Research and Development and Technology in the Philippines

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PIDS
Philippine Institute for Development Studies
Surian sa mga Pag-aaral Pangkaunlaran ng Pilipinas

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This paper was prepared for the PIDS Perspective Paper Symposium Series and presented on September 5, 2002 as part of the Institute's celebration of its silver founding anniversary.

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Perspective Paper Series No. 10

PHILIPPINE INSTITUTE FOR DEVELOPMENT STUDIES
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ISBN 971-564-072-9
RP 12-03-500

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Foreword

The Philippine Institute for Development Studies (PIDS) celebrated its silver founding anniversary in 2002. In this connection, various activities were held to highlight the contribution and significance of policy research in governance as well as to commemorate more than two decades of providing competent research.

One of these activities is the Perspective Paper Symposium Series where the PIDS research fellows presented a perspective of the development and evolution of issues and concerns over the past 25 years in their respective fields of specialization such as infrastructure, banking and finance, science and technology, human resources development and labor markets, competition policy, poverty analysis and housing development. The 11 papers covered most of the themes in the PIDS research agenda and presented reviews of specific policy issues from where policy debates can proceed with greater focus.

Such outputs, however, are best disseminated in book formats so as to widen the reach of the excellent observations, analyses and recommendations put forward by the Institute's inhouse pool of researchers. Thus, the Institute presents 11 commendable titles under the *Perspective Paper Series* as its contribution to Philippine policy research.

It is with confident expectation that this *Series* will provide the essential answers to the concerns and gaps in various policy issues which the Institute has been trying to address in the last 25 years.

Economic growth is determined by how well a country mobilizes its resources to improve productivity in order to increase production of goods and services. Generally, resources include labor and human skills, capital, land and natural resources, while major factors affecting productivity are technology, research and development. The latter is the focus of this book.

Mario B. Lamberte

MARIO B. LAMBERTE, Ph.D.
President, PIDS

1
Introduction

This paper analyzes research and development (R&D) and technology from the perspective of Philippine economic growth. It examines the productivity performance of the economy and analyzes how it has been affected by developments in R&D and technology. It also assesses general R&D and technology policies alongside institutional structure and arrangements. National as well as specific sectoral gaps are identified, while weaknesses in institutional arrangements are highlighted. Insights for policy are derived from the analysis.

The paper has six sections. The next section focuses on the framework of analysis. The third section gives a brief discussion of some of the major historical developments in Philippine R&D and technology. The fourth section analyzes Philippine growth performance in terms of changes in structure and productivity. The fifth section identifies major gaps in R&D and technology in the country. The sixth and final section derives insights for policymaking.

2
Framework of Analysis

Economic growth is determined by how well a country mobilizes its resources to improve productivity in order to increase production of goods and services. Generally, resources include labor and human skills, capital, land and natural resources, while major factors affecting productivity are technology, research and development. The latter is the focus of the paper.

Generally, there are two approaches to economic growth. One approach is to increase the utilization or the amount of factor inputs or resources for production. For example, increasing the utilization of available arable land, which had been previously considered idle, can expand output from agriculture. One drawback of this approach is that if one keeps on increasing the amount of the same factor inputs into the production process, the increase in the level of output that can be generated will eventually be subject to diminishing returns. Stated graphically in terms of production function, output increases rapidly at the initial stage (around point a in Figure 1). However, if one keeps on adding the amount of the same factor input, the increase in output may not be as much as in the initial stage (movement toward point b along production function 1).

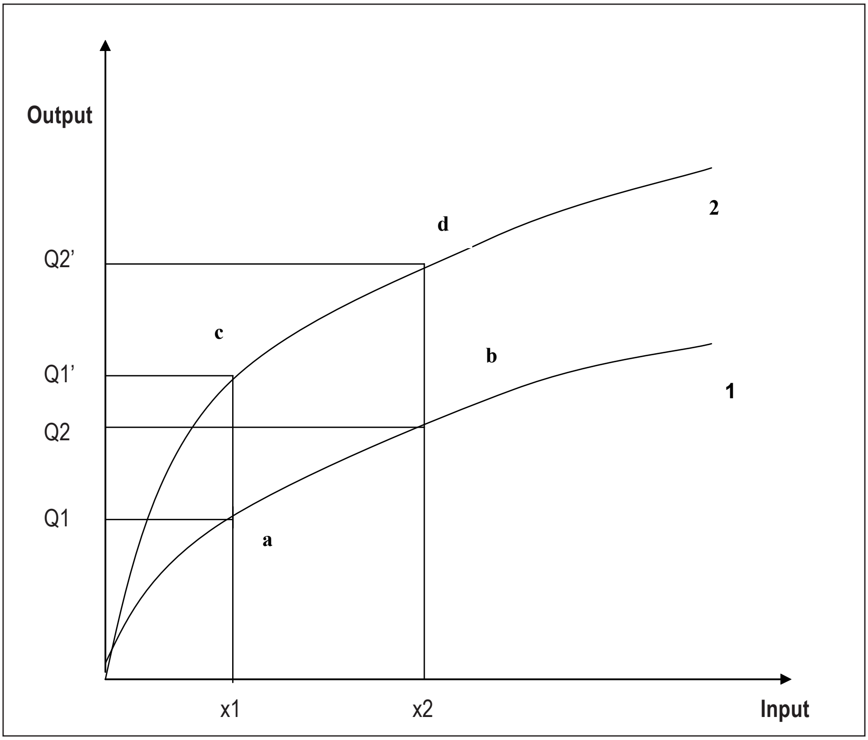
Krugman (1994), in a highly controversial paper titled “The Myths of Asia’s Miracle,” which appeared in *Foreign Affairs*, argues that Singapore’s rapid growth was due to capital accumulation, and certainly not a “miracle.” Its growth path is similar to the capital accumulation type of growth of the Soviet Union, which first experienced rapid growth during the 1950s and then suffered a significant economic slowdown later, having reached its limits. “Economic growth that is based on expansion of inputs, rather than on the growth of output per unit of input, is inevitably subject to diminishing returns,” he says.

The second approach deals with improved productivity through more efficient utilization of the same amount of inputs. Stated graphically, this means an outward shift in the production function (from 1 to 2 in Figure 1). Thus in this shifted production function, for every level of factor input, there is a corresponding higher level of output, indicating a higher productivity of output per unit of input (from point a to point c, and from point b to d). The productivity improvement could largely be due to the introduction of the process of technological innovation in production. The process of technological innovation could involve a range of activities such as the utilization of better machinery, use of better production management and methods, and the application of best practices, whether in factories or in offices.

Technological innovation and economic growth are mutually reinforcing (Hirono 1985). That is, higher rate of growth tends to generate productivity improvement through technology innovation through research and development, and vice versa. This is especially true when there are increasing returns to scale. In such cases, the outward shift of the production function would have no boundaries, implying the absence of limits to growth.

Historically, the whole idea of technology affecting economic growth dates back to the 18th and 19th centuries when scientific principles, which had accumulated since the start of modern science in 16th and 17th centuries, were turned into technologies and applied to the process of production during the Industrial Revolution in Western Europe. The steam engine, for example, which triggered the start of the Revolution, was the result of the accumulation of knowledge through scientific discoveries and the application to the process of production.

Figure 1. Production function



However, the relationships between technological innovation and economic growth were made evident by the remarkable experience of Japan after the World War II and South Korea after the Korea War in 1960s. Through technological development policies that started to turn the wheel of technological innovation process, these countries were able to achieve rapid economic growth in a sustained manner. In a significantly shorter period of time compared to Western Europe, these countries were able to transform their economies from almost completely devastated right after the war into highly advanced industrial economies at present.

The process of technological innovation referred to here (Figure 2) was conceptualized by Yamada (1964) and later cited by Choi (1983). As shown in the figure, it is a dynamic process of progressive technological advances and economic growth, each one reinforcing the other. The process continues in a sustained manner, and in each round growth improves.

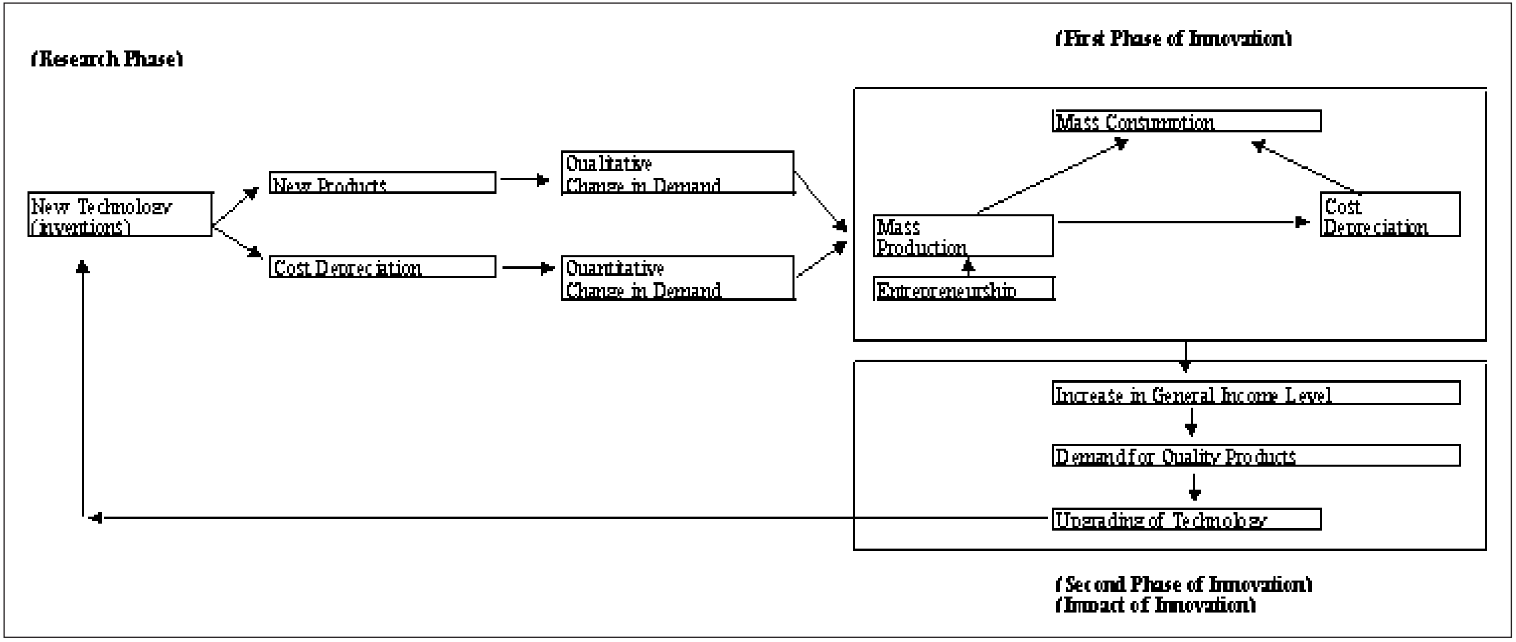
Generally, technological innovation involves two major parts—research and innovation. The innovation part consists of two phases. In the first part, the introduction of new technology leads to new products and reduces the cost of production. These new products have better quality than before. Because of the reduction in cost per unit, for the same total cost of production, the quantity of output that could be produced would increase. Better quality products and greater volume of production result in mass production that could attract entrepreneurs to increase their marketing effort and could further reduce cost because of economies of scale. Mass production and lower cost could result in mass consumption. These whole set of activities could lead to improved income for the general public. Increased income could lead to changes in taste, which in turn could result in higher demand for more quality products. This impulse could trigger pressure to improve the existing technology. Thus, the entire process repeats itself and continues in this cycle toward economic prosperity.

The outstanding performance of Japan and South Korea is worth noting. They have been able to close their technological gap with highly advanced industrial countries in so short a period of time. From the perspective of developing countries, the question to ask is: Can this fast catching-up process generally hold for the rest of technologically backward countries? There are two schools of thought on this issue that ought to be reviewed briefly because of their implications on the Philippine case.

The first school of thought,[1] which started with Gerschenkron's (1962) discussion of the advantageous backwardness, deals with the issue of convergence (Barro and Sala-i-Martin 1995). The convergence school states that technologically backward countries benefit from the technology created by advanced countries. One of the strongest postulates of this school categorically states that the "... catch-up growth is proportional to the difference in technological capabilities between a follower and the leaders.

[1]The paper of Evenson and Westphal (1995) provides a good survey of literature on this issue.

Figure 2. Technological innovation process



Source: Quoted from Choi (1983) but original source is Yamada (1964).

This predicts an inverse relationship between technological capabilities at any point in time and subsequent productivity (as well as economic) growth" (Evenson and Westphal 1995).

Through technology transfer, backward countries can catch up with advanced nations. With appropriate policies and investments on education, physical capital, general management capability, research and development (R&D), backward countries can learn the technology developed in advanced nations. Along with these developments is a convergence of income and productivity levels.

The other school argues that the process may not be that easy and straightforward. Although newly industrialized countries (NICs)[2] have grown rapidly in recent times and have in fact converged to the leading countries in terms of income and productivity, most developing countries are not on a similar path of convergence toward advanced nations. In fact, there is a divergence (Easterly 1981; Williamson 1991). A whole range of factors may be responsible for the divergence and the widening gap between most developing countries and advanced nations. These factors can include adverse institutions and deficient policy regimes. Choi (1983) includes a number of factors like the vicious circle of poverty in which most developing countries are trapped. He cites other factors:

- Developing countries are weak in policy formulation for scientific and technological development. In these countries, public interest in science and development is low. Their traditional cultures are hostile and can pose hindrances to the creation of viable science policy.
- There is lack of viable institutional setups and inadequate R&D systems in these countries. Often, research equipment is inadequate, research budgets are nil, and research budget allocation is extremely inefficient.
- There is very limited scientific manpower in these countries.
- Most of these countries rely heavily on imported technology. However, there are no clear-cut policies and programs to develop domestic capability to modify and improve these imported technologies for domestic applications. There are no policies to address technology dependence.
- There is lack of participation of relevant sectors in these economies in the development of science and technology, particularly in the industrial sector to which most of the applied research and development efforts are directed.

[2]Generally known to include South Korea, Hong Kong, Singapore, and Taiwan.

3

Historical Development in R&D and Technology in the Philippines[3]

Philippine science and technology (S&T) has a long history, dating back to the early American colonial period during which the Bureau of Science was created. The American government, through this Bureau, formed the Philippine S&T. However, the coverage was very limited. It mainly focused on agriculture, health and food processing. Thus, because of the colonial economic policy, the development of industrial technology was largely neglected.

Moreover, the public school system was created at about the same period. Through the creation of the University of the Philippines (UP) system and the various S&T-related agencies and laboratories, the Bureau became effectively the training ground for Filipino scientists.

Major shifts in the direction of Philippine S&T took place right after the proclamation of independence in 1946. It was reorganized into an Institute of Science and was put under the Office of the President of the Philippines. Despite these changes the real effects in terms of its impact on the economy were marginal. The Institute suffered from lack of support, planning and coordination. In fact, the Bell Mission's Recommendation mentioned that the Institute had no capability to support S&T development for lack of basic information, neglect of experimentation, and small budget for R&D activities.

There were also major shifts in the 1950s and 1960s that focused on S&T institutional capacity building. This was done through the establishment of infrastructure-support facilities like new research agencies and manpower development. Again, the effects were not significant. The usual problems of lack of coordination and planning, especially technology planning, prevented the system from effectively performing its functions. This was manifested in the unplanned activities of the researchers within the agencies. Most areas of research were left to the researchers to define under the assumption that they were attuned to the interests of the country. They were expected to look for technologies and scientific breakthroughs with

[3]Partly based on Eclar (1991) and K-Soo (1996).

good commercialization potential. Without clear research directions, researches were done for their own sake, leaving to chance the commercialization of the output.

In response to these problems and to the need for S&T to generate products and processes that were supposed to have greater beneficial impact on the country, focus was re-directed toward applied research in the 1970s. Furthermore, in the 1980s, research utilization was given stronger emphasis. This led to a reorganization and creation of the National Science and Technology Authority (NSTA) in 1982. One rationale for the reorganization was the need for an effective and efficient utilization of the results of R&D activities through greater commercialization of outputs. A significant innovation under the reorganization was the creation of the S&T Council System, which became responsible for the sectoral formulation of policy and strategies for its specific field and allocation of funds. There were four councils under the system: PCHRD, PCIERD, PCARRD and NRCP (Table 1 for the exact names of the councils and institutes under the DOST). Later, the NRCP was replaced by PCAMRD and PCASTRD. The NSTA, for its part, had eight research and development institutes and support agencies under it. In the mid-1980s, regional offices for S&T promotion and extension were established to further hasten the development of S&T. There was also a conscious effort to assist and encourage creative local inventors through institution building and support measures. A national center for excellence for the basic sciences was established in the UP campus. A scientific career system was also created to attract scientists to a career path that would professionalize and upgrade their status. Furthermore, linkage between the academe and the private sector was strengthened with the creation of institutional networks.

The creation of the councils and research institutes under the NSTA showed a clear shift in science policy from one of a technology push to a demand-pull strategy. In this strategy, user and market demand serve as the basis for conducting R&D / S&T programs. Thus, scientists and researchers were placed in R&D programs whose results were supposed to have high demand potentials.

After the EDSA Revolution in 1986, the NSTA was reorganized into what is now called the Department of Science and Technology (DOST) by

Table 1. DOST councils

PCARRD	Philippine Council for Agriculture, Forestry and Natural Resources Research and Development
PCAMRD	Philippine Council for Aquatic and Marine Research and Development
PCIERD	Philippine Council for Industry and Energy Research and Development
PCHRD	Philippine Council for Health Research and Development
PCASTRD	Philippine Council for Advanced Science and Technology Research and Development
NRCP	National Research Council of the Philippines

virtue of Executive Order 128. The DOST, being headed by a Cabinet secretary, was mandated to continue providing central direction, leadership and coordination of S&T efforts and formulation and implementation of policies, plans, programs and projects for S&T development.

For a more effective delivery of certain functions, the DOST was further restructured, resulting in the establishment of the Technology Application and Promotion Institute (TAPI). This institute was created to serve as the implementing arm of the DOST in pushing for the commercialization of technologies and marketing the technology services of other operating agencies of the Department. In addition, the Science Education Institute (SEI) was created to undertake and formulate plans for the development of S&T education and training in the country. Moreover, the Science and Technology Information Institute (STII) was established to serve as the information arm of the Department through the development and maintenance of an S&T databank and information networks.

The National Institute of Science and Technology was reorganized into the present Industrial Technology Development Institute, which will undertake applied R&D, transfer R&D results to end-users, and provide technical, advisory, and consultancy services in the fields of industrial manufacturing, mineral processing, and energy. Entry into the advanced technology areas was formalized with the creation of the Advanced Science and Technology Institute (ASTI). In line with this, additional S&T councils, namely, the PCASTRD and the PCAMRD, were created to further strengthen the Council system.

Furthermore, the leadership of DOST placed greater emphasis on massive technology transfer activities. It also initiated specific interventions through various programs such as the Comprehensive Technology Transfer and Commercialization (CTTC). The CTTC was intended to serve as a mechanism for identifying and pushing concrete results of R&D toward productive application and utilization. The initial phase of the program that covered the period 1989-1992 included a number of technologies whose utilization was envisioned to create substantial impact on the national socioeconomic development process and on the lives of many Filipinos, in general. The program covered areas such as financing, technology packages and training centers.

In most R&D institutes technology transfer units were established to carry out the added responsibility of transferring completed researches. Provincial S&T centers were set up to help ensure the efficient and effective transfer of technologies in the provinces.

S&T services were also provided to supplement R&D and technology transfer. Such services included the upgrading of testing, standardization and quality control services and various forms of technical assistance and consulting services. Assistance to investors was also provided. This consisted of patenting assistance for inventions with commercial potentials; assistance in the availment of financing for commercially viable inventions; marketing assistance; support to pilot plant operations for selected top-priority technologies for commercialization; and support to the upgrading of inventions, expertise and capabilities.

R&D institutes undertook contract researches to foster the collaboration among the institutes, the private sector and the academe. Furthermore, they initiated funding assistance to technology developers and acceptors through tie-ups with financing institutions such as the Development Bank of the Philippines, Technology Livelihood Resource Center, LandBank, and Private Development Corporation of the Philippines.

Incentives were provided under the Omnibus Investment Law for the conduct of certain R&D and S&T activities in the private sector. The major incentives included income tax holiday, duty-free importation of capital equipment, deduction from taxable income for the necessary and major infrastructure and facilities in less developed areas, access to bonded manufacturing/trading warehouse system and employment of foreign nationals.

To facilitate the transfer of foreign technology, science parks were set up. These parks were also intended to a) serve as vehicles for university interaction with private industry; b) develop new knowledge-based industries and strengthen existing ones; and c) provide a propitious environment for innovation and contract research. Moreover, technology business incubators were initiated in certain areas to assist the transfer and commercialization of technologies by helping ensure the survival and successful growth of new technology firms by providing them with appropriate marketing, financial, technical, and management assistance.

In 1998 a presidential task force on S&T was formed to deal with the overall problems confronting R&D and S&T development in the country, and to formulate an S&T development plan that would support the national development goal of attaining a newly industrialized country status by the year 2000. The task force was composed of DOST, DA, DTI, DOTC,[4] as well as the presidential adviser on public resources and three academic institutions directly involved in S&T. The task force submitted a report to the President in March 1989, embodying the development of 15 leading edges to steer the country toward industrial development. These 15 leading edges were: (1) aquaculture and (2) marine fisheries, (3) forestry and (4) natural resources, (5) process industry, (6) food and (7) feed industry, (8) energy, (9) transportation, (10) construction industry, (11) information technology, (12) electronics, (13) instrumentation and control, (14) emerging technologies, and (15) pharmaceuticals.

To attain the objectives set in the S&T Master Plan (STMP), the following strategies were pursued: modernize the production sectors through massive technology transfer from domestic and foreign sources; upgrade the R&D capability through intensified activities in high priority

[4]DA – Department of Agriculture; DTI – Department of Trade and Industry; DOTC – Department of Transportation and Communication.

sector and S&T infrastructure development such as manpower development; and develop information networks, institutional building and S&T culture development (Tables 2 to 3).

During the Ramos administration, the DOST initiated a Science and Technology Agenda for National Development (STAND Philippines 2000), which embodied the country's technology development plan in the medium term, in particular, for the period 1993-1998. The STAND identified seven export winners, 11 domestic needs, three other supporting industries, and coconut industry as priority investment areas. The seven identified export winners were computer software; fashion accessories; gifts, toys, and houseware; marine products; metals fabrications; furniture; and dried fruits. The domestic needs included food, housing, health, clothing, transportation, communication, disaster mitigation, defense, environment, manpower development and energy. Because of their linkages with the above sectors, three additional support industries were included in the list of priority sectors, namely, packaging, chemicals and metals. Lastly, because of its strategic importance, the coconut industry was included in the list.

The very recent S&T framework plan is entitled "Competence, Competitiveness, Conscience: The Medium-Term Plan of the Department of Science and Technology (1999-2004)." Although this plan has not yet been fully analyzed because it has not been subjected to any critical

Table 2. Summary of science and technology policies by strategy

1. Modernization of production sectors
   a. Generation and active diffusion of employment-oriented and high value-added technologies
   b. Emphasis on developmental R&D toward commercialization
   c. Proper selection and acquisition of essential and appropriate technologies
   d. Adaptation, absorption and mastery of imported technologies
   e. Dissemination of appropriate technology
   f. Technologies with increasing accessibility to S&T information and services
   g. Reducing environmental degradation and mitigating adverse impacts of natural hazards

2. Upgrading of R&D activities
   a. Establishing R&D priorities
   b. Development of local materials and indigenous technologies
   c. Stimulation of private sector participation
   d. Reducing environmental degradation and mitigating adverse impacts of natural hazards

3. Development of S&T infrastructure
   a. Development of high-quality S&T manpower in growth areas
   b. Expansion of S&T education and training
   c. Development of S&T institutions
   d. Development of an S&T culture

Source: Eclar (1991)

Table 3. Summary of S&T policy programs in the Philippines

		Policy and Program	Brief Description
1	**Modernization of the Production Sectors**		
	A	Comprehensive Technology Transfer and Commercialization Program (CTTC)	The CTTC serves as a mechanism to link technology generators and users. It aims to hasten the process of industrialization through commercialization of technologies whose utilization is envisioned.
	B	Support programs to the CTTC	
	B-1	Production of technology packages	Provision of info and economic feasibility studies
	B-2	Investors fora	Venues for technology generators
	B-3	National and regional technology fairs	Organized to showcase new technologies for transfer
	B-4	Technology financing programs	Funding assistance to technology
	B-5	Information services	Info packages on mature technologies
	B-6	DOST training centers	Conduct technology training
	B-7	Regional and provincial S&T centers	Ensure the transfer of technologies
	B-8	DOST Academy Technology Business Entrepreneurship Development Program	Link between DOST and the academe for technology commercialization
	C	Technology business incubators	Assists new technology firms through technical, financial, and marketing assistance
	D	Science and technology parks	Facilitates the transfer of university-industry interaction in advanced technology
	E	Global search for technology	Search and acquisition of commerciable technologies abroad
	F	Program of assistance to investors	Assistance to patenting, financing and marketing
2	**Upgrading of R&D Activities**		
	A	R&D priority plan (export winners, basic needs, and coconut industry)	Indication of preferred areas of R&D domestic
	B	Grant-in-aids program	Support of R&D activities
	C	Contract Research Program	Sponsored research with other agencies
	D	R&D Incentive Programs	Incentives for the conduct of R&D activities
3	**Development of R&D Infrastructure**		
	A	Manpower Development Program in Science and Engineering	Graduate and undergrad scholarship program in priority areas
	B	Grade school and secondary school level	Development of the grade school network serving as feeder schools for HS and technical schools
	C	Vocational and Technical Education	Development of vocational and technical schools in the industrializing areas
	D	Scientific Career System (SCS)	Career path for scientists that will develop their technical expertise
	E	Utilization of Filipino exports	Employment of Filipino expatriates
	F	Recognition of S&T efforts	Conferment of the rank and title of National Scientists
	G	Balik Scientists Program	Taking advantage of trained Filipino scientists and engineers thru information exchange
	H	Development of S&T culture	Promotion of science consciousness and innovativeness
	I	Organizing and strengthening of S&T	Strengthening of S&T sectoral network and establishment of new S&T institutions and mechanisms

discussion, its six flagship programs are worth mentioning here: comprehensive program to enhance technology enterprises; integrated program on clean technologies; establishment of a packaging R&D center; expansion of regional metrology centers; S&T intervention program for the poor, vulnerable and disabled; and comprehensive S&T program for Mindanao. Although the vision and direction of the plan is novel, there are no specific implementation rules and guidelines.

4
Philippine Growth Performance

Philippine growth and structural change

The last 35 years have seen a “roller-coaster” Philippine economic growth performance. Growth was highest during the 1973-82 period, averaging 5.5 percent per year (Table 4). This was the peak period of the Marcos regime, which was not sustained, however, as dissatisfaction among Filipinos with the military regime mounted. This situation eventually led to a political uprising in the period 1983-85. The political crisis triggered an economic crisis that resulted in an economic collapse. The economy contracted by –4.1 percent per year during this period.

The Marcos administration was finally forced out of power in the early 1986, which gave way to Aquino government. Thus, in the following period, 1986-90, the euphoria brought about economic recovery under the new government. Growth was averaging 4.5 percent per annum during this period. However, toward the end of the Aquino administration, a political tug-of-war led to a series of military coup attempts. Although the attempts failed, they created political uncertainties and instability. This, together with the series of natural calamities and energy crisis, brought the economy to a halt in the 1991-93 period. The economy contracted again by –0.1 percent per year during the period.

Table 4. The Philippine economy (in percent)

	GDP Growth	Employment Growth	Export/GDP	Import/GDP
1967-72	4.8	3.3	13.6	17.4
1973-82	5.5	3.1	16.0	22.8
1983-85	-4.1	3.2	15.4	20.4
1986-90	4.5	2.1	17.4	23.0
1991-93	-0.1	3.7	19.5	30.2
1994-97	4.9	3.3	24.5	39.3
1998-2000	3.5	-0.3	45.8	43.2

Sources: National Income Accounts, Philippine Statistical Yearbook, and Selected Philippine Economic Indicators

The Ramos administration revived the economy with a growth averaging 4.9 percent per year from 1994 to 1997. However, the Asian financial crisis, the El Niño effects on agricultural production in 1998, and the political scandals that wreaked havoc on the Estrada administration took a heavy toll on the economy. Growth slid to 3.5 percent per year in the 1998-2000 period. Indeed, the last 35 years was a period of boom-and-bust growth cycle. Economic growth could not be sustained. Weak economic and political fundamentals were believed to be the major forces behind such dismal performance.

Employment performance, however, was generally not as disappointing. Employment growth was averaging more than 3 percent per year over the years, except for the last period, 1998-2000, when it contracted by -0.3 percent per year.

Major economic policy shifts occurred when the Aquino government took over in 1986. Structural reforms like trade liberalization, foreign exchange liberalization, investment reforms, banking reforms, privatization, among others, were implemented. These reforms intensified in the 1990s and are still being pursued today.

One of the major results of these reforms is the increasing share of foreign trade in the Philippine economy. From 13.6 percent export-to-GDP ratio in the 1967-72 period, the share increased to 45.8 percent in 1998-2000. Similarly, import-to-GDP ratio increased from 17.4 percent to 43.2 percent over the same period. The rise in the trade sector is mainly attributed to the recent surge in the demand for semiconductors in the world market. To date, almost 60 percent of the country's exports consist of the highly raw-material-import-dependent semiconductors.

However, in spite of the reforms and the dramatic rise in foreign trade, apparent signs of structural weaknesses prevail in the local economy. These are seen in the stagnating share of industry in general and of manufacturing in particular in the last 35 years (Table 5). The share of industry picked up from 31.7 percent in the 1967-72 period to 37.4 percent in 1983-85. It has declined since then and continued its decent to 30.9 percent share in 1998-

Table 5. Production structure (in percent)

	Gross Value Added Shares			
	Agriculture	Industry	Manufacturing	Services
1967-72	29.3	31.7	24.7	39.0
1973-82	27.9	36.8	25.6	35.3
1983-85	23.9	37.4	24.7	38.7
1986-90	23.1	34.7	25.0	42.2
1991-93	21.5	33.2	24.4	45.4
1994-97	20.7	32.2	22.8	47.0
1998-2000	17.2	30.9	21.9	52.0

Sources: National Income Accounts, Philippine Statistical Yearbook

2000. A similarly dismal record for the manufacturing sector is observed over the same period. The drop in the share of agriculture showed up in the increasing share of the service sector.

The disappointing and stagnating share of industry and manufacturing sectors is also observed in the structure of employment. Employment share in industry is about 15 percent and 10 percent in manufacturing. These shares have practically stagnated as compared to the rising employment share in the service sector.

The contrasting performance of the foreign trade sector and the industrial sector in general and the manufacturing subsector in particular in terms of output and employment generation in the midst of policy reforms indicate the absence of "trickle-down" effects. Considering that these policy reforms have been pursued for quite some time, the lack of concrete trickle-down effects strongly implies a high degree of duality existing between the local and foreign sectors.

Total factor productivity

Productivity indicators that are available in Philippine literature show poor performance. In fact, estimates suggest negative TFP[5] growth, indicating that it has not been a source of economic growth.

Cororaton and Cuenca (2001) have updated the TFP estimates of Cororaton and Caparas (1998) from 1980-1996 to 1980-1998, using growth accounting method in translog form at the level and major sectors of the economy. Some insights were drawn from the estimates. At the sectoral level, the results are mixed. Some sectors showed improving TFP in the 1990s, while others have declining TFP, especially the nontradable service sectors, like real estate. Because of this the economy as a whole saw a decline in TFP in 1990s. The decline may be due to capital movement toward the nontradable sectors during the period when foreign capital inflow surged, which in turn was aggravated by the prolonged real appreciation of the local currency.

De Silva (2001) has applied growth accounting method to estimate TFP. Her estimation period was much longer, from 1971 to 1998. Of her major findings, she says, "From 1990 to 1997, the average TFP growth is estimated at –0.8 percent, only a slight improvement from the average rate estimated for the 1980s." On the whole, "The movements of total factor productivity (TFP) indicate that it did not drive the growth of real output during the past 25 years."

Austria (1998), using a macrodynamic model with output and inflation interaction, showed that the TFP for an extended period of time, 1967 to 1997, declined by -0.47 percent. Lim (1998), using a Cobb-Douglas

[5]Total factor productivity (TFP) growth takes into account labor and capital inputs together in productivity computation.

production function, showed negative TFP for industry and services, sectors that account for 75 percent of GDP.

However, Cororaton and Abdula (1997) showed slightly positive TFP for the manufacturing sector. However, in the TFP study they conducted on specific industries within the manufacturing sector, Cororaton et al. (1996) observed that the number of manufacturing industries with negative TFP increased from 1956 to 1992, while the above average TFP for the entire manufacturing sector was slightly above zero.

In a very recent TFP research, Cororaton (2002) attempted to extend the estimation period from 1967 to 2000; decompose the contribution of labor types; decompose the effects of sectoral movement of labor; and analyze the factors determining TFP. The major findings of the paper are as follows:

- *TFP estimate and sources of growth*. Annual TFP estimates from 1967 to 2000 are presented in Table 6, while the three-year moving average of the business-fluctuation-adjusted TFP is shown in Figure 3. In most of the years in the last 35 years, TFP fell below zero. Positive estimates are seen in the second half of the 1980s and toward 2000.

Interesting results may be observed in the analysis of the decomposition of output growth in Figure 4 in which TFP is considered as one of the contributing factors during the different critical subperiods over the past 35 years. While it may be true that the contribution of TFP to the overall economic growth has been negative, in terms of trend in an extended period it has improved. For example, from –4.26 percentage points in GDP growth in the subperiod 1983-85, it improved through the years to reach a contribution of +0.93 in the last subperiod, 1998-2000. This may be due to the effects of various economic policy reforms pursued in the last decade.

Through the years, capital is the largest contributor to growth.

- *Decomposition of TFP growth*. There have been sizeable changes in the structure of labor quality over the years. The share of skilled workers, loosely defined as those who have at least finished high school, increased from 19 percent in 1967-72 to 45 percent in 1998-2000 (Figure 5).

There are, however, noticeable labor movements across sectors. Agriculture, which used to employ 56 percent of labor in 1967-72, has declining employment share. In 1998-2000, its employment share dropped to 38 percent. Labor moved to the service sector and not to the industry sector. The share of service sector employment increased from 29 percent in 1967-72 to 45 percent in 1998-2000. Employment share in industry hovers around 16 percent.

What are the effects of these factor changes on TFP? Table 7 presents the results of decomposing the effects of labor quality on TFP. The results are presented per subperiod. The second column is the unadjusted TFP, which are period averages of the same estimates that appeared in Table 6. The third column presents the results for TFP growth adjusted for quality of labor. The last two columns compare the estimates by taking the difference and the ratio. A higher difference will imply a bigger contribution of labor

Table 6. Estimated Philippine total factor productivity

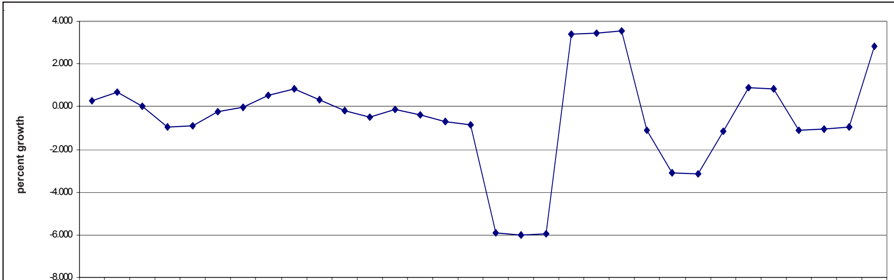
Year	Unadjusted TFP	Business Fluctuation Adjustment Factor	Business Fluctuation Adjusted TFP	3-Year Moving Average Adjusted TFP
1967	-5.11	-3.8206	-1.293	
1968	1.13	1.1588	-0.032	0.280
1969	6.79	4.6197	2.166	0.670
1970	0.67	0.7964	-0.125	0.033
1971	-4.71	-2.7647	-1.943	-0.976
1972	-0.15	0.7088	-0.859	-0.884
1973	5.53	5.3769	0.151	-0.217
1974	-1.95	-2.0102	0.056	-0.021
1975	-4.32	-4.0452	-0.272	0.535
1976	7.07	5.2500	1.822	0.859
1977	1.01	-0.0134	1.027	0.331
1978	-7.45	-5.5928	-1.855	-0.170
1979	0.98	0.6572	0.318	-0.485
1980	3.72	3.6401	0.083	-0.146
1981	-1.69	-0.8533	-0.840	-0.373
1982	-0.76	-0.3997	-0.360	-0.701
1983	-4.20	-3.3004	-0.902	-0.875
1984	-8.77	-7.4009	-1.364	-5.901
1985	-8.36	7.0756	-15.438	-6.014
1986	1.78	3.0208	-1.239	-5.938
1987	1.23	2.3696	-1.136	3.410
1988	6.28	-6.3261	12.606	3.444
1989	1.51	2.6487	-1.138	3.517
1990	0.69	1.6101	-0.916	-1.104
1991	-4.92	-3.6642	-1.258	-3.103
1992	-3.50	3.6341	-7.134	-3.160
1993	-1.22	-0.1330	-1.089	-1.147
1994	0.56	-4.2166	4.781	0.869
1995	1.35	2.4392	-1.086	0.827
1996	1.60	2.8100	-1.214	-1.085
1997	1.06	2.0206	-0.956	-1.041
1998	-1.36	-0.4103	-0.954	-0.954
1999	2.50	3.4493	-0.951	2.818
2000	4.74	-5.6227	10.360	

quality to TFP growth. In terms of ratio, the further it deviates from 1 the bigger its TFP contribution becomes.

In spite of the increasing share of skilled labor to total employment, its contribution to TFP has declined. The drop is quite evident in Figure 6. From 2.11 percentage point contribution to TFP growth, it declined to 0.16 in 1991-93. It started to recover, however, in the succeeding subperiods, but still way below its contribution in the earlier periods.

This decline may imply a number of things. First, it may be true that skilled labor, as loosely defined in terms of level of schooling, may not have

Figure 3. Three-year moving average business-fluctuation-adjusted TFP growth

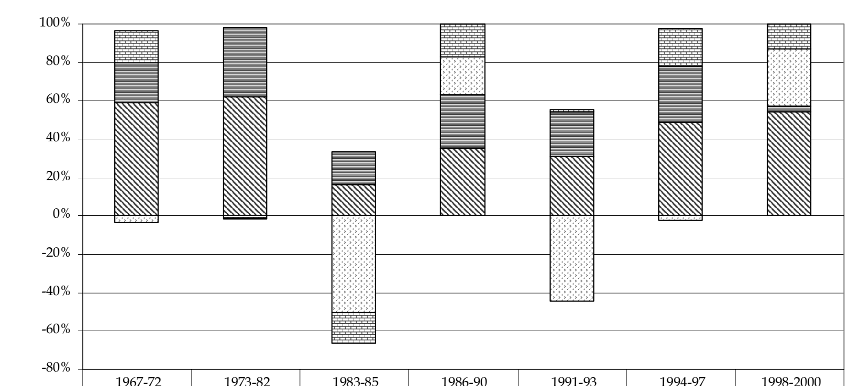


year/value	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Series1	0.280	0.670	0.033	-0.976	-0.884	-0.217	-0.021	0.535	0.859	0.331	-0.170	-0.485	-0.146	-0.373	-0.701	-0.875

year/value	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Series1	-5.901	-6.014	-5.938	3.410	3.444	3.517	-1.104	-3.103	-3.160	-1.147	0.869	0.827	-1.085	-1.041	-0.954	2.818

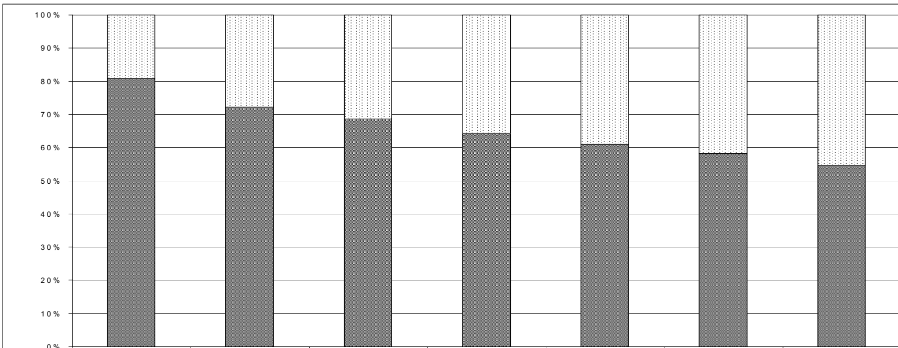
year/value

Figure 4. Decomposition of output growth



	1967-72	1973-82	1983-85	1986-90	1991-93	1994-97	1998-2000
Bus Fluc	0.88	-0.05	-1.34	0.58	0.08	0.90	0.41
TFP	-0.18	-0.04	-4.26	0.67	-2.47	-0.11	0.93
labor	1.06	1.93	1.46	0.94	1.28	1.31	0.08
capital	3.07	3.33	1.38	1.18	1.73	2.22	1.71

Figure 5. Types of labor

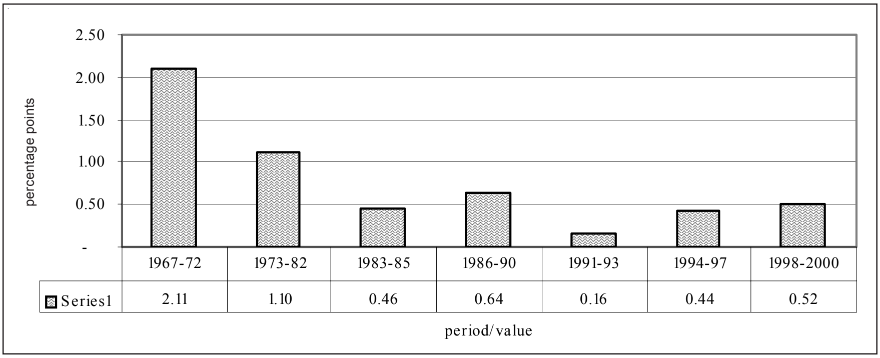


	1967-72	1973-82	1983-85	1986-90	1991-93	1994-97	1998-2000
skilled	0.19	0.28	0.31	0.36	0.39	0.42	0.45
unskilled	0.81	0.72	0.69	0.64	0.61	0.58	0.55

Table 7. Effects of labor quality on TFP

Period	Unadjusted TFP	TFP Adjusted for Labor Quality	Difference: (Unadjusted -Adjusted)	Ratio: (Unadjusted/Adjusted)
1967-72	(0.23)	(2.34)	2.11	0.10
1973-82	0.21	(0.89)	1.10	(0.24)
1983-85	(7.11)	(7.57)	0.46	0.94
1986-90	2.30	1.66	0.64	1.39
1991-93	(3.21)	(3.38)	0.16	0.95
1994-97	1.14	0.71	0.44	1.61
1998-2000	1.96	1.44	0.52	1.36

Figure 6. Contribution of labor quality to TFP growth



captured the actual skill development of labor. Second, the quality of education that could have produced the necessary skills to improve productivity may have declined through time. Some facts that may support this. Cororaton (1999), for instance, has observed that while the Philippines is one of the countries that has produced one of the highest numbers of college graduates in the region, it has produced one of the lowest numbers of graduates specializing in science and technology and engineering.[6] Third, the marginal productivity of workers with higher education, as well as the efficiency of education itself, may have deteriorated. Fourth, the massive number of Filipinos working abroad may have created brain drain, resulting in loses in productivity in the local economy.

The results imply a number of things; the crucial ones are: (1) that the drive to improve education in the country should somehow be reflected in productivity improvement, otherwise the whole exercise could become frustrating if trained Filipinos will end up seeking employment elsewhere; and (2) that the structure of incentives, particularly labor incentives, would have to be examined quite closely. The structure of incentives could include

[6]Discussed further in the next section.

the structure of relative factor wages to address the problems related to the graduates specializing in science and technology. The efficiency of the educational system, including the curricula, books and manuals, training of teachers and professors, has to be examined closely.

The effects of movement of labor across sectors on TFP have improved through the years, indicating efficiency effects, however small, from labor movement out of agriculture (Table 8). Except for the subperiod 1991-93, the effect on TFP has increased through time, as shown in Figure 7. One wonders whether labor movement to industry, or to the manufacturing sector in particular, instead of the service sector could have contributed to higher TFP growth or not.

● *Determining factors of TFP*. A number of regression experiments were conducted on the computed TFP and the various determining factors listed earlier. Of the experiments, only two regression specifications resulted in better test results (Table 9). Trade indicators, exports and imports lumped together, are positive determinants of TFP growth. This is because the

Table 8. Effects of sectoral labor movement on TFP

Period	Unadjusted TFP	TFP Adjusted for Sectoral Labor Movement	Difference: (Unadjusted - Adjusted)	Ratio: (Unadjusted/ Adjusted)
1967-72	(0.23)	(0.48)	0.25	0.48
1973-82	0.21	0.16	0.05	1.31
1983-85	(7.11)	(7.51)	0.40	0.95
1986-90	2.30	1.85	0.45	1.25
1991-93	(3.21)	(3.04)	(0.18)	1.06
1994-97	1.14	0.57	0.58	2.02
1998-2000	1.96	1.40	0.55	1.40

Figure 7. Contribution of sectoral labor movement to TFP growth

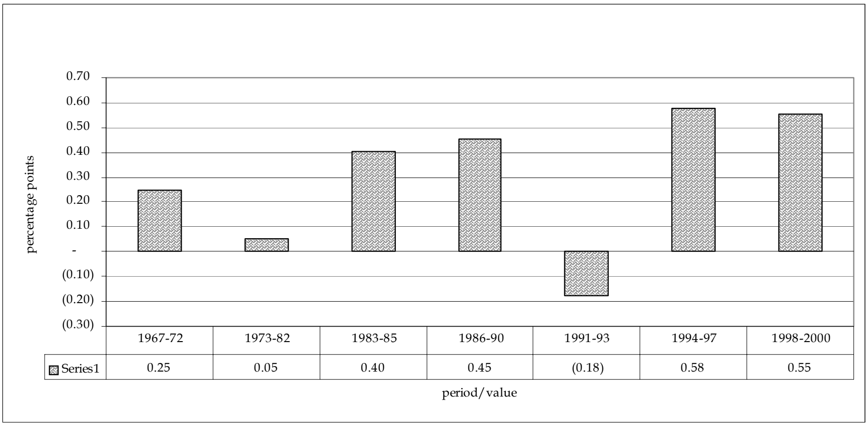


Table 9. Determinants of total factor productivity (Dependent variable: 3-year moving average of TFP)

	Regression No. 1 OLS 1975-1999			Regression No. 2 OLS 1976-1999		
	Coefficient	Standard Error	t-Statistic	Coefficient	Standard Error	t-Statistic
Variables:						
Constant	-89.4	17.1	-5.2	-86.3	16.6	-5.2
Exports				26.2	6.9	3.8
Imports(-1)				8.7	8.1	1.1
Exports+imports	18.7	4.9	3.8			
Foreign direct investment (-1)	304.8	54.3	5.6	325.0	53.8	6.0
Research and development (2)	1943.2	766.4	2.5	2193.8	754.5	2.9
Price changes	-6.7	3.1	-2.2	-7.8	3.0	-2.6
Share of manufacturing	300.0	61.0	4.9	289.9	58.9	4.9
D83	9.0	2.2	4.1	8.9	2.1	4.3
D87	7.1	1.4	5.0	6.8	1.4	5.0
D91	-4.7	1.4	-3.3	-4.5	1.4	-3.2
R-squared	0.849			0.870		
Adjusted R-squared	0.769			0.787		
DW	2.122			2.226		
F-Statistics	10.576			10.447		

Definition of variables

Exports	: exports/GDP
Imports(-1)	: one year lag of imports/GDP
Exports+imports	: (exports+imports)/GDP
Foreign direct investment (-1)	: one year lag of foreign direct investment/GDP
Share of manufacturing	: manufacturing GVA/GDP
Research and Development(-2)	: two year lag of Research and Development Expenditure/GDP
Price changes	: annual change in GDP deflator
D83, D87, D91	: dummy variables

country's exports are highly import-dependent. The coefficient of the combined trade indicator is statistically significant. The positive effect of exports on TFP implies that exports can bring about economies of scale with larger export market. It can also expose local producers to international best practices in production. Furthermore, foreign competition in the export market can translate into improved efficiency in the production operations of local producers. On the other hand, the positive effect of imports on TFP indicates transfer of modern technology into the local economy, since imports is one major vehicle for moving in appropriate foreign technology. Therefore, a higher volume of imports necessarily decreases the technological gap between local and foreign technology in terms of modern equipment, production processes and management.

That foreign direct investments (FDI) have lagged one year is not only positively affecting TFP growth but also highly statistically significant. FDI is another major vehicle for transferring foreign technology.

Price changes, an indicator of economic stability and fundamentals, is negatively related to TFP growth. This means high and unstable prices create a lot of economic uncertainties that discourage investors from investing in productivity-improving projects.

The share of gross value-added of manufacturing to total gross domestic product was included to capture externalities and spillover effects of production technology to the rest of the economy. The share of agriculture and service sectors turned out to be statistically insignificant. The positive and highly statistically significant coefficient of the share of manufacturing indicates that this sector has far greater spillover effects on the rest of the economy than other sectors. Its development therefore is an important factor affecting TFP growth.

Expenditure on research and development lagged two years is positive and statistically significant, indicating that it is also another important factor determining TFP growth.

In sum, the major conclusions of the paper are:

- Although the last 35 years saw mostly negative TFP growth in the Philippines, the underlying trend is encouraging: the contribution of TFP growth to the overall economic growth consistently improved from –4.26 percentage points in the middle of 1980s to +0.93 in 1998-2000. During this period major economic policy reforms were pursued.
- In spite of the increasing share of skilled labor to the total, loosely defined as those who have at least finished high school, its contribution to TFP growth is observed to have declined through time. This could imply a number of things, including: (a) the deterioration in the quality of education necessary for productivity improvement, (b) the deterioration in the marginal productivity of workers with higher education and in the efficiency of education itself, and (c) brain drain due to the surge in the number of Filipinos working abroad. These are critical issues in the Philippines that need to be examined quite closely.
- Efficiency improvements seem to have been gained from the movement of labor out of agriculture.
- Sound macroeconomic fundamentals, price stability, and opening up of the economy to foreign trade and investments are critical factors affecting TFP growth. Spillover effects on TFP from manufacturing seem to be far significant than from service and agriculture sectors. Expenditure on research and development is also another important factor affecting TFP.

5
Gaps in Philippine R&D and Technology

The poor productivity performance in the Philippines can largely be due to R&D gaps. There are national as well as sectoral gaps in terms of expenditure, budget, manpower, and inefficiency in institutional arrangement.

Local vs. international

Cororaton (1999) surveyed a UNESCO-based data on R&D indicators for 91 countries and found that the Philippines ranks very low in terms of R&D effort. Table 10 shows that out of 91 countries the Philippines placed 73rd place in terms of the number of scientists and engineers per million population. It has only 152 scientists and engineers per million population. This number is far below the maximum of 6,736 scientists and engineers per million population. In terms of R&D expenditure to GNP ratio, the Philippines is at the 60th place with a ratio of 0.2 percent in 1992. This is far below the maximum of three percent.

Gaps at the national level

Based on an econometric study, Cororaton (1999) provides some estimates of the magnitude of the gaps in R&D at the national level. R&D gaps are defined as those factors that have prevented the economy from operating at its full potential in terms of productivity. These factors could be either in the form of (a) low R&D investments and inadequate R&D manpower; (b) institutional weaknesses as a result of poor system, management and leadership; (c) policy lapses and failures; or d) all three combined. But in the estimation only the first two have been considered because of limited data.

The results indicate that the resulting R&D expenditure gap is 0.5778. This means that R&D expenditure-GNP ratio would have to increase by 0.5778 for the Philippine TFP to reach the TFP frontier. The average R&D expenditure–GNP ratio during the 1980s was 0.1667 percent. Thus the total R&D expenditure-GNP ratio needed to reach the frontier is 0.1667 + 0.5778 = 0.7445. This is a sizeable increase from the current level but lower than what has been proposed for S&T in House Bill no. 2214 at one percent of GNP.

Table 10. PCGNP, SE/MP, and GERD/GNP (in 91 countries of the world)

No.	Country	Per Capita GNP (US$)	Scientists/Engineers per Million Population	Gross Expenditure on R&D/GNP (%)	Year
1	Switzerland	37,930	2,409	1.8	1989
2	Japan	34,630	5,677	3	1992
3	Denmark	27,970	2,341	1.8	1991
4	Norway	26,390	3,159	1.9	1991
5	United States	25,880	3,873	2.9	1989
6	Germany (Federal)	25,580	2,882	2.8	1989
7	Iceland	24,630	3,067	1.1	1991
8	Austria	24,630	1,146	1.4	1989
9	Sweden	23,530	3,081	2.9	1991
10	France	23,420	2,267	2.4	1991
11	Belgium	22,870	1,856	1.7	1990
12	Singapore	22,500	1,284	0.9	1984
13	Netherlands	22,010	2,656	1.9	1991
14	Canada	19,510	2,322	1.6	1991
15	Kuwait	19,420	924	0.9	1984
16	Italy	19,300	1,366	1.3	1990
17	Finland	18,850	2,282	2.1	1991
18	United Kingdom	18,350	2,334	2.1	1991
19	Australia	18,000	2,477	1.4	1990
20	Israel	14,530	4,836	2.1	1984
21	Brunei Darusalam	14,240	91	0.1	1984
22	Ireland	13,530	1,801	0.9	1988
23	Spain	13,440	956	0.9	1990
24	New Zealand	13,350	1,555	0.9	1990
25	Qatar	12,820	593	0	1986
26	Cyprus	10,260	205	0.2	1992
27	Portugal	9,320	599	0.6	1990
28	Korea, Republic	8,260	1,990	2.1	1992
29	Argentina	8,110	350	0.3	1988
30	Greece	7,700	53	0.3	1986
31	Slovenia	7,040	2,998	1.5	1992
32	Seychelles	6,680	281	1.3	1983
33	Uruguay	4,660	686	-	
34	Mexico	4,180	226	0.2	1984
35	Gabon	3,880	189	0	1987
36	Hungary	3,840	1,200	1.1	1992
37	Trinidad and Tobago	3,740	240	0.8	1984
38	Chile	3,520	364	0.7	1988
39	Malaysia	3,480	326	0.1	1992
40	Czechoslovakia	3,200	3,247	1.8	
	a. Former		4,190	3.3	1989
	b. Czech Republic		3,248	1.8	1992
41	Mauritius	3,150	361	0.4	1992
42	South Africa	3,040	319	1	1991
43	Brazil	2,970	391	0.4	1985
44	Venezuela	2,760	208	0.5	1992
45	Russian Federation	2,650	5,930	1.8	1991
46	Croatia	2,560	1,977	-	1992

Table 10 cont'd.

No.	Country	Per Capita GNP (US$)	Scientists/Engineers per Million Population	Gross Expenditure on R&D/GNP (%)	Year
47	Turkey	2,500	209	0.8	1991
48	Thailand	2,410	173	0.2	1991
49	Poland	2,410	1,083	0.9	1992
50	Costa Rica	2,400	539	0.3	1992
51	Latvia	2,320	3,387	0.3	1992
52	Fiji	2,250	…	0.3	1986
53	Belarus	2,160	3,300	0.9	1992
54	Peru	2,110	273	0.2	1981
55	Ukraine	1,910	6,761	-	1989
56	Tunisia	1,790	388	0.3	1992
57	Colombia	1,670	39	0.1	1982
58	Paraguay	1,580	248	0.03	
59	Jamaica	1,540	8	0	1986
60	Jordan	1,440	106	0.3	1989
61	El Salvador	1,360	19	0	1992
62	Lithuania	1,350	1,278	-	1992
63	Ecuador	1,280	169	0.1	1990
64	Romania	1,270	1,220	0.7	1992
65	Bulgaria	1,250	4,240	0.7	1992
66	Guatemala	1,200	99	0.2	1988
67	Uzbekistan	960	1,760	-	1992
68	Philippines*	950	152	0.2	1992
69	Indonesia	880	181	0.2	1988
70	Macedonia(FYR)	820	1,258	-	1991
71	Bolivia	770	250	1.7	1991
72	Egypt	720	458	1	1991
73	Sri Lanka	640	173	0.2	1991
74	Congo	620	461	0	1984
75	Senegal	600	342	-	1981
76	Honduras	600	138	-	
77	China	530	1,128	0.5	1991
78	Guyana	530	115	0.2	1982
79	Guinea	520	264	-	1984
80	Pakistan	430	54	0.9	1990
81	Central African Rep.	370	55	0.2	1990
82	Benin	370	177	0.7	1989
83	Nicaragua	340	214	-	1987
84	India	320	151	0.8	1990
85	Nigeria	280	15	0.1	1987
86	Guinea-Bissau	240	263	-	
87	Vietnam	200	334	0.4	1985
88	Nepal	200	22	-	1980
89	Madagascar	200	22	0.5	1988
90	Burundi	160	32	0.3	1989
91	Rwanda	80	12	0.5	1985

*1992 figures computed by DOST.

Basic source of data: UNESCO. *Statistical Yearbook,* 1995; UNESCO. *World Science Report,* 1996; World Bank. *World Development Report,* 1996.

Applying this ratio to the 1997 GNP of P2,527 billion will result in a total R&D expenditure of roughly P18.8 billion. This R&D investment gap is substantial considering that the present level of R&D spending is approximately P3 billion. While this is a significant gap, for all intents and purposes, this could not be feasibly financed by the national government because it will result in significant budgetary impact. The government has other equally important and pressing needs, especially in the area of basic infrastructure like market roads, bridges and port; and in the social sector like education and health. Furthermore, it may be totally ineffective and inefficient to reallocate existing limited government resources in favor of R&D activities because of the institutional inefficiencies in the R&D system, as well as in the S&T structure. David et al. (1999), for example, argue that while agricultural research continues to be underfunded, efficiency of public sector research funding has been significantly lowered by the misallocation of limited budgetary resources, as well as by institutional weaknesses of the agricultural research system. Thus, unless these institutional weaknesses are addressed, additional government funding for R&D will only go to waste.

In other progressive countries, the bulk of R&D investment comes from the private sector. The challenge therefore is how to encourage the private sector to participate in R&D activities. It is also important to identify the necessary infrastructure, incentive system and investment safeguards that will enable the said sector to do its own R&D.

In terms of manpower, it was observed that the manpower gap is around 197 scientists and engineers per million population. The average ratio for the decade of the 1980s was only 108. For the Philippine TFP to bridge the gap it needs R&D manpower of 108 + 197 = 305 per million population.

Sectoral gaps and problems

Technology-related issues and problems are generally similar across sectors. They largely focus on four major problems: (a) underinvestment in R&D; (b) lack of adequate and technically capable R&D manpower; (c) institutional weaknesses; and (d) policy failures. Below is a brief discussion on the following sectors: agriculture, fishery, manufacturing, education, and health.

Agriculture[7]

Underfunded research in agriculture

The agricultural sector has been performing poorly since the 1980s. David et al. (1999) attribute this poor performance to a number of factors, one of which is the inadequate public support service, particularly in agricultural research and development. The agricultural research system has been severely underfunded, with public expenditures in the early 1980s representing only 0.3 percent of agriculture gross value-added, in contrast

[7]Largely based on the paper of David et al. 1999.

to an average of one percent among developing countries and two to three percent among developed countries (Table 11). In fact, only five percent of the total public expenditure for agriculture has been allocated for agriculture research; whereas the ratio of budgetary outlay for price stabilization programs alone was in the range of 10 percent over the past decade (Table 12).

Apart from the problem of inadequate funding for research, there are other equally, if note more, important gaps in agricultural research. David et al. (1999) identify them as: (a) inefficiencies caused by the misallocation of research resources within the sector (e.g., across research program areas and ecological regions); and (b) weaknesses in the institutional framework of the research system, including the organizational structure, lack of accountability, fragmentation of research, incentive problems, instability in leadership, and weak linkage between research and extension.

Misallocation of research resources

Using the congruence rule, which defines the optimal research resource allocation across commodity program areas as proportional to the respective commodity value-added or value of production shares (in other words, given a total budget for agricultural research, the research intensity ratio, i.e., research expenditure as a ratio of the value-added should be equal across commodity research program areas), David et al. (1999) find that the allocation of research expenditures across commodities and regions has

Table 11. Agricultural research intensity ratios of selected countries

Country	RIR (%)	Reference Year
Philippines	0.33	1992
Thailand	1.40	1992
Indonesia	0.27	1990
Malaysia	1.06	1992
China	0.43	1993
Taiwan	4.65	1992
Australia	3.54	1992
India	0.52	1990
Pakistan	0.47	1992
Bangladesh	0.25	1992
Sri Lanka	0.36	1993
South Korea	0.56	1993
Japan	3.36	1992
Developing countries	1.00	
Developed countries	2-3	

Source: David (1998)

Table 12. Distribution of public expenditures for agriculture and natural resources by policy instruments, 1987-1994 (%)

	1987-94	1994
Agrarian reform	26	24
Natural resources and environment	23	23
Agriculture	51	53
Irrigation (NIA)	12	8
Price stabilization (NFA)	9	13
Research	4	5
Extension	7	9
Coconut development	2	2
Livestock	1	2
Others	17	15

Source: David (1998)

been highly incongruent to their relative economic importance measures in terms of gross value-added contribution of the commodity. In particular, relatively greater research budgets are provided to minor commodities such as cotton, silk or carabao, and too little to major ones such as corn, coconut, fisheries and others. Furthermore, Mindanao regions are relatively neglected in terms of research budgets of the DA and SUCs compared to regions in Luzon and to a lesser extent to those in the Visayas. They add that "while congruency does not strictly coincide with optimal research resources allocation, the differences in research intensity ratios observed among commodities and across regions cannot be explained by possible differences in cost research (probability of research success, etc.), future market potential nor equity considerations."

Other indications of misallocation of resources and institutional weaknesses in agricultural research are also discussed in David et al. (1999) and Ponce (1998). Some of these are:

- *Extremely high proportion of personal salaries*. The expenditure for personal salaries (PS) on the average tends to be disproportionately high at 58 percent, while maintenance and operating expenses (MOE) are about 36 percent, and capital outlays (CO) only six percent. In agricultural research systems in more developed countries, where salary rates are much higher, the distribution of expenditures is 40 percent for PS, 40 percent for MOE, and 20 percent for CO.

Generally, in almost all research agencies, the shares of PS are high, at least 50 percent. In a number of commodity research agencies and SUCs, the shares can be as high as 70 to 80 percent. PhilRice, however, is an exception. The structure of expenditure is 40 percent for PS, 50 percent for MOE, and 10 percent for CO. This allows for a more efficient utilization of its manpower and physical facilities, as well as promotes more systematic and long-term research planning.

UPLB, which undertakes the bulk of research in agriculture, has also the same expenditure structure with PS share as high as 70 percent. Moreover, research projects under the different institutes, centers, and research units of the university are primarily driven by priorities of external donors, which contribute about half of the research funding. As such, the effectiveness of research is constrained by uncertain and short-term nature of funding, even though the university may have the most competent scientists in the country in different fields of agriculture.

The expenditure pattern in the different research agencies in agriculture in the Philippines shows that the extremely high share of PS may reflect overstaffing, bureaucratic rigidities, and poor planning.

- *Unfocused projects*. An analysis of the work and financial plans and projects completed indicate that research projects are highly fragmented and short-term in nature. Research findings and outputs are neither carried over to future researches nor used for extension to benefit the clientele. This is because there is no adequate system or clear mechanism whereby research findings are fully transferred to the targeted end-users. Also, there are no systems where researches are continued on a long-term and continuous basis. Thus, the analysis of the profile of the researches indicates that, generally, research projects do not reflect a sense of problem orientation.
- *Lack of a clear network among SUCs*. Ponce (1998) argues that SUCs are basically independent from each other despite their hierarchical designations as national multi-commodity research centers, regional research stations, and cooperating stations. The national multi-commodity research center's (UPLB, CLSU, VISCA and USM) linkage to the regional and cooperating stations are ad hoc in character and project-related. There exists no institutionalized linkage resulting from clearly defined complementary functions.
- *Lack of a clear network between DA and attached agencies*. Ponce (1998) also argues that the DA research system consists of national experiment stations operated by (a) various bureaus such as BPI, BAI, BFAR and BSWM; (b) attached agencies such as PhilRice, PCC, PCA, SRA and FIDA; (c) Regional Integrated Centers under the regional offices of the DA; and (d) Regional Outreach Stations. Similar to the network among the SUCs, there exists no clear functional delineation between the national stations and the regional experiment stations and between the region and the provisional stations. Each station, even within the DA proper, exists independently of others in terms of programs. Thus, national centers do not exactly orchestrate the national research and development programs of their assigned commodities.
- *Lack of clear link with the private sector*. Ponce (1998) cites the weak link between the private sector and the larger community of research stations. Most private research centers exist principally to meet the needs of the companies that established them. As such, they do not interact with the rest of the research community dominated essentially by the government

sector, except for a few privately operated research centers that perform public services such as the Twin Rivers Research Center. There is also a mechanism whereby this link could be fostered and developed.

- *Other institutional gaps*. Ponce (1998) cites other institutional weaknesses, namely, (a) the lack of a well defined and institutionalized mechanism for collaboration among R&D subsystems; and (b) an inefficient funding system and lack of accountability. The present funding system is still very much like the old project approach, where the research outputs are essentially in the forms of research reports. This weakens the system of program approach and leads to a distortion of national priorities. Furthermore, the present funding approach gives rise to a much-diffused structure of research implementation that makes it difficult to pinpoint responsibility.

- *Manpower gaps*. In terms of R&D manpower profile in agriculture, the authors find that the problem has nothing to do with number but lies in the relatively low level of scientific qualification of the agriculture research system. This is particularly true in both the DA and DENR research agencies. The very low ratios of technical manpower resources with advanced degrees at the DA and DENR compare quite unfavorably with similar institutions in some Asian countries like Malaysia, Indonesia and Bangladesh.

On the other hand, the qualities of research manpower in Sacs are not uniformly nor always significantly better. Although the share of manpower may be higher in SUCs than in agencies, there is a big and worsening problem of inbreeding. Furthermore, local scientists who were trained and educated abroad are generally not attuned to recent developments or frontier international knowledge. Also, there is a big gap in the quality of faculties and researchers in UPLB and other SUCs.

Fisheries sector[8]

One of the sectors included in the R&D study is the fisheries sector. This sector is important not only because it has direct impact on national health and nutrition (that is, fish is the source of about 75 percent of the total animal protein requirement of the country, in fact more than poultry and livestock combined) but also because its structure, particularly supply, is directly affected by the state of the environment. To a certain extent, the fisheries sector can be one output indicator of what has been happening in the environment.

Israel (1999) points out that the weak performance of the fisheries sector has been the result of several interrelated problems, the top three of which are (a) resource depletion in coastal waters due to overfishing and destructive fishing, as manifested by the deterioration of important fish stocks and species and the degradation of ecosystems; (b) large-scale environmental damage, as evidenced by the destruction of coral reefs and

[8]Based on the paper of Israel (1999).

mangroves in marine areas and pollution of major river lakes; and (c) proliferation of industrial, agricultural, commercial, and domestic activities, which discharge pollutants into marine waters, contributing to the deterioration of ecosystems and rendering marine food potentially harmful for consumption.

R&D is important to the development of the fisheries sector, particularly to its long-term survival. Primarily, R&D is crucial to generating new information and technologies that can increase output above the current low and dwindling levels.

The responsibility of managing and coordinating fisheries R&D in the Philippines has been the task of the Philippine Council for Aquatic and Marine Research and Development (PCAMRD). The Council, which is under the DOST, is tasked to plan, monitor, as well as evaluate fisheries R&D. Israel (1999) discusses the R&D structure of the fisheries sector.

Furthermore, PCAMRD interacts with two government agencies whose R&D scope covers the fisheries sector. These agencies are the Bureau of Agricultural Research (BAR) of the Department of Agriculture (DA) and the Ecosystem Research and Development Bureau (ERDB) of the Department of Environment and Natural Resources (DENR). These agencies are mandated to coordinate all researches of the regional offices and line agencies within their respective departments. The BAR covers fisheries research because fisheries are administratively classified under the agricultural sector. The ERDB does so since aquatic resources form part of the natural resource base and therefore falls under DENR.

Institutional gaps and issues

Israel (1999) finds one of the biggest gaps resulting from the present institutional arrangement is the weak coordination and poor collaboration among government agencies. PCAMRD is the agency tasked to manage and coordinate overall fisheries R&D while the BAR and the ERDB coordinate fisheries research of the regional offices and line agencies of their respective departments. Because of the similarity in functions and constituency, potential overlapping existed among the three agencies. To address this problem, they have delineated their functions through existing Memoranda of Agreements (MOAs). Implementation of these agreements, however, has been hampered by poor collaboration. In particular, in violation of the MOAs, the agencies do not actually jointly review all research proposals submitted for funding. Furthermore, collaboration is weak or does not exist in several activities, and strong only in one aspect.

Another crucial institutional problem deals with a possible duplication of functions between PCAMRD and the Bureau of Fisheries and Aquatic Resources (BFAR), arising from the existing Fisheries Code. The Code has reconstituted the BFAR from a staff to a line bureau under the DA and assigned it the function of formulating and implementing a Comprehensive Fishery Research and Development Program. To effect this program, the law created a new agency within BFAR, the National Fisheries Research and Development Institute (NFDRI), which has become its main research arm. Among the functions of this agency are the establishment of a national infrastructure that will facilitate, monitor, and implement various research needs and activities of the fisheries sector; and the establishment, strengthening, and expansion of a network of fisheries-related communities through effective communication linkages nationwide. These functions of the BFAR and the NFRDI may duplicate those of the PCAMRD. For one, the responsibilities of formulating and implementing an overall plan for fisheries R&D and coordinating its implementation are mandates of the Council. For another, the Council has already established a network of research institutions, the NARRDS, to serve as an implementing arm for fisheries R&D. At a larger scale, the Agricultural Commission has noted the duplication of functions in the R&D programs in the fishery and agriculture sectors.

Under which agency and department should the task of managing, coordinating, and implementing R&D fall is a long-running issue that has a life of its own in fisheries circles. At present, this question is far from settled and creates a lot of bureaucratic and institutional inefficiencies.

Capability issues

Capability issues surrounding R&D in fisheries include low investment (including public, private, as well as foreign investments), funding problems, manpower shortage, and poor maintenance of existing capital.

Low public investment

The most glaring resource-related problem in R&D is historically low government funding that agriculture as a whole receives (Tables 13 and 14). In developed countries, average public spending on investment in agriculture R&D is about two percent of their agricultural GVA. In contrast, only about 0.019 percent of GVA is allocated locally. Regionally, the Philippines has the lowest R&D allocation for agriculture in Asia.

In fisheries, allocation averages only about 0.102 percent of fisheries value-added, which is close to what agriculture is getting. However, the fisheries R&D budget is only about 3.6 percent of the total expenditure for agriculture and natural resources R&D combined. Thus, compared to agriculture and natural resources, the fisheries sector is getting the worse end of the deal in the sharing of government funds.

A look at disaggregate data indicates not only the low government funding for fisheries R&D but also the uneven government allocation among institutions. In 1996, among the NARRDS members, the budget in total magnitude and as ratios to number of researchers and projects differed widely (Tables 15 and 16). The ratios of budget to number of researchers and projects were low for many institutions, including some zonal centers.

To address the problem of low budget for agriculture and fisheries R&D, the AFMA stipulated that allocations be increased to at least one percent of GVA by year 2001. For its part, the Fisheries Code legislated the

Table 13. Public expenditures for research and development in agriculture and natural resources, gross value-added in agriculture including fishery and forestry, and research intensity ratios (RIR), 1992-1996

	1992	1993	1994	1995	1996
1. Research expenditures (₱ million)					
a. without SEAFDEC	800	853	1,065	1,290	1,554
	(1,027)	(1,121)	(1,400)	(1,638)	(1,919)
b. with SEAFDEC	881	958	1,184	1,434	1,707
	(1,228)	(1,248)	(1,540)	(1,815)	(2,114)
2. Gross value-added (₱ million)	281,748	303,415	355,612	392,954	449,080
3. Research intensity ratio (%)					
1a/2	0.28	0.28	0.3	0.33	0.35
	(0.36)	(0.37)	(0.39)	(0.42)	(0.43)
1b/2	0.31	0.32	0.33	0.36	0.38
	(0.40)	(0.41)	(0.43)	(0.46)	(0.47)

Note:
[a]Refers to direct budgetary outlay. Figures in parentheses refer to total research expenditure, including external grants from local and foreign sources.
Source: Israel (1998)

creation of a special fund for fisheries R&D in the initial amount of P100 million. The AFMA is mute regarding the sharing of funds between agriculture and fisheries. Assuming that allocation will be proportionate to output contribution, the budget for fisheries should jump substantially from its current levels. There is already doubt that the planned increases in allocations will fully materialize soon, given the mounting fiscal deficits.

Low private investment

Data on private investment in fisheries R&D are scarce. This is understandable given the natural aversion of the private sector to divulge information. This notwithstanding, private entities have been involved in one way or another in R&D, especially in applied research and technology verification activities, where the likelihood of generating new technologies for immediate commercial application is high.

Much of the private sector involvement in fisheries R&D is in aquaculture. During the rapid development of this industry in the last 20 years, private firms have been collaborating with national institutions and locally based international research agencies in the conduct of applied research covering many commodities, including prawn, tilapia, milkfish, crab and other commercially profitable species.

In the commercial fisheries, private sector participation in R&D is limited since research in capture technologies usually requires larger investments and results are difficult to patent. Also, a lot of the research activities, such as stock and resource assessments, have social externalities that go beyond the private interests of private operators and, thus, are better

Table 14. Public expenditures for research and development in agriculture, natural resources, and related environmental issues (in million pesos)

	1992	1993	1994	1995	1996	1997
DA	459.74	464.27	651.59	758.84	913.90	na
	(501)	(524)	(696)	(842)	(1030)	(na)
DENR	68.98	78.60	109.69	120.8	149.33	213.97
	(85)	(93)	(123)	(133)	(161)	(218)
ERDB	23.03	21.04	15.65	15.58	21.78	64.16
	(32)	(30)	(24)	(23)	(32)	(66)
ERDS	43.35	55.08	92.12	99.65	122.21	149.81
	(50)	(60)	(97)	(104)	(123)	(152)
PAWB	2.60	2.48	1.92	5.57	5.34	10.69
	(3)	(2)	(2)	(6)	(5)	(11)
DOST	81.25	100.52	103.01	153.08	180.13	228.42
	(150)	(160)	(188)	(217)	(277)	(378)
PCARRD	42.82	56.24	56.88	88.66	105.00	127.10
	(62)	(84)	(99)	(123)	(168)	(180)
PCAMRD	9.60	11.01	10.96	9.09	18.61	19.40
	(50)	(26)	(40)	(32)	(46)	(89)
FPRDI	28.83	33.27	35.16	55.33	56.53	81.93
	(38)	(50)	(49)	(62)	(62)	(110)
SCUs	189.57	209.42	200.88	257.72	309.68	331.71
	(292)	(344)	(393)	(446)	(452)	(496)
UP System	91.71	94.54	80.61	113.66	130.52	128.05
	(183)	(203)	(239)	(261)	(235)	(237)
UPLB	87.32	90.69	76.73	108.88	123.69	120.36
	(162)	(196)	(219)	(251)	(223)	(224)
UPMSI	3.70	3.70	3.15	3.97	5.67	5.79
	(na)	(na)	(na)	(na)	(na)	(na)
UPVISAYAS	0.69	0.15	0.73	0.82	1.17	1.90
	(18)	(3)	(17)	(7)	(6)	(7)
Other major universities	81.98	95.88	95.53	112.57	142.97	165.84
	(92)	(122)	(129)	(153)	(181)	(221)
Other universities	15.88	18.99	24.74	31.49	36.19	37.82
	(na)	(na)	(na)	(na)	(na)	(na)
SEAFDEC	81.25	104.72	118.75	143.25	153.48	185.27
	(101)	(127)	(140)	(177)	(195)	(213)
Total without SEAFDEC	**799.54**	**852.81**	**1,065.17**	**1,290.44**	**1,553.04**	**na**
	(986)	**(1060)**	**(1356)**	**(1555)**	**(1919)**	**(na)**
Total with SEAFDEC	**880.79**	**957.53**	**1,183.92**	**1,433.69**	**1,706.52**	**na**
	(1087)	**(1188)**	**(1496)**	**(1732)**	**(2114)**	**(na)**

Source: David (1998)
Numbers in ( ) include external grants

left to government and international research agencies to conduct. The common practice in the commercial fisheries has been to use imported technologies outright or modify to some extent said technologies to suit local requirements and needs.

Table 15. Agency-funded fisheries R&D projects of NARRDS institutions

Institution	Number of Researchers	Budget (P)	Budget: Researcher Ratio
DA-BFAR	61	3,754,000	61,541
DMMMSU	13	1,072,903	82,531
UPLB	9	3,373,580	374,842
UPV	44	2,193,075	49,843
MSU-Naawan	25	1,257,125	50,285
ZSCMST	15	790,000	52,667
DA-CAR	-	230,100	-
DA-Region 1	2	1,007,000	503,500
DA-Region 2	10	889,000	88,900
DA-Region 4	-	4,572,000	-
DA-Region 5	-	2,180,046	-
DA-Region 6	-	785,000	-
DA-Region 8	-	415,000	-
DA-Region 11	-	902,044	-
DA-Region 13	-	310,000	-
DA-ARMM	-	87,000	-
DENR-Region 10	-	4,165,000	-
BU	-	543,000	-
CMU	2	11,000	5,500
CSC	-	341,000	-
CSU	18	548,040	30,447
CCSPC	-	1,461,033	-
CVPC	-	244,000	-
DOSCST	-	972,500	-
ISCOF	19	2,425,000	127,632
MMSU	17	100,000	5,882
MSU-SULU	-	590,488	-
MSU-TCTO	21	1,330,000	63,333
NIPSC	3	5,450,248	1,816,749
NMP	-	64,564	-
NVSIT	5	136,000	27,200
PALSU	-	1,110,000	-
PIT	-	308,000	-
PSPC	12	25,000	2,083
PSU	8	321,000	40,125
TONC	-	60,000	-
UEP	-	496,370	-
UPMSI	25	3,579,400	143,176
Average	17	1,265,777	195,902

- means no data
Source: Israel (1998)

In the municipal fisheries, private investment in monetary terms is low because the poor economic position of the municipal fishermen practically prevents them from making such investment. However, manpower involvement in R&D is substantial among fishermen and their

Table 16. Agency-funded fisheries R&D projects of NARRDS, 1996

Institution	Number of Projects	Budget (P)	Budget: Project Ratio
DA-BFAR	11	3,754,000	341,273
DMMMSU	30	1,072,903	35,763
UPLB	9	3,373,580	374,842
UPV	8	2,193,075	274,134
MSU-Naawan	7	1,257,125	179,589
ZSCMST	7	790,000	112,857
DA-CAR	4	230,100	57,525
DA-Region 1	10	1,007,000	100,700
DA-Region 2	8	889,000	111,125
DA-Region 3	41	4,572,000	111,512
DA-Region 4	12	2,180,046	181,671
DA-Region 5	12	785,000	65,417
DA-Region 6	8	415,000	51,875
DA-Region 8	8	902,044	112,756
DA-Region 11	10	310,000	31,000
DA-Region 13	3	87,000	29,000
DA-ARMM	1	4,165,000	4,165,000
BU	3	543,000	181,000
CMU	1	11,000	11,000
CSC	4	341,000	85,250
CSU	6	548,040	91,340
CCSPC	4	1,461,033	365,258
CVPC	2	244,000	122,000
DOSCST	3	972,500	324,167
ISCOF	9	2,425,000	269,444
MMSU	12	100,000	8,333
MSU-SULU	1	590,488	590,488
MSU-TCTO	8	1,330,000	166,250
NIPSC	13	5,450,248	419,250
NMP	3	64,564	21,521
NVSIT	2	136,000	68,000
PALSU	4	1,110,000	277,500
PIT	3	308,000	102,667
PSPC	1	25,000	25,000
PSU	6	321,000	53,500
TONC	1	60,000	60,000
UEP	3	496,370	165,457
UPMSI	31	3,579,400	115,465
Total	309	48,099,516	155,662

Source: Israel (1998)

families by way of participation in the conduct of numerous coastal resource management and similar projects undertaken by government and international agencies.

Available data show that the share of private investment in fisheries R&D is low (Table 17). To promote this type of investment, the AFMA encourages government research agencies to go into cofinancing agreements with the private sector, provided that the terms and conditions of the agreements are beneficial to the country. For reasons already cited, the possibility of these agreements actually happening will be higher in aquaculture than in the commercial and fisheries subsectors.

Low foreign investment

Figures show that the contribution of foreign funding for fisheries R&D was more than half of total funding (Table 17). In recent years, however, this share has gone down (Tables 18 and 19). By 1996, only seven percent of the total funds of NARRDS institutions came from foreign sources (Table 20). Furthermore, funding was concentrated only in a few concerns, mostly the environment and OPAs.

Foreign funding is important because it is essentially a signaling mechanism. Low outside investment for domestic R&D could mean that local research institutions and their programs are not internationally competitive and vice versa. Furthermore, in this time of economic crisis, foreign money may be the only viable way of increasing allocations. It is interesting to note that the AFMA and Fisheries Code did not address the issue of international funding for R&D.

Untimely release of funds

Aside from low allocations, a commonly cited fund-related problem in fisheries R&D is the untimely release of government funds to institutions, programs and projects. In fact, this constraint is true not only for R&D but also for other activities depending on government support. In fisheries, it is acute because of the importance that time and season play in the conduct of activities. Although no data can be used to validate this, research activities are reported to be cancelled or haphazardly conducted because of the delay in the release of funds. A review of the FSP pointed out other problems related to the management of government funds (PRIMEX and ANZDEC 1996). These include the excessive control by the Department of Budget and Management (DBM) over a large proportion of program funds; the diversion of some funds to other activities not necessarily directly related

Table 17. R&D expenditures for fisheries by sector and source of funds, 1988-1994 (in million pesos)

Sector	Foreign	%	Government	%	Private Sector	%	Grand Total
Marine fisheries	218.45	73.48	75.78	25.49	3.08	1.04	297.31
Inland aquatic resources	60.73	37.96	98.08	61.31	1.17	0.73	159.98
Socioeconomics	4.67	18.65	20.35	81.35	-	-	25.02
Total	283.85	58.85	194.21	40.37	4.25	0.88	482.31

Source: Israel (1998)

Table 18. R&D expenditures for fisheries of selected NARRDS institutions by source of external grants, 1992-1996 (in thousand pesos)

Institution	Funds	1992	1993	1994	1995	1996	Average	%
DA-BFAR	Local	0	0	200	144	1,087	286	100
	Foreign	0	0	0	0	0	0	0
	Subtotal	0	0	200	144	1,087	286	100
DOST-PCAMRD	Local	12,310	8,140	18,780	19,060	23,200	16,298	60.25
	Foreign	28,060	6,760	10,660	3,670	4,610	10,752	39.75
	Subtotal	40,370	14,900	29,440	22,730	27,810	27,050	100
UPV	Local	15,553	2,409	13,531	2,804	3,472	7,554	64.86
	Foreign	0	0	17,356	2,873	237	4,093	35.14
	Subtotal	15,553	2,409	30,887	5,677	3,709	11,647	100
Total without SEAFDEC AQD	Local	27,863	10,549	32,511	22,008	27,759	24,138	61.92
	Foreign	28,060	6,760	28,016	6,543	4,847	14,845	38.08
	Total	55,923	17,309	60,527	28,551	32,606	38,983	100
SEAFDEC AQD	Local	0	0	0	0	0	0	0
	Foreign	3,150	3,550	3,770	8,490	8,040	5,400	100
	Subtotal	130,009	54,269	143,484	79,357	93,639	5,400	100
Total with SEAFDEC AQD	Local	27,863	10,549	32,511	22,008	27,759	24,138	54.39
	Foreign	31,210	10,310	31,786	15,033	12,887	20,245	45.61
	Total	185,932	71,578	204,011	107,908	126,245	44,383	100

Source: Cororaton et al. (1998)

Table 19. Distribution of manpower for fishery R&D

Agency	PhD	MS	BS	ASSOC	Total	%
Zonal area for Northern Luzon (Regions I, II, III and CAR)	11	57	25	-	93	12.33
Zonal area for Southern Luzon (Regions NCR, IV and V)	20	45	131	12	208	27.59
Zonal area for Visayas (Regions VI, VII and VIII)	31	117	166	6	320	42.44
Zonal area for Northern Mindanao (Regions X, XI, and Caraga)	2	19	53	-	74	9.81
Zonal area for Southern Mindanao (Regions IX and XII)	3	21	35	-	59	7.82
Total	67	259	410	18	754	100
%	8.89	34.35	54.38	2.39	100	

Source: Israel (1998)

Table 20. Distribution of the NARRDS R&D program budget

Commodity	Source of Funds		Total
	Local (P)	Foreign (P)	Budget
Export winners			
Seaweed	7,236,997	0	7,236,997
Crab	2,613,727	842,677	3,456,404
Tuna	225,000	0	225,000
Shrimp	1,605,739	0	1,605,739
Basic domestic needs			
Tilapia	2,664,975	0	2,664,975
Milkfish	80,903	0	80,903
Small pelagics	2,257,428	0	2,257,428
Environment	29,000,173	2,262,513	31,262,686
Other priority areas	14,837,104	1,500,000	16,337,104
Total	60,522,046	4,605,190	65,127,236

Source: Israel (1998)

to the program; the lack of coordination between the DBM and program administrators regarding fund utilization; and the lack of a financial monitoring system for the funds.

Manpower shortage

Earlier figures show that the NARRDS institutions relatively have limited R&D manpower at all levels (Table 18). They also indicate that personnel

Table 21. Manpower for fisheries R&D of selected NARRDS institutions, 1998

Institution	PhD	MS	BS	NI	Total
DA-BFAR	2	21	42	1	66
DOST-PCAMRD	4	11	10	0	25
DMMMSU	1	6	15	0	22
UPLB	1	1	0	0	2
UPV	0	12	13	1	26
MSU-Naawan	4	19	13	0	36
MSU-Marawi	1	15	10	1	27
CLSU	1	7	2	0	10
UPMSI	3	2	20	0	25
BU	4	9	2	0	15
MMSU	1	2	4	0	7
PSU	0	3	1	0	4
Average without SEAFDEC AQD	2	10	13	0	25
SEAFDEC	21	43	1	0	65
Average with SEAFDEC AQD	1	7	7	0	15

Note: NI means not indicated
Source: Cororaton et al. (1998)

capability varies greatly between regions and programs and senior personnel, especially those with doctorate degrees, are concentrated only in a few institutions (Table 21). Masteral degree holders have offset the limited number of doctorate degree holders, in limited cases. While this is so, it cannot be denied that more doctorate degree holders are required in NARRDS institutions to provide organizational and research leadership.

A comparison of selected NARRDS and NARRDN institutions suggests that the manpower in fisheries R&D is no more than 10 percent of that in agriculture although the percentage of Ph.D. holders is a bit higher (Table 22). This proportion is highly uneven and not reflective of the higher ratio of fisheries output to total agricultural production (Table 23). The graduate-to-undergraduate ratio of fisheries R&D staff appears to be significantly lower compared to that of agriculture.

The problem of limited manpower in fisheries R&D, especially in institutions located in the provinces, deserves attention because of the rural nature of many fishing activities. Researchers working in the countryside are more exposed to the actual problems in fisheries and are in a better position to correctly identify priority research areas for implementation. More of them should be recruited then to enhance the capability of the sector to conduct hands-on and meaningful, instead of "ivory tower," research.

Table 22. Comparison of the number of R&D personnel in selected NARRDS and NARRDN institutions, 1995-1996

Institution	PhD	MS	BS	Total	Graduate: Undergraduate
NARRDS					
UPLB	4	3	2	9	3.50
DMMMSU	1	9	3	13	3.33
UPV	15	13	16	44	1.75
MSU-NAAWAN	2	14	9	25	1.78
CLSU	1	10	0	11	0
UPMSI	15	6	4	25	5.25
ZSCMST	3	7	5	15	2
Average	5	9	6	18	2.52
NARRDN					
UPLB	53	206	225	484	1.15
USM	37	72	8	117	13.63
ViSCA	39	69	24	132	4.50
BSU	15	36	36	87	1.42
CMU	43	135	139	317	1.28
ISU	17	61	13	91	6
CSSAC	19	40	30	89	1.97
Average	32	88	68	188	4.28

Note: NARRDN stands for National Agriculture and Natural Resources Research and Development Network, the counterpart of NARRDS. NARRDS data are for 1996 while NARRDN data are for 1995. NARRDS data are specifically for fisheries R&D manpower only.

Source: Israel (1998)

The Fisheries Code did not address the problem of limited R&D manpower in fisheries. The AFMA, on the other hand, stipulated the creation of a science fund to sustain career development. Since the manpower problem is directly related to funding, the planned increases in the total R&D allotment, should they materialize, will go a long way toward addressing it.

Low level and poor maintenance of capital assets

While the data presented here concentrate only on funding and personnel resources, capital resources, in particular, buildings, facilities and equipment also help determine the success or failure of R&D. In fisheries, the capital resources for R&D have been wanting, more so in provincial institutions which receive smaller shares of the research budget. The problem of inadequate capital assets is worsened further by poor maintenance. There have been reports that proper maintenance is sometimes sacrificed by institutions to meet more immediate expenses, such as salaries and wages. In sites close to the sea, the faster deterioration of capital assets brought about by salt makes the problem of poor maintenance very serious.

Table 23. R&D expenditures for fisheries

Year	R&D in Fisheries (Pm) (1)	GNP (Pm) (2)	GVA Forestry and Fisheries (Pm) (3)	GVA Fisheries (Pm) (4)	(1)/(2)	(1)/(3)	(1)/(4)
1982	14.52	313,544	74,055	14,084	0.005	0.020	0.103
1983	14.67	363,268	82,545	17,580	0.004	0.018	0.083
1984	10.14	508,485	129,824	22,666	0.002	0.008	0.045
1985	15.82	556,074	140,554	27,058	0.003	0.011	0.058
1986	22.02	596,276	145,807	32,019	0.004	0.015	0.069
1987	18.07	673,130	163,927	31,256	0.003	0.011	0.058
1988	33.4	792,012	183,515	34,708	0.004	0.018	0.096
1989	37.03	912,027	210,009	36,460	0.004	0.018	0.102
1990	76.33	1,082,557	235,956	40,833	0.007	0.032	0.187
1991	67.74	1,266,070	261,868	47,276	0.005	0.026	0.143
1992	109.98	1,385,562	294,922	51,633	0.008	0.037	0.213
1993	119.49	1,500,287	318,546	57,533	0.008	0.038	0.208
1994	38.34	1,737,315	372,853	65,860	0.002	0.010	0.058
1995	63.89	1,970,519	412,965	70,206	0.003	0.015	0.091
Average	45.82	975,509	216,239	39,227	0.004	0.019	0.102

Source: Israel (1998)

Like the manpower problem, the inadequate and poor maintenance of capital assets is a function of funding. If the NARRDS institutions get a raise in their allocations, they could purchase enough capital assets and spare money for maintenance. Again, the solution rests a lot on the fulfillment of the increased allocations promised by the AFMA and Fisheries Code.

Manufacturing

Macapanpan (1999) conducted a survey on the private sector innovation activities in the country in five industry groups: food processing; textile and garments; metals and metal fabrication; chemicals; and electronics and electrical machinery. The major conclusions of the study are the following:

- Only big firms do engage themselves in innovation. These are industry leaders. Smaller firms may just go “along for the ride,” not even considered “followers.”
- Firms expect innovative activities to improve their competitiveness through improved quality, lower production costs, and enhanced marketing performance. Government standards and regulations and environmental concerns are not important drivers of innovation activities. As predicted by literature and studies, firms will formulate their technology strategy to support their overall business strategy.
- The steel industry has not acquired any significant new technology in spite of recommendations from various studies. The same is true for the textile industry, which has fallen behind in modernizing their equipment to remain competitive, quality- and cost-wise.

● Of the total respondent firms (more than 60), only seven firms employ Ph.D.s and only about 20 have masteral degree performing any innovation activity. A majority employ only college graduates or lower in their innovation activities, implying a very low level of innovation activity.

● Government research institutions rank very low as a source of innovation ideas. From interviews, the perception of the firms is that these research institutions lag even in monitoring technology developments in their respective fields. Internal R&D is not relied upon, except by the firms in the electronics and electrical industry. Ideas for innovation activities are usually sourced from the outside in the form of consultancy services, information on competitor activity generated by monitoring, purchase of technology, tangible and intangible, and the recruitment of manpower with the required skills.

● Financial constraints such as risk and rate of return, lack of financing, and taxation are the major hindrances to innovation. Technical constraints such as lack of information on new technologies, deficiency in external technical services, innovation costs, and uncertainty rank next as barriers to innovations. Others mentioned include difficulty in obtaining patents, low technological standards, lack of skilled personnel, and lack of opportunities for cooperation with other companies.

● Philippine firms are deficient in experience and organization to fully exploit technology as a source of competitive advantage. This situation is not helped by the lack of government assistance and support. Government has been remiss in aligning the educational system toward a globally and technologically competitive economy. The Philippine schools do not provide the requisite technical and technological skills and knowledge. Government research institutions have not diffused their findings to the private sector.

In addition, Nolasco (1999) identifies other gaps and major loopholes in the system:

● The overall system is loose and chaotic in the sense that different government agencies do have different sets of priority sectors. Furthermore, some of the goals are unaligned. For example, NEDA, DTI and BOI have different sets of strategic sectors. DFA and NEDA have conflicting interests with the BOI industry planners, especially in terms of granting incentives. In particular, the Department of Energy is looking into the possibility of developing wind energy while DOST is eyeing the solar energy.

● Government, with such limited amount of budget alloted to R&D, limits the amount of expenditure on R&D.

● Support facilities like testing centers, either government-run or government-subsidized, standardization institution and support industries like casing and others are lacking or nonexistent. Access to recent and state-of-the-art technologies is lacking due to poor databases.

● The system only reaches out to a handful of firms, usually the larger ones. Small- and medium-scale firms have minimum access to the system.

● People and staff in the incentive promotion desk are not fully familiar with the system of incentives. For example, some of them are not even aware of (1) the contents of the R&D incentives scheme LOPA; and (2) the fact that R&D incentives have existed for more than six years. Most of them think that R&D has been integrated into the IPP LOPA only in the past two years, when in fact it has been there since early 1991.

- Government and private sector linkages are very weak. Thus, commercialization of developed technologies has not been well been.

As a result of these gaps and problems, only 11 companies, or a total of 13 projects, were granted incentives during the period 1991-1997. Meanwhile, the results of Halos (1999) on the survey and interview with private firms in the chemical industries indicate that there has been a considerable reduction in R&D investments. The exceptions are in the sugar and coconut industries where research funds have been mandated by government. In fact, the intensity of research activities by the private sector, except sugarcane and coconut, appears to have declined from the level in the 1980s. Information on R&D is scarce and hard to come by, but there are clear indications of this slowdown. For example, a number of multinational pesticide companies used to maintain research groups distinct from marketing group, but only two have continue to do so at present. The regional research station of a multinational agrichemical firm has reduced not only the number (from five to three) but also the rank of its research staff (from two senior and two junior level).

Another observation of Halos (1999) deals with government policy. To be sure, the government has adopted a policy of promoting local innovations and R&D activities. This is manifested in a major legislation, RA 7459, which was signed into law in April 1992. The law provides multi-incentives package to encourage the development of inventions and facilitate their commercial application. For example, the law provides for presidential awards, tax/duty exemptions, loan assistance, and invention assistance development in prototyping, piloting, training, study tours, attendance to conferences/seminars and laboratory tests and analyses. Various councils of the DOST provide counterpart R&D funds to private companies. Although respondents agreed that tax exemption for R&D equipment is conducive to their R&D initiatives, interviewees found the *procedures too cumbersome*. Similarly, they found the *availment procedures and equity requirements for technology-commercialization loans cumbersome and too steep for small entrepreneurs*." In fact, producers of organic fertilizers bewail the data required for FPA registration.

Patalinghug (1999) argues that small- and medium-size enterprises 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 knowhow 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."

Table 24. Tertiary education across selected Pacific Rim countries

Country	(1)	(2)	(3)	(4)	(5)	(6)
China (1991)	2,124,121	0.17	80,459	3.79	59,748	74.26
Japan (1989)	2,683,035	2.13	85,263	3.18	54,167	63.53
South Korea (1991)	1,723,886	3.83	92,599	5.37	28,479	30.76
Australia (1991)	534,538	2.92	92,903	17.38	26,876	28.93
Singapore (1983)	35,192	1.13	1,869	5.31	532	28.46
Malaysia (1990)	121,412	0.58	4,981	4.10	1,251	25.12
Thailand (1989)	765,395	1.24	21,044	2.75	4,928	23.42
New Zealand (1991)	136,332	3.78	13,792	10.12	2,863	20.76
Philippines (1991)	1,656,815	2.39	63,794	3.85	5,520	8.65

Column definition:
(1) Number of students at tertiary level
(2) Number tertiary students as percent of population
(3) Number of post-baccalaureate students
(4) Post-baccalaureate as % of tertiary students
(5) Number of post-baccalaureate science and engineering students
(6) Post-baccalaureate science and engineering as percent of post-baccalaureate students
Basic source of data: UNESCO World Science Report (1996).

Education

Table 24 shows that while the Philippine educational system produces a very high number of tertiary graduates, the post-baccalaureate science and engineering students, as a percent of post-baccalaureate students, is low. In column 6 of the table, the Philippines ranks the lowest in the list with a ratio of only 8.65. This is far from the second lowest of 20.76 percent, which is for New Zealand. The highest is China with a ratio of 74.26 percent.

The low number of scientists and engineers is reflective of the general tendency of the educational system in the Philippines to produce nontechnical graduates. There is in fact a dilemma in the present education system because of the educational "mismatch": while there is a great demand for technical and engineering-related graduates by local industries, private tertiary schools continue to produce nontechnical graduates. This is, indeed, a big policy area problem. One of the factors that would explain this is that private schools prefer not to go into these technical-related courses because of their high laboratory requirement that is capital intensive. Nontechnical courses are less laboratory-intensive and therefore less capital-intensive.

The pool of R&D manpower is dominated by people with basic college degrees and generally have very limited advanced technical training. This in itself presents a big stumbling block because new technologies available are already in advanced state and require special technical skills. Thus, the lack of adequate R&D manpower places the country in a very disadvantaged position because it does not have enough technical capability to adopt, through R&D, developed technologies in the market. In other words, with inadequate technological capability, the Philippine may find it difficult to catch up in terms of access to and mastery of the key emerging or leading-edge technologies. This, in turn, negatively affects future growth and international competitiveness.

This inadequacy of supply of R&D manpower can be traced back to the problem in basic education that is at the moment in a poor state. This problem is rooted in the teacher training policy of the country and the status of teaching profession (Magpantay 1995). He says:

> To be able to teach in high schools, teachers must have BSE with a major and minor field. This degree program is short on content and heavy on methodology of teaching. In the end, teachers are knowledgeable in the standard way of teaching but do not know how to teach. Worse, students who enter . . . college are generally not very creative and imaginative due to the low status afforded the profession. In any family, the intelligent among the children are encouraged to take up medicine, law, and, if mathematically inclined, engineering while the least academically capable are asked to take up BSE or BSEE programs. It is no wonder then that science and math educations in the primary and secondary levels are in bad shape. Students are taught by the least academically inclined people who went through a program that emphasizes more on the form than on the content.

The poor S&T educational system results in low supply of skilled manpower (Sachs 1998). Says Sachs:

> In particular, there is a severe shortage of science teachers at the school level. The quality of science education at the college level is also poor. A substantial fraction of high school science teachers have no training in science and mathematics (but rather have degrees in education). High school math and physics curricula are badly in need of reform. A World Bank-funded engineering and science education project has provided scholarship for masters and doctoral training in science and engineering, but the scope of the project is limited. In general, there is a lack of capacity to do research, which will become particularly problematic in the future when forms will have greater demand for adopting and innovating existing technologies. Increasing the supply of science and technology education is probably the most crucial investment in science and technology that needs to be made *now*.

Health

The Center for Economic Policy Research (CEPR) conducted an analysis of the fund flow for health research and development in the Philippines. Among the major objectives of the analysis were to: trace the flow of health R&D resources; assess the system for setting health R&D priorities; and determine if health R&D funds match the priorities of the research agenda.

Some of the major insights derived from the CEPR-DOH findings, which are relevant to the present R&D gaps analysis in this section, include:

- Of the P394 billion government budget for 1996, health resources accounted for P75 billion, or 19 percent, while R&D resources had a meager share of P3 billion or less than one percent.

● Resources for health R&D amounted to P421 million. This was equivalent to 17 percent of R&D resources and one percent of health resources. The latter is below two percent of the national health expenditures, the proportion recommended by the Commission for Health Research and Development for health R&D.

Other important gaps

Eclar (1991) examines the long history of S&T and R&D in the Philippines. In fact, he says, its beginnings can be traced back to the American colonial period. There have been significant changes since then, including changes in the structure, system, leadership and administration. Recently, programs and plans have been launched like the Science and Technology Master Plan (STMP) in 1990 and the Science and Technology Agenda for National Development (STAND) in 1993. However, there are no successes that can be cited. But there are clear indications of failure (Patalinghug 1999). For example, the S&T sector faces the following major problems: under-utilization of S&T for development, as reflected in the low quality and productivity of the production sector and heavy dependence on imports; underinvestment in S&T developments in terms of manpower training, technological services, R&D facilities, and financial resources; weak linkages between technology generation, adaptation, and utilization; and slow commercialization of technologies because of very weak delivery system, which in turn is the result of weak linkages, especially between government research institutes and the end-users.

Patalinghug (1999) further says that 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 value-added chain. The shift from primary exports (coconut, sugar) to manufactured exports (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.

Furthermore, there are a number of clear institutional gaps as well. Among the crucial ones are:

● *Failure in execution and implementation*. Patalinghug (1999) compared the S&T systems in the Philippines and in South Korea. One of his observations was 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 and organization arrangement to ensure timely and correct implementation."

There are substantial defects within the existing intragovernment coordination system. In particular, the system of performance monitoring and evaluation is lacking or defective. In fact, the government's Investment Coordination Committee (ICC, chaired by NEDA) has been lengthily reviewing projects intended to address the adverse effect of the financial crisis. But basing on the 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 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.

- *Other causes of institutional failure*. Some argue that Korean leadership has the political will and the ability to generate consensus among its stakeholder to give top priority to S&T development in the allocation of resources. Magpantay (1995), on the other hand, claims that the DOST is a highly inefficient structure largely because it "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." This is manifested in the DOST's STMP 15 leading edges and STAND 22 R&D priority areas. These areas are all-inclusive and practically cover all industries and all technologies with too little financial resources. This kind of situation is a clear example of poor planning and poor budgeting. Patalinghug (1999) in fact concludes, "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."
- *Failure of industrial policy*. There are renewed attempts to formulate industrial policy (Patalinghug 1999). This 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 and SMEDC) have not stressed the need for active promotion of technology to build a strong foundation for industrialization." The STAND has identified what is called "export winners" or "industry / product winners." Patalinghug argues that identifying these winners without technology is like a vehicle without an engine. Twelve priority sectors have been implicitly identified in the recent polevaulting strategy. However, the technologies in support of these "must-do" programs have yet to be identified.

6
Policy Insights

R&D investments

There are convincing pieces of evidence showing significant underinvestment in R&D in the Philippines. This is true at the national as well as the various sectoral levels. For example, Cororaton (1999) estimates a gap in R&D expenditure of 0.5778 percent of GNP at the national level. David et al. (1999) have also observed significant underinvestment in agriculture. Israel (1999) also finds the same thing in the fisheries sector. Underinvestment in R&D is also very apparent in the private manufacturing sector as observed by Macapanpan (1999) and Halos (1999). The recently completed study on the flow of R&D funds in the health sector by CEPR-DOH (1998) also found significant underinvestment in R&D.

There are also equally convincing set of facts indicating high rates of return on R&D investments. This being the case, underinvestment in R&D and high rates of return may imply high opportunity cost. While it is extremely difficult to compute this opportunity cost because of lack of information, it is manifested in other indicators like productivity. Productivity performance in the Philippines has been very poor. In fact, this has been the major factor behind its unsustainable growth path. In principle, R&D activities lead to innovation, technological progress, and finally economic growth and prosperity. A huge body of literature can support this.

The biggest issue at hand is: Who would fill the gap? Rough calculations indicate that there is a gap of about P14 billion at current prices. For sure, the government sector cannot fill in this gap because of financial constraints. Furthermore, the government has other equally important concerns such as basic infrastructure and other social sector needs. Naturally, it has to be the private sector (either local or foreign). However, the private sector responds to proper incentives. (Further discussion on this is given later in the section.)

Part of the gap can be attributed to the inefficiency of allocation of resources. In fact, in agriculture, David et al. (1999) argue, misallocation of public sector research funding is an equally important consideration as underinvestment. They cite specific examples. Using the congruence rule, they find that "relatively greater research budgets are provided for minor commodities such as cotton, silk, or carabao, and too little on major ones such as corn, coconut, fisheries and others. Furthermore, Mindanao regions are relatively neglected in terms of research budgets of the DA and SUCs compared to Luzon and to a lesser extent to the Visayas. While congruency does not strictly coincide with optimal research resource allocation, the differences in research intensity ratios observed among commodities and across regions cannot be explained by possible differences in cost of research (probability of research success, etc.), future market potential, or equity considerations.

Another manifestation of misallocation of resources lies in the allocation of budgetary resources by type of expenditure. David et al. (1999) also observe that "too little resources are available to perform research activities and to properly maintain the physical facilities, after the salaries of personnel have been paid. Indeed, the average share of personal services to direct budgetary outlays is close to 60 percent and as high as 70 to 80 percent in many cases. Consequently, either the research manpower is underutilized or the research agenda is driven by donors' priorities."

Due to lack of information because of extremely poor databases on R&D activities, misallocation of research resources in other sectors like the manufacturing cannot be conducted. However, given the nature and the extent of problems in the R&D system in the Philippines, the issues on agriculture seem generic to all sectors of the economy.

Aside from underinvestment and misallocation of research resources, there is another big problem of untimely release of funds to institutions, programs and projects. In fact, this is true not only in R&D but also in other activities that are dependent upon government funding and support. Israel (1999) mentions this as one of the major concerns in the fisheries sector. He says, "In fisheries, it is acute because of the importance that time and season play in the conduct of activities. Although there are no data which can be used to validate this, research activities are reported to be cancelled or haphazardly conducted because of the delay in the release of funds."

Patalinghug (1999) has recommended that DBM be involved with DOST in the S&T and R&D planning formulation stage so that S&T and R&D resources are made available to implement such plan without delays. This issue will also be touched upon later in the discussion on institutional arrangement.

R&D manpower

The issues surrounding R&D manpower are equally, if not more, problematic. This is because the problems in this area can be traced back to the educational system which is not only difficult to reform, but takes a long time for reforms to bear fruit. Lag time would usually take about 15 to 20 years—the required time to properly educate and equip the children with the necessary skills and talents before they enter the workforce.

Cororaton (1999) estimates that the gap in the R&D manpower is about 197 scientists and engineers per million population. In agriculture, David et al. (1999) observe that the R&D manpower is not so much in terms of the number as in relatively low level of scientific qualification of agriculture research. They, in fact, gave a warning that there is an urgent need to strengthen manpower capability in DA and DENR research agencies. Israel (1999) also observed a severe shortage of qualified personnel in the fisheries sector. The same is true in the private manufacturing sector (Macapanpan 1999; Halos 1999). In fact, in the recent PIDS survey (Cororaton et al. 1999), it was observed that the majority of R&D personnel have only basic college degrees. A small percentage has doctoral degrees mostly in social sciences. A very tiny percentage of Ph.D. holders are in engineering and technology.

While the Philippine educational system produces one of the biggest numbers of college graduates, compared to other countries, it generates one of the smallest numbers of graduates with science and engineering skills (Cororaton 1999). A host of factors are behind this issue. At the tertiary level there is a dilemma in the present educational system because of the educational "mismatch." While there is a great demand for technical and engineering-related graduates by local industries, private tertiary schools continue to produce nontechnical graduates. One of the factors that would explain this is that private schools, which dominate the tertiary level, prefer not to go into these technical courses because of their high laboratory requirement that is capital-intensive. Nontechnical courses are less laboratory-intensive and therefore less capital-intensive.

At the secondary level, a substantial fraction of high school science teachers have no formal training in science and mathematics (Magpantay 1995; Sachs et al. 1998). Rather, they have degrees in education. There is, therefore, an urgent need to reform high school math and physics curricula. This problem also holds true at the primary level.

In almost all sectors, the lack of adequate manpower surfaces. Thus, for the country to sustain a long-term growth there is an urgent need to reform the science and technology education system. In fact, investment in science and technology education is the most crucial investment that needs to be made now (Sachs et al. 1998). Otherwise, it would be too late since returns to this investment have usually very long gestation period or time lag.

Patalinghug (1999) offers specific recommendations: (1) strengthen S&T education at the elementary and secondary school levels. The quantity and quality of elementary and secondary teachers of science and mathematics must be addressed in the Medium-Term Philippine Development Plan (MTPDP) for 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;[9] and (4) expand the Philippine Science High School system.

Incentive system

People, especially the private sector, respond to incentives. Incentives that are deemed particularly important to R&D activities include a stable economy; institutional protection; access to capital and financing, especially by the SMEs; good R&D infrastructure; and fiscal incentives.

Normally, there are high risks involved in R&D activities. In particular, there are uncertainties in the outcome of an R&D undertaking. Positive and favorable results of an R&D undertaking will not emerge 100 percent or with certainty. In fact, there are great possibilities of failure. Furthermore, there is high incidence of spillover or externality that is hard to appropriate. In this regard, government intervention is critically needed.

There is ample literature and empirical evidence that support the fact that a stable macroeconomy helps encourage productivity-enhancing activities like R&D, especially by the private sector. Therefore, conducive macroeconomy is one of the major incentives that can be offered to private investors. The role of the government is particularly important in being able to manage the economy so that inflation rate, interest rates, risk premiums, among others, are kept at a minimum.

There are also clear indications from the literature that institutional protection is critically needed. Institutional protection comes in the form of patents and intellectual property rights. These issues have not been addressed in detail in the present paper, but certainly there are problem areas that need to be ironed out here. To be sure, there are indications that the number of patents granted declined through time.

Macapanpan (1999), Halos (1999), and Nolasco (1999) observe through company interviews and surveys that one of the major constraints preventing some of the firms, especially the SMEs, from conducting and pursuing R&D activities and plans is the lack of access to cheap capital and financing. The cost of capital in the Philippines is traditionally high because of distortions in the financial system.

R&D and S&T infrastructure is also one crucial incentive that could attract the private sector to pursue technology-related activities. Proper infrastructure could come in the form of a strengthened educational system, which can produce a workforce with adequate R&D capabilities, good and updated databases and information system; wide and easy-to-access network on technology developments; a mechanism whereby Filipino scientists and engineers working abroad can come home to work; and a mechanism whereby research results and output of research institutions and universities can be delivered to the endusers, among others.

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[9]South Korea did this in the early 1960s with great success.

Macapanpan (1999), Halos (1999), and Nolasco (1999) also note that fiscal incentives are important in attracting the private sector to go into R&D activities. Cororaton (1999) lists down some of the major fiscal incentives in the Philippines and notes that these are generally similar to the ones offered in other countries. However, fiscal incentives have to be handled properly, as these would have significant budgetary implications. Furthermore, although fiscal incentives are important, results would indicate that there are major inefficiencies in the granting of incentive in the BOI. For example, Nolasco (1999) states that from 1991 to 1997, only 11 companies or a total of 13 projects were granted incentives. Patalinghug (1999) therefore suggests the need to "design an incentive package, with strict qualifying requirements on what constitutes R&D activities, to encourage private sector R&D. An external peer review committee is recommended to act as the screening mechanism." The granting of fiscal incentives may be conducted on a competitive basis through a set of performance criteria that may be defined by the government.

Israel (1999) discusses other important incentive issues that need attention. He notes, in particular, that in most cases, researchers conducting research using the funds of their own agencies get minimal financial incentives. Remunerations from projects funded by other government sources have been uncompetitively low. As a result, many researchers tend to do odd jobs not related to research, or consulting work for the private and international organizations. The results of the PIDS survey on R&D manpower, particularly on R&D personnel with Ph.D. degrees, validate this trend (Cororaton et al. 1999).

The Magna Carta for the Government Science and Technology Personnel (RA 8439) was recently passed to address the problem of low incentives, but it remains to be seen whether this will solve the problem. In particular, the law allows for the provision of honoraria, share of royalties, hazard allowance, and other benefits to science and technology workers.

Patalinghug (1999) offers other recommendations to improve the S&T incentives. These include: (1) allocation of an annual funding for the implementation of the Scientific Career System (SCS); and (2) implementation of 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. With regard to the first, entry into SCS should be limited by giving top priority to the target groups, natural scientists, and engineers.

Institutional arrangement and S&T coordination mechanism

There is no doubt that the entire R&D system, as well as the general S&T system, is in a state of disarray because of lack of leadership, direction, and coordination. There are systems, as well as administrative failures, that result in wrong implementation of the plans, projects, and programs. There are also policy failures due to the lack of focus on technology in the overall development strategy. To address these problems, Patalinghug (1999) recommends the following reforms:

- DBM must be involved with DOST in the S&T plan formulation stage so that S&T resources are available to implement the plan;
- STCC must draft a Medium-Term Science and Technology Development Plan (MTSTDP) a year before the drafting by NEDA of the next MTPDP. An interagency joint committee must integrate the MTSTDP into the MTPDP 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;
- 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; and
- 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.

R&D delivery system

Eclar (1991) has noted that there is very slow commercialization of technologies in the Philippines. This is largely due to the very weak delivery system and poor linkages of S&T organizations with industry and other government agencies. To improve the linkages Patalinghug (1999) has a number of recommendations:

- 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.
- Establish funding schemes through DOST and CHED to support a consortium or network of schools to maximize use of resources.
- Focus funding support for developing core competence on 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.
- 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.
- Install a scanning and monitoring scheme of world technological trends for dissemination to local industries, research institutes, and universities.

Eclar (1991) conducted a comprehensive analysis of factors affecting commercialization of technologies. Her study identified user participation.

Her findings: Successful commercialization is promoted when a user with a specific need has been identified at the start of the project. The user generally maintains an interest in the progress of the research and takes on the commercialization of the results at the completion of the research project to meet his earlier expressed need. This is reinforced when the user's interest in the project is translated into support or costsharing.

Another important factor is pilot testing. Demonstration of the technical viability of the technology in a semicommercial scale helps convince an industry user to start off the commercialization process. Commercial success is promoted when the user himself has provided material inputs to the pilot test.

Industrial strategy

The market of technology is highly imperfect and the economic environment within which these developing countries are operating is adverse to technology-based institutions. The Philippines is undergoing market-based reforms[10] in line with globalization. While these are extremely important and necessary to overhaul the inefficient production structure of the economy, it lacks focus and provides no clear direction for technological innovation. The recent S&T plan of the government lists down 23 industries as priority areas. The list is simply too long since the production lines of these industries are totally unrelated. The case of Japan, and to a great extent the South Korea, is very clear: the technological innovation strategy was attuned, synchronized, and consistent with the overall industrial strategy. This is a very important lesson for the Philippines during this period of economic reform. The process of technological innovation cannot start and gain momentum unless some kind of an industrial strategy is adopted. Activities in technology area are simply too risky and to a great extent capital-intensive. Unless clear directions are set, the private sector may be unwilling or hesitant to come in and participate no matter how attractive government incentives are. In the Philippines, incentives are being offered to R&D-related activities, but there are very few takers.

Here's a word of caution in letting the government take an active role in industrial strategy. To prevent the policy failure of the past from recurring, the strategy has to be market-friendly. That is, it should not go against the market, but instead assist in its development. If, for example, market signals indicate that it is the semiconductor industry that is the leading sector both in the domestic and export markets,[11] then government effort should be directed toward supporting the industry in terms of infrastructure, manpower development, incentives, research institution, etc. The

[10]Economic reforms include trade reforms, financial reforms, fiscal reforms, exchange rate reforms, investment reforms, and other market reforms through privatization and liberalization.

[11]At present, almost 60 percent of the country's export consists of semiconductors.

technological innovation strategy that is consistent with this is the development of a system whereby the economy is able to move up the production ladder from the present assembly-type activities to activities with higher value added. Manpower development and research institutions are key to the development of this system.

Statistical information and accounting system

Good and accurate analysis of R&D opportunities is one of the major factors that would help encourage private, as well as public, investment into R&D and S&T-related activities. This is because there are normally high risks involved in R&D investments (particularly the uncertainty in the outcome of an R&D undertaking) couple with high incidence of spillover or externality that is hard to appropriate. These uncertainties and other market failures can be minimized if the statistical information and accounting system is well established. A good information system leads to good analysis on the structure and nature of R&D activities. If there are significant market failures, with good analysis, then appropriate and correct policy measures can easily be formulated to correct these market kinks. However, the present statistical information and accounting system is extremely poor. It generates very inaccurate information of the variables of particular interest in policy. This assessment is based on the recent R&D survey conducted by PIDS (Cororaton et al. 1999). Thus, there is an urgent need to overhaul the statistical information and accounting system on R&D and S&T activities. The first major step involves making the survey questionnaire consistent with the accounting system of the institutions so that information can flow immediately from the information system of the respective institutions into R&D database. The next major step involves reconciling the variables in the questionnaire consistent with the NSO-PSIC sectoral breakdown. The third recommendation deals with institutionalizing the data system in NSO, because of its expertise in gathering information and extensive nationwide network, both of which will help ensure that regular information is generated and regular monitoring and analysis are conducted.

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Economic growth is determined by how well a country mobilizes its resources to improve productivity in order to increase production of goods and services. Generally, resources include labor and human skills, capital, land and natural resources, while major factors affecting productivity are technology, research and development. The latter is the focus of the book.

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