is essentially patterned after that of the Japanese experience.

Both Japan and Korea have successfully entered the knowledge-creation phase where its S & T institutions are capable of developing world-class indigenous technologies. The Korean experience is worth analyzing because its success was achieved within a short time span. Furthermore, Korea's S&T development efforts were undertaken under conditions where it faced scarcity of financial, natural and human resources. And their educational system was not as developed at that time compared to that of the Philippines.

In a later section, a comparison between the S & T administrative structure in Korea and the Philippines is made to convey a statement that basically in form and intent, the Philippine S & T development plan is comparable to that of Korea. Thus, the basic weakness of the Philippine experience is in its execution and implementation. Although there are some weaknesses in the plan-formulation process in the Philippines because the planning exercise is detached from the budgeting exercise, the more decisive factor is the weakness of the institutional and organizational arrangement to ensure timely and correct implementation.

The existing intra-government coordination system is defective. The system of performance monitoring and evaluation is lacking or ineffective. In fact, the government's Investment Coordination Committee (chaired by NEDA) has been lengthily reviewing projects intended to address the adverse effect of the financial crisis. But basing from ICC's inefficiency in evaluating development projects, it is more likely that these projects will be approved at a time when the economic conditions they are supposed to address are no longer there. The ideal institutional arrangement is definitely to establish a coordination mechanism between the S & T plan, the budget plan, and the Medium Term Philippine Development Plan. Unfortunately, prospects of establishing this linkage in the Philippine bureaucracy in the short run are not promising. The most realistic alternative is to draft a substantive S & T chapter to be incorporated in the MTPDP. At present, the S & T section of MTPDP is at most 4 pages long. Furthermore, it fails to integrate the S & T requirements in the other chapters. For instance, MTPDP's chapter on "Agri- Industrial Development" is silent on what S&T framework development in this sector is anchored.

Table 1

South Korea: R&D Expenditures by Sector, 1989-1993
(in million dollars)

Year	Public Sector (%)	Private Sector (%)	Total (%)	% of GNP
1989	718 (20)	2,803 (80)	4,146 (100)	1.90
1990	814 (19)	3,333 (81)	4.676 (100)	1.88
1991	1,020 (20)	4,178 (80)	5,466 (100)	1.94
1992	1,098 (18)	5,138 (82)	6,328 (100)	2.09
1993	1,295 (17)	6,320(83)	7,615 (100)	2.33

Source: Ministry of Science and Technology, Republic of Korea, Science and Technology in Korea: 1995.

Table 2

South Korea: R&D Expenditures by Research Institutes, 1989-1993
(in million dollars)

Year	National & Public Institutes (%)	Universities & Colleges (%)	Private Companies (%)	Total (%)
1989	746 (18)	332 (8)	3,068 (74)	4,146 (100)
1990	1,029 (22)	327 (7)	3,320 (71)	4,676 (100)
1991	1,203 (22)	383 (7)	3,380 (71)	5,466 (100)
1992	1,329 (21)	380 (6)	4,619 (73)	6,328 (100)
1993	1,599 (21)	533 (7)	5,483 (72)	7,615 (100)

Source: Ministry of Science and Technology, Republic of Korea, Science and Technology in Korea: 1995.

Table 3

U.S.: Sources of Funds for Basic Research by Sector, 1975-1984
(in million dollars)

Year	Total	Federal Gov't	Industry	Universities & Colleges	Other Non-Profit Organizations
1975	4,608	3,139	705	478	286
1976	4,977	3,436	769	475	297
1977	5,537	3,823	850	527	337
1978	6,392	4,445	964	605	378
1979	7,257	4,044	1,091	711	411
1980	8,039	5,559	1,265	805	460
1981	9,217	6,236	1,585	909	487
1982	9,886	6,588	1,805	983	510
1983	10,610	6,970	2,025	1,075	540
1984	11,850	7,775	2,270	1,220	585

Source: David Mowery and Nathan Rosenberg, Technology and the Pursuit of Economic Growth (Cambridge: Cambridge University Press, 1989).

Table 4

R&D Expenditure by Sector in the Philippines
(₱ million at 1985 prices)

	1989	1990	1991	1992
Higher Education	159.3	183.9	166.5	230.5
Government	682.8	472.4	585.4	919.5
Non-Government	98.9	108.9	77.9	72.8
Private Industry	297.4	342.1	300.4	341.6
Total	1,238.3	1,107.3	1,130.2	1,564.4

Source: DOST, "Generation of S&T Statistics and Indicators in the Philippines (1995).

VIII. Trends in R & D Expenditures and Manpower

R & D expenditures (in current terms) increased by 23.1 percent in annual basis between 1989 and 1992 (based on DOST survey) and by 17.2 percent between 1993 and 1996 (based on PIDS survey). On the average, the government provided 52.7 percent of the R & D expenditures during the 1989-1992 period, and 62.9% percent during the 1993-1996 period. Industry support provided approximately 26 percent of total R & D expenditures during the 1989-1996 period. In both surveys, government agencies and SUCs contributed the biggest share to total R & D expenditures (see Table 5).

R & D manpower is shown in Table 6. Full-time and part-time R & D manpower are combined in Table 6. The total full-time R & D manpower was 9,719 in 1992 (using the DOST survey) and 9,896 in 1996 (using the PIDS survey). Total manpower increased by an average annual rate of 3.2 percent during 1989-1992 period and 9.4 percent during the 1993-1996 period. Full-time R & D manpower increased at an average annual rate of 4.3 percent over the 1989-92 period and 8.3 percent over the 1993-96 period. In both categories, government agencies and SUCs utilized the biggest number of R & D personnel. Private sector contributed only 11.3 percent of total R & D manpower for the 1989-1996 period. Most of the R & D personnel have bachelors degree, and those with Ph.D.degrees have a negligible share. R & D personnel with Ph.D.degrees are dominated by those in the social sciences, while those in engineering and technology have less than 10 percent share of total R & D personnel with Ph.D. degrees.

Although the baseline figures derived from the DOST survey and PIDS survey differ, they indicated similar trends. In terms of coverage, the DOST survey had a response rate of 60.7 percent from the survey population of 2,112 institutions. On the other hand, the PIDS survey had a response rate of 51 percent from the survey population of 412 institutions. The response rate for the private sector in the DOST survey was three times the response rate for the public sector. On the other hand, the response rate of SUCs in the PIDS survey was only 14 percent higher than the response rate of the government agencies.

The bottomline of these surveys is that the public sector provides the bulk of R & D expenditures and personnel. Policy reforms in the S & T sector must therefore address how to significantly increase the share of private R & D in the Philippines.

Improving the private sector participation in R & D can take any of the following collaborative arrangements: (1) industry-government-academe linkages, (2) government-private sector-academe cooperative research, (3) reorientation of the activities and research of the S & T community in order to be relevant to the needs of the industry, and (4) establishment of regional quality centers to promote standards and provide technical support services.

One of the objectives of these linkages is to encourage science and engineering students to pursue careers in manufacturing. Private firms can actively participate in these effort by working closely with academic institutions in sponsoring plant visits, summer internships, and encouraging students to pursue problem-solving thesis research which are relevant to some of the technical issues facing Philippine industry. Sabbatical time of science and engineering faculty can also be spent in the private sector in order to strengthen the industry-academe linkages.

A demand-driven R & D thrust requires an administrative and organizational structure that allows public R & D institutes to exploit the commercial potential of new technologies. Government research institutes can have greater control over their budgets, provided that they raised at least 30% of their operating expenditures from market-based user charges (or from private endowment).

Ouchi (1989) classifies two types of industry-academe collaborations: (a) secretariats, and (b) operating entities. The secretariat type establishes a small organization to coordinate the research activities of the participating institutions. An operating entity establishes new R & D centers where personnel of participating institutions are seconded for the collaborative projects. The main purpose of the collaborative research is to work on high-technology projects. No single firm would develop these technologies because they are weakly appropriable, even if they are critical to the growth of the entire industry. In U.S., Japan, and Europe, the collaboration between the academe and the private sector involves a dominant share of total funding by the private sector. In the Philippines, funding large science projects has not occurred. However, in the light of existing resource constraints, science and technology research fund should be allocated based on a competitive peer review mechanism and probably must be focused towards a decentralized support of technology generation and diffusion.

The fundamental role of S&T policy is to improve the quantity and quality of S & T human resources and to upgrade its institutional and regulatory capacity to enhance innovation. This involves looking into the professional status of teachers and researchers, S&T incentive system, and taking into account that a qualified and dynamic research community is a product of good science and technology education. The importance of quality standards for science and technology teaching, curriculum development, and teacher development at primary, secondary, tertiary, and graduate levels (as important as laboratory, equipment, and building provision) must be stressed in the formulation and implementation of S&T policy in the Philippines.

The institutional initiatives adopted to enhance the innovation environment must be geared towards promoting private firm's efficiency and quality of production through the application of technology in their manufacturing processes. If the private sector perceives that the activities of the S & T community is relevant to their productive activity, and that a higher degree of appropriability of generated technology is possible, private sector participation in R & D in the Philippines will significantly increase.

Table 5

R & D Expenditures By Major Sectors: 1989 – 1996
(At Current Prices in Thousand Pesos)

Sector	1989	1990	1991	1992	1993	1994	1995	1996
Higher Education	210,840	274,793	290,047	433,234	380,029	419,801	457,063	531,981
Government	903,503	705,908	1,019,628	1,728,348	1,036,304	1,131,363	1,433,187	1,742,483
Non-Government	130,867	162,779	135,713	136,866	155,626	170,442	207,700	249,918
Private Industry	393,491	511,264	523,288	642,101	547,484	599,603	730,677	879,195
Total	1,638,701	1,564,744	1,968,676	2,940,549	2,119,444	2,321,210	2,828,628	3,403,577

Sources: DOST, "National Survey of Scientific and Technological Activities: Integrated Report" (1992).
PIDS, "Survey of Activities in Research and Development" (1998).

Table 6

R & D Personnel By Major Sectors: 1989 – 1996

Sector	1989	1990	1991	1992	1993	1994	1995	1996
Higher Education	6,772	6,824	6,876	6,929	5,384	6,177	6,363	7,027
Government	4,948	5,034	5,919	6,065	4,298	4,931	5,080	5,609
Non-Government	843	893	896	922	701	804	829	914
Private Sector	1,646	1,630	1,652	1,694	1,297	1,487	1,532	1,692
Total	14,209	14,381	15,343	15,610	11,679	13,399	13,804	15,242

Sources: DOST, "National Survey of Scientific and Technological Activities: Integrated Report" (1992).
PIDS, "Survey of Activities in Research and Development" (1998).

Note: R & D personnel is the sum of full-time and part-time head-count in each category.

IX. Institutional and Organizational Arrangement

The role of government in R&D activities is to provide direct and indirect assistance. Direct assistance is provided in the form of subsidies and incentives. Indirect assistance is extended through government-funded research laboratories and institutions such as ITDI, MIRDC, PCIERD, ASTI, TAPI, PCARRD, and PCASTRD.

The nature of government policy intervention can be viewed in different contexts. One possibility is for government to implement an industry targeting or selective intervention policy by identifying industries which play a strategic or crucial role in industrial development. The need for specific technologies in these targeted sectors is identified, and R&D efforts are targeted at acquiring, developing, mastering and perfecting these targeted technologies.

Another framework is facilitative in nature. Government encourages importation of technology through licensing, joint-venture, or foreign direct investment. This policy must be complemented by other measures to enhance firm-level capability such as assistance extended to private firms in negotiating for technology-transfer agreements with foreign suppliers, improving access to credit, acquisition of capital equipment, technical assistance in technology assessment, and training assistance.

And government has a role in setting stringent performance standards in exchange for industry assistance. Export-performance measures are usually used to encourage domestic firms to be innovative by exposing them to international best practice.

The management and organization of government-funded science and technology activities are being re-examined. Some sectors are asking questions if there is a need to reorganize the S&T sector in the country to reduce its size, improve its efficiency, and enhance its effectiveness. One organizational arrangement is to separate the government's involvement in science and technology policy, science funding, and the carrying out of R&D activities (The New Zealand model). Under this framework, the research institutes in New Zealand are more flexible because the corporate structure: (a) provides full commercial powers, (b) allows to borrow funds, (c) allows to form joint ventures and subsidiary companies, and (d) allows each institute to have a clearly defined purpose and customer base. These features permit government R&D institutes to fully exploit the commercial potential of new technologies and to create better collaboration between the public and private sectors.

Singapore creates a $50 million Technology Development Fund (TDF) to assist technology start-up companies in their innovative activities. It is administered by the National Science and Technology Board. Malaysia has alloted $50 million for soft loans to promote private sector industry research consortia and $50 million Industrial Technology Assistance Fund (ITAF) to assist innovative small and medium enterprises. Malaysia's programs are administered by the Ministry of Trade and Industry. In New Zealand, the Technology for Business Growth (TBG) scheme is a $10.6 million program designed to finance R&D projects within firms for collaborative R&D projects between private firms and research institutions. Peru created an industrial technology research fund by allocating 2 percent of net income of industrial enterprises before taxes (1 percent in the case of mining). This allocation system was observed to have a built-in bias in favor of large firms (Sagasti, 1975). The ideal set-up is to provide support for SMEs with matching grants for university-industry cooperative R & D.

The role of the state in R&D can be either direct, indirect or facilitative. The imposition of taxes or the granting of subsidies is too interventionist. One possibility is to develop a policy environment that gives incentives to private firms to undertake R&D. This environment can be enhanced if the government's investment incentives are extended to R&D activities. Table 7 suggests a set of possible incentives for R&D activities.

In 1965, the public sector accounted for 90 percent of Korea's R & D expenditures, but by 1990 the private sector's share rose to 90 percent from 10 percent in 1965. Thus, in Korea, the private sector plays a leading role in industrial technology development. The intervention of the Korean government to induce private sector investment in R & D was successful because of the package of incentives described in Table 8. Like the predicament of the private sector in the Philippines today, Korean private sector was reluctant and incapable of developing in-house R & D. The reluctance was based on the uncertainty, risk, and high cost that accompany R & D investments. The lack of capability was attributable to the limited number of technical personnel that can adapt, assimilate, disseminate, and improve imported technologies. But the big difference between the Philippine and Korean experience is that the Korean government successfully developed its R & D capability to support and guide the private sector to import, assimilate, improve and develop indigenous technology.

Table 7

Suggested Incentives to Promote Private Sector R&D

A. Incentives to Promote Private Sector Industry Research Consortia and their Common R&D Facilities

1. The granting of pioneer status to companies specifically set up to conduct industry-wide R&D

2. Making available soft loans or matching grants of up to $1 million.

3. Making available land for such facilities

4. Providing discounts or exemptions for utility or other rates

B. Quality Assistance Scheme

1. A subsidized consultancy service (say maximum 15 days) to provide training and technical advice on:

   - quality systems and procedures
   - adoption of quality standards
   - specific product assessment
   - inspection and test methods
   - production of quality manuals

2. Special focus would be accorded to SMEs.

<u>Table 7 continued</u>

C. Public Procurement Policy to Stimulate Innovation and Product Development for Indigenous Firms:

1. Instituting dialogue between procurement agencies and suppliers to encourage forward planning

2. Providing more positive consideration to innovative local firms in unfair competition with foreign suppliers and for other justifiable reasons

D. Industrial R&D Incentives Through Appropriate Fiscal Measures:

1. Enlarging the scope of the double-deductions incentive scheme to include a wider range of R&D activities,

2. Lowering or abolishing tariffs, import duties, and sales tax for essential R&D equipment

E. Industrial Technical Assistance Fund

1. Broadening coverage to include all firms (while retaining the emphasis on Small and Medium-Scale Enterprises)

2. Provide the maximum level of matching grant to $1 million for R&D

F. Extend the scope of double-deductions to include certain categories of revenue expenditure, subject to a maximum of 5 percent of net manufacturing sales of a company, as follows:

<u>Table 7 continued</u>

1. Emoluments of employees engaged in scientific and technical R&D activities which are related to the business of the company;

2. Contract research and consultancy fees for scientific and technical work related to the business of the company;

3. Royalty payments on technology licensing agreements;

4. Acquisition of scientific and technical information for R&D purposes;

5. Other costs which are readily identifiable as incurred in the process of conducting scientific and technical work.

Table 8

R & D Incentives for the Private Sector in Korea

A. Tax deduction of a maximum of 4 percent of the total sales on the reserve fund for R & D, technical information, R & D manpower and facilities and so forth.

B. Tax deduction of up to 15 percent of total expenditures on HRD and in-house technical training centers and colleges.

C. Tax deduction of up to 10 percent of their investment for R & d facilities.

D. Application of a depreciation rate 90 percent a year on R & D and test facilities.

E. Support of up to 50 percent of R & D expenditure when private industrial R & D institutes are involved in national R & D projects.

F. Provision of financial support of up to 90 percent of total cost when small firms commercialize new technologies

G. Extension of support of up to 80 percent of total R & D investment by GOCCs when relevant private R & D institutes and R & D unions develop indigenous R & D products.

H. Provision of long-term, low interest loans for R & D and commercialization to the private industries by Korean Development Bank, the Citizens National Bank, and the Industrial Bank of Korea.

I. Comprehensive financial support by the Korea Technology Banking Corporation (KTB) to private companies for technology development activities.

J. Information service on technology data collection, application and distribution.

Table 8 continued

K. Implementation of standardization and quality control.

L. Protection of intellectual property rights for new inventions and innovations.

M. Introduction of a new bidding system based on price and quality

N. Administrative assistance for joint research among industry, university and government science research institutes

Source: Ki – Soo (1996), Table 13, page 36.

An assessment of the institutional and organizational arrangement for S & T development must start with a comparative analysis of two S & T administrative systems.

Korea's Ministry of Science and Technology (MOST) was created in 1967 through the enactment of the Science and Technology Promotion Law. The Philippines' Department of Science and Technology (DOST) was established in 1987 under Executive Order 128. MOST is headed by a cabinet-ranked Minister complemented by one Vice-Minister and three Assistant Ministers. On the other hand, DOST is headed by a Secretary with cabinet rank and supported by three Undersecretaries and three Assistant Secretaries. R & D coordination in the MOST structure is achieved through the six divisions, each headed by a coordinator: (1) R & D planning and management, (2) basic research, (3) machinery and materials, (4) electric and electronics, (5) chemical and bio-technology and (7) natural resources and ocean. These six divisions are supervised by an Assistant Minister for R & D Policy and Coordination. Another Assistant Minister coordinates nuclear energy planning and nuclear safety (see Figure 1). In contrast, DOST is coordinated through five sectoral planning councils (covering the areas of agriculture and forestry, health, aquatic marine resources research, industry and energy, and advanced science and technology), seven R & D institutes (covering the following areas: industrial technology, nuclear research, forest products, food and nutrition, textile, metals, and advanced science and technology) and six S & T service agencies (focused on the following areas: science education and training, information networks, commercialization of technology, weather forecasting, and volcanology and seismology). The five councils are coordinated by an inter-council coordinating committee instead of an undersecretary or an assistant secretary as in Korea (see Figure 2).

Thus, in terms of the structure of R & D coordination, MOST and DOST are essentially comparable. However, DOST is slightly heavy on the top management level (e.g. three undersecretaries instead of one). In addition, DOST has 13 regional offices and 73 provincial centers which are not found in the MOST structure. One of STAND'S S & T programs is the monitoring of global developments and technological advances to keep abreast with rapid technological changes. MOST's structure addresses this concern by operating 15 science attaches and offices in the U.S., Japan, Austria, Belgium, Germany, Russia, China, France, and Hungary. DOST only indirectly addresses this concern through a loose coordination with the Department of Foreign Affairs (DFA). Probably a more effective management control is to designate one undersecretary and one assistant secretary to supervise the five sectoral councils, another duo to supervise the seven R & D institutes, and a third set of top management to supervise the six S & T services groups. After all, these three undersecretaries and three assistant secretaries are accountable to the Secretary for their managerial performance.

Another similarity between MOST and DOST is the existence of a coordinating mechanism. For MOST, it uses three coordinating mechanisms: (1) National Science and Technology Council (under the Office of the Prime Minister), (2) Presidential Council on Science and Technology (which is required to submit quarterly reports to the President), and (3) Pan-National Conferences on Science and Technology Promotion (to address problems in the S & T sector). DOST's coordinating mechanism is the Science and Technology Coordinating Council (STCC) (chaired by the DOST Secretary and composed of eight other cabinet Secretaries, two representatives from the private sector and one from the academe) to oversee the implementation of the S & T development plans. While STCC can meet as frequently as its counterparts in MOST, DOST's effective command of bureaucracy for S & T development would be more compelling if STCC is headed by the President rather than by the DOST Secretary.

The other features of MOST and DOST that are similar are the following: information network structure (KORDIC for MOST and STII for DOST), centers of excellence program, science park program, science high school program, and government-supported R & D institutes. On the other hand, Korean Institute for Science and Technology (KIST) was successful in recruiting hundreds of Korean scientist and engineers working abroad. DOST's Balik Scientist Program has not been effective in attracting Filipino scientist and engineers working abroad. Korea has succeeded in strengthening and expanding S & T education at the tertiary level. Qualified faculty members were recruited from abroad, and educational institutions were established (such as the Kwang-ju Institute of Science and Technology, KJIST; and the Korean Advanced Institute of Science and Technology, KAIST). KAIST alone has produced 2,157 B.S, graduates, 8,200 M.S. graduates, and 2,011 Ph.D. graduates from 1973 to 1994.

If MOST and DOST are essentially comparable in structure, what explains the contrasting performance in the S & T development in their respective economies? Some analysts argue that the answer lies in the political will of Korean leadership and the consensus among its stakeholders to give top priority to

S & T development in the allocation of resources. On the other hand, DOST performance is described by Magpantay (1995):

> *The DOST is doing too many S & T activities, charged with too many functions, operating in a bureaucracy with too many constraints and given too little support.*

Another assessment of DOST (and the Philippine system of S & T management) concluded that STMP's 15 leading edges and STAND's 22 R & D priority areas are all-inclusive and practically cover all industries and all technologies with too little financial resources. For instance, the total budget for DOST (in U.S. dollars) in 1995 is less than the budget for one Korean RDI such as the Korean Institute of Science and Technology (Ki-Soo, 1996).

Two possible options for DOST's streamlining were suggested. One option is to create a lean and effective DOST. A cabinet-level agency with no regional and provincial units, responsible for drafting the S & T Development Plan that NEDA will have to take seriously in the drafting of the Medium Term Philippine Development Plan. This lean DOST consists of a technology management unit, an NSF-type funding unit, a technology venture capital unit, a unit in charge of data bank and information network, and an S & T secondary education unit. All government-supported research institutes will be privatized. The second option is to maintain the existing DOST structure, but institute the following reforms: (1) transfer PCARRD to DA, PCHRD to DOH, and other agencies to relevant departments, (2) embark on advanced education program for the staff of DOST's R & D institutes, (3) set-up a think-tank unit, (4) encourage non-performing staff to retire, (5) reduce the ratio of administrative staff to technical staff, (6) upgrade the criteria for hiring, promotion, and tenure, and (7) induce the private sector to set-up industrial research centers (Magpantay, 1995). Given the political, legal, and bureaucratic difficulties to be encountered if the first option is chosen, the second option seems to be in the realm of the possible.

DOST must therefore effectively address the following problems: (1) shortage of high-quality S & T manpower, (2) dependence on technology importation, (3) low level of private sector participation in R & D, (4) low level of basic research in core, strategic, and emerging technologies such as biotechnology, new materials science, robotics, and information technology, (5) lack of technology data bank and information network, (6) absence of science programs for the younger generation, and (7) insufficient financial resources for S & T development. But STMP and STAND already addressed some of these concerns. If R & D institutes are given the mandate to undertake R & D, and provide technical services, training, and consultancy, but only 2 percent of its personnel have Ph.D. degrees, then it is not surprising that R & D is neglected and training, technical services, and consultancy are instead pursued. DOST's concentration on these activities that can easily be undertaken by the private sector will not justify the government's continued intervention in the S & T sector. Traditionally, DOST should be responsible for R & D activities in the basic science, generic technologies and big science projects in collaboration with universities, while the private sector takes a leading role in search and development of new industrial technologies. This is not happening in the Philippines.

The most reasonable conclusion that can be made is that both STMP and STAND cannot be implemented. Their defects are the following: (1) budgeting and planning were not harmonized in the drafting of the S & T plan, (2) capabilities of implementing agencies were ignored, (3) solid support from various stakeholders was lacking, and (4) therefore resources for S & T development were insufficient. By any standards, the amount actually used for R & D in the DOST budget is absolutely too little.

X. Recommendations

The analysis of the previous sections leads to a conclusion that the S & T administrative system in the Philippines is comparable in form to that of Korea, but lags behind in performance. While successive attempts at S & T planning correctly identified the general problems in the sector, the projects and programs intended to address them are either too little too late or are implemented too haphazardly.

The following recommendations are intended to address the shortcomings of the present S & T management system:

A. Science and Technology Infrastructure

1. Strengthen S & T education at the elementary and secondary school level. The quantity and quality of elementary and secondary teachers of science and mathematics must be addressed in the Medium-Term Philippine Development Plan: 1999-2004.

2. A strong science and engineering program is also needed to support an expansion of science and engineering enrollment at the tertiary level. Expand the facilities of science and engineering institutions. Encourage the hiring of qualified faculty from abroad.

3. Intensify the effective recruitment of Filipino scientists and engineers working abroad by designing an incentive program that matches the cost of ESEP.

4. Expand the Philippine Science High School system.

B. Science and Technology Incentives

5. Implement the Scientific Career System (SCS) by allocating an annual funding for its implementation, but limiting entry into SCS by giving top priority on the target groups: natural scientists and engineers.

6. Undertake a competitive bidding strictly based on merit in the awarding of research projects by pooling a major portion of the country's R & D resources to be administered by an NSF-type agency.

7. Design an incentive package to encourage private sector R & D with strict qualifying requirements on what constitutes R & D activities. An external peer review committee is recommended to act as the screening mechanism.

C. R & D Delivery System

8. Reorganize the government-supported R & D institutes into a new corporate structure that gives them flexibility as well as responsibility to gradually develop its fiscal autonomy. The Crown Research Institutes (CRIs) of New Zealand is one model that needs to be examined. CRIs create opportunities

for better R & D collaboration and transfer of technology between the public and the private sector. Its structure also provides full commercial powers.

9. Establish funding schemes through DOST and CHED to support consortium or network of schools to maximize use of resources.

10. Focus funding support for developing core competence in targeted regional universities. For instance, University of San Carlos can specialize in chemistry and chemical engineering; MSU-IIT in mechanical engineering, and Xavier University in biochemistry and agricultural engineering.

11. Promotion of S & T culture by giving Presidential Awards to outstanding science and engineering projects selected through a nationwide competitive search. Encouragement of science TV and radio programs, fairs, plant tours, and apprenticeship.

12. Install a scanning and monitoring system of world technological trends for dissemination to local industries, research institutes and universities.

D. Science and Technology Coordination Mechanism

13. DBM must be involved with DOST in the S & T plan formulation stage so that S & T resources are available to implement the plan.

14. STCC must draft a Medium-Term Science and Technology Development Plan a year before the drafting by NEDA of the next Medium Term Philippine Development Plan. An inter-agency joint committee must integrate the Medium Term Science and Technology Development Plan into the Medium Term Philippine Development Plan by decomposing them into annual budget plan, annual S & T plan, and annual economic plan, and then harmonizing its goals, projects, programs, strategies, resource requirements, and timetables.

15. DOST must establish a Project and Program Monitoring Unit staffed by at most three persons whose main job is to coordinate the selection, through competitive bidding, of external evaluators and reviewers for the different projects and programs implemented under the S & T plan.

16. An STCC chaired by the President must meet at least once every three months to address current problems that pose obstacles to the implementation of the S & T plan. An MOT unit attached to DOST (just like PIDS is attached to NEDA) will act as the technical secretariat of STCC under the direct supervision of the DOST Secretary.

The government may give priority to Group D Recommendations (S & T Coordination Mechanism) over Group A Recommendations (S & T Infrastructure). However, while the planning and coordinating mechanism is lacking, this is a problem that the government can easily address in the short-term. The same applies to S & T Incentives[1]
(Group B Recommendations) and R & D Delivery System (Group C Recommendations). Therefore, developing the S & T Infrastructure is the most crucial and important aspect of S & T development. At current prices, it requires a minimum investment of P6 billion per year just to catch up with our Asian neighbors in terms of S & T infrastructures, facilities, curriculum, and personnel.

[1] Recommendation # 7 is different from those concerns addressed by R.A. 7459 (Investors and Invention Act of the Philippines). The latter addressed small-scale inventive and innovative activities in shopfloors of small inventors and entrepreneurs. It mainly addressed the concerns of the Filipino Inventors Society for recognition, intellectual property protection, cash awards, tax incentives, and financial assistance. The latter is focused on encouraging big science research and private sector industrial innovation (that cost billions of pesos) and requires incentives of the types shown in Tables 7 and 8.

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FIGURE 1
Organization Chart of Ministry of Science and Technology

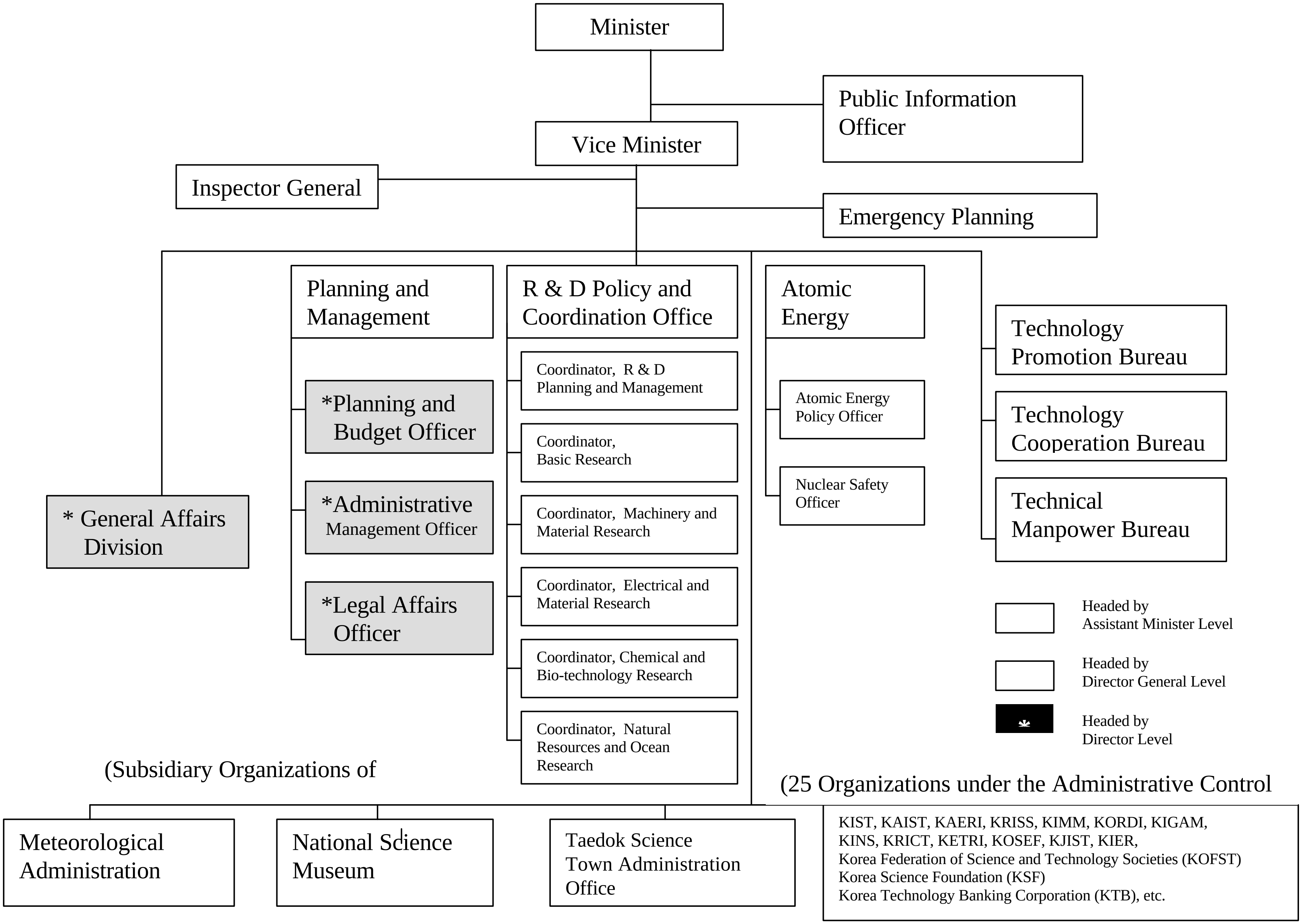
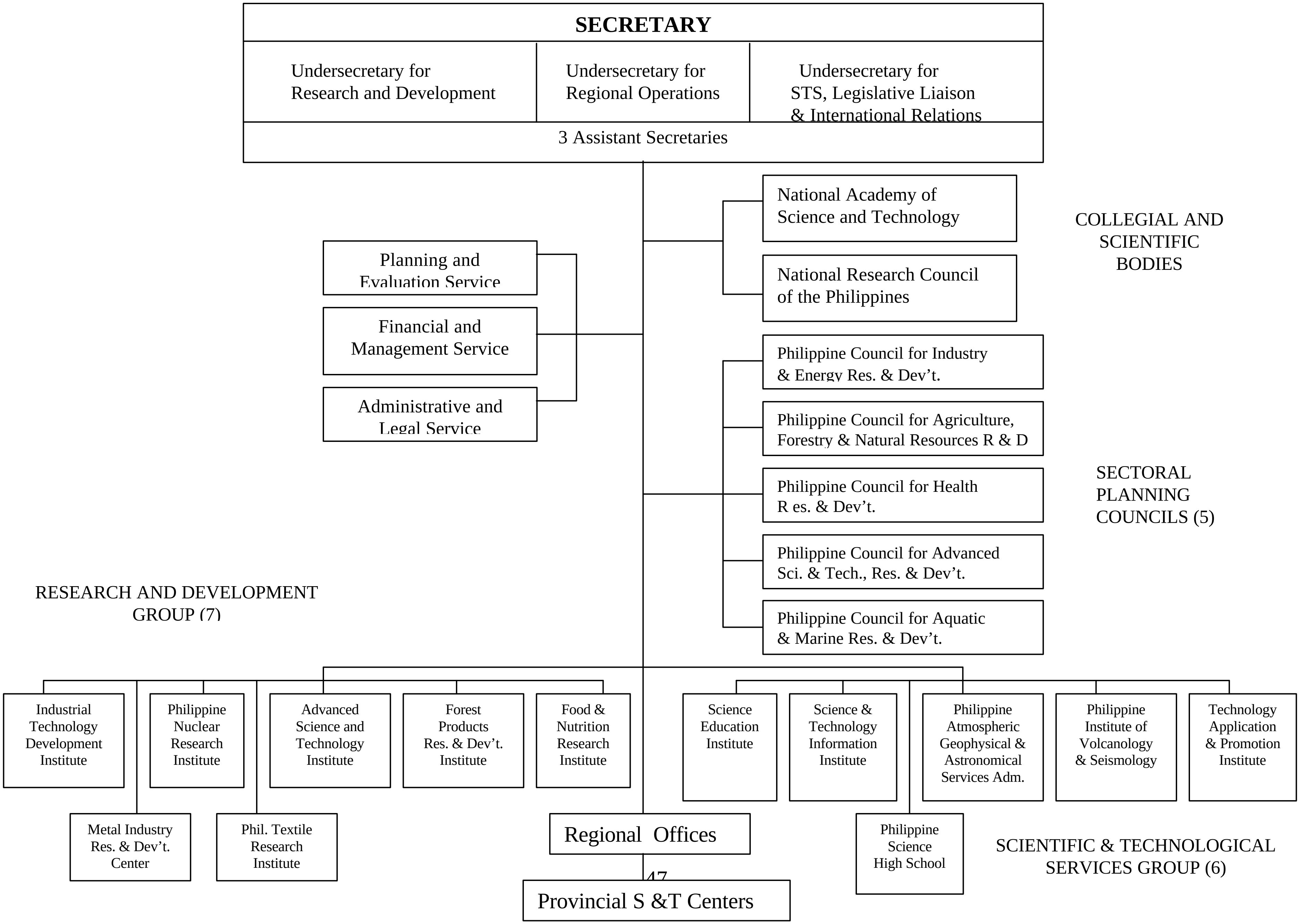


FIGURE 2

DEPARTMENT OF SCIENCE AND TECHNOLOGY

ORGANIZATIONAL CHART



APPENDIX 1

STMP PRIORITY SECTORS

1. Agriculture
2. Aquaculture and Marine Fisheries
3. Forestry and Natural Resources
4. Metal and Engineering
5. Textile Industry
6. Mining and Minerals
7. Process Industry
8. Food and Feed Industry
9. Energy
10. Transportation
11. Construction Industry
12. Information Technology
13. Electronics, Instrumentation and Control
14. Emerging Technologies
15. Pharmaceutical

Source: Science and Technology Master Plan, Department of Science and Technology (Manila, 1990).

APPENDIX 2

STAND PRIORITY LIST

A. Export Winners

1. Computer Software
2. Fashion Accessories
3. Marine Products
4. Fruits
5. Gifts, Toys and Housewares
6. Furniture
7. Metals Fabrication

B. Basic Domestic Needs

1. Food
2. Housing
3. Health and Nutrition
4. Clothing
5. Environment
6. Energy
7. Transport
8. Telecommunications
9. Defense
10. Manpower
11. Disaster/Hazard Mitigation

C. Support Industries

1. Packaging
2. Metals
3. Chemicals

D. Coconut Industry

1. Production
2. Processing
3. Development of New Products

Source: Science and Technology Agenda for National Development, Department of Science and Technology (Manila, 1993).