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Philippine Institute for Development Studies

## Research and Development: A Review of Literature

*Caesar B. Cororaton*

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**PHILIPPINE INSTITUTE FOR DEVELOPMENT STUDIES  
AND THE  
DEPARTMENT OF BUDGET AND MANAGEMENT**

**RESEARCH AND DEVELOPMENT:  
A REVIEW OF LITERATURE  
(FINAL REPORT)**

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# **Research and Development: A Review of Literature<sup>1</sup>**

**Caesar B. Cororaton<sup>2</sup>**  
*(Revised Draft Report, December, 1998)*

## **I. Introduction**

Research and Development (R&D) is defined as any systematic and creative work undertaken in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this knowledge to devise new applications.<sup>3</sup> R&D activities include basic research, applied research, and experimental development.

This review of literature delves into the following issues related to R&D: (1) low level of R&D in the Philippines; (2) opportunity cost of such low level in R&D; (3) historical development in science and technology (S&T) and the current policy objectives and measures, and institutional arrangement and organizational structure of the present S&T governing bodies; (4) the level of S&T and the intensity of R&D activities, as well as the institutional arrangement and organizational structure in other countries such South Korea, Taiwan, and New Zealand, and (5) incomplete market structure or market imperfections in research and innovation, and the role of government through intervention in the

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<sup>3</sup>The original source of definitions is UNESCO, but the definitions below taken from the survey questionnaire of the National Statistical Office (NSO). Basic research - any experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular or specific application or use in view. Applied Research - any original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective. Experimental Development - any systematic work, drawing on existing knowledge gained from research and/or practical experience that is directed to producing new materials, products, and devices, to installing new processes, systems and services, and to improving substantially those already produced or installed.

form of the provision of subsidies and incentives. These issues are analyzed with the end-view of seeing and understanding the present gaps and weaknesses in the system of S&T and R&D in the Philippines. This paper heavily depends on the available domestic and international literature on S&T and R&D.

## **II. Underinvestment in R&D May be Economically Costly**

This section will show that while the current level of R&D in the Philippines is very low, the economic costs associated with low levels of R&D are substantial. Some of the implicit economic costs include: (1) low productivity; and (2) foregone economic opportunity due to substantial returns to R&D investments as shown in other countries, as well as in the Philippines.

### **II.A Current R&D Levels in the Philippines**

The common indicator of R&D levels, in particular, and S&T capability, in general, are the number of R&D scientists and engineers per million of population and the ratio of gross expenditure on R&D to gross national product (GNP). Table 1 shows some comparative R&D indicators of 91 countries. Based on the indicators, the Philippines belongs to the group of countries with low R&D level. The ratio of R&D expenditure to GNP ratio was 0.2 percent for the Philippines in 1992. This level is very low compared to the technologically-aggressive and high-growing economies.

Similarly, the Philippines ranks low in terms of the number of R&D personnel. In 1992, the ratio of the number of scientists and engineers per million population was 152. From the supply side, this low level of S&T and R&D personnel is a result of the country's educational system that produces very low science and engineering-related graduates. While the number of students at the tertiary level is high in the Philippines, the number of tertiary students taking up science and engineering-related courses is low (Table 2). 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 non-technical graduates. This is a big policy area problem, indeed. 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 which is capital intensive. Non-technical courses are less laboratory intensive and therefore less capital intensive.

Furthermore, in a recent survey conduct by the Philippine Institute for Development Studies (Cororaton et al, 1998) on R&D activities of government agencies and state universities and colleges (SUCs), it was observed that more 40 percent of R&D personnel with Ph.D. degrees are in social sciences, while only less than 10 percent are in engineering and technology (Figure 1). About 35 percent are in agriculture-related sectors.

Figures 2 to 4 show the relationship between R&D indicators and the level of income of countries. The general trend is that high income countries have high R&D indicators. While it can perhaps be argued that there can be some causality problem regarding which comes first, either economic growth or R&D and other technology-related activities, there are strong empirical evidences pointing to the fact that the causality chain starts from R&D investment to technological innovation to productivity increases and, finally, to economic growth and prosperity.

## **II.B Rates of Return to R&D Investments<sup>4</sup>**

Although estimation techniques used in computing for the rates of return to R&D investment are far from perfect mainly because of data problems, the estimated rates of return found in the literature for both developed and developing countries and for both agriculture and industry are encouragingly high. Evenson and Westphal (1995) surveyed the results of 156 studies

estimating rates of return to R&D investments in agriculture and 40 studies in industries. They found that, indeed, the rates are very high, even higher than other forms of investment like basic infrastructure. Table 3 shows that of the public agricultural research more than half of the results of the studies surveyed show rates of return higher than 50 percent. Only few studies show estimated rates of return lower than 10 percent. It is also worth noting that in terms of the distribution of estimated returns, developing countries have higher estimated rates compared to developed countries. There are relatively fewer studies reporting rates of return to private sector R&D used in agriculture, but again the estimated rates of return are also high.

One of the major reasons behind the large returns to developing countries' R&D in agriculture is the spillover effect from developed country research. "Indeed, LDC systems, in concentrating on adaptive invention, do rely on the international agricultural research centers (IARCs) and developed country systems for pioneering invention and pre-technology science. At least in principle, this ought to enable them to generate equal returns with lower skill levels." (Evenson and Westphal, 1995).

In the Philippines, Librero (1997) surveyed studies on rates of return to investment in agricultural research for selected countries and commodities and found the same pattern of high estimates for rates of return. The estimated rates of return are shown in Table 4. In the Philippines, estimated rates of return are particularly high for sugarcane, mango, and poultry. Cororaton (1998) estimated the rate of return to R&D investment in the primary sector, which includes agriculture and mining industries, and found high rates of return, averaging between 54 and 60 percent.

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<sup>4</sup>See Appendix for a review of methodologies used for computing rates of return to R&D investments

On the other hand, few studies have estimated returns to industrial R&D in developing countries. This is because “it is exceedingly difficult to measure directly the overall volume of technological effort related to technological change in the industrial sector. Generally, one can at most infer the results of such activity from estimates of productivity growth.” (Evenson and Westphal, 1995). In spite of these, the limited number of estimates of rates of return to industrial R&D investments indicate that they are similarly very high. Among the possible reasons for these high returns to R&D investments is through the achievement of efficiency gains as a result of R&D. “Most LDC firms are well behind the local production frontier and even further behind the frontier of international best practice. Given this evidence, the estimates suggest that there is tremendous potential for realizing high returns from investments that would enable the achievement of best practice.” Another possible reason for the high rates of return to industrial R&D is the spillover effects of R&D results across different sectors and industries, including agriculture. Griliches (1991) and Nadiri (1993) have looked into a number of empirical estimates and found that R&D spillovers are of substantial importance and suggests that the social returns are considerably higher than private returns.

In the Philippines, there are few empirical evidences on the rates of return to industrial R&D. The studies conducted by Pack (1987, 1990) which focused on the computed potential returns from productivity enhancing expenditures on adaptive modifications and skills development in a sample of Philippine textile firms indicate that more than 80 percent of the firms in the industry would realize higher returns from such expenditures than from alternative investments. However, the studies of Cororaton (1998) and Cororaton and Abdula (1997) show relatively lower rate of return to industrial R&D investment. The former shows rates of return ranging from 10 to 12 percent, while the latter about 10 percent.



## **II.C     Estimates of Productivity in the Philippines**

The Philippine economy performed poorly over the last three decades compared to its Asian neighbors. The Philippines grew an average of 2.5 percent per annum over the period 1980-1996, far below the growth performance of Singapore (8.0 percent), South Korea (8.2 percent), Thailand (8.0 percent), Malaysia (8.2 percent), and Indonesia (7.6 percent). One of the major reasons behind this poor economic performance, as suggested in the literature on Philippine economic development, is the deterioration in productivity.

The declining productivity over the years is borne out in a number of productivity studies done at the macro level. Table 5 shows some of the estimates of total factor productivity (TFP). For example, Williamson (1969) estimated a declining TFP from 55 percent in the period 1947-55 to 15 percent in 1955-65. The results of Sanchez (1983) and Patalinghug (1984) showed relatively constant TFP growth in the 1960s up to the early 1980s. However, the results of Austria and Martin (1992) showed a big drop in TFP growth in the period 1950-87 of -11 percent. According to the authors, this drop in productivity growth can be explained by the inability of the country to allocate its resources efficiently because of policies that intervened in the process of resource allocation.

In a more recent productivity paper, Austria (1997) found that for the period 1960 to 1996, TFP of the entire economy declined by -0.4 percent. However, it is worth noting that in the more recent period, especially in the last 4 to 5 years, productivity improved (see Figure 2). Austria (1997) attributed this improvement to the favorable effects, in particular efficiency effects, of the economic reforms implemented.

The overall declining productivity is also reflected at the manufacturing level. The results of Hooley (1985), showed that "over the period 1956-80, TFP decreased by 0.15 percent annually. Since 1975, TFP has been

declining at an alarming rate of 2 percent or more per year. For the manufacturing sector as a whole, the data paint a very clear picture: one of slow TFP growth during the late fifties and sixties, unmistakable retardation after 1970, with rates of advance after 1975 assuming significantly larger negative dimensions. When certain additional adjustments for labor quality improvements are made, the average rates are uniformly lower for the entire period as well as for all subperiods."

In a more recent study on manufacturing TFP, Cororaton et al (1996) came out with productivity estimates that indicate a general decline in productivity. The decline in productivity is mainly caused by the deterioration of technical progress over time. The study suggests that this is attributed to the general failure in the approach of acquiring and adapting new or foreign technology.

Cororaton and Abdula (1997) investigated some possible determinants of manufacturing TFP. Among the factors included in the analysis were: exports, imports, tariff protection, domestic wages, government R&D expenditure as a percent of GDP, foreign direct investment, and inflation rate. As argued in the paper, each of these variables attempted to capture key features of the economy. For example, inflation rate captures economic stability in the system. In principle, high inflation will deter productivity enhancing programs and investment. The results of the investigation are shown in Table 6. One of the major relevant results in the paper is the statistically significant and positive coefficient of the variable that captures R&D efforts. This is indicative of the importance on R&D expenditure as a major factor to focus on any productivity enhancing program.

Cororaton (1998) found that for the period 1981 to 1996, TFP of the primary sector (which includes agriculture and mining industries) declined by an average of  $-0.2$  percent. Industry TFP improved marginally by an average of  $0.9$

percent over the same period, while the service sector TFP declined by an average of –2.9 percent.

Umpa (1997) did a correlation analysis between the level of economic growth and development and S&T capability. He found that “The number of R&D scientists per million population and the gross expenditure on research and development as a percentage of gross national product both provide a very accurate prediction of the per capita gross national product among nations.” Therefore, there is strong support to the hypothesis that economic success is dependent on science and technology capability.

### **III. Philippine S&T Policies and R&D Programs**

#### **III.A Evolution of S&T Policies.**<sup>5</sup>

Philippine S&T has a long history. It can be traced back to the early American colonial period with the creation of the Bureau of Science. 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

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<sup>5</sup>Based on the paper of Eclar (1991).

marginal. The Institute suffered from lack of support, planning, and coordination. In fact, in the Bell Mission's Recommendation, it was mentioned that the Institute had no capability to support S&T development because of the lack of basic information, neglect of experimentation and small budget for R&D activities.

There were also major shifts in the 1950s and 1960s which 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 performing effectively its functions. This was manifested in the unplanned activities of the researchers within the agencies. Areas of research were for most part left to the researchers to define under the presumption that they were attuned to the interests of the country. They were left to look for technologies and scientific breakthroughs with good commercialization potential. With no 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 are supposed to have greater beneficial impact on the country, focus was re-directed towards applied research in the 1970s. Furthermore, in the 1980s, research utilization was given stronger emphasis. This led to the reorganization of the NSCB into the National Science and Technology Authority (NSTA) in 1982. One rationale for NSCB's 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 of the NSTA was the creation of the S&T Council System, where an S&T council became responsible for the sectoral formulation of policy and strategies for its specific field and allocation of funds. There were 4 councils under the system PCHRD, PCIERD, PACRRD and NRCP (Table 7 for the exact names of the councils and institutes of the DOST). Later NRCP was

replaced by PCAMRD and PCASTRD. Furthermore, the NSTA had 8 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 and the scientific career system was created to attract scientists to a career path that would professionalize and upgrade the status of scientists. Furthermore, linkage between the academe and the private sector were strengthened with the creation of institutional networks.

Thus, the creation of these councils and research institutes under the NSTA showed a clear shift in science policy from being a technology push strategy to demand pull. In the demand pull 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) under 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 formulating and implementing policies, plans, programs and projects for S&T development.

For a more effective delivery of certain functions, the DOST was further restructured which resulted in the establishment of the Technology Application and Promotion Institute (TAPI). This particular 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 and mandated to undertake and formulate plans for the development of S&T education and training. 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 a S&T data bank and information networks.

The National institute of Science and technology was reorganized into the present Industrial Technology Development Institute in order to undertake applied R&D and to transfer R&D results to end-users and to 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 were created to further strengthen the Council system, namely the PCASTRD and the PCAMRD.

Furthermore, the leadership of DOST added emphasis on massive technology transfer activities. Specific interventions were initiated through various programs such as the Comprehensive Technology Transfer and Commercialization (CTTC) Program. The CTTC was intended to serve as a mechanism for identifying and pushing concrete results of R&D towards productive application and utilization. The initial phase of the program which covered the period 1989-1992 included a number of technologies whose utilization was envisioned to create substantial impact on the national socio-economic 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 in order to carry out the added responsibility of transferring completed researches.

Provincial S&T Centers were established to help ensure the efficient and effective transfer of technologies in the provinces.

S&T services were also provided in order to supplement R&D and technology transfer. S&T services included the upgrading of testing, standardization and quality control services and various forms of technical assistance and consulting services. Also, assistance to investors were 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 pilot plant operations for selected top priority technologies for commercialization; and support the upgrading of inventions, expertise and capabilities.

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

Incentives were provided under the Omnibus Investment Law for the conduct of certain R&D and S&T activities in the private sector. Some of 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 serve as the vehicle for university interaction with private industry; to develop new knowledge-based industries and strengthen existing ones; and to provide conducive 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 1988 A Presidential Task Force on S&T was formed specifically to deal with the overall problems confronting R&D and S&T development in the country and to formulate an S&T Development Plan which supports the national development goal of attaining a newly industrializing country status by the year 2000. The task force is composed of DOST, DOA, DTI, DOTC<sup>6</sup>, 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 on March 1989, embodying the development of 15 leading edges to steer the country to industrial development. These 15 leading edges are: aquaculture and marine fisheries; forestry and natural resources; process industry; food and feed industry; energy; transportation; construction industry; information technology; electronics; instrumentation and control; emerging technologies; and pharmaceuticals.

To attain the objectives set in the S&T Master Plan (STMP), the following strategies were pursued: (i) modernize the production sectors through massive technology transfer from domestic and foreign sources, (ii) upgrade of R&D capability through intensified activities in high priority sector and S&T infrastructure development such as manpower development, and (iii) develop information networks, institutional building and S&T culture development (Tables 8A to 8C).

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<sup>6</sup>DOA – Department of Agriculture; DTI – Department of Trade and industry; DOTC – Department of Transport and Communication.



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, eleven domestic needs, three supporting and coconut industries as priority investment areas. The seven identified export winners are: computer software; fashion accessories; gifts, toys, and houseware; marine products; metals fabrications; furniture; and dried fruits. The domestic needs sectors include: food; housing; health; clothing; transportation; communication; disaster mitigation; defense; and environment; manpower; development 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, special focus was given to the coconut industry, and therefore was included in the list.

### **III.B. Proposed S&T Bill<sup>7</sup>**

To give R&D and S&T development a further boost, the Congress proposed a bill that will to increase the allocation of government funds to the sector is currently in being reviewed in Congress. In particular, the House Bill No. 2214, which is currently under review and deliberation, proposes that approximately one percent (1%) of Gross National Product will be allocated for all scientific and technological activities for the first 10 years once it is approved. On the 11<sup>th</sup> year onwards, the 1% GNP allocation will be for R&D activities only. The proposed allocation is patterned after the experience of developed countries that attained industrialization when they allocated approximately 1% of their GNP to R&D activities. The bill further proposes that the recipient of GNP allocation be divided between the government and the private sector. In the first year, the government will receive approximately 80 percent of the R&D expenditures while the private sector will receive 20 percent. The share of the government will

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<sup>7</sup>Summarized by Ma. Teresa Duenas-Caparas, Research Associate, PIDS.

gradually decrease over the years with only 30 percent on the 20<sup>th</sup> year upon implementation of the bill. The private sector can benefit from the S&T/R&D allocation basically through incentives. The high government share in the first years is part of a transition process where S&T activities will be initiated first by the public sector, and will be eventually passed on to the private sector.

Based on historical data, R&D expenditure grew on average by 15.1 percent from 1989 to 1997. However, this growth rate is not enough to propel the country to “Nic-hood”. As it is, R&D expenditures were only 0.19 percent of GNP, a share far from the desired level of 1 percent. The gap is partly due to the lack of appropriate funding from the government.

The Bill also proposes that from the government share, 30 percent will be for DOST while the remaining 70 percent be divided among other government departments. In 1995, DOST received 15 percent of the S&T appropriations. The largest recipient was the Department of Agriculture with approximately 40 percent of the appropriation. The development of human resources similarly received a large allocation with the State Colleges and universities, and the Commission on Higher Education as the prime beneficiary. The allocation among government agencies will also be gradually shifted over the years. The first five years, human resource development agencies and the DOST share receive 60 percent of the S&T allocation. Industry and agricultural agencies shall receive 15 percent each. The purpose of this allocation is to enhance agricultural productivity, ensure the sufficiency of basic food and services, and to initiate a system toward a more elaborately transformed product. On the 6th year onwards, agriculture will only receive 5 percent of the budget, and human resource development allocation will remain at 35 percent. DOST and Industry agencies will receive higher S&T allocation to help attain competency in the production of elaborately manufactured products.

### **III.C Few Comments and an Assessment.**

There are two key reasons why S&T/R&D policies in the Philippines suffered major setback: (i) underutilization of S&T for development as reflected in the low quality and low productivity of the production sectors; and (ii) weak linkage between technology generation, adaptation and use. Underinvestment in S&T development is in terms of manpower training, technological servicing, R&D facilities and financial resources.

The weak linkage can be attributed to: (i) poor linkage between technology generation, adaptation and use; (ii) slow commercialization of technologies due to weak delivery system; (iii) poor linkages of S&T organizations with industry and other government agencies; and (iv) low appreciation of R&D due to short-term perspective of private and government agencies.

There are possible ways of improving the delivery system and the commercialization of R&D output. Eclar (1991) attempted to investigate some of factors that may be important in improving the delivery system and commercialization. In particular, the study identified user participation as one important factor. 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 in order to meet his earlier expressed need. This is reinforced when the user's interest in the project is translated into support or cost-sharing. Another important factor, as identified by the study, is pilot testing. Demonstration of the technical viability of the technology in a semi-commercial scale helps convince an industry user to start off commercialization. Commercial success is promoted when the user himself has provided material inputs to the pilot test.

In spite of the expressed importance of S&T and R&D development in the Philippines and the series of well-intentioned strategies, the state of S&T and R&D development remains far behind other Asian countries by any measure. One reason behind this is the low private sector participation in R&D activities. Most countries that achieved a healthy partnership between public and private sectors in R&D. The bulk of R&D expenditure that originates from the private sector in Japan is 83 percent, Korea 82 percent, Taiwan 65 percent, Singapore 62 percent, Thailand 40 percent. In the Philippines, the share of the private sector remains at 20 percent for R&D expenditure, or even less.

Aside from the problem of underinvestment in R&D, the Philippines also suffers from the shortage of S&T manpower. Because of lack of better and quality employment opportunities in the domestic economy brain drain of technical personnel as well as S&T professionals is one crippling problem the S&T manpower development process. In 1992, the Philippines had only 15,610 personnel engaged in R&D activities, representing 152 personnel per million population. The UNESCO puts the critical mass of S&T personnel at 380 per million population to implement the application of technology.

The STMP and STAND 2000 have too many identified areas to be supported with too little financial resources. It is highly doubtful as to how much attention was given to the consideration of the viability of its implementation. There is weak linkage between planning and budgeting, and little consideration of budget availability in plan formulation stage. With insufficient budget allocation, the DOST had to cancel and reduce its financial supports for S&T development programs and projects.

#### **IV. R&D and S&T Experiences of Other Countries.**

Is the current R&D and S&T system in the Philippines comparable, or at par with those of other countries, especially those which have proceeded aggressively with technology development? This section will take a cursory look

at the experiences of other countries. Two of the countries discussed are “tiger” economies in the region: South Korea and Taiwan. These countries are generally claimed to have adopted very aggressive R&D and S&T policies that eventually led to their present day economic prosperity. The other country is New Zealand, which not too long ago changed its system of institutional arrangement to an efficient partnership with the private sector.

#### **IV.A South Korea<sup>8</sup>**

**Policies and Development.** In South Korea (Korea from here on), S&T development strategy went through several different phases to make it attune to the changing national development objectives and strategies, as well as to the changing economic environment. R&D and S&T policies have constantly been adjusted to meet economic and social development needs of the country throughout its economic growth and industrialization. Tables 9 and 10 outline briefly the progress in the economy and the S&T development and industrial technology that accompanied the economic progress.

The main goal of development in the 1960s was to develop the basic industries for import substitution. Thus, the following industries were actively supported: fertilizer, cement, oil refinery and steel. During the same period, export-oriented light industries were vigorously encouraged. However, at that particular period, technological capability that would support such development strategy was not available. To remedy the problem strong emphasis in the field of S&T was placed on the importation of technologies needed to build up the basic and light industries.

The policy formulation in Korea was dynamic. While the importation of needed technology was going on, the government actively pursued a policy of building up technology capability through the setting up of S&T infrastructure such as technological training and education. Thus, as the starting point of the

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<sup>8</sup>Based on the paper of Ki-Soo (1996).

institutionalization of R&D/S&T for industrial technology, the Korea Institute of Science and Technology (KIST) was established in 1966. As a first major move to develop the badly needed technological capability, the KIST recruited hundreds of qualified Korean scientists and engineers working abroad through the government support and incentive system.

To establish and strengthen the institutional framework, the Ministry of Science and Technology (MOST) was created in 1967 as the central government agency looking into the development of R&D/S&T (Table 11). Furthermore, at about the same period the S&T Promotion Law was enacted to provide the legal basis for S&T development. Under this institutional framework, the first major task was the training of skilled workers and craftsmen. Thus, vocational education and training programs were launched on critical technical fields needed both by the public and private sectors. Furthermore, industrial firms were encouraged to conduct in-plant training programs with government support.

The direction of economic policies moved towards the development of heavy and chemical industries through the absorption of imported technology in the 1970s. During the period, policy emphasis was on fostering more technology-intensive industries. To facilitate this, serious effort was made to improve on imported and existing technologies and to meet the ever-increasing needs of scientists and engineers. Thus, assimilation of imported technology in the private sector was encouraged aggressively. Technical personnel who were trained at the technology-suppliers firms played an important role also in the process of technology assimilation. Technologies were assimilated in order to better adopt to local conditions and therefore to reduce production costs. Government support and backing were very visible in all the effort and initiative to develop, adapt and assimilate foreign technology, especially during the initial phases when the industry was first reluctant to venture into in-house R&D because of high-risks involved and limited financial resources to carry on the R&D activities. In fact, to further support the assimilation process, a dozen of

other government-supported R&D institutes were established specializing in the area of machinery, electricity, electronics and telecommunication, chemistry, and shipbuilding.

S&T education at the college level was strengthened and expanded in order to meet the increasing demand for college graduate and to increase its level of technical manpower and facilitate the process of industrialization. In line with this objective, the government drastically expanded college and graduate level education. It placed special emphasis on such fields as chemical, mechanical, electrical and electronics engineering. The S&T education system was further given a boost by the recruitment of qualified faculty members from abroad and by the financial support to expand the educational facilities significantly. In particular, in 1970, the government opened a new graduate school, the Korea Advanced Institute of Science and technology (KAIST), with a special mandate to train leading scientists and engineers.

In the 1980s, in an effort to solve the social problems which had been neglected during the period of rapid economic growth development, policy directions in Korea moved towards socio-economic development. Thus, the government started reducing the intervention in economic activities and began minimizing the measures that protected domestic industries from foreign competition to enhance the competitiveness of industries. During the same period, S&T policy started emphasizing in the localization of key strategic high technologies, and in the development of high caliber S&T manpower and in the promotion of private sector R&D capabilities. In fact, the government formally launched the National R&D project in 1982 to aggressively push for the localization of key industries. This initiative was financed by both the government and the private industries and was put to a clear focus on developing key strategic technologies which normally could not be pursued by the industry alone. With this and the government's encouragement and support, the private sector

took the “driver’s seat” so to speak in R&D activities through their own R&D institutes

The active participation of the private sector in R&D has been the key element in the development process in Korea. Under the Industrial Technology Development Promotion, the private sector has been provided with enough incentive to participate in R&D. The incentives include tax privileges and financial support such as tax deduction and tariff exemption on R&D reserve funds and subsidies, R&D equipment and facilities, human resource development expenditures (Table 12). As a result the number of private firms with R&D capability to do research increased drastically. In fact, at present the private takes a dominant role in R&D activities (Table 13)

Even with the increased participation of the private sector in R&D, the government continues to upgrade and improve the existing R&D/S&T infrastructure. This improvement focuses on two major areas: manpower development (Table 14 for details); and S&T information system and network. The latter strengthens the information system including S&T data collection, application and distribution. It also includes intensifying the information highway network in order to facilitate the rapid transmission of S&T information to the end-users and to fortify the foreign technology information collection through associate institutions abroad.

This infrastructure build-up comes about because of increased investment in R&D. The emphasis on technology development and R&D will continue to be so in the future with the expected expansion of R&D investment from 2.1 percent of GNP to 4 percent in 1996 and 5 percent in 2001, along with the expected increase in the S&T manpower from 15.6 persons per 10,000 population in 1990 to 23.5 in 1996 and 30 in 2001.



**S&T Administrative System in Korea.** S&T development in Korea started with the creation of the MOST and the passing of the S&T Promotional Law in 1967. Since the creation of the MOST, the government has been formulating and implementing comprehensive S&T development plans and programs as part of the mid-term and long term-term economic and social development plans. At present, 10 ministries and 5 administrative units are directly involved in R&D activities. By arrangement, each related ministry is in-charge of its respective industrial technology development through its R&D institutes, while the MOST is responsible for the R&D activities of the basic science and generic technologies, strategic field of high technologies and core technologies and big science and multi-disciplinary technologies such as aerospace, ocean and nuclear energy.

The institutional arrangement of government-supported R&D institutes under the MOST is also quite extensive. Since the establishment of KIST in 1966, the government has expanded the government-supported R&D institutes specializing in materials and metals, energy, resources, electricity, chemicals electronics and communication, nuclear, and ocean to meet R&D needs in the specific fields. As of 1995, there are twenty eight government-supported institutes existing in Korea, twenty two under the MOST, two under the Ministry of Information and Communication, one under the Ministry of Agriculture and one under the Ministry of Finance and Economy.

#### **IV.B Technology Policies in Taiwan.**<sup>9</sup>

The technology development strategy adopted in Taiwan is one that is encouraging strongly private sector participation. This can be observed from the technology policies pursued which can be grouped in three categories: supply side, demand side and environment side. In the supply side, the government directly influences the technology supply through the provision of financial resources, manpower assistance, and technical assistance. In the

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<sup>9</sup> Based on the paper of Jiann-Chyuan Wang (1998).

demand side the government affects the technology sector through the provision of stable market for contract research and through the use of government procurement programs to guide the direction of technological development. In the environment side, the government creates a favorable economic climate in order to indirectly affect the behavior of the firms in terms of their R&D activities. Their behavior can be affected through tax incentives, patent protection and other regulations.

The government, through its Industrial Development Bureau (IDB), developed what is called the “Targeted Leading Product”. Firms which develop, produce, and market products which belong to this list will receive various government support and incentives. Products will be considered Targeted Leading Products if they meet the following criteria:

- (a) the product is in a newly-developed, high-tech industry (such as communications, aerospace, advanced materials, semiconductors, etc.),
- (b) the technology necessary for the development of the product exceeds the existing level of technical expertise in the domestic industry,
- (c) the product has high market potential, and has the capability of stimulating the development of related industries.

**Supply-Side.** As mentioned above, there are three types of supply-side policies adopted to encourage R&D activities in firms which produce products that belong to the list of Targeted Leading Products: (i) financial support; (ii) manpower assistance; and (iii) technical assistance.

The financial support of the government to qualified firms are in two forms: financial subsidies and loans. According to the regulations governing the implementation of the Targeted Leading Products, 50 percent of the development funds required for the targeted leading product development plans which have been approved will be put up by the government. In addition, the other 50

percent financial requirement will be extended in the form of a loan under IDB's Matching Funds Program (MFP). However, the firms which have received the financial assistance through MFP are obligated to pay back the loan after the product has been on the market for one year. In addition, the firms are required to pay royalties of 1-4 percent (in most cases 1 percent) of annual product sales for up to three years.

In terms of manpower assistance, the Ministry of Economic Affairs (MOEA) established universities and non-profit organizations which train manpower for research. However, because of high demand for R&D staff, the system could not cope up. This created a shortage. Furthermore, Taiwan's educational system focuses on the cultivation of teachers and professors. The training of technical research manpower has given relatively less emphasis. Thus, in the light of these shortages in the supply of technical research manpower, adjustments would have to be done, such as coordinating the educational planning with research manpower demands, and encouraging cooperative research and efforts in research manpower cultivation.

In terms of technical assistance, government support can be classified into two types: (i) technical consulting services to local firms which are upgrading their production technologies; and (ii) transfer of key technologies developed in the state-owned research institutes (e.g., the Industrial technology research Institute (ITRI) and the Information Industry Institute (III)) to the industrial sector.

ITRI, which was created by the government in 1973, has been an important channel for government intervention in R&D. In fact, more than 60 percent of the Science and Technology Research Project, which has an annual budget of over NT\$10 billion, is under the purview of ITRI. Furthermore, ITRI has been quite involved in several cooperative research projects with private firms. Cooperative research can allow local firms to send their personnel to ITRI right

from the beginning of the joint research project. This type of cooperative arrangement facilitates the technology transfer and therefore bridges the gap between ITRI and the private sector on what technologies that should be developed. In other words, through cooperative research the government facilitates its technical assistance to the private sector.

**Demand-Side.** There are two ways by which the government can support technology development through the demand side: public procurement and contract research. However, not much details are available on contract research. What is discussed here is only the public procurement.

There are high risks involved in R&D activities, especially in the early stages of the product development. In public procurement the government provides a guaranteed contract to purchase new or strategic products developed by the private firms in Taiwan. Thus, through this guarantee, it provides a stable market demand for R&D products, and therefore greatly reduces uncertainty, especially in the early stages. By minimizing the uncertainty, the public procurement provides incentives to local firms to engage activity in R&D investment.

In Taiwan at present, laws and regulations related to public procurement include the “Administrative Law of Public Enterprises”, as well as the laws defining the procedures for imports. However, there are indications pointing to the fact that there are some problems in terms of effective and adequate enforcement of these regulations. In advanced countries, public procurement policy has been effectively used to enhance long-term competitiveness for certain industries.

**Environment-side.** Here the government attempts to create an environment that is conducive to R&D investment through innovation-oriented regulations and tax incentive schemes. A number of regulations have been

pursued. The more important ones include the Fair Trade law which encourages a fair, competitive environment. This encourages small and medium enterprises to get engaged more in R&D investment. Patents, protection of royalties and intellectual property rights (IPR) have also been enforced to safeguard the private sector in their R&D activities. Some of the IPR laws include, the copyright law, the cable TV law, the industrial design law.

Furthermore, to encourage and stimulate R&D investment and technological upgrading, the government formulated the “Statute for Industrial Upgrading and Promotion” (SIUP). Enacted in 1991, through this SIUP, the government implemented R&D promotional policies such as R&D tax credits<sup>10</sup>, accelerated depreciation of equipment, exemption from tariffs.

#### **IV.C    The Science System in New Zealand.**<sup>11</sup>

Prior to the reforms, the science system in New Zealand was dominated by a small number of large government departments with mixed and overlapping roles. The departments were funded directly by the government on an institution by institution basis. With the onset of the recent reforms, the entire system was reorganized into a system with three separate, independently-run, and highly focused major components. The three components are (i) technology policy; (ii) science funding; and (iii) science operations (see Figure 6). The separation of these components enabled clearer objectives to be established at all levels in the science system. The separation also allows each component to focus on its own set of activities, and therefore creates a better system of accountability.

**Policy Making on Technology.** Although the present science system has three separate components, the overall policy making body regarding science and technology matters in New Zealand is still the Government. Broad

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<sup>10</sup>In the R&D tax credit scheme, firms with at least NT\$3million dollars worth of investment in R&D in one year are eligible for 15 percent credit. Firms spending more than NT\$3 million and with R&D intensity (measured as the ratio of R&D spending to sales) of 3 percent are eligible for incremental credit at 20 percent on the amount exceeding NT\$3 million.

directions are based on the recommendations to the Cabinet of a Cabinet Committee. The members of this Committee, however, is not permanent, but could change from time to time. Presently, there are three ministerial portfolios in the government with specific responsibilities for research, science and technology. These are the (i) Research, Science and Technology (RS&T); (ii) Education; and (iii) Crown Research Institutes.

**Policy Advise.** RS&T's main responsibilities include: (a) giving policy advise to the Ministry of Research and Technology on science and technology policy, including advise on science and priorities and funding; (b) gathering and dissemination statistics and descriptive information on research, science and technology and for administering international science relations at a government-to-government level. It also acts as the agent of the Minister of Research in the overall administration and monitoring of public investment in science and technology; (c) providing a consultative form on issues and policy proposals in research, science and technology.

**Funding.** In 1990, the Foundation for Research, Science and Technology (FRST) was created as an independent statutory authority. FRST's main function involves the allocation of funds for research and development and scientific services which fall within the definition of public good science and technology. Other agencies responsible for funding allocation to other specific and key sectors are: the Health Research Council which is the main funder for health research, Animal Health Board which allocates funds to research on the study of epidemiology of TB, as well as new toxins and their application; Agricultural and Marketing Research and Development Trust which funds research activities on agriculture, pastoral, horticultural and forestry industries.

**Science Operations.** In 1992, the different department carrying out research projects were reorganized and restructured to enable their research

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<sup>11</sup>Based on the article "The Science System in New Zealand"

activities to be continued in newly-formed government-owned companies, or Crown Research Institutes (CRIs). The structure of CRI provides a more open and flexible for management of science. It creates avenues for better collaboration between the public and private sectors in the fields of research and development, as well as in the transfer of technology. Furthermore, the company structure of the CRIs provides full commercial powers. The structure also allows access funds through borrowings, as well as permits joint ventures. The structure also allows to form subsidiary companies so that the CRIs can fully exploit the commercial potential of new development in the country.

Although separate, the CRIs are closely linked to the science web, local as well as international. Their science operations are liked with Universities, Polytechnics, other government departments, and research associations and research organizations with similar activities.

## **V. Institutional Issues on the Innovation System**

**The Role of the Public Sector.** It is well established and understood that R&D or knowledge-based investment is a major factor of long term growth. In fact, the chain of causality starts from R&D investment to technological innovation to productivity increases, and finally, to economic growth and prosperity. However, there are a host of factors that tend to prevent R&D activities from being pursued. In the literature, the common deterrent factors include: pervasiveness of knowledge spillovers and the problem of appropriability R&D outcomes, the credit constraints faced by research organizations/institutions, and the contractual incompleteness induced by the impossibility of describing in advance the characteristics of innovation developed. All these factors have mutually reinforcing effects of discouraging and preventing R&D investments, as well as of diffusing developed knowledge to future potential innovators. Because of these imperfections, the government, through public intervention, has a major role in ironing out these market kinks. The usual

government interventions include granting of subsidies to organizations/institutions doing R&D activities, and allocating and enforcing property rights to innovations. While government intervention is clear, the form government intervention should take is totally vague and unclear. It is highly controversial among policy makers, resulting in so much debate. Although the debate process is good in a democratic system, the cost of delay in implementation of policies could be tremendous. Among the key issues being debated are: "Should public intervention be centralized or decentralized? Should it emphasize the provision of R&D subsidies or instead should it confine itself to the design and enforcement of patent legislation? Should R&D subsidies be targeted to particular sectors, industries, or firms, or instead should R&D subsidies be provided on a nondiscriminatory basis? Should public financial participation in R&D investments take the form of direct subsidies (e.g., tax subsidies or government transfers) or instead should it involve the government's participation as a creditor and/or as a shareholder? And so on." (Aghion and Howitt, 1997)

**Targeted Versus Untargeted Subsidies.** One way to intervene into the market is to target R&D subsidies, i.e., to aim them at particular projects, firms or sectors. However, targeted R&D subsidies are often criticized for being arbitrary and discretionary in the choice of beneficiary because it is the government, rather than a properly functioning market, that decides who will receive the subsidies. This implies that there is always the possibility (in fact great possibilities) that the government will commit some mistakes, especially in cases where there is limited information available to it. This is particularly true for knowledge externalities (spillover) which are hard to identify and measure adequately. In fact, there are severe informational asymmetries between the government and the potential beneficiaries regarding the measurement of R&D inputs and the impact of R&D subsidies. On the other hand, there are big incentives for firms to waste resources for lobbying lucrative contracts. Furthermore, "picking winners is always hazardous, especially in the R&D sector



whose activities are often unpredictable. Even if the government makes the right decision ex ante, it may appear to be a bad decision ex-post if the project fails.” (Aghion and Howitt, 1997)

Subsidies which are not aimed at any particular firm, industry, or project are called untargeted subsidies. Such subsidies include research tax credits, amortisement, tax deduction on stock options, tax deduction for firms that invest in joint R&D funds, credit guarantees, subsidized insurance for risky capital investment, and the like. In some cases, these subsidies may end-up being wasted in financing some investment undertakings. For example, tax credits may end up financing investments that would have taken place anyway without government subsidy.

Given these factors, which is therefore better and economically optimal: targeted or untargeted subsidies? If the government does not have enough information about which projects have positive externalities, then targeted subsidies run the risk of being awarded arbitrarily. Extending subsidies can be wasteful and can put a lot of pressure on government revenue. On the other hand, if subsidies are extended indiscriminately, then untargeted subsidies can also be wasteful if some projects would have been taken anyway without subsidy. Based on these two conflicting factors, the government is likely to find targeted subsidies useful in certain areas where it has expertise and has all the necessary information about the project. Otherwise, it may be efficient to use untargeted subsidies.

**Ex-ante Versus Ex-post Subsidies.** When considering targeted subsidies, there is another issue of whether the subsidy is to be extended up front (ex-ante) or only in the case of success (ex-post). Aghion and Howitt (1997) has shown “that the government can achieve the first-best result by simply paying over the externality (or the amount of subsidy required) to the firm if it succeeds. In this way, the firm completely internalizes the externality and

therefore chooses the right effort. Ex-ante subsidy is completely useless in stimulating R&D effort because it is independent of whether success occurs.” It has been suggested, however, that when public funds are costly and generally limited, at the same time there is adverse selection as well as moral hazard, the government can benefit from offering a “menu” from which firms choose a combination of ex-post and ex-ante rewards because this will enable it to direct funds more cost effectively.

**Auction System.** Because of market imperfections, there are indeed real difficulty involved in determining the value of innovation that right policy intervention may be based upon. Kremer (1996) suggested an auction system for patent rights which will help reveal the private value of innovations. The government could then use the revealed private value in determining the social value of an innovation, which in turn can be used in determining the amount that has to be paid to the innovator. If this is done properly, the innovator will have the right incentive to innovate. Furthermore, once the auction is done and the government has purchased the patent, the government can place it under the public domain, thus eliminating monopoly distortions and any rent to be gained through costly imitation. However, this system has involves some inherent difficulties. The difficulties could come from (1) the calculation of the correct ratio of private to social value of innovation (the difficulty could arise from the fact that the ratio is affected by factors such as elasticity of demand, effectiveness of the patent system, and the rate of subsequent innovation which are not totally revealed from an auction system); and (2) the collusion behavior between bidders and the inventor, thereby resulting in few bidders entering the auction, making the entire system unreliable in arriving at the revealed value of the innovation.

## **VI. Some Policy Insights.**

R&D is crucial in a country's development process, yet some economic agents are hesitant in pursuing it. This is because there are high risks involved in R&D activities (particularly the uncertainty involved in the outcome of an R&D undertaking), as well as there is high incidence of spillover or externality that is hard to appropriate. Thus, to push R&D activities to the frontier, government interventions are critically needed. But the formulation of what type and form of government intervention to implement is a delicate thing to do, and often times controversial, because of imperfect information. Wrong policy formulation could run the risk of wasting limited government revenue and resources. However, the experiences of Korea and Taiwan show that proper targeting of industries and tailor-fitting of R&D incentive structure could work very well, if accompanied by a sound human resource development. In fact, coordination in these two areas and implementation of a good program for a continuous manpower training and development, propelled and sustained economic growth in these two Asian countries.

Aside from the fact that the Philippines has been underinvesting in R&D, poor coordination and lack of coordinated planning in relation to R&D are two major problems confronting the innovation and technology sector in the country. At the different government departments and agencies, survey and interviews indicate a seemingly chaotic and confusing system of institutional arrangements because of a lack of coordinated focus in terms of strategic sectors and programs. Furthermore, Magpantay (1995) has argued that the DOST has expanded its size too much over the years and has become too complicated a system to be able to perform its functions effectively. The Department is doing a lot of unfocused and not well-programmed set of activities through the different councils and institutions it presently has at the moment. Certainly, this leads to institutional inefficiencies. A reorganization of the structure of the Department is called for. Perhaps the recent institutional reforms in New

Zealand can be a model for reforms. Prior to the reforms, the science system in that country was dominated by large government departments with mixed and overlapping roles. However, with the reforms, the system has changed into one that has three separate, independently-run, and highly focused parts. These parts form the: (i) technology policy component; (ii) science funding component; and (iii) science operations component. The separation allows each part to focus on its own set of activities, and therefore creates a better system of accountability.

## References

- Aghion, P. and Howitt, 1997. *Endogenous Growth Theory* The MIT Press, Cambridge, Massachusetts.
- Congress of the Philippines, 1997. "Report and Recommendation of the Congressional Commission on Agricultural Modernization"
- Cororaton, Caesar, 1998. "Rates of Return to R&D Investment" Mimeo. Philippine Institute for Development Studies.
- Cororaton, Caesar, et. Al. 1996. "Estimation of Total Factor Productivity of Philippine Manufacturing Industries" PIDS Discussion Paper 96-.
- Cororaton, Caesar and Maria Teresa Duenas-Caparas, 1998, "Total Factor Productivity Estimates for the Philippine Economy" Revised Final Report submitted to the TWG-Productivity Indicators and Monitoring System.
- Cororaton, Caesar and Rahimaisa Abdula, 1997. "Productivity of Philippine Manufacturing" Mimeo, Philippine Institute for Development Studies.
- Department of Science and Technology. 1992. "Compendium of Available S&T Statistics". S&T Resource Assessment and Evaluation Division. Planning and Evaluation Service. Department of Science and Technology. Bicutan, Taguig, Metro Manila, Philippines, June 1992.
- Department of Science and Technology, 1993. "National Survey of Scientific and Technological Activities (NSSTA)" Integrated Report. S&T Resource Assessment and Evaluation Division. Planning and Evaluation Service. Department of Science and Technology. Bicutan, Taguig, Metro Manila, Philippines
- Eclar, V. (1991). "Analysis of Policies and Factors Affecting Successful Commercialization of technologies". Ph.D. Dissertation, College of Public Administration, University of the Philippines.
- Evenson and Westphal, 1995. "Technological Change and Technology Strategy" Chapter 37. *Handbook of Development Economics*, Volume II. Edited by J. Behrman and T.N. Srinivasan, Elsevier Science B.V.
- Fuglie K, et al *Agricultural Research and Development: Public and Private Investments Under Alternative markets and institutions*. An Economic Research Service Report. US Department of Agriculture.

- Griliches, Z. 1991. "The Search for R&D Spillovers" NBER Working Paper No. 3768. Cambridge, Massachusetts. National Bureau of Economic Research.
- Goto and Suzuki, 1989. "R&D Capital Rate of Return on R&D Investment and Spillover of R&D in Japanese Manufacturing Industries," *The Review of Economics and Statistics*, LXXI(4):555-564.
- Jiann-Chyuan Wang (1998). "The Impacts of R&D Expenditure on Taiwan's Economic Growth and Related Industrial Technology Policy" A paper presented during the Study Meeting on Total Factor Productivity, Singapore, May 1998.
- Ki-Soo, 1996. "Science and Technology Development Policy in Korea and the Philippines." Masteral Thesis, College of Public Administration, University of the Philippines.
- Kremer, M. 1996. "A Mechanism for Encouraging Innovation" MIT Mimeo.
- Librero, Aida, 1997. "Research Investment in Agriculture and Natural Resources" A Paper presented to Hon. Richard J. Gordon and the PCARRD Technical Advisory Committee at the Subic Bay Metropolitan Authority, Subic Bay, Zambales.
- Librero, 1997
- Magpantay, Jose, 1995. "Streamlining the Science and technology Sector for the Country's Development Goals" Philippine Institute for Development Studies.
- Nadiri, M.I. 1993 "Innovations and Technological Spillovers" NBER Working Paper No. 4423. Cambridge, Massachusetts. National Bureau of Economic Research.
- National Statistical Coordination Board 1979, 1983, 1985, 1990. Input-Output Tables of the Philippines
- New Zealand. "The Science System in New Zealand"
- Pack, H. 1987. *Productivity, technology, and Industrial Development* New York: Oxford University Press.
- Pack, H. 1990. "Industrial Efficiency and Technology Choice' in: R.E Evenson and G. Ranis, eds. *Science and Technology: Lessons for Development Policy*. Boulder, Colorado: Westview.

Philippines Institute for Development Studies, 1998. "Survey of Activities in Research and Development" Draft report prepared by Caesar B. Cororaton.

Solow. R. 1956. "A Contribution to the Theory of Economic Growth" *Quarterly Journal of Economics* 70(1): 65-94

Umpa, Camar. 1997. "Science, Technology and Economic Growth: Toward a Theory" *Lecturn*. Vol. 3, No. 7MSU-Iligan Institue of Technology, Iligan City.

United Nations Educational, Scientific and Cultural Organization

## TABLES AND FIGURES

**Table 1. PCGNP,SE/MP, and GERD/GNP among 91 countries of the world**

No.	Country	Per Capital 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 & Tobago	3,740	240	0.8	1984
38	Chile	3,520	364	0.7	1988
39	Malaysia	3,480	326	0.1	1992
40	Czeckoslovakia	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
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	<b>Philippines *</b>	<b>950</b>	<b>152</b>	<b>0.2</b>	<b>1992</b>
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

**Table 2. 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)						
South Korea (1991)	2,683,035	2.13	85,263	3.18	54,167	63.53
Australia (1991)	1,723,886	3.83	92,599	5.37	28,479	30.76
Singapore (1983)	534,538	2.92	92,903	17.38	26,876	28.93
Malaysia (1990)	35,192	1.13	1,869	5.31	532	28.46
Thailand (1989)						
New Zealand (1991)	121,412	0.58	4,981	4.1	1,251	25.12
Philippines (1991)	765,395	1.24	21,044	2.75	4,928	23.42
	136,332	3.78	13,792	10.12	2,863	20.76
	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 & engineering students  
(6) : Post-baccalaureate science & engineering as percent of post-baccalaureate students

Source: Basic source of data UNESCO World Science Report (1996).

**Table 3: Estimated Rates of Return to R&D**

			Range of Estimates				
	No. of Studies	Estimate not Significant	1-24	25-49	50-75	75+	Mean
<b>Public Sector Agriculture Research</b>							
Africa	10	1	2	3	3	1	41
Latin America	36	2	14	22	13	13	46
Asia	35	2	7	20	23	25	56
All Developing	85	5	23	45	40	44	80
All Developed	71	5	21	54	26	29	48
<b>Private Sector Industrial Research</b>							
Developing	5	0	0	3	3	2	58
Developed	35	0	10	20	10	5	44
<b>Public Sector Agriculture Extension</b>							
Developing	17	1	4	2	4	6	50
Developed	6	0	1	0	3	2	63

Source: Evenson and Westphal (1995)

**Table 4 Rates of Return to Investment in Agricultural Research for Selected Countries and Commodities**

Country	Commodity	Annual Rate of Return (%)
Malaysia	Rubber	24
Indonesia	Rice	133
Japan	Rice	25-27
USA	Corn	35-40
Mexico	Corn	35
Australia	Sugarcane	40-50
India	Sugarcane	63
South Africa	Sugarcane	40-50
Philippines	Rice	11-20
	Corn	29-48
	Sugarcane	51-71
	Mango	85-107
	Poultry	154-163
	Coconut	12-48

Source: Librero (1997)

**Table 5. Distribution of the Sources of Growth in the Philippines, Various Studies (%)**

Factors	Williamson (1969)		Sanchez (1983)*	Patalinghug (1984)	Austria & Martin (1992)	
	1947-55	1955-65	1960-73	1960-82	1950-87**	
Capital	9	25	24	48		87
Labour	33	54	52	23		24
Land	3	5	n.a.	n.a.		n.a.
Education	n.a.	n.a.	n.a.	6		n.a.
TFP	55	15	24	23		-11
Total	100	100	100	100		100
GDP growth	7.3	4.5	4.6	5.5		4.6

\* Sanchez (1983) decomposed the growth of the Philippines for the period 1960-73 only to use the data in comparison with Korea. TFP growth during this period was 1.1 per cent, higher than her estimates of -0.8 per cent for 1957-75.

\*\* The output elasticities estimated from equation (5a) were multiplied by the average growth rate of capital and labour to arrive at the contribution of each factor to GDP growth. For the period 1950-87, capital and labour grew at 6.2 and 3.0 per cent, resp.

Source: Austria, Myrna & Martin, Will, Economics Division Working Papers, *Macroeconomic Instability & Growth in the Phil: a Dynamic Approach*. Research School of Pacific Studies, Australian National University, 1992.

**Table 6 Determinants of TFP Growth in Manufacturing**

Dependent Variable: TFP Growth		
Independent Variables:	<b>Coefficients</b>	<b>t-statistics</b>
Constant	5.316	(27.267)
Exports(-1)	0.148	(8.581)
Imports(-1)	-0.519	(-18.522)
D(Tariff)	-1.740	(-33.438)
Wage	-0.126	(-9.353)
DRD(-1)	0.101	(9.353)
FDI(-2)	0.005	(14.081)
INF	-0.153	(-14.081)
INF(-1)	-0.468	(-23.088)
Adjusted R2 = 0.997	F-Stat = 448.63	DW = 0.65
<b>Where:</b> <b>Exports(-1):</b> real growth of exports, lagged one period <b>Imports(-1):</b> real growth of imports, lagged one period <b>D(tariff):</b> period differential of average nominal tariff rates <b>Wage:</b> growth of research and development expenditure as % of GDP, lagged one period <b>FDI(-2):</b> foreign direct investment <b>INF:</b> inflation <b>INF(-1):</b> Inflation, lagged one period		

Source: Cororaton and Abdula (1997)

**Table 7. 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

**Table 8A. Summary of Science and Technology Policies by Strategy**

1.	Modernization of Production Sectors
1.1	Generation and active Diffusion of Employment oriented and High Value added Technologies.
1.2	Emphasis on Developmental R&D towards Commercialization.
1.3	Proper Selection and Acquisition of Essential and Appropriate Technologies.
1.4	Adaptation, Absorption and Mastery of Imported Technologies.
1.5	Dissemination of Appropriate.
1.6	Technologies Increasing Accessibility to S&T information and Services.
1.7	Reducing Environmental Degradation and Mitigating Adverse Impacts of Natural Hazards.
2.	Upgrading of R&D Activities
2.1	Establishing R&D Priorities.
2.2	Development of Local Materials and Indigenous Technologies.
2.3	Stimulation of Private Sector Participation.
2.4	Reducing Environmental Degradation and Mitigating Adverse Impacts of Natural Hazards.
3.	Development of S&T Infrastructure
3.1	Development of High Quality S&T Manpower in Growth Areas.
3.2	Expansion of S&T Education and Training.
3.3	Development of S&T Institutions.
3.4	Development of an S&T Culture

Source: Eclar (1991)

**Table 8B. Summary of S&T Policy Programs in the Philippines**

		<b>Policy and Program</b>	<b>Brief Description</b>
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 For a	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	Conducts 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 inter-action 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 domestic needs, and coconut industry)	Indication of preferred areas of R&D
	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	Dev't of the grade school network serving as feeder schools for HS and technical schools
	C	Vocational and Technical Education	Dev't 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 Network and Institutions	Strengthening of S&T sectoral network and establishment of new S&T institutions and mechanisms

**Table 8C. Summary of Existing Policy Measures**

Category	Policy Tool	Existing Policy Measures
A. Supply Side		
1. Technology-related	Scientific and technical	<ul style="list-style-type: none"> <li>- Government R&amp;D Institutes</li> <li>- Demonstration projects/ pilot tests</li> <li>- Priorities Plan</li> <li>- Preferential use of Filipino expertise</li> <li>- Technology Packages</li> </ul>
2. Managerial	Information	<ul style="list-style-type: none"> <li>- National Information system for Science and Technology</li> <li>- R&amp;D data base</li> <li>- Foreign technology data base</li> </ul>
3. Political	Taxation	<ul style="list-style-type: none"> <li>- Tax incentives for R&amp;D regulations</li> <li>- Patent Law</li> <li>- Environmental and health regulations</li> </ul>
	Policy planning	<ul style="list-style-type: none"> <li>- S&amp;T planning</li> <li>- Sectoral planning and coordination</li> <li>- Public consultation</li> </ul>
	Public services	<ul style="list-style-type: none"> <li>- Infrastructure building</li> </ul>
	Public enterprise	<ul style="list-style-type: none"> <li>- Technology Business Incubators</li> </ul>
4. Institutional	Private sector initiative	<ul style="list-style-type: none"> <li>- Setting-up S&amp;T organization/networks</li> </ul>
B. Demand Side		
5. Market-related	Procurement	<ul style="list-style-type: none"> <li>- Product performance standards</li> </ul>
	Commercial	<ul style="list-style-type: none"> <li>- Trade agreements</li> <li>- Tariffs</li> </ul>

**Table 9. Outline of the S&T Development Strategy: Korea**

Period	Industrialization	S&T Development
1960s	<ul style="list-style-type: none"> <li>- Develop import-substitution industries</li> <li>- Expand export-oriented light industries</li> <li>- Support producer-goods industries</li> </ul>	<ul style="list-style-type: none"> <li>- build up infrastructure</li> <li>- strengthen S&amp;T education and technical training</li> <li>- promote foreign technology imports</li> </ul>
1970s	<ul style="list-style-type: none"> <li>- expand heavy and chemical industries</li> <li>- shift emphasis from capital import to technology import</li> <li>- strengthen export-oriented industrial competitiveness</li> </ul>	<ul style="list-style-type: none"> <li>- expand S&amp;T education and technical training</li> <li>- improve institutional mechanism for adapting imported technology</li> <li>- promote research and development applicable to industrial needs</li> </ul>
1980s	<ul style="list-style-type: none"> <li>- transform industrial structure to one with comparative advantage</li> <li>- expand technology-intensive industries</li> <li>- encourage manpower development and productivity</li> </ul>	<ul style="list-style-type: none"> <li>- develop and acquire top-level scientists and engineers</li> <li>- launch the national R&amp;D Project</li> <li>- promote industrial technology development and industrial labs</li> </ul>
1990s	<ul style="list-style-type: none"> <li>- promote structural adjustment and technological innovation in industries</li> <li>- promote efficient use of human and other resources</li> <li>- improve information networks</li> </ul>	<ul style="list-style-type: none"> <li>- reinforce the National R&amp;D Project to develop core and fundamental technologies</li> <li>- strengthen demand-oriented technology development system</li> <li>- globalize R&amp;D systems and improve information networks</li> </ul>

Source: 1993 Science and technology Policy in Korea, MOST, Republic of Korea.  
Quoted from Ki-Soo, 1996.



**Table 10. Progress of Industrial Technology**

	1960s	1970s	Since mid-1980s
Target Industries	Basic and light industries	Heavy and chemical industries	Strategic conventional and selected high-tech industries
Technical Task Emphasis	Importation of technologies	Assimilation of the imported technology	Technology generation through indigenous R&D
Form of Technology Acquisition	Dependence on technology importation	Imitation of imported technology	Creation through domestic R&D activities
Critical Human resources	Foreign experts and skilled workers	Local technical personnel	Local scientists and engineers
Production technology	Non-existence	Insufficient	Relatively sufficient
Supply source of components and parts	Foreign-made	Mostly foreign	Mostly local
Technology Transfer	Grant-in-aid	Mostly dependent on importation	Mostly import but export some technologies
- technology transfer form	Package form Turn-key project	Foreign investment and Joint Venture	Direct investment and cross-licensing
- target technology	Degraded technologies	Mature technologies	R&D stage and application stage

Source: Science and Technology Long-term Development Plan, MOST, 1986  
Quoted from Ki-Soo, 1996.

**Table 11. Among the main functions of the MOST include:**

<ul style="list-style-type: none"> <li>➤ The provision of technology forecasts for the setting up of the basic policy for S&amp;T development;</li> <li>➤ The implementation of national R&amp;D projects including core technology, future-oriented technology, big science and technology, and nuclear technology;</li> <li>➤ The provision of support to basic and applied R&amp;D activities conducted by government-sponsored institutes, university R&amp;D centers and private sector R&amp;D institutes;</li> <li>➤ The formulation of policies for R&amp;D investment, human resources, information and international cooperation in S&amp;T;</li> <li>➤ The promotion of the commercialization of developed technology and joint research among industries, academe and research institutes;</li> <li>➤ The promotion of public awareness and understanding of S&amp;T, construction and management of science towns as a mecca for advanced industries;</li> </ul>
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**Table 12. Incentive Measures for the Private Sector in Korea**

- Tax deduction of a maximum of 4 percent of the total sales on the reserve fund for R&D technical information, R%D manpower and facilities;
- Tax deduction of up to 15 percent of total expenditures on HRD and in-house technical training centers and colleges.
- Tax deduction of up to 10 percent of their investment for R&D facilities.
- Application of depreciation rate 90 percent a year on R&D and test facilities.
- Support of up to 50 percent of R%D expenditure when private industrial R&D institutes are involved in national R&D projects.
- Provision of financial support of up to 90 percent of total cost when small firms commercialize new technologies.
- Extension of support of up to 80 percent of total R&D investment by GOCCs when relevant private R&D institutes and R&D unions develop indigenous R&D products.
- Provision of long-term, low interest loans for R&D and commercialization to the private industries by KDB, the Citizens' National Bank, and the IBK.
- Comprehensive financial support by the Korea Technology Banking corporation (KTB) to private companies for technology development activities.
- Information service on technology data collection, application and distribution.
- Implementation of standardization and quality control such as KS and KT.
- Protection of intellectual property rights for new invention and innovations.
- Introduction of a new bidding system based on price and quality.
- Administrative assistance for joint research among industry, university, and GSRI.

**Table 13. R&D Expenditure and R&D Institutes by Sector in Korea**

	Public Sector				Private Sector		
	Institute	Researcher	Expenditure		Institute	Researcher	Expenditure
1989	222	10204	718 (20)		1855	56016	2803 (80)
1990	221	10434	814 (19)		1884	60069	3333 (81)
1991	240	10529	1020 (20)		2111	65723	4178 (80)
1992	265	14434	1098 (18)		2821	74330	5138 (82)
1993	261	16068	1295 (17)		3057	82696	6320 (83)

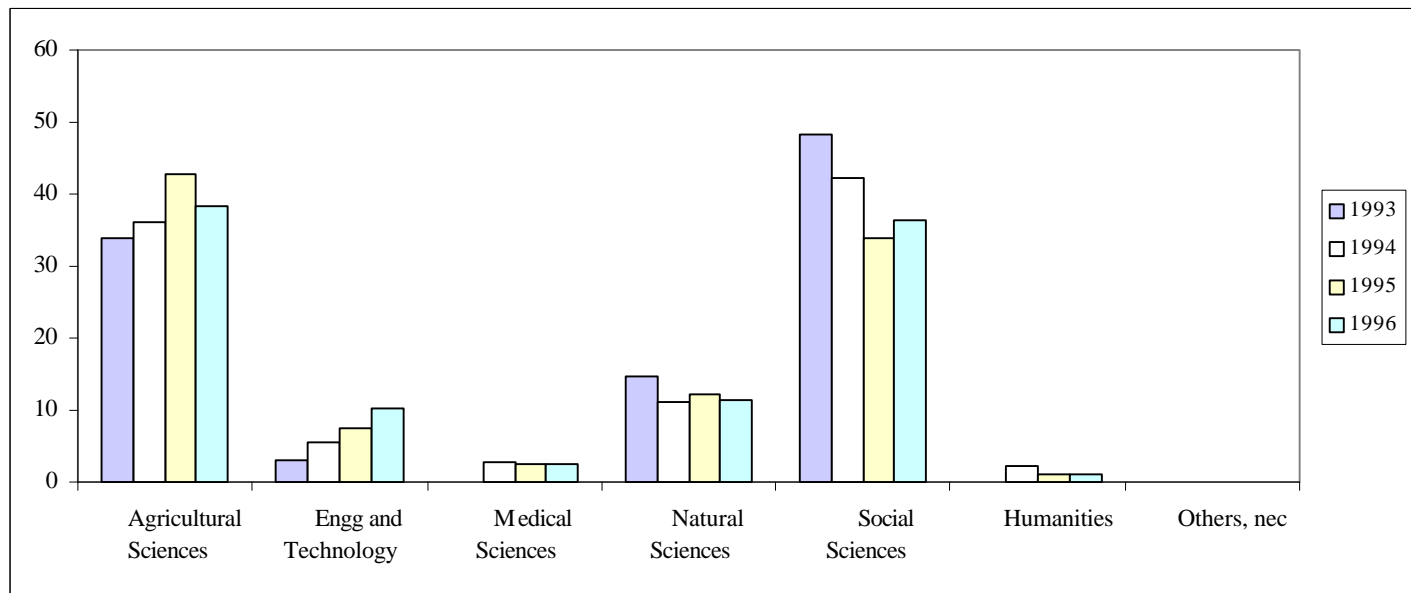
\* non-profit institutes are included in the public sector.

Source: Ki-Soo, 1996.

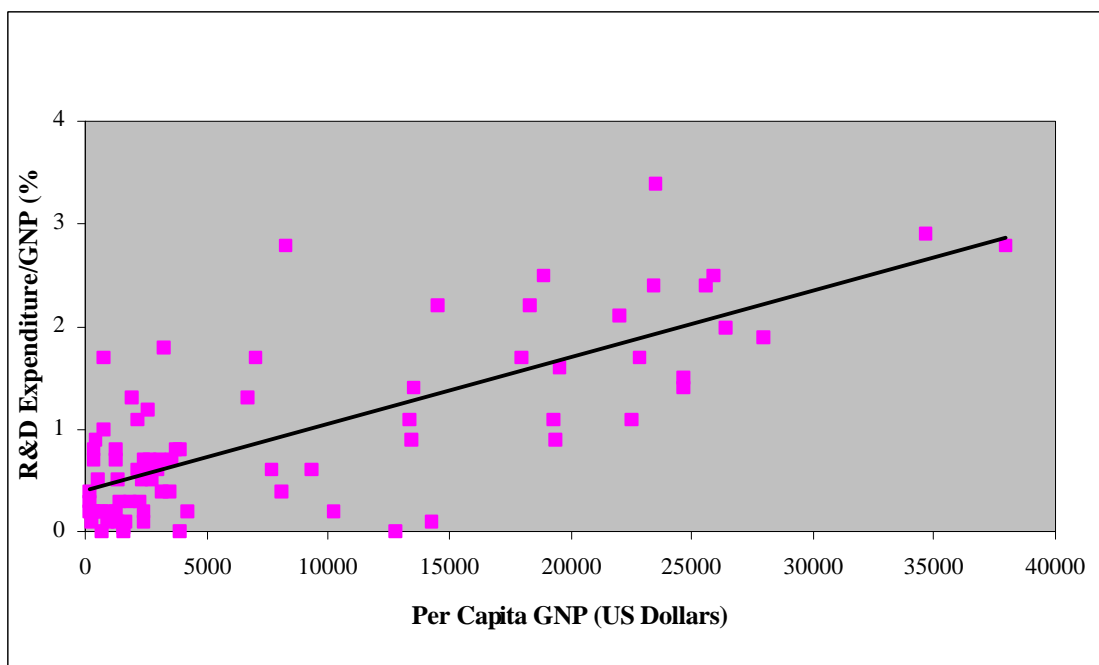
**Table14. Programs for S&T Manpower Development in Korea**

- Enlarging of university enrollment in the areas of science and engineering.
- Restructuring of the undergraduate system into a graduate-education orientation.
- Operation of 15 science and high schools nation-wide and expansion of current undergraduate and graduate programs of the KAIST.
- Establishment of the Kwangju Advanced Institute of Science and Technology.
- Expansion of a Post-Doc program and diversification of the training countries.
- Assistance to joint graduate program among university, industry and GSRI.
- Assistance of establishing In-company technical Colleges and tax incentives.
- A program of repatriation of Korean scientists and engineers from abroad.

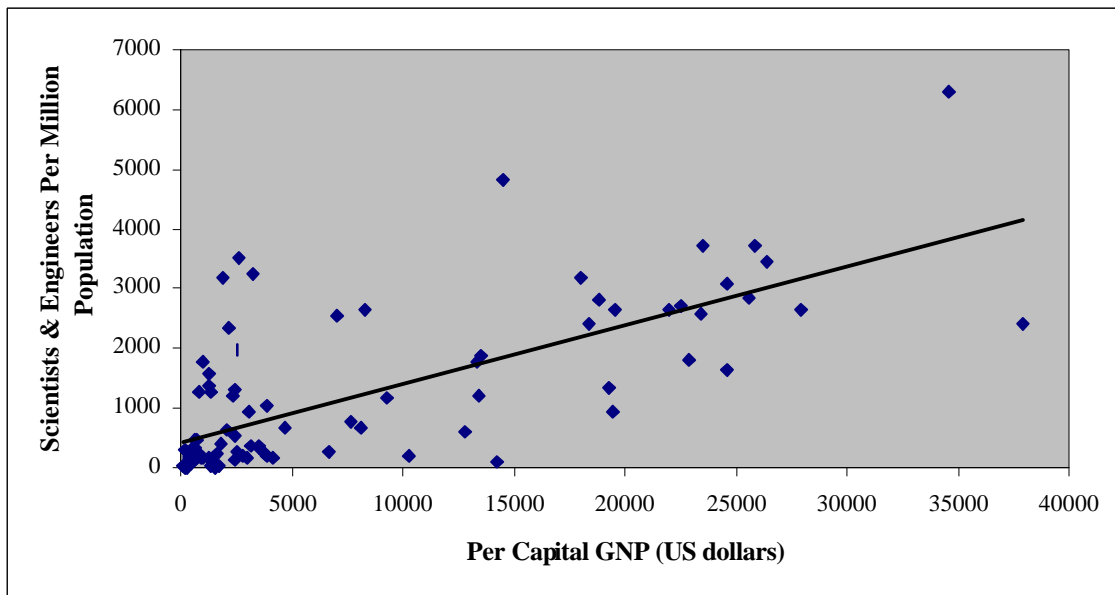
**Figure 1. Phd Personnel, Field of Activity (all respondents, % distribution)**



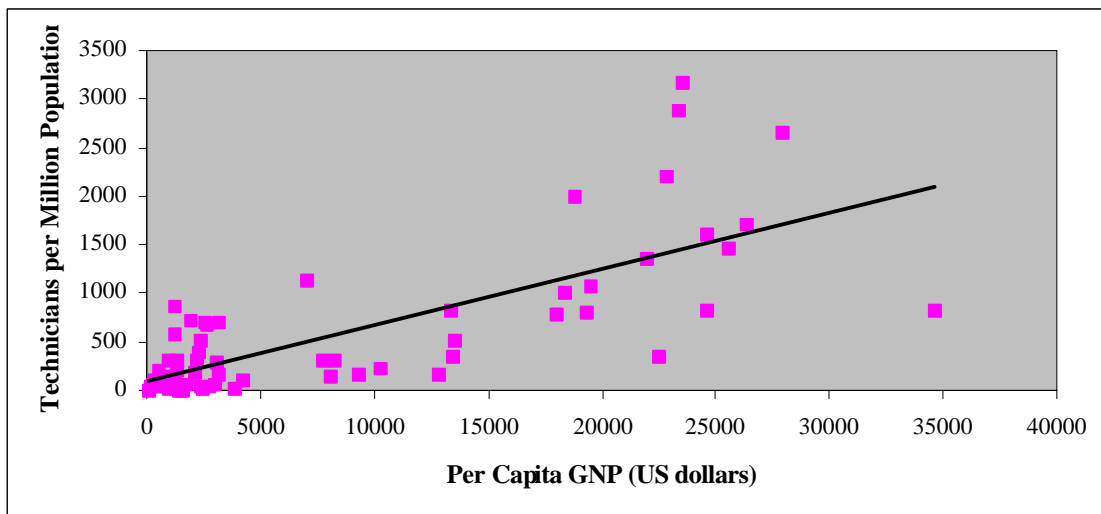
**Figure 2. R&D Expenditure/GNP vs Per Capita GNP**



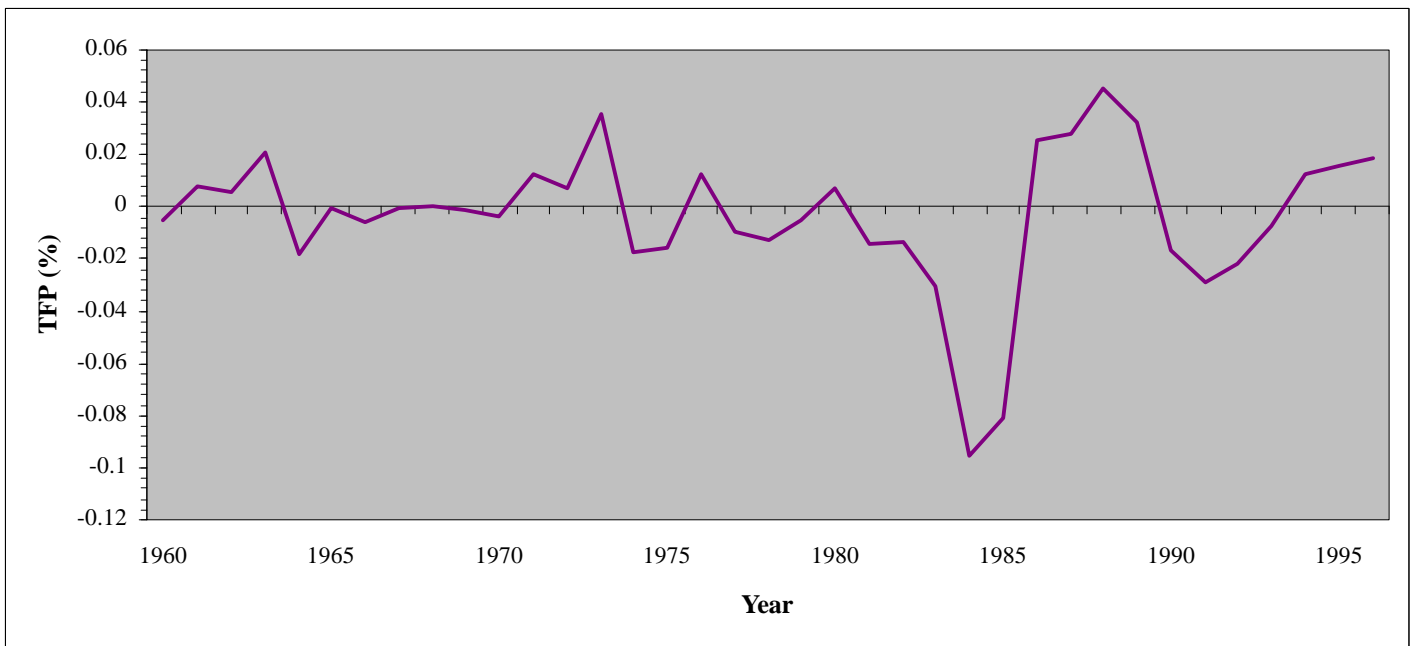
**Figure 3. Scientists and Engineers per Million Population**



**Figure 4. Technicians Per Million Population vs Per Capita GNP**



**Figure 5. Annual TFP Growth Rate, Philippines, 1960-1996**



**Figure 6. The Overall Organizational Structure of the Science System in New Zealand**

