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Technological Innovations in Japan and S&T Experiences in the Philippines: *Drawing Policy Lessons for the Philippines*

Caesar B. Cororaton

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

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ABSTRACT

The objective of the paper is to draw technology-related policy lessons for the Philippines by examining Japan's experience on technological innovation after the second world war and by reviewing the present set-up of science and technology (S&T) in the Philippines. The paper argues that given its present structure, the Philippines may find it hard to attain a productivity-based sustained growth through a technological innovation-based strategy. This is not only because of low investments in research and development (R&D), but also because of institutional rigidities in the Philippines as well as imperfections in the technology market. Furthermore, the paper argues that while the ongoing economic reforms are extremely necessary to remove efficiencies in production, on the whole it provides no clear direction for S&T. As a result the process of technological innovation can hardly gain momentum and contribute significantly to a productivity-based sustained economic growth.

The paper examines the process of technological innovations in Japan by looking at the following factors: the initial conditions, the economic environment in which economy was operating, the goals and strategies pursued, institutions established, economic policies implemented, programs developed, the role of government in the entire process, and the involvement of the private sector. The paper reviews in great detail the science and technology experience in the Philippines. In the light of the above, the paper draws policy lessons for the Philippines. It provides general as well as specific policy lessons and recommendations.

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Executive Summary

Three major issues were laid out at the outset: (a) a productivity-based growth is sustainable in the long run than a factor accumulation-based growth; (b) a growth strategy that is consistent with productivity-based growth is technological innovation-based; and (c) in developing countries where institutional rigidities as well as market imperfections are prevalent (discussed in Section I) technological innovation-based growth strategy is extremely difficult to implement. The impressive growth of the Japanese economy after WWII was generally a productivity-based growth achieved through a technological innovation-based strategy. Technological innovation as discussed in Section I involves a dynamic process, and it in each step of the process economic growth improves as experienced in Japan. In this respect, Japan’s case provides useful policy insights to developing countries like the Philippines that is struggling to grow and develop. It was on this background that the paper was conceptualized.

The objective of the paper was to draw technology-related policy lessons for the Philippines from Japan’s experience on technological innovation after the second world war. To get a clearer view of the technological development in Japan, the paper analyzed the initial conditions, the economic environment in which economy was operating, the goals and strategies pursued, institutions established, economic policies implemented, programs developed, the role of government in the entire process, and the involvement of the private sector. To put the discussion in Philippine perspective, the paper discussed in great detail the present set-up of science and technology (S&T) in the country. Towards the end of the paper, a list of general as well as specific policy lessons and recommendations was drawn.

The review of Japan’s post war growth revealed the following:

(1) Japan has been accumulating valuable experience on economic growth and technological development years before the war that turned out to be one of the major driving forces that propelled the economy to a rapid growth during the post war. For example, the practice of industrial policies, the establishment of some key institutions, the emergence of institutional arrangements such as subcontracting, etc., the increase in production capacities in basic industries during the pre-war period were very instrumental during the post-war recovery. All told, key ingredients for an

industrial take-off were already present. Although the war brought a lot of damage, there were important legacies that later became key factors in the reconstruction period and in the rapid economic growth in the 1960s and 1970s.

(2) As the post-war recovery progressed, other growth-reinforcing factors emerged. The following are often cited in the literature: (a) abundant supply of well-educated and well-disciplined labor force; (b) high level of savings propensity among the households; (c) competitive spirit of major economic actors: (d) high-growth economic policies of the government under continued political stability; and (e) favorable international economic environment. As a result, productivity surged. Estimates indicate that more than 50 percent of the growth in the 1950s and 1960s was attributable to the growth in total factor productivity. Along with the rapid growth were major changes in the production structure, employment, etc. The dramatic improvement in agriculture productivity because of the introduction of new farming technologies and the rise of the industrial sector widened substantially the size of the middle class, which in turn created the necessary domestic market for the early industrialization phase. Rapid export expansion came about after the industrial base had been fully developed.

(3) Japan’s goal right after the war was to restore the economy to the pre-war period and to become a wealthy nation without military power through industrialization. Japan’s growth strategy during the period had three major features: (i) unbalanced growth wherein key industries were selected for promotion; (ii) export orientation; (iii) introduction, assimilation, and improvement of foreign advanced technology.

(4) The technological development strategy in Japan supported the whole industrialization process. Japan allowed the importation of advanced foreign technologies into the industries that had been initially focused to start the process after the war. Because of well-educated and well-trained technical and scientific manpower these foreign technologies had been absorbed adequately into the industries. Furthermore, because of sufficient absorptive capabilities, improvements were introduced on these technologies. The process did not remain static, however. In fact, a new trend in technological innovation emerged in the 1970s. Although foreign advanced technology continued to flow in, greater emphasis was given to research and development (R&D) to develop and produce indigenous technology. During this period local manufacturers were finding it hard to import advanced foreign technologies when they had no

technologies to offer in return. Thus, because of the overwhelmingly positive spillover effects of R&D on the technological base, both Japanese industrialists and the government stepped up their R&D activities.

(5) Japan’s factor endowments can generally be described as labor-abundant and inadequate supply of raw materials. Factor substitution therefore favored raw materials. Furthermore, the production process increased the efficiency of limited capital by using high and advanced technology in its pursuit of its export-oriented industrialization. It strengthened the international competitiveness of few and key strategic industries by a bold introduction and application of up-to-date advanced technologies developed in foreign countries. Factor substitutions were effected through changes in the relative factor prices in the form of tax incentives, subsidies, and low interest rates. There were also incentives in the form of accelerated depreciation, tariff protection, etc. It is important to note that while arguments in neoclassical economics would indicate inefficiency effects in resource allocation from these factor price distortions, what transpired in Japan was the opposite; these policies turned out to be highly effective. One possible explanation may lie in its well-planned and well-coordinated industrial policy. It was able to successfully adopt advanced western technologies to its own particular economic conditions. This may have prevented the possible theoretical inefficiency effects.

(6) R&D became the key factor in the development of indigenous technology. While the government provided the necessary R&D infrastructure, incentives, subsidies and other forms of support, the bulk of R&D activities were done by the private sector. Thus, experimental development became the key R&D activity. Experimental development comprises as 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. Furthermore, the patent system that started long before the war was instrumental in encouraging and supporting R&D initiatives from the private sector and from other private individuals.

(7) Another key factor in the technological development in Japan is the manpower development through basic and formal education, vocational training, and other private sector sponsored skills development programs.

In contrast, the review of Philippine S&T experience showed that:

(a) The economic growth record is dismal as evidenced by the boom-bust growth performance in the last two decades. The contribution of productivity to growth is low or even negative. Political as well as economic factors contributed to this growth performance. Uncoordinated implementation of policies resulted in inefficiencies, which in turn contributed to the poor growth record.

(b) While productivity is found to be highly dependent on R&D, little focus and emphasis is given to this. While appropriate R&D institutions and structure are in place, uncoordinated effort and lack of direction resulted in very weak institutional arrangements among these institutions. Furthermore, investments in R&D, both in physical and human capital, are extremely low. This is because private sector participation is very minimal. The review showed that while incentives are offered to R&D related activities, very few are willing to avail of them. This is because of lack of direction in the overall R&D activities in the country.

(c) The paper also discussed a number of sectoral gaps in R&D in the Philippines. Gaps are quite evident in agriculture, fishery, manufacturing, and education. Gaps are in the form of low investments, misallocation of limited R&D resources, uncoordinated planning and budgeting, alarmingly poor quality in basic education, etc.

From the above review, the paper attempted to draw policy lessons and to come out with some policy recommendations for the Philippines. Some are general while the others are very specific policy issues in the Philippines. Two general issues that may need further elaboration involve the role of: (i) industrial strategy; and (ii) proper institutional arrangements.

The current debate in economic literature puts the issue of industrial strategy that is along the arguments of Hirshman (1958) in the sideline. In fact, the current issue of the day is globalization by “making prices right”. While this may be justified by the failures in some countries which adopted import substitution policies through targeting like the Philippines, Brazil, India to name a few, “making prices totally right” may not be totally realistic especially if technological change and innovation is at the heart of the growth 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 because of the factors outlined in Section I. The case in point is the Philippines. It has been exerting a lot of effort in implementing economic reforms that are consistent with globalization. While the ongoing set of economic reforms[1] are extremely important and necessary to overhaul the inefficient production structure of the economy, it lacks focus and provides no clear direction to where the process of technological innovation should go. 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 case of South Korea, is very clear: the technological innovation strategy was attuned, synchronized and made 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.

There is one word of caution though in letting the government take an active role in industrial strategy. To prevent the policy failure of the past, 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 semi-conductor industry that is the leading sector both in the domestic and export markets,[2] then government effort should be directed towards supporting the industry in terms of infrastructure, manpower development, incentives, research institution, etc. The 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.

The second issue involves institutional arrangements. The review of S&T experience in the Philippines provides a clue that some key ingredients for a technology-based growth strategy may have already been present. While they may not be as comparable to

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

[2]At present almost 60 percent of the country's export is semi-conductor.

that of Japan, the relatively long S&T experience, the institutions, the policies and, to a limited extent, the manpower are present. However, there appears to be institutional failure to exploit all these because of very weak institutional arrangements. Planning and budgeting exercises are uncoordinated resulting in very poor performance. There is also lack of focus, especially in attracting and getting the participation of the private sector, through for example the commercialization of developed technologies.

Equally relevant specific policy recommendations focused on the following: (1) R&D investments; (2) R&D manpower; (3) incentive system; (4) institutional arrangement and S&T coordination mechanism; (5) R&D delivery system; and (6) statistical information and accounting system.

Technological Innovations in Japan and S&T Experiences in the Philippines:
(Drawing Policy Lessons for the Philippines)[1]

Caesar B. Cororaton[2]

I. Introduction

Economic growth is determined by how well a country mobilizes its resources in order to increase the production of goods and services. Generally, resources include labor and human skills, capital, land and natural resources.

There are two approaches to economic growth (Choi, 1983). One approach is to increase the utilization or the amount of factor inputs or resources for production. For example, output from agriculture can be expanded by increasing the utilization of available arable land, that had been previously considered idle, for farming. One drawback in 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 a 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 that may be generated may not be as much as in the initial stage (movement towards point b along production function 1).

Krugman (1995) in a highly controversial paper that appeared in the Foreign Affairs on “The Myths of Asia’s Miracle” 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 that first experienced

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[1]This paper was done while the author was a visiting Research Fellow at the Japan Institute of International Affairs, Tokyo, Japan from October 2000 to March 2001. The paper greatly benefited from the discussion with Professor Ryokichi Hirono of Seikie University. However, gaps and errors in the paper are the sole responsibility of the author. Comments may be directed to: **ccororaton@MAIL.PIDS.gov.ph**.

[2]Senior Research Fellow, Philippine Institute for Development Studies. Ph.D. (Economics) 1990, Clark University, Worcester Massachusetts, USA.

rapid growth during the 1950s and then suffered a significant economic slowdown later because limits have been reached. "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."

This leads to the second approach that deals with improved productivity through a 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. As we shall discuss below, this process of technological innovation could involve a range of activities. For example, it could involve the utilization of better machineries, better production management and methods, the application of best practices, etc. It could take place in factories or in offices.

It is important to note at this juncture that technological innovation and economic growth are mutually reinforcing (Hirono, 1985). That is, higher rate of growth would tend to generate productivity improvement through technology innovation, and vice versa. This is especially true when there is increasing returns to scale. In such cases the outward shift of the production function would have no boundaries, implying that there would be no limits to growth.

Historically, the whole idea of technology affecting economic growth dates back to the 18th and 19th centuries when scientific principles, which were 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 industrial revolution, was the result of the accumulation of knowledge through scientific discoveries and the application to the process of production.

However, the relationships between technological innovation and economic growth were made evident by the remarkable experiences of Japan after the World War II (which the present paper will delve into) and South Korea in the 1960s or after the Korea War. 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 the development in western Europe, these countries were able to transform their economies from almost completely devastated right after the war to highly advanced industrial economies at present.

The process of technological innovation that is being referred to is shown in Figure 2. This was conceptualized by Yamada (1964) and later cited in Choi (1983). It is shown here to emphasize the point that 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 would involve two major parts, the research part and the innovation part. The innovation part would two have two phases. In the first part, the introduction of new technology would lead to new products and would reduce the cost of production. These new products would 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 would 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 of the people 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 once more. It goes on repeating in circle towards economic prosperity.

The performance of Japan and South Korea is indeed outstanding. 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 developing countries? There are two schools of thought on this issue that ought to be reviewed briefly because of their implications to the Philippines case.

The first school[3], which started with Gerschenkron's (1962) discussion of the advantageous of 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. 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 there will be convergence of income and productivity levels.

However, in the other side of the spectrum the other school argues that the process may not be that easy and straightforward. Although newly industrialized countries (NICs)[4] 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 towards advanced nations. In fact there is a divergence (Easterly, 1981

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

[4] Generally known to include South Korea, Hongkong, Singapore, and Taiwan.

and 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) would include a number of factors like the vicious circle of poverty in which most developing countries are trapped. Other factors cited by Choi are:

1. Developing countries are weak in policy formulation for scientific and technological development. In these countries, public interest on science and development is low. Their traditional cultures are hostile and can pose hindrances to the creation of viable science policy.

2. There is lack of a 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.

3. There is very limited scientific manpower in these countries.

4. Most of these countries rely heavily on imported technology. However, there are no clear-cut policies and programs to develop domestic capability to be able to modify and improve these imported technologies for domestic applications. There are no policies to address technology dependence.

5. 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.

The final point that will be touched on in this section which would again have important bearing later on in the discussion of the Philippine case deals with the issue of industrial strategy and the role of government. The issue is relevant in the present context because of: (a) countries which have performed remarkably well like Japan[5] and South Korea have applied industrial strategy

[5] Whose experience the paper will heavily draw policy lessons from for the Philippines.

which largely centered on technological development and with extremely strong government leadership; and (b) industrial strategy with strong government intervention may seem be inappropriate in a "globalized" world market.[6]

There are two schools of thought that are worthy of review.[7] One is based on the argument of the neoclassical school which centers on neutral government policy, while the other is based on industrial strategists' idea of selective intervention by government to manage technological change so as to achieve a dynamically efficient industrialization.

According to the neoclassical school the role of the government is simply to provide an economic environment in which market forces will realize the efficient allocation of resources. If there are market failures, then the appropriate policy instruments are prices and price-denominated policies (e.g., taxes and subsidies), and have to be applied in a neutral manner; meaning that policies should not selectively discriminate. If there are lacking institutions, then the government's proper role is only to facilitate the establishment of such institutions that should function as market agents. If social overheads are too large and expensive for the private sector to undertake, then the government can provide, but not with the idea of promoting specific industrial activities. The neoclassical advocates support for human capital formation, but only in ways that do not discriminate other activities.

On the other hand, according to the other school "market forces *alone* are not responsible for the purported market success of economies like Japan or Korea. Neutral policy regime is not a necessary condition for successful industrialization" (Pack and Westphal, 1986). Furthermore, this school states that neutral policy regime may not be generally sufficient condition for rapid industrialization that is based on technological change. This is because acquisition of technological

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[6] The ongoing economic reforms in the Philippines are largely premised on a free trade world environment.

[7]The paper of Pack and Westphal (1986), which this part heavily draws from, provides a good review on this issue.

capability happens neither automatically nor costlessly. Key elements of technology are often imperfectly traded, or worse, in a great number of cases, they are not traded at all. As we have discussed above, on top of the issue of poverty trap, there are a lot of institutional bottlenecks that may hinder the growth of science and technology in these countries. All these factors provide stumbling blocks to the growth process of these countries, especially in terms of technological development.

This paper will attempt to look into the technological innovation experience of Japan during the early period of its rapid economic growth after WW II. What were the initial conditions, the economic environment in which the economy was operating at the time, the goals and strategies pursued, economic policies implemented, programs developed, the role of government, are some of the main issues that will be touched upon. The paper will then try to contrast this experience with that of the Philippines and will attempt to draw policy lessons for the country in the light of the issues raised above.

II. Patterns of Technological Innovations in Japan

Initial Conditions

Before the War. Even years before World War II (WW II) broke out Japan had already embarked on an industrial development program. If fact, heavy and chemical industries already made remarkable growth in the 1920s, and by the beginning of the 1930's, these industries were at the verge of a rapid take-off (Takafusa, 1994). The textile industry grew rapidly, as well as heavy industries such as steel. Another standout industry was rayon production whose production technology was perfected in the 1930s. In machinery, Japan became almost completely self-sufficient, except for special high-end items. This formed the basis for the development of military supply industries. During this period, exports grew rapidly also. These developments since the 1920s allowed the Japanese to accumulate valuable experience on economic growth and technological development that proved to be one of the major driving forces that propelled the economy to a rapid growth after the war.

Industrial policies during the period such as government subsidies gave birth to a number of new industries and big corporations. These industries include electric power, electric smelting of aluminum, electronics, and automobile industries to name a few. In fact, origins of some of the present-day big corporations in Japan (such as Toyota, Toshiba, NEC, Nippon, Nissan, etc.) can be traced back to this period.

A number of important economic laws were passed and implemented during this period as well. Among the important ones which started Japan's march towards industrialization include: The Oil Industry Law of 1934, the Automotive Industry Law in 1936, the Artificial Oil Industry Law and the Steel Industry Law of 1937, and the Machine Tools Industry Law and the Aircraft Manufacturing Industry Law of 1938.

A number of key economic institutions were established during the period. For example, the Cabinet Planning Board was organized in 1927. Originally, it consisted of the Planning Agency and the Resource Bureau. Later on, in 1937 the Planning Agency was reorganized and was tasked to implement the Five-Year Plan for Key

Industries. In 1956, the Science and Technology Agency was established. During this period, the Council for Science and Technology was also created which acted as the policy-making body on science and technology at the national level. Furthermore, many national as well as industry-sponsored research institutions were founded. For example, the Tokyo Industrial Testing Laboratory and Institute of Physical and Chemical Research already existed and were closely linked with industries.

Foundations of the Postwar Economy. And then WW II broke out in Europe. When it spread to Asia it brought tremendous damage to Japan. It was estimated that about one-fourth of Japan's physical assets were lost (Takafusa, 1994). Table 1 shows some estimates of the extent of the damage.

However, although the war was devastating, one positive aspect that came out of it for Japan was the building-up of production capacity. Capacities were propped up for purposes of producing armaments. Heavy industries and chemical industries were compelled to increase their plant and equipment for the production of military supplies. According to Takafusa (1994) much of these production capacities were spared during the war. For example, steel production capacity that stood at 3 million tons in 1937, increased to 6.6 million tons during the peak of the war. After the war it was left with still a substantial capacity of 5.6 million tons. Similarly, copper refining, lead and aluminum that saw major capacity expansion during the war, were left with huge production capacity after the war. Machine tool production capacity which stood at 22,000 machines in 1937, increased to 60,000 machines at the height of the war. After the war capacity declined slightly to 54,000 machines. Thus, although the war brought substantial damage to Japan, it did not go back to square one right after the war. Experiences and expertise were accumulated, skills developed, and some production capacities remained. "The fact that the plant and equipment of heavy and chemical industries survived the war, as did their technical specialists and laborers, provided the necessary conditions for the postwar economic recovery that was centered on these industries. This is one important legacy" (Takafusa, 1994).

Another important legacy cited by Takafusa was the organizational structure of industry. Before the war subcontracting in the field of machinery, aircraft, and automobiles were practiced. After the war, it remained practiced by big firms. Usually big firms do the assembly, while subcontracting firms make the materials and components. Subcontracting system serves as an important mechanism of transferring and diffusing technology, especially from bigger principal firms to smaller sub-contractor firms. In Japan, 65 percent of small and medium enterprises produce under subcontracting arrangements, and 82 percent of them are specialized in the machinery and textile sectors. In the transportation machinery sector, 81 percent of small and medium enterprises were subcontractors in 1981, and 88 percent of them are specialized in subcontracting. In Japan subcontracting is extensive because there is less vertical integration (Nagaoka, 1989).

Usually subcontracting arrangement involves implicit contracts involving technical guidance, supply of working, leasing of equipment, and risk sharing by a principal firm. Also, the system provides strong incentives and pressures for subcontractors to innovate. Typically, the principal firm would be responsible for developing designs and specifications, and provides the necessary technical assistance to the subcontractors, while the subcontractors would undertake the production according to these instructions from the principal. Similar to the principal firms, subcontractors have high technical capabilities, thus such arrangements do not create serious technical problems. Subcontracting is a major feature of Japan’s development. This is especially true in the machinery sector in which it enjoys strong international competitiveness due to such subcontracting arrangements.

Also, in the area of finance, financial institutions were set up during the war, but largely to serve the munitions companies. Nevertheless, financial experiences were gained.

Furthermore, during this period, Japan became internationally known for its “administrative guidance”. Generally, the government had the power to instruct business on various issues, directly or indirectly. For example, during the war the Bank of Japan exerted strong control over private-sector banks.

Labor unions existed, but were dismantled during the war. However, their rebirth after the war was one of the factors that improved the welfare of the labor sector, which in turn established a generally productive relationship between labor and management. Also, the social security systems (which covered health, insurance, and pension) that evolved during the years and which benefited labor’s welfare greatly provided the necessary stability in the labor sector. Takafusa (1994) claims that these social security systems constituted one of the cornerstones of the postwar economic development.

All told, even before WW II broke out, key ingredients for an industrial take-off were present. Technological experience started to accumulate. Concerns for planning and for identifying key industries already became major policy issues. Some key institutions were established. The government as an institution was very strong to manage the development process. Even during and right after the war, the industrial base of the economy expanded. Although the war brought a lot of damage, it left important legacies that later became key factors during the reconstruction period and the rapid economic growth era in the 1960s and 1970s

Conditions for Rapid Growth

Table 2 shows how the economy of Japan sailed through the rapid economic growth path after the war. For fifteen years starting 1955, Japan grew annually by 10.3 percent, more than twice the annual average growth of 4.4 percent of the rest of OECD countries over the same period. Even during the second half of the 1970s when the world economic environment was severely affected by the second oil crisis, Japan stood out as the highest growing industrial economy.

Improvement in productivity played a major role in the rapid growth of Japan after the war. Evidences on total factor productivity (TFP) computed using the growth accounting method indicate that more than 50 percent of Japan’s economic growth in the 1950s and 1960s can be attributed to TFP growth and more than 20 percent was due to improvement in technical knowledge. Table 3 indicates that the contribution of productivity to Japan’s growth during this period was a lot higher than those in the US, West Germany, France, and the United Kingdom.

Another major factor that contributed to Japan’s postwar growth was the high rate of capital formation that was propped up by the continuous acquisition and development of technology. As will be discussed below, this high rate of capital formation came about because of high propensity to save.

A number of factors were behind this extraordinarily high economic growth in Japan. Hirono (1980) singled out five of them, namely: (a) abundant supply of well-educated and well-disciplined labor force; (b) high level of savings propensity among the households; (c) competitive spirit of major economic actors: (d) high-growth economic policies of the government under continued political stability; and (e) favorable international economic environment.

Labor Force. There was a rapid improvement in school attendance at all levels after the war that expanded significantly the supply of better educated workforce. According to Hirono (1980) in 1945 nearly 100 percent of children between 6 and 12 years old were enrolled in the primary schools. For those between 13 and 17 years old, 28 percent of them were in secondary schools and 5 percent in the tertiary levels. In 1960, those percentages improved to 100 percent, 74 percent, and 10 percent respectively, and in 1975, the percentages improved further to 100 percent, 92 percent, and 24 percent.

Furthermore, aside from better education, Japanese workers were highly disciplined, industrious, and loyal to the employers that provided the necessary stability in the workplace. The stability prevailed as labor unions became stronger and labor relations established. An institutional foundation for industrial relations was put in place by the government through the passage of three pieces of legislation: the Labor Union Law, the Labor Standards Law, and the Labor Relations Adjustment Law. These laws provided the legislative framework on labor issues.

Three basic features of employment in Japan that brought about substantial improvement to the welfare of labor include age-based seniority in wages, lifelong employment, and enterprise-based unions. In enterprise-based unions, unions were organized at the firm or factory level and would comprise blue-collar and white-collar, as well as skilled and unskilled labor. Enterprise unions and lifetime employment reinforce the solidarity and loyalty of employees to the employers. For example, employees themselves would try to prevent labor strikes and work stoppages. During labor disputes, labor, together with the employers, would try hard to settle the disputes at once in order to prevent further deterioration. These were major factors that stabilized Japanese industrial relations and merited the envy of other countries (Takafusa, 1994).

High Savings Propensity At the time when personal income was still at low levels, traditional concept of savings as a virtue of life resulted in high rates of savings in households (Hirono, 1980). Household savings were channeled to the banking and life insurance institutions, which in turn financed projects both in the private and public sectors. Gross capital formation increased dramatically as a result, increasing productive capacity and economic infrastructure. Table 4 below shows how savings and capital improved after the war. From a savings propensity of 0.09 in 1955, it improved to 0.23 in 1977. Likewise, from an investment rate of 26.2 percent in 1955, it improved to a peak of 35.8 percent in 1972, but declined marginally to 31.2 percent in 1997.

Competitive Spirit. One of the major reforms enforced by the Americans during their six and a half years of occupation of Japan after the war was the promotion of democratic forces to develop organizations in labor, industry, and agriculture. A major part of this process was the liquidation of the zaibatsu and the dissolution of the large industrial and banking institutions. The four major zaibatsu, Mitsui, Mitsubishi, Sumitomo, and Yasuda were dismantled and restructured. For example, the holding company of Mitsui that held the stocks of its subsidiaries was dissolved and the stocks held by the parent company were transferred to the subsidiaries. The same thing happened to the other three and the smaller zaibatsu.

In line with this reform was the enactment of the Anti-Monopoly Law in 1947. It prohibited the formation of trust, all cartel activities, joining of international cartels, crossholding of directorships, and even stockholding by corporations (Takafusa, 1994). However, in 1949 the bans on participation in international cartels and corporate stockholding were lifted because they were believed to hinder the flow of foreign investment into Japan.

The Anti-Monopoly law was followed by the introduction of a policy designed to eliminate the excessive concentration of economic power. Table 5 shows the impact of this policy on industry concentration ratios. Except for food processing, concentration ratios of industries went down indicating entry of more firms.

Competition policy is relevant in technological development because it increases the pace of technological changes in production methods and processes, product development, raw materials use, factor substitution, and management know-how. Furthermore, competition puts pressure on cost reduction and improvement in factor productivity, particularly labor productivity that can be shared by labor itself, as well as by all stakeholders. However, in the case of Japan, while the goal was to maintain competition within industry, government competition policies that used to be very rigid in the 1940s and 1950s on business practices regarding cartel arrangements, changed through time in response to the changing structure and requirements of industries. Government competition policies in particular allowed differences in factor intensity across industries and took into consideration pressures from foreign competition brought about by its export orientation. By the very nature of the production process involved in iron and steel and other heavy and chemical industries which is capital intensive and the risks involved in the introduction of new technologies into these industries, some degree of cartel arrangements were eventually allowed under government support particularly during economic downswings. Also, mergers were permitted. There were mergers which took place in iron and steel, automotive industry, ship building and in banks in order to strengthen the competitiveness of these industries in the international markets. However, according to Hirono

(1980), in spite of these changes in government competition policies, a consistent improvement in labor productivity was observed during the period. “While the Fair Trade Commission has been continuously active in implementing the anti-monopoly legislations ever since its founding, it is not an unfair statement that the government’s competition policy has undergone some significant modifications during the last thirty years. Whether the changes observed in government competition policy have reduced effective competition in Japanese industries or not is certainly a matter requiring serious study. One thing, however, is true that in spite of such changes in the government’s competition policy there has been a consistent rise in the level of labor productivity in the Japanese industry.” (Hirono, 1980). This would indicate that the objective of increasing labor productivity was achieved even though cartel arrangements, mergers, and the like were re-introduced into the system. This may be partly due to the government’s strong presence or guidance in the system

Growth Policies. A more detailed treatment of economic growth policies in Japan is done in the section on government policies below. However, generally, it was widely observed that implemented policies were formulated towards achieving the following objectives: to restore the Japanese to prewar level right after the war, and to double the national income. In the National Income-Doubling Plan, for example, the government sought to double either the real gross national expenditure or the real gross national product in the space of the decade (Takasusa, 1994). According to Hirono (1980) “all the monetary, fiscal and specific policy measures available of the government were mobilized to increase the national output, modernize production facilities, expand exports, and foreign exchange earnings to ensure a continued supply of energy and raw materials required for expanded production at home, facilitate the inflow of advanced foreign technology and management know-how, improve the level of domestic absorptive capacity towards an effective utilization and development of new scientific knowledge and technologies, expand and improve the economic and social infrastructures including transport, communications and power network to reduce the cost of production and distribution pre unit of output and throughput, and enable banking and other financial institutions assist manufacturing and other corporations to expand capital investment." All this, together with the consensus by majority of the Japanese for building a national wealth, resulted in the growth miracle during the postwar.

Favorable International Environment. The international climate during the period was highly favorable. Between 1950 and 1965, the world economic growth was impressively high. The world economy was moving at an unprecedented average growth of 5 percent under the Bretton Woods system and the GATT institution. Table 6 shows the growth of exports of Japan and the other six OECD countries during the period. These countries enjoyed high rates of growth in exports, resulting in substantial increases in the export share to their respective gross national expenditure.

This favorable international environment contributed to the steady export growth of Japan. Also, as the world economic progressed, the supply of materials became abundant which allowed Japan to increase its imports of its raw material requirements. During this period, Japan enjoyed favorable terms of trade as export prices were high and prices of crude oil and other raw materials were on the declining trend. In terms of volume of major export items of Japan, Table 7 indicates substantial improvement in chemical products, metal and metal products, and machinery. Incidentally, these were the industry focus in the early postwar growth strategy in Japan wherein both production and technological capabilities were substantially improved.

In the financial sector, Table 8 shows substantial amount of foreign capital that flowed into Japan to help domestic savings finance huge investment requirements. These inflows consisted of direct investment, portfolio investment, bank loans and bonds. From US$3.2 million in 1950 capital inflow increased substantially to almost US$6 billion in 1977.

Patterns of Growth

Behind this rapid economic growth in Japan after the war was the massive transformation of its economic structure. One clear indication of the transformation was the movement of labor across sectors. Table 9a and Figure

3 show how labor in Japan had moved sectorally since the war. In 1948, farmers accounted for almost 46 percent of total employment. Self-employed accounted for 17 percent, while employees accounted for 37 percent of total employment. In 1963, the share of farmers went down consistently to just 26 percent. While self-employed more or less retained their share, employees increased their share to almost 56 percent. In 1983, the share of farmers dropped to just 8 percent. Self-employed did not change much, but the share of employees shoot up to almost 74 percent.

In terms of labor movement across major sectors, there was a clear movement to the secondary sector (particularly manufacturing) and to the tertiary sector (particularly, wholesale and retail trade sector). The employment share of the secondary sector improved from 23.5 percent in 1955 to 35.2 percent in 1977 (Table 9b). Over the same period, the share of manufacturing employment increased from 17.6 percent to 25.9 percent. On the other hand, employment in the tertiary sector (or the service sector) improved from 35.5 percent in 1955 to 53.3 percent in 1977.

The labor movement away from the farms did not adversely affect the production output of agriculture. In fact, the introduction of technology into agriculture and the successful land reform program of the government contributed substantially to the improvement of agriculture production. This was especially true in the Northern part of Japan in terms of rice production. Takafusa (1994) cited the case of Tohoku region. During the prewar days, the region was only producing 30 kilos per hectare. After the introduction of better agriculture technology, its production improved to 45-60 kilos per hectare.

Through time there was a clear improvement in productivity. Table 10 shows that the man-hours spent on rice production declined significantly from 196 per 10 acres in 1952 to 75 in 1977. The yield however, improved considerably from 325 kilogram per 10 acres to 455 over the same period. The factors behind this improved rice productivity include: (1) breading of improved strains of rice; (2) increased fertilizer production; (3) rational application of fertilizer; (4) spread of new agricultural chemicals; and (5) development of technology for early planting (White papers of Japan, 1979-80).

A closer look at the pattern of manufacturing growth in Japan is essential in understanding the dynamics of the industrialization process, as well as the technological development, during the postwar. Through an industrial policy the development process focused on few key industries initially. Through time as the process progressed, the focus shifted to other industries.

Right after the war, policies were focused on resurrecting and rationalizing four key manufacturing industries: electric power, steel industry, marine transportation industry, and the coal industry (Takafusa, 1994). Meanwhile, during the period there was a policy to substitute coal for petroleum as the major source of energy during the mid-1950s (Hirono, 1980). This substitution gave birth to the petrochemical industry, which incidentally provided a window for many advanced technologies developed abroad to enter Japan. These technologies diffused to other related industries and created the favorable ripple effects. In fact, the rapid pace of plant and equipment investment in the iron and steel and the petrochemical manufacturing industries during the 1960s changed tremendously the manufacturing landscape (Hirono, 1980).

Detailed treatment of this is done in the section on growth strategies below, but at this point it is worthwhile to note that the increasing share of machinery, electrical, transportation equipment and of iron, and metal products in production from 1955 to 1977 is indicative of the policy focus during the period. The former improved its share to the total manufacturing production from 20 percent in 1955 to almost 40 percent in 1977, while the latter from 12 percent to 14 percent (Table 11). As a result of the growth of the manufacturing sector, the structure of the overall economy underwent substantial changes during the period. The share of the primary sector went down from 18.5 percent in 1995 to just 4.9 percent in 1977. The secondary sector’s share increased from 34.7 percent in 1955 to 42.9 percent in 1970 (Table 12). However, brought about by the recessionary effects in the mid 1970s, the share of the manufacturing sector dropped in 1975. But thereafter, it recovered. Meanwhile, the share of the tertiary sector continued to surge during the period.

Favorable international environment and improvement in productivity in heavy and chemical industries (because of government's focus on these industries) increased the international competitiveness of Japanese products and thus allowed it to improve its export performance considerably. During this period changes in the structure of exports took place. In 1955 exports from heavy and chemical industries accounted for 38 percent, while exports from light industries accounted for 52 percent (Table 13). In a span of two decades, the structure changed dramatically with exports from heavy and chemical industries capturing about 85 percent while those from light industries 12.5 percent. The change in the structure was due to export of machineries.

Goals, Strategies, and Directions

Majority of Japanese during the early part of the postwar period wanted nothing but to restore the economy to the pre-war period and to become a wealthy nation without military power through industrialization. Takafusa (1994) calls this as a "National Consensus for Building a Wealthy Nation". The statement of this goal was quite clear in the National Income-Doubling Plan that was launched during the period. The Plan sought to double either the real gross national product or the real gross national expenditure in a span of a decade. Thus, capital investments stepped up. In fact, the *White Paper on the Economy* for 1961 employed the phrase "investment breeds investment", to describe the acceleration of investment during the period.

Japan's growth strategy during the period had three major features: (1) unbalanced growth wherein key industries were selected for promotion; (2) export orientation; (3) introduction, assimilation, and improvement of foreign advanced technology. In addition, another very important feature of Japan's growth strategy was the "continued reliance on the part of the government and the private sector alike on the role of industrial policy in managing the long-term industrial and economic development of the nation." (Hirono, 1980). Thus, the overall industrial policy utilized all government policy measures in a systematic way and in the "most appropriate combinations so that industrial development may take place in a more planned fashion, moving from lower stage to higher stage without interruption, and may be accelerated sufficiently ahead of time when changes in demand appear at home and abroad.” (Hirono, 1980).

In the unbalanced growth strategy[8], heavy industries were given more emphasis than light industries. These industries include: electric power, steel industry, marine transportation industry, the coal industry, and petrochemical industry. During the period, major bottlenecks were often pointed in the electric power. Electric power was in extremely short supply, resulting in regular power outages. It was therefore thought that growth could proceed only if power supplies were to be massively expanded. Table 14 shows how power capacity considerably expanded during the period.

In the steel industry, the capacity was short and, therefore had to be expanded and improved. There were two rationalization programs that were instituted by the Ministry of International Trade and Industry (MITI). In the first rationalization program (1951-1955) the emphasis was the introduction of rolling processes to produce the steel sheet. This was the area in which Japan was really behind during that period. In the second program, investment was focused into rolling processes. As a result of these programs, production capacity was boosted from 12.5 million metric tons of pig iron, 28.2 million metric tons of crude steel, and 140 million metric tons of rolled steel.

[8] An economic approach to development first advocated by Hirshman, (1958). There is also another approach called the balanced growth strategy by Nurske (1953). Unbalanced approach states that most important sector be given priority first because developing countries usually lack the capital necessary for investment for the development of all sector simultaneously. Greater investments will therefore have to be poured into these selected industries only. Growth in these sectors will consequently result in increased growth in the other sectors. On the other hand, the balanced growth theory states that all sectors have to be developed simultaneously. This is because all industries are linked and interdependent. If only few industries are selected, growth will be hindered because their products would have limited market. Market limits are reached as a result of the fact that other industries (which contribute to the overall market) have not been allowed to grow as much as the key ones. Thus the unbalanced growth approach creates its own bottlenecks.

WW II wiped out almost completely the merchant marine. It therefore had to be rebuilt from scratch. Massive program was implemented to rebuild the industry. Table 15 shows how the capacity of the industry improved drastically during the period. It also shows how much government finance was made available for the construction.

Since Japan at that time was heavily dependent on coal as a source of energy, the industry therefore had to be promoted. However, at about the same period, there was a concerted effort to substitute petroleum for coal as a source of energy. It was during this occasion when the petrochemical industry started to pick up and became the window of opportunities for advanced foreign technology to flow into Japan. As a result, the industry was one of the fastest growing industries in postwar Japan between the late 1950s and early 1970s. Petrochemical complexes were built. New technologies were imported and further developed. The growth of the industry had a ripple effect that resulted in the birth of new industries and created a flood of new technologies. Very important to note here is that during this period Japan had the capacity to absorb all these technologies because of its well-trained and experienced workforce. According to Takafusa (1994) “It was this latent strength that underpinned the rapid economic growth of the postwar period.”

Although one of the major strategies of Japan was export orientation, this was not realized until the stage when it started to develop indigenous products and processes (Nagoaka, 1989). Therefore, initially it relied heavily on the domestic market. Thus, during the early years after the war the importation and assimilation of foreign technology was associated with sales to the domestic market (i.e., either import substitution or development of a new market in the domestic market). Substantial export expansion because came about only when Japan started to produce indigenous products. It took considerable technological effort, though, for newly introduced technology to generate sizeable exports.

Technological Development Strategy in Japan

There were clear shifts through time in technological emphasis in Japan. In the 1940s and 1950s, technologies that were imported were of prewar origin.

These included the coking technology, vinyl chloride resin and nylon manufacturing technologies (Hirono, 1985). Once these technologies were imported, they were adapted to the needs and conditions of Japanese companies in terms of manpower, machinery, management, and money. They were also continuously improved. These developments gave rise to new industries such as the synthetic, chemical fiber manufacturing, and petro-chemicals.

In the middle to the late 1950s, imported technologies found their ways into machinery and metal production. Later, in the 1960s, the application of these technologies spread into the manufacturing of electrical machinery, general machinery, precision machinery, and shipbuilding. It was also during the 1960s when a whole range of electronic products came into existence. Furthermore, as a result of technological innovations that took place in the chemical industry in the 1950s, the iron and steel industries got modernized. In the process, its production got boosted. Thus, these industries saw considerable growth within the period.

Thus, the technological development strategy in Japan supported the whole industrialization process. Japan allowed the importation of advanced foreign technologies into the industries that had been initially focused to start the process after the war. Because of well-educated and well-trained technical and scientific manpower these foreign technologies had been absorbed adequately into the industries. Because of sufficient absorptive capabilities, improvements were also introduced on these technologies.

Figure 5 indicates the flow of foreign technology into Japan. There was a rapid inflow of technology in the second half of the 1960s until it reached a peak in 1972. Figure 6 also shows a clear indication of massive inflow of foreign technologies as payments to the flow of technical know-how surpassed significantly the receipts. This was especially true in the second half of the 1960s.

The inflow of imported advanced foreign technologies went into three major industries. From the period 1950 to 1977, chemical industries absorbed 17.5 percent of the inflow of foreign technology (Table 16). Over the same period, machinery absorbed 25.8 percent; of which specialized machineries accounted for 15.3 percent. Electrical equipment also absorbed a sizeable share of 17.1 percent. There are two important developments to note here: (a) that the inflow of advanced foreign technology came in the form of either imported machinery and equipment or licensing Japanese manufacturers to produce with or without foreign equity participation (Hirono, 1985); and (b) that these industries were the initial focus of the industrial policy after the war, thus synchronizing the technological development strategy with the general framework of industrial policy.

The process did not remain static. In fact, a new trend in technological innovation emerged in the 1970s (Hirono, 1985). Although foreign advanced technology continued to flow in, greater emphasis was given to research and development (R&D) to develop and produce indigenous technology. Also, there were pressures coming from the fact that local manufacturers were finding it hard to import advanced foreign technologies when they had no technologies to offer in return. Furthermore, there were clear indications that Japan had been fast closing the technological gap with advanced countries of Europe and America. Table 17 shows that while the total number of licensed technology increased from 564 in 1963 to 952 in 1968, imports of new technology declined from 366 in 963 to 282 in 1968. As a result the ratio of new imported technology to total licensed technology drastically went down from 64.9 percent in 1963 to 29.6 percent in 1968. All this would indicate that the number of attractive know-how that can be imported on profitable terms declined significantly during the period.

Thus, because of the overwhelmingly positive spillover effects of R&D on the technological base, both Japanese industrialists and the government stepped up their R&D activities. Figure 7 indicates the rise in R&D expenditure. From a ratio to gross national product (GNP) of 1.3 percent in 1962, it increased to 1.7 percent in 1970, 2.0 percent in 1980 and 2.7 percent in 1989. Aside from government R&D expenditure, there was also strong effort from the government to promote science and technology in general. Table 18 shows the rapid increase in the government budget for the promotion of science and technology. From 9 billion yen in 1963, the promotional budget increased to 37.4 billion yen in 1972 (about 3.3

percent of the total national budget). These funds were budgeted for national universities, research institutions, subsidies, among others.

Another important component of the technological development strategy in Japan was that while the government promoted its development in line with the industrial policy, it placed the private sector in the forefront of R&D activities. As we shall observe below, the private sector accounted for the main part of R&D activities. Private sector R&D activities were promoted through various forms of government incentives and subsidies.

Choice of Appropriate Technology

Central to the economic literature in the 1950s and 1960s on how to accelerate development was the lengthy debate on the choice of appropriate technology. A brief treatment on this is presented here to put the discussion on the choice of appropriate technology in Japan and the government policy measures that effected this choice (discussed in the next section) in theoretical perspective.

Assume that the initial factor price ratio is $(w/r)_0$ in Figure 8a, where w is the wage rate while r is the price of capital. Given this factor price, the appropriate choice of technology is given at point A. At this point an output level of q_0 is produced. In modernizing the sector, effort is exerted to substitute labor for advanced equipment and machineries, which is equivalent to shifting the point of operation to point B. This point represents another set of technology which is usually arrived at by distorting the factor price ratio to $(w/r)_1$. Normally, the policy measure to effect this factor price change is by artificially lowering r through government subsidies on interest rates or on the cost of borrowing. Often, this is accompanied by another policy measure that artificially overvalues the foreign exchange rate so that the importation of advanced equipment is made less costly. Therefore at point B capital K_1 is employed, while employment is reduced to L_1.

However, the policy-induced shift is theoretically inefficient. In a labor-abundant economy, at K_1 of capital, L_2 of labor may be readily available. If the old choice of technology were retained (represented by the ray in which point A lies), then q_1 level of output is attainable. In the choice of technology where the factor price ratio was distorted, $(w/r)_1$, labor represented by the line segment L_1L_2 will be forced to work in the less productive and less efficient informal sector, which is outside the sector wherein the process of modernization is taking place. This informal sector will be producing at an output level of q_i, which is less than the difference between q_0 and q_1. Thus, $q_0 + q_i$ will be less than q_1. Therefore, the new choice of technology is inefficient.

This argument can also be depicted in the production function shown in Figure 8b. Capital of k_0 that produces an output of q_0 corresponds to point A in the previous chart. If capital in augmented to k_1, which represents the same level of capital earlier, the potential output is q_1, which is the same level as in the previous chart. However, with a distorted factor price, q_1 is not attained. It is q_1' that is reached, which is lower than q_1. The gap between (q_1-q_1') represents the loss in potential output due to technical inefficiency. The inefficiency can be due to a number of things like the inadequacy of mastery of the adopted production engineering and method, the absence of competitive incentives due to price distortions by way of government subsidies, etc.

Thus, given this labor-abundant economy the appropriate choice of technology should be small-scale and labor intensive that requires a small amount of capital investment. This kind of technology would generate the maximum employment effects. This is the type of technology that is not developed in foreign countries, but rather, it is a traditional domestic technology.

It is important to highlight the results of this theory in discussing the Japan experience because, given its factor endowments which can be generally described as labor-abundant and inadequate supply of raw materials, Japan had chosen something like point B as its choice of technology instead of point A in its industrialization process. In particular, Japan did not substitute labor for capital, but for resources (Choi, 1983). Furthermore, it increased the efficiency of limited capital by using high and advanced technology in its pursuit of its export-oriented industrialization. It strengthened the international competitiveness of few and key strategic industries by a bold introduction and application of up-to-date advanced technologies developed in foreign countries. The possible theoretical results of the shift as discussed above may potentially result in some inefficiency, but in the case of Japan, because of its well-planned and well-coordinated industrial policy it was able to successfully adopt advanced western technologies to its own particular economic conditions in its industrialization process and to overcome the possible inefficiencies and therefore to attain a rapid economic growth. Imported technologies were adapted to specific industrial, commercial and market requirements in Japan. Product development, including design and packaging, were all made to fit local preferences, as well as advertising, sales promotion, and customer services (Hirono, 1985). The point to emphasize here is that the selection of the appropriate technology to adopt should fit well into the circumstances where the economy is in. The technological adaptation effort must be within the overall framework of industrial policy.

Government Policies

The government passed in the early 1950s two important laws to re-invigorate the economy after the ruins of the war [9]. The Law for the Acceleration of Rationalization of Enterprises, and the Special Taxation Measures Law were implemented. The former, drawn up by MITI in 1952, designated the following industries to be the main focus: iron, steel, steel rolling, oil refining, metals, chemical fertilizer, soda and dyes (Takafusa, 1995). Policy measures targeted to these industries include subsidies to upgrade technology, loans of government-owned machinery and equipment, shortened depreciation period for experimental and research facilities, special depreciation provisions for the installation of modern plant and equipment, in particular, 50 percent depreciation of the purchase price in the first year, and reductions on excise on modern plant and equipment. According to Takafusa (1995), together with the reduction in excise taxes on fixed assets, this special depreciation of 50 percent proved to be effective in stimulating corporate investments.

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[9] Discussion is largely based on Takafusa (1995).

Furthermore, the law had provisions for both central and local governments to improve roads and port facilities where essential to further stimulate industry. Furthermore, construction of infrastructure was basically funded from public resources to attract industries to more rural regions.

On the other hand, in the Special Taxation Measures Law, the scheme of accelerated depreciated was allowed. In particular, the law allowed 40 to 50 percent of the value of the machine to be depreciated and counted as a loss in the first year or so after installation, even though the machine might be expected to last for more than 10 years. Under this scheme, when companies made big investments, their losses got magnified, resulting in lower profits and therefore lower tax base.

Takafusa (1995) claims that the accelerated depreciation scheme was problematic from the perspective of “fairness”, but the law was designed in the first place to favor accumulation of capital. On hindsight, it may be safe to argue that the incentives provided by these laws played a major role in the postwar development of Japanese industry in which many companies embarked on ambitious programs of capital investment. It was further argued that it was in the 1950s when Japan’s policies took their basic shape and were most effective.

Generally within the same period MITI realized that machine and electronics industries would become important and would therefore have to be supported. Thus, it pushed for the passage of two important legislations: the Law for Special Provisional Measures to Promote the Machinery Industry and the Law for Special Provisional Measures to Promote Electronics Industry. Under these laws, MITI was allowed to draw up rationalization plans and to secure funds for their implementation to these industries. Furthermore, according to Takafusa (1995) these laws allowed the establishment of “cartels covering the items manufactured, their quantities, and technology”.

Government continued to push for policies for the promotion of technological innovations.[10] Hirono (1985)

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[10] Discussion here is largely based on Hirono (1985), which in turn was largely based on the Science and Technology Agency White Paper, 1982.

grouped these policies into three main categories: (a) tax measures; (b) provisions of government subsidies to private industry, research organizations, and universities and other institutions of higher learning and specialized disciplines; and (c) provision and improvement of economic, social and administrative infrastructure for promoting R&D activities and technological innovations in the private sector.

Included in the tax measures were the accelerated depreciation allowances for plant, machinery and equipment used in R&D activities in the strategic sectors defined by the MITI. There were also reductions in real estate or property taxes and business taxes for R&D installations and programs in “technopolis” across the country. In particular, partial deductions were allowed from corporate income tax in cases when (i) R&D expenditures beyond the maximum reached in the past tax years, (ii) income is derived from technology export, and (iii) making pecuniary contributions to non-profit research organizations.

There were also local tax measures like exemptions of property tax, utilities tax and property acquisition tax for R&D installations and assets acquired by non-profit educational institutions. There was also reduction in property tax for R&D plant and equipment owned and managed by mining and industrial technology research cooperatives.

High tariffs, including quantitative import restrictions and other non-tariff barriers were also utilized to shield these protected strategic sectors from foreign competitions and to widen local production and industrial base of Japan. Moreover, attractive export incentives were provided to those strategic sectors that were importing advanced technologies in order to expand both their output and export so that they could exploit the economies of scale in production.

Table 19 shows a detailed set of fiscal incentives for technology-related activities in Japan. Incidentally, it was shown in some econometric studies that indeed in the 1950s the fiscal incentives were fairly effective in raising the level of private investment (Nagoaka, 1989). In particular the accelerated depreciation scheme helped companies not only by increasing their rate of return from investment but also by reducing credit risks for banks. Furthermore, it was also observed that targeted measures, such as the tax exemptions for commercializing new products, were ineffective in encouraging new industries to grow, especially during their infancy or initial stage. These industries were the synthetic fibers, synthetic rubber, fertilizer, petrochemicals and antibiotics.

Apart from tax reductions and exceptions, there were also provisions for low-interest loans by government financial institutions. For example, the Japan Development Bank provided such low interest loans to R&D activities for developing indigenous technology, innovating large-scale computer technology and producing high technology in electronics and machinery industries.

Another example was the provision by the Small and Medium Enterprise Finance Corporations loans with low interest rates to smaller enterprises that conducted R&D activities related to new developments in technologies and in electronics and machineries. The Center for Development of R&D Enterprises provided smaller industries with guarantee for their R&D loans from commercial banks. Furthermore, coverage for insurance was extended by the Small and Medium Enterprises Credit Insurance for R&D activities and for commercializing new technologies.

The second category of government support included the provision of subsidies to private industry and research organizations and universities, including organizations of higher learning and specialized disciplines. Covered in this category were R&D activities in priority areas such as nuclear and other sources of energy, space, marine resources development, biotechnology among others. The Ministry of Education provided subsidies to R&D programs in science and technology in the state universities, research institutions, as well as in private universities. Moreover, the New Technology Development Corporation granted subsidies to private industry to develop new technologies and to encourage government research laboratories to and universities to transfer technologies to the private sector.

MITI contracted out to the private industry many of the required R&D activities for developing new large-scale industrial technologies, energy-saving technologies, and new alternative sources of energy, as well as for innovating medical, health and welfare equipment manufacturing technologies and basic technologies for future generation industries.

The amount of subsidies granted to R&D related activities was huge. For example, in 1980 the subsidy from the Science and Technology Agency amounted to 307.9 billion yen, from Ministry of Education 166.1 billion yen, and from the Ministry of International Trade and Industry 119.2 billion yen. For the year, these subsidies comprised 91.6 percent of all government subsidies for R&D activity in the private sector, including universities, research organizations.

Table 20 lists down some specific incentives granted by the government to R&D-related activities in Japan. One very important lesson that can be gained from the Japan experience in granting incentives is that, although these incentives were directed to particular groups of industries, competitive basis in granting the incentives was pursued. The competitive process of granting was done according to the criteria set by the government. This process greatly eliminated the possible rent seeking behavior.

The last category of government support involved the provision and improvement of the economic, social and administrative infrastructure for promoting R&D activity and technological innovations in the private sector. One of the major components here was the establishment of national network on scientific and technological information through improved cooperation and coordination among public and private agencies collecting, collating, analyzing, evaluating, and publishing science and technology information to better meet the overall and specific needs of information by consumers in Japan as well as in overseas. The Tsukuba Research and Development Park that was established in 1971 accelerated the research and education on science and technology by bringing together government research laboratories, educational institutions, and some selected private research organizations and universities.

Another important component was the streamlining of technical evaluation procedures and systems, including industrial standards. There were significant upgrading of government and semi-government research laboratories and testing stations.

Research and Development

Basic Structure. It was earlier discussed that there was a substantial increase in R&D effort in Japan. This was indicated by the rise in the ratio of R&D expenditure to GNP. From 1.3 percent in 1962, the ratio increased to 1.7 percent in 1970, 2.0 percent in 1980, and 2.7 percent in 1989 (Figure 7). It was also discussed earlier that this rise was mainly due to the effort of developing and producing indigenous technology during the time when Japan already was approaching the technological limits of advanced countries in Europe and America. Initially, the strategy of Japan was to import advanced technology from these countries. However, the development in Japan was so rapid that it was able to close the technological gap in a relatively short period.

Although the government actively promoted technological development as evidenced by the various support and subsidies it extended to the private sector, it was the private sector that always dominated all R&D activities in Japan. Table 21 and Figure 9 indicate that almost 70 percent of the total R&D expenditure came from various private companies. In the 1960s, research institutes accounted for about 17 percent, but in the 1970s the share increased to more than 20 percent. The share of universities went down from more than 20 percent in the 1960s to less than 10 percent in 1980. All this would indicate that although the government exerted substantial effort in pushing for technological development in Japan, it took the back seat. The role of the government was to put in place the necessary infrastructure for technological development and to grant incentives to the private sector.

UNESCO defined three major categories of R&D activities. These are basic research, applied research, and experimental development. Basic research involves 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 encompasses any original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective. Experimental development comprises 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.

Table 22 shows the breakdown of R&D activities in Japan in terms of the three categories and of the type of organization. On the whole, the emphasis of R&D was on the third category. Its share increased from 49.1 percent in 1970 to 58.4 percent in 1978. Basic or fundamental research as well as applied research went down over the same period. The emphasis on third category was due to the effort of the private sector, which dominated the R&D field, to focus on development research. Development research of the private sector increased from 63.6 percent in 1970 to 77.1 percent in 1978. Research institutes, which captured about 20 percent of R&D activities, were more of applied and development research as indicated by the share of about 40 percent in each category. Universities were originally into fundamental research, but moved into more applied research as indicated by the shares. In 1970 the share of fundamental or basic research in the universities was 80 percent. In 1978, it went down to 57.3 percent. On the other, the share of applied research increased from 20 percent to 37.3 percent over the same period.

Of the OECD countries, Japan and Germany took a generally similar path in R&D in which the industry took a dominant share, in contrast to countries like the USA, France, Canada, and the United Kingdom where the government sector took the commanding share in R&D expenditure (Figure 10).

<u>Objectives of Technology</u>. The White Papers of Japan on Science and Technology publish regular survey results on the objectives of the private sector on its technological effort. It is interesting to see in Table 23 that there were major shifts in the emphasis over time.

In the 1950s, the dominant concerns were better quality and performance (40 percent) and mass production (23 percent). Through time, however, as some of these objectives were realized, emphasis shifted to other concerns like resource conservation (18 percent) and energy conservation (18 percent). Despite the major shift however, the objectives of better quality and performance topped all the rest.

Public-Private Sector Link. Discussed earlier was the fact that although the private sector played the leading role in technological development in Japan, the support extended from the public was significant. In 1961 the law on research associations was implemented. The law gave a legal status to cooperative research associations. Thus, to foster further the link between the private and the public sector under this law, R&D cooperatives were installed in major private enterprises interested in technological innovations under the guidance and financial assistance by the MITI. This policy proved to be very effective in research involving high-risk, high-cost and long-gestation R&D programs to develop indigenous technology. In particular, those cooperatives were very essential in the development of large-scale computers and integrated circuits. Likewise, in the apparel, as well as in non-ferrous metals manufacturing, such cooperatives were established. From 1961 to 1983 seventy one research associations were established. The government took a leading in the establishment of these cooperatives since they were used as implementing organizations for government-assisted R&D projects.

A number of concerns, however, were raised against the establishment of these cooperatives. For example, there were issues that the cooperatives might not generate positive results because the participating companies are in stiff competition against each other both in the factor and production markets, and therefore it would be likely that they would not assign their best capable scientists and engineers to such cooperatives (Hirono, 1985). Another concern was that such cooperative might prevent free competition among the participating firms, and therefore might result in some inefficiency. Furthermore, there were criticisms from the US that such cooperatives might result in unfair competition between Japanese and American companies because of the possibility that through the cooperatives, Japanese companies might be pooling their resources together and the Japanese government subsidizing the participating enterprises to enable them to be more competitive in the international market.

Another channel whereby the link between the private and the public sectors was reinforced was through the establishment of 19 technopolies of the MITI wherein government financial resources were utilized to install the most up-to-date economic and social infrastructures and facilities conducive to the activities of technology-intensive industries. The facilities included specialized R&D laboratories. The local governments were also fairly active in supporting the private sector's effort in technological innovations in these technopolies.

Another very important feature of R&D in Japan early on was the existence of trading companies that facilitated the importation of technologies, both general and specialized, most appropriate to the requirement of the local manufacturers. Such trading companies served as the identifiers of technology needs within Japan and of the availability of such technologies abroad. These companies were instrumental not only in supplying information to the buyers of technology in Japan, but also in investing their own financial resources in setting up their manufacturing subsidiaries either unilaterally or in joint venture with the foreign supplier of the imported technologies or the local buyers of the technologies (Hirono, 1985). Through time, however, as the local buyers of technologies gained valuable experience, they themselves imported their own technology requirement. Local manufacturers were also sending local engineers and managers for training abroad. This development was facilitated by the assistance provided by the Japan External Trade Organization, a subsidiary of MITI, in providing and obtaining the necessary information on the nature, costs and benefits of alternative technologies available abroad.

Also, national research laboratories were established and played an important complementary role for private R&D. These laboratories served five objectives: basis research not undertaken by universities; applied research involving large-scale research equipment; technology transfer; research that private industry cannot adequately undertake (e.g. pollution issues); and research for the establishment of standards, testing and methods and norms. Furthermore, these national research laboratories provided basic technological information in the planning stages of private R&D (Nagaoka, 1989). Together with the MITI these laboratories played a major leadership role in cooperative R&D. In addition, they were the major agents of assessing private R&D projects assisted by the government. Also, by accepting researchers from the private enterprises as trainees, these laboratories were able to transfer skills related to R&D to the private sector.

Patent System. Japan has a long history of patent protection (Nagoaka, 1989). The first patent regulation was established in 1885. In 1899, it acceded to the Paris Convention and accepted application by foreigners. Active patenting activities remained active since then. One feature of the system was the protection of a utility model[11]. More than 40 percent of the world patent applications have been filled by Japanese in recent years.

Apparently, R&D activities have been encouraged greatly by the very active patent system in Japan. Apart from the positive impact particularly on the problem of appropriability of R&D benefits, it provided a vehicle for evaluating and recognizing the technological effort of workers by the patent experts. In particular, many companies in Japan implemented a special incentive to encourage employees to create innovations and make suggestions for improving efficiency. This widened the participation in inventing activities in Japan.

Manpower Development

Structure of Workforce. One of the major driving forces of technological development and rapid economic growth in Japan was the absorptive capability of its pool of manpower. Imported technologies were adapted, assimilated, and diffused because of its well-trained labor force. Figure 11 shows the continuous rise in the pool of researchers; from 106 researchers per 1000

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[11]Patent protection for utility model was implemented by virtue of a 1905 legislation that followed the German system as a model.

persons in 1962, the number increased to 172 in 1970, 303 in 1980 and 462 in 1989. Similar to R&D expenditure discussed above, the private sector or the companies employed a sizeable part (more than 50 percent) of this pool of researchers (Table 24). Researcher institutions employed fewer number of researchers compared to the universities as a whole.

As expected in terms of research specialization, the researchers specialized in areas where demand existed. Table 25 indicates that in the second half of the 1960s, more than 20 percent of the researchers were specialized in chemistry and related fields, 15 percent in machinery, about 13 percent in electrical and related fields. Those employed in the private sector more than 30 percent had specialization in chemistry, 20 percent in machinery, and another 20 percent in electrical and related fields. One would note that these were the same industries in which the early industrialization process after the war was focused. However, in research institutes researchers were specialized in agriculture (about 30 percent) and chemistry (15 percent), while researchers in universities were in medicine (about 40 percent) and chemistry (10 percent).

Formal Educational System. The early educational system in Japan can be traced back to the Meiji Restoration that began in 1868 in which a group of reform-minded leaders created an educational system that integrated various aspects of French, German, and other Western models with indigenous social and cultural elements.[12] However, after WWII when Japan was occupied by the Americans, the system was modified through major reforms. The reforms were based on a mission report containing the blueprint for the postwar Japanese educational system submitted by a group of American educators and other US experts. The basic philosophy of the reform was the democratization of education. The reform was meant to dismantle the centralized, multi-track education system in Japan over the last three-quarters of the century into an American-style decentralized, egalitarian, single-track system. Japan had adopted a 6-3-3-4 single track school system throughout the country. Six years of elementary schools

[12]Discussion here is based on Amano (1997).

education and three years of lower secondary school education are compulsory.

The other major reforms in the educational system included: (1) the introduction of public elections for boards of education; (2) the liberalized publication of textbooks, (3) the flexibility in planning for the school curriculum, (4) the consolidation of highly variegated secondary schools into middle and high schools, (5) the consolidation of various institutions for higher education into two-year junior colleges and four-year universities.

However, when the occupation ended in 1952, there were counter-reformation moves in reviving the old system by certain sectors. Indeed, several changes were re-introduced into the system, but still the egalitarian, open structure of the school system based of the American system was retained.

When Japan entered into a rapid growth in the 1950s students who went on to the secondary schools surged. The ratio of students who went to high school increased from 52 percent in 1955 to 58 percent in 1960, to 71 percent in 1965, to 82 percent in 1970, and more than 90 percent in 1975. In 1991, the enrollment rate for elementary and secondary schools was 100 percent (Table 26). These high rates were mainly due to the compulsory educational system in the six years of elementary and in the three years of lower secondary school.

Higher education was also popularized. As a result of the increase in high school enrollment, the proportion of those who entered two-year or four-year colleges surged as well. The ratio 18-years-old who went on further to higher education increased from 10 percent in 1955 to 17 percent in 1965, to 24 percent in 1970, to 38 percent in 1975. These results were striking contrast to the pre-war period. For example, in 1935 only 40 percent of all students who completed elementary schooling continued to secondary school, and only a tiny 3 percent went on further to higher education.

Another very important feature of the educational system in Japan is that it did not only provide an equal education opportunity, as indicated by enrollment ratio in all levels of education, it also ensured the same quality of educations in all schools, thereby reducing regional disparities. The generally similar quality of education across regions where ensured by clear standards of school facilities, and well qualified and better paid teachers, among others.

Government support to the educational system was substantial. Both the national and the local governments were active in shaping up the system. In the period 1960-65, the cumulative public education expenditure amounted to 5.9 trillion yen. In 1971-75, it increased to 27.7 trillion yen. In 1981-85, it increased further to 78.6 trillion yen. The share of financial resources that came from the national government was slightly lower than from the local government, about 45 percent from the former and 55 percent from the latter (Table 27). These resources went into elementary and lower secondary schools, which are compulsory in Japan (Table 28). Substantial shares are also attributed to upper secondary school and universities and colleges.

Private educational institutions played an important role in the overall system as well. In higher education, the majority of students attended private schools. Also, most of the special training schools and miscellaneous schools are private schools. Table 29 shows the number of private school students and teachers, and their proportion to the overall system.

Assistance to the private educational institutions from the government was also significant. In 1991 for example, the national government budgeted Y364 billion in subsidies to the private schools. Of this amount, 70 percent was spent for the current expenses of private universities and colleges, 22 percent for upper secondary schools. Apart from these subsidies, the government also granted resources for educational and research equipment and facilities, which are increasing in recent years.

Other Trainings. Institutions for human resource development (HRD) and other trainings also existed. Both the national and local governments set up vocational institutions and centers, vocational training colleges, skill development centers. In these institutions, trainings were also provided to those who are unemployed and wanting to look for jobs elsewhere, those who wanted to change jobs or look for another job after the mandatory retirement and for the handicapped.

A major feature of the vocational training system in Japan that is worth noting is the active participation of the private enterprises (Nagaoka, 1989) In fact, vocational training is mainly supported by the private sector, unlike countries in Europe where vocational institutions are public entities. In Japan, training is mostly on-the-job activities. However, these enterprises also provide seminars or formal training courses for employees. Many large companies finance graduate education abroad or in Japan. Company incentives are also provided to those who are able to obtain certificates of skills training. Investment in HRD in Japan by the private sector is supported by the unique lifetime employment system widely adopted after the war. With this system, the private sector is encouraged to appropriate investments in training and education since the employees work for them in many years ahead. Thus, HRD practice at the company level played a major role in shaping up the pool of manpower in Japan.

Administrative Structure

Figure 12 shows the administrative structure of science and technology in Japan. Science and Technology Agency (STA) is the highest administrative agency on science and technology. The policy-making function however was entrusted to the Council for Science and Technology (CST). While the Japanese Science Council, with a membership of 210 experts in 1979, deliberated on major theoretical issues and advices the government on science and technology matters, the CST was entrusted with the formulation of more concrete policies (Choi, 1983). Other related agencies include: the Atomic Energy Commission, the Space Activities Commission and the Council for Ocean Development which operating under the jurisdiction of the Office of the Prime Minister.

One feature of Japan’s science and technology policy formulation is that the CST or the STA sets only policy directions, leaving the implementation to the relevant ministries and agencies. Another interesting feature is the leading role of businesses in industrial technology development. The government plays a limited and indirect role through granting of subsidies in major projects, tax incentives, and loans.

As the policy-making body, the Council for Science and Technology proposed to the Prime Minister in 1971 the following recommendations as the country’s science and technology goals (Choi, 1983):

1. the application of science and technology to the country’s social and economic needs as a means of promoting their advancement;
2. the sowing of seeds for the promotion of science and technology and the construction of their foundations, and;
3. the promotion of basic science.

In 1977, the same council proposed the following as the basic goals of Japan’s science and technology policy:

a. the securing of a stable supply of resources and their economization;
b. the finding to environmental and industrial safety problems;
c. the improvement if public health and medical systems;
d. the promotion of pilot science and technology projects;
e. the fostering of technology power to promote international cooperation and strengthen the nation’s international competitiveness.

III. Philippine Experience in Science and Technology

Patterns of Growth

The Philippine economic growth is described as dismal in the last two decades. It went through a “roller-coaster ride” in the 1980s and 1990s (Figure 13). The early 1980s saw the economy growing at 3.5 percent. In 1984-1985 the economy contracted by a significant –14.6 percent in real terms. This economic collapse was brought about by the political turmoil arising from the assassination of a major political opponent of the Marcos administration. When Mrs. Aquino took over the administration in 1986, the economy bounced back strongly with a high growth of 6.8 percent in 1988. However, this was not sustained. The economy started to take a dip thereafter because of a number of reasons, among which the major ones are: series of military coup attempts, natural calamities, electric power crisis, and unfavorable international economic environment. But when Mr. Ramos was elected to the presidency in 1992, the economy recovered again attaining a growth of about 6 percent in 1996. The familiar problem of unsustainability of growth surfaced anew when the economy started dipping in the succeeding years. Mainly because of the Asian financial crisis that broke out in mid-1997 and the drought brought about by the El Nino effect in 1998, the economy again contracted. There was a slight recovery though in 1999, but at the rate the political situation is deteriorating at present [13] this might not be sustained based on the last 20 years of boom-bust growth track record. Indeed, the economic prospects for the Philippines may not be so promising.

Indeed, the Philippine economy is moving along a boom-bust growth cycle. While it may be true that the political instability is a major factor behind this, the weak economic structure also contributed significantly to this pattern of growth. Figure 14 shows the high inflation rate during the period. Inflation peaked to almost 50 percent at the height of the economic crisis in the mid-1980. In 1991, inflation surged again. High inflation during the period was caused mainly by

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[13] On January 20, 2001 the vice president was sworn into the Office of the President because of graft and corruption charges against the elected president whose term of office was supposed to end in 2004.

macroeconomic mismanagement as indicated by huge government budget deficit and unsustainable accumulation of both foreign and domestic debt.

Figure 15 shows estimates of total factor productivity (TFP). Except in the second half of the 1980s, TFP estimates were negative. In the 1990s, TFP estimates were all negative as well. It is important to elaborate further at this point the sectoral TFP analysis of Cororaton and Cuenca (2000) as it shows a clear example of uncoordinated and policy failures in the Philippines which resulted in unfavorable resource allocation effects, weak economic fundamentals, and less growth. Their sectoral analysis indicates that it is the service sector that pulled down the overall TFP growth. Furthermore, they found that although the contribution of TFP was negative for the whole economy, there was actually an improvement during the 1990s. From a negative contribution during the 1980s, it flipped to a slightly positive contribution during the 1990s. Based on their sectoral TFP analysis, the pattern for agriculture was similar: from negative TFP contribution in the 1980s to positive contribution in the 1990s. For mining, manufacturing, and utilities the contribution of TFP growth was positive during the two decades. However, there was a significant slowdown during the 1990s relative to the 1980s. Generally, for non-tradables, particularly the service-related sectors, capital accumulation type of growth was evident.

Based on their TFP estimates, they concluded that there were favorable as well as unfavorable trends. Sectoral estimates showed improving TFP in the 1990s, although a number of the sectoral TFP levels were still negative. However, for the economy as a whole, 1990 saw a slight decline in TFP. This could indicate that there were unfavorable resource allocation effects because of the capital accumulation type of growth in the non-tradable sectors, particularly the service-related sectors, relative to the rest of the sectors in the economy. One factor that could have triggered this capital accumulation type of growth was the prolonged real appreciation of the currency in the face of an aggressive trade reform program in the first half of the 1990s. This kind of an economic environment is usually not conducive to production activities, both for domestic consumption and exports. In a period when capital inflow is massive (in mid-1990s as will be pointed shortly), non-tradable sector like the real estate sector becomes an attractive destination of capital.

Table 30 shows the investment pattern during the period. Similar to the output growth path, a dip in the investment ratio occurred in the mid-1980s. However, there was a significant improvement in the 1990s. One of the major factors behind this was the surge in net foreign direct investment. However, a major part of this investment went to the real estate sector because of policy failure as pointed out above, and therefore the impact on productive capacity was minimal since some of these real estate investments were speculative in nature as they were investments in condominium and other high-rise structures and buildings. On the other hand, net portfolio investment picked up during the same period. But these investments were highly speculative as well because when the Asian financial crisis broke out in 1977, these investments evaporated immediately.

Savings are not adequate to finance investment. Figure 16 shows that the savings rate[14] has always been below the investment rate. It was only in three instances when the savings rate surpassed the investment rate: in 1986, 1988 and 1999. In these years, investments were low because of economic recession. For sure, this is one major economic fundamental where the Philippines should improve on to make the economic activities viable. Certainly, this is difficult to achieve in an atmosphere of political instability.

However, significant structural changes took place since the 1950s. Table 31 shows that agriculture sector captured 34.7 percent of production in 1950. Through the years, this share declined, so that by 1998 it was only 17.4 percent. The share of industry increased during the period when the government embarked on an import substitution policy. From a share of 27.1 in 1950, it increased to 38.8 percent in 1980. Similarly, the share of the manufacturing sector increased from 16.1 percent in 1950 to 25.7 percent in 1980. Seemingly, one indicator

[14] Savings rate here refers to the gross national savings computed using the resource gap formula, that is, gross domestic investment plus current account balance net of official transfers.

of failure of industrialization process in the Philippines is the declining share of industry, particularly the manufacturing sector, in the last two decades. The shares declined to 31.8 percent in 1998 for industry in general and to 21.8 percent for manufacturing in particular. Over this long period, the share of the service sector increased from 38.2 percent in 1950 to 51.3 percent in 1998.

Table 32 shows the structure of employment. Generally, a similar pattern is observed in the sectoral share of employment. There was a clear movement from agriculture to the service sector. One striking thing however is the pattern of employment in the manufacturing that stagnated at around 10 percent of total employment in the last 40 years. This labor movement could have aggravated the pressing problem of poverty in the country because of low productivity in the service sector. de Dios (1993) observed that “The decline in the share of agriculture in employment has been significant; but since the industrial share has stagnated, it is services, a large part of which is in the so-called ‘informal sector’, which served as the receptacle for labor shed by agriculture but which industry failed to absorb. The lack of employment opportunities condemns the majority of the labor force to jobs with low productivity and poor pay”.

There were significant changes in the export sector as well in the last 3 decades that are important to take not of. The share of the semi-conductor industry surged from zero in 1970 to 48 percent of total merchandise export receipts in 1999 (Table 33 and Figure 17). If finished electrical machinery is included, the total share is more than half of the total exports. However, the value added component in semi-conductor export is very thin because it is only labor contribution that comes from local sources. All the rest comes from foreign sources. In fact, the semi-conductor industry in the Philippines is only at the assembly stage. The production process has to progress and to move up the ladder for it to contribute significantly to the economy. And there can be sizeable room for growth in this area because of the present era wherein information technology is the in thing.

Garments used to be a major export item, but its share declined since 1990. The shares of agriculture-based exports have also been declining such as sugar, coconut-related crops, banana, as well as mining-related commodities like copper.

All told, the economic as well as the political environment where the Philippines is in at present is not generally conducive to a sustained growth. Although major economic reforms are underway, the political squabbles among different quarters do not seem to settle down and are in fact taking a heavy toll on the economy.

The Importance of R&D in the Philippines

In the Philippines, two studies attempted to conduct a regression analysis to examine some possible determinants of TFP in the Philippines: Austria (1997) and Cororaton and Abdula (1997). It is important to highlight these at this point because they put the discussion on technology-related issues in Philippines perspective.

The first study considered TFP of the entire economy as the dependent variable in the regression, while the second TFP of the manufacturing sector. In Austria's paper, TFP of the entire economy was regressed against trade and investment policy indicators. The indicators include tariff rates, share of exports to GDP, share of imports to GDP, foreign direct investments (FDI), and inflation. Both tariff and import shares are used to capture the trade liberalization program of the government through reduction in tariff and non-tariff barriers. FDI is one major vehicle for transferring technology from abroad, thus its inclusion in the analysis would attempt to capture transfer of technology. Inflation is a “catch-all” indicator of economic instability. High inflation means macroeconomic instability. Normally, economic instability discourages productivity-enhancing programs from being adopted (like R&D) and investment.

The regression results show a statistically significant effect of exports on TFP growth (Table 34). The two major exports of the Philippines are garments and semi-conductors that account more than 60 percent of total merchandise exports. These exports are highly import-dependent in terms of raw materials and technology. In fact, these exports are closely tied up with the foreigner buyers through consignment. Thus, the growth in exports could also be a vehicle of technology transfer.

Contrary to the general expectation, imports have a negative effect on TFP. There are two possible explanations for this. First, in the regression, total imports were considered. Imports of machinery and equipment, which usually embody new production techniques and technology, are only a fraction of the total. Thus, the inclusion of the total imports might have captured other effects also. Second, unavailability of skilled workers who can adequately operate the new machines and equipment might have led to their inefficient use, thus causing lower productivity.

Tariff rate has a negative effect on TFP, although the coefficient is not statistically significant. Effective rate of protection (EPR) could have been the more appropriate indicator of tariff liberalization, but time series on EPR is not available. However, Austria (1997) cited other studies that showed that when protection is reduced at a moderate rate, the rise in productivity is highest; and when protection is reduced at an excessively fast rate or when it is not reduced at all, the rise in productivity is lowest.

Foreign direct investments (FDI) have positive effect in one of the estimated equations but are not statistically significant (Equation 1 in Table 35). While it may take some time before FDI brings about productivity effects, the result of incorporating a one-year lag in FDI yields a positive effect, (Equation 2). However, the effect of including both total FDI and FDI in manufacturing shows a significant positive effect of total FDI on TFP growth, but a significant negative effect of FDI in manufacturing (Equation 3). Austria (1997) attempted to explain the negative effect of manufacturing FDI by citing the fact that multinational companies are oriented towards the global market, thus, there may be less room for adaptation of technology to the local economy in a wide scale manner. Lastly, inflation, which is a catch-all variable of macroeconomic instability, has a significant negative effect on TFP.

In a similar exercise, Cororaton and Abdula (1997) conducted a regression analyzing some possible factors affecting manufacturing TFP. The factors included in the analysis were: estimated TFP of the manufacturing sector, exports, imports, tariff, minimum wages, R&D, foreign direct investment and inflation. The variables entered the analysis either as ratios to GDP or in first difference or both.

All estimated coefficients are statistically significant (see Table 36). Exports ratio is positively affecting TFP of manufacturing. The reason discussed above with regard to export may also apply here, i.e., exports could be one channel through which foreign technology is transferred to the local economy. This is because of the close tie-up of the major exporters in the Philippines with the foreign direct buyers. However, similar to the previous results, the same negative effect of imports on TFP manufacturing is seen in the result.[15]

Tariff has negative effects on manufacturing TFP. This would imply that a reduction in the tariff protection would result in productivity improvement (probably due to efficiency gain from a competitive environment). FDI has a significant positive effect on TFP.

Minimum wage, usually wage rate for unskilled labor, in the Philippines is legislated. The results show that an increase in minimum real wage decreases productivity, which is generally expected. Usually, a wage system that is not based on productivity is inefficient. Inflation, an indicator of economic instability, negatively affects productivity. High inflation occurs in an economic system with lots of uncertainty. This prevents organization from pursuing productivity-enhancing programs.

R&D as a percent of GDP has a positive effect on TFP. This has an important policy implication because, usually, technological change cannot be realized without

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[15] The negative coefficient showed up when capital import was included in the regression instead of total imports. Although the reason behind this may be unclear, the authors would attribute this to the inappropriateness of technology adopted by industries. Such technology that functions merely as input, entails no significant effect on domestic science and technology (Yap, 1989).

technological infrastructure. Furthermore, the effectiveness of technology transfer requires distinct activities and investments, and a certain level of technological development in the country to minimize the cost of implementing the new technology and to maximize its productivity once in place. Normally, the technological development of a country depends upon R&D investments and on the efficiency of its R&D institutional system.

Patterns, Developments, and Policies in R&D and Technology

Level of R&D Effort. Cororaton (1998) 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 37 shows that out of 91 countries the Philippines is at the 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 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 3 percent.

The low number of scientists and engineers is reflective of the general tendency of the educational system in the Philippines to produce non-technical graduates. Table 38 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.

There is in fact 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 non-technical 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 the high laboratory requirement that is capital intensive. Non-technical courses are less laboratory intensive and therefore less capital intensive.

Furthermore, in a recent survey conducted 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 than 30 percent of R&D personnel with Ph.D. degrees are in social sciences, while only less than 10 percent are in engineering and technology (Figures 18 and 19). About 15 percent are in agriculture-related sectors.

S&T Background, Policies and Programs. Philippine science and technology (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 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 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 performing effectively its functions. This was manifested in the unplanned activities of the researchers within the agencies. Most areas of research were left to the researchers for them to define under the presumption that they were attuned to the interests of the country. They were expected to look for technologies and scientific breakthroughs with 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 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 a reorganization and creation of the National Science and Technology Authority (NSTA) in 1982. One rationale for 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, 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 39 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 the councils and research institutes under the NSTA showed a clear shift in science policy from being a technology push to demand pull strategy. 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, namely the PCASTRD and the PCAMRD, were created to further strengthen the Council system.

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 that 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. 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 lastly, 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, funding assistance to technology developers and acceptors through 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 were: 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 vehicles for university interaction with private industry; to develop new knowledge-based industries and strengthen existing ones; and to 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.

A Presidential Task Force on S&T was formed, in 1988, 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 was composed of DOST, DOA, DTI, DOTC[16], 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 were: 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.

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[16] DOA–Department of Agriculture; DTI – Department of Trade and industry; DOTC–Department of Transport and Communication.

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 the 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 40 to 41).

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 include: 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, special focus was given to the coconut industry, and therefore 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 discussion, it is worth mentioning the its six flagship programs include (1) comprehensive program to enhance technology enterprises: (2) integrated program on clean technologies; (3) establishment of a packaging R&D center; (4) expansion of regional metrology centers; (5) S&T intervention program for poor, vulnerable and disabled; and (6) comprehensive S&T program for Mindanao. Although the vision and direction of the plan is novel, there are no specific implementation rules and guidelines.

Some General Insights. 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 developed countries 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, braindrain of technical personnel as well as S&T professionals results. This is one crippling problem in 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 their implementation. There was 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.

R&D is crucial in a country's development process, yet some economic agents are hesitant in pursing 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, surveys and interviews indicate a seemingly chaotic and confusing system of institutional arrangements because of 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. Certainly, this leads to institutional inefficiencies. A reorganization of the structure of the Department is called for.

Gaps in R&D in the Philippines

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

Gaps at the National Level

Based on an econometric study, Cororaton (1998) 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 (i) low R&D investments and inadequate R&D manpower, (ii) institutional weaknesses as a result of poor system, management and leadership, (iii) policy lapses and failures, or all three combined. But in the estimation only the first two have been considered because of data availability.

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 in S&T Bill (House Bill no. 2214) of 1 percent of GNP.

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 intense and purposes, this could not feasibly be 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 of social sector like education and health. Furthermore, it may be totally ineffective and inefficient to re-allocate 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 (1998), for example, argues 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 into R&D will only go to waste and will not result in productivity gains.

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 needed so as the said sector can do its own R&D.

In terms of manpower, it was observed that the gap of is around 197 scientists and engineers per million population. The average ratio for the decades of the 1980s was only 108. For the Philippine TFP to reach the gap it should need 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: (i) underinvestment in R&D, (ii) lack of adequate and technically capable R&D manpower, (iii) institutional weaknesses, and (iv) policy failures. Below is a brief discussion on the following sectors: agriculture, fishery, manufacturing, education, and health.

Agriculture[17]

Underfunded Research in Agriculture. The agricultural sector performed poorly since the 1980s. David et al (1998) attribute this poor performance to a number of factors, and one of them is the inadequate public support services 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 to an average of 1 percent among developing countries and 2-3 percent among developed countries (Table 42). In fact, only 5 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 43)."

Apart from the problem of inadequate funding for research, there are other equally important gaps, if not more important ones, in agricultural research. David et al (1998) identified them as: (i) inefficiencies caused by the misallocation of research resources within the

[17] Largely based on the paper of David et al 1998.

sector (e.g., across research program areas and ecological regions) and (ii) 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 (1998) found that the "allocation of research expenditures across commodities and regions have 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, and 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 further added 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 (1998) and Ponce (1998). Some of these are:

(1) Overly High Share for 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) is about 36 percent and capital outlays (CO) only 6 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 activities related to 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-tern nature of funding, even though the university may have the most able scientists in the country in different fields in agriculture.

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

(2) 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 not carried 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 in 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.

(3) No 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."

(4) No Clear Network Between DA and Attached Agencies. In addition, Ponce (1998) also argues that the DA research system consists of national experiment stations operated by (i) various bureaus such as BPI, BAI, BFAR, and BSWM; (ii) attached agencies such as PhiRice, PCC, PCA, SRA and FIDA; (iii) Regional Integrated Centers under the regional offices of the DA; and (iv) 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 exists independently of each other in terms of programs even within the DA proper. Thus, national centers do not exactly orchestrate the national research and development programs of their assigned commodities.

(5) No Clear Link with the Private Sector. Furthermore, Ponce (1998) also 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.

(6) Other Institutional Gaps. Other institutional weaknesses cited by Ponce (1998) are (a) the lack of well-defined and institutionalized mechanism for collaboration among R&D subsystems and (b) the inefficient funding system and lack of accountability.

The present funding system is still very much like the old project-approach one where the research outputs are essentially in the forms of research reports. This weakens the system of program approach and leads to distortion of national priorities. Furthermore, the present funding approach gives rise to a much-diffused structure of research implementation where it becomes difficult to pinpoint responsibility.

Manpower Gaps. In terms of R&D manpower profile in agriculture, the authors found that the problem is not in terms of the number, but 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 of some of the Asian countries like Malaysia, Indonesia, and even Bangladesh.

On the other hand, the quality of research manpower in SUCs is not uniformly nor always significantly better. Although share of manpower in SUCs may be higher than in agencies, there is a big and worsening problem of in-breeding. Furthermore, local scientists who were trained and educated abroad, are not generally 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[18]

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 (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 side, is directly affected by what has been happening in the environment. To a certain extent, the fisheries sector can be one output indicator of what has been happening in the environment.

[18]Based on the paper of Israel (1998).

Israel (1998) has pointed out that the weak performance of the fisheries sector has been the result of several interrelated problems which include the top three important ones: (i) 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 ecosystems; (ii) large-scale environmental damage, as evidenced by the destruction of coral reefs and mangroves in marine areas and pollution of major river lakes; and (iii) 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 (PCARMRD). The Council, which is under the DOST, is tasked to plan, monitor, as well evaluate fisheries R&D. The paper of Israel (1998) 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 Gap and Issues. Israel (1998) found that one of the biggest gaps which results 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 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.

Aside from poor collaboration, another crucial institutional problem deals with a possible duplication problem between PCAMRD and the Bureau of Fisheries and Aquatic Resources (BFAR) arising from the existing Fisheries Code. The Code 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 becomes 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 implementing are mandates of the Council. Likewise, the Council has already established a network of research institutions, the NARRDS, to serve as implementing arm for fisheries R&D. At a larger scale, the duplication of functions in the R&D programs in the fishery and agriculture sectors has been noted by the Agricultural Commission.

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 institution inefficiencies.

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

(i) Low Public Investment. The most glaring resource-related problem in R&D is historically low government funding that agriculture as a whole receives (Tables 44 and 45). In developed countries, average public spending on investment in agriculture R&D is about 2 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.

For fisheries, in particular, 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 fishery 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 46 and 47). It can be seen also that 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 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, it is known that 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.

A lot of the private sector involvement in fisheries R&D is in aquaculture. During the rapid development of this industry in the last twenty 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 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.

In the municipal fisheries, private investment in money terms is low because the poor economic position of the municipal fishermen practically prevents them from doing such investment. However, manpower involvement in R&D is substantial among fishermen and their 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 48). To promote this type of investment, the AFMA encourages government research agencies to go into co-financing 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 48). In recent years, however, this share has gone down (Tables 49 and 50). By 1996, only 7 percent of the total funds of NARRDS institutions came from foreign sources (Table 51). 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. The AFMA and Fisheries Code did not address the issue of international funding for R&D.

(ii) Untimely Release of Funds. Aside from the 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 there are no data that 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. The 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 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.

(iii) Shortage of Manpower. Earlier figures show that the NARRDS institutions relatively have limited R&D manpower at all levels (Table 50). They also indicate that personnel capability varies greatly between regions and programs and that senior personnel, especially those with doctorate degrees, are concentrated only in a few institutions (Table 52). The limited number of doctorate degree holders has been compensated, in some cases, by masteral degree holders. While this is so, it cannot be denied that more doctorate degree holders are required in NARRDS institutions to provide the 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 53). This proportion is highly uneven and not reflective of the higher ratio of fisheries output to total agricultural production (Table 54). The graduate to undergraduate ratio of fisheries R&D staff appears to be significantly lower compared to that of agriculture also.

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 fisheries 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.

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 towards addressing it.

(iv) 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.

Like the manpower problem, the inadequate and poor maintenance of capital assets is 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 materialization of the increased allocations promised by the AFMA and Fisheries Code.

Manufacturing

One of the major factors that hindered the study team to conduct a thorough and a detailed study on the manufacturing sector R&D is the lack of historical information that can help track down R&D developments in the sector. As mentioned in Section II, the breakdown of R&D expenditure that is available up until 1992 is entirely different from the sectoral breakdown in the PSIC. As such, historical information is not consistent with what is available in the NSO data system. This is a major hurdle because usually R&D activities, in the form of investments and manpower availability, are analyzed against indicators of sectoral output performance. For example, in the congruence rule discussed in Section III, optimal allocation of R&D budget should be proportional to the respective commodity value added or value of production shares. While the latter is available from the NSO data, the former is not. However, David et al (1998), after a tedious task of gathering and assembling information from almost all sectors in agriculture, were able to apply the analysis in a preliminary way. Based on the analysis, they were able to conclude that R&D allocation in agriculture is *far* from optimal.

However, the same analysis *cannot* be done in the manufacturing sector because of the absence of R&D data. What was done, instead, was to conduct a small survey (Macapanpan, 1998 and Halos, 1998) on selected industries in the manufacturing sector, and company interviews (Nolasco, 1998) within those selected industries, including the BOI. The discussion here is largely based on these papers.

The paper of Macapanpan (1998) is focused on Philippines’ private sector innovation activities. It was based on a survey of selected companies from five industry groups: (1) food processing, (2) textile and garments, (3) metals and metal fabrication, (4) chemicals and (5) electronics and electrical machineries. The major conclusions of the study are the following:

(a) Only big firms do engage themselves in innovation. These are industry leaders. Smaller firms may just be 'along for the ride', not even considered "followers".

(b) "Innovations activities are perceived by the firms 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 for innovation activities.* As predicted by literature and studies, firms will formulate their technology strategy to support their overall business strategy.

(c) "*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."

(d) "Of the total respondent firms (more than 60), only seven firms employ Phds 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*."

(e) "*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."

(f) "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."

(g) "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 requisite technical and technological skills and knowledge are not provided by the Philippine schools. Government research institutions have not diffused their findings to the private sector."

Based on a survey, Macapanpan (1998) therefore was able to identify major gaps and stumbling blocks that prevent the private sector from fully exploiting the benefits of being technological-attuned and -updated productive units. Moreover, based on interviews, Nolasco (1998) identified further gaps and major loopholes in the system:

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

(ii) Government, with such limited amount of budget allotted to R&D, limits the amount of expenditure on R&D.

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

(iv) System only reaches out to a handful of firms, usually the larger ones. Small and medium scale firms have minimum access to the system.

(v) People and staff in the incentive promotion desk are not too familiar with the system of incentives. For example, some of them are not even aware of (a) the contents of the R&D incentives scheme LOPA and (b) the fact that R&D incentives existed for more than six years. Most of them would recall 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.

(vi) Government and private sector linkages are very weak. Thus, commercialization of developed technologies has not well been promoted.

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 (1998) on the survey and interview with private firms in the chemical industries, which produce chemical inputs into agriculture (such as fertilizer and pesticides), indicated 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 are 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 remained to do so at present. The regional research station of a multinational agri-chemical firm has reduced not only the number (from 5 to 3) but also the rank of its research staff (from 2 senior and 2 junior level).

Another observation of Halos (1998) deals with the government policy. For 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.

In general, Patalinghug (1998) argues that small and medium 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 know-how to shift to more advanced technologies, (5) inadequate mechanism for transfer of technologies and (6) inertia of entrepreneurs because of no perceived or actual need for technology."

Education

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. 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, 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. Non-technical 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.

Furthermore, in a recent survey conducted 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 than 30 percent of R&D personnel with Ph.D. degrees are in social sciences while only less than 5 percent are in engineering and technology (Figures 18 and 19). About 15 percent are in agriculture-related sectors.

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. The bad shape in the basic education is rooted to the teacher training policy of the country and the status of teaching profession (Magpantay, 1985). "To be able to teach in high schools, teachers must have BSE with a major and minor field. This degree program is short on the content and heavy on the methodology of teaching. In the end, teachers are knowledgeable in the standard way of teaching but do not know what to teach. And worse, the students, who enter the education colleges, are generally not very creative and imaginative due to 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 the 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, 1988). “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 present study did not have the opportunity to include an analysis on the health sector R&D. However, the Center for Economic Policy Research (CEPR), under the funding from the Department of Health, recently conducted an analysis of the funds flow of health research and development in the Philippines. Among the major objectives of the analysis were to: (a) trace the flow of health R&D resources; (b) assess the system for setting health R&D priorities; and (c) determine if health R&D funds match with 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:

(i) "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.

(ii) 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) discussed the long history of S&T and R&D in the Philippines. In fact, its beginnings can be traced back to the American colonial period. There were 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. There are, however, clear indications of failure (Patalinghug, 1998). For example, the S&T sector faces the following major problems: (a) underutilization of S&T for development as reflected in the low quality and productivity of the production sector and heavy dependence on imports; (b) underinvestment in S&T developments in terms of manpower training, technological services, R&D facilities and financial resources; (c) weak linkages between technology generation, adaptation and utilization; and (d) 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 (1998) further cited 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."

Institutional Weaknesses. There are a number of clear institutional gaps. Some of these include:

(i) Failure in Execution and Implementation. Patalinghug (1998) made a comparison between the S&T system 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 big defects within the existing intra-government 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 from 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".

(ii) Other Causes of Institutional Failure. Some argues that Korean leadership has the political will and the consensus among its stakeholder to give top priority to S&T development in the allocation of resources. Magpantay (1995), on the other hand, claimed 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 is a clear example of poor planning and poor budgeting. Patalinghug (1998) in fact concluded that "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".

(iii) Failure of Industrial Policy. There are renewed attempts to formulate industrial policy (Patalinghug, 1998). 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.

There are at least twelve priority sectors that have been implicitly identified in the recent pole-vaulting strategy. However, the technologies in support of these "must-do" programs have yet to be identified.

IV. Policy Lessons for the Philippines

Three major issues were laid out at the outset: (a) a productivity-based growth is sustainable in the long run than a factor accumulation-based growth; (b) a growth strategy that is consistent with productivity-based growth is technological innovation-based; and (c) in developing countries where institutional rigidities as well as market imperfections are prevalent technological innovation-based growth strategy is extremely difficult to implement. The impressive growth of the Japanese economy after WWII was generally a productivity-based growth achieved through a technological innovation-based strategy. Technological innovation as discussed in Section I involves a dynamic process, and it in each step of the process economic growth improves as experienced in Japan. The experience of Japan could therefore shed light and provide useful policy lessons for developing countries like the Philippines that is struggling to grow and develop. It was on this background that the paper was conceptualized.

The paper attempted to review the growth process in Japan after WWII. It went to analyze the initial conditions, the economic environment in which economy was operating, the goals and strategies pursued, institutions established, economic policies implemented, programs developed, the role of government in the entire process, and the involvement of the private sector. Since the main objective was to draw policy lessons for the Philippines, the paper analyzed in great detail the S&T experiences in the Philippines to provide some comparisons.

The analysis of the experience of Japan provided the following lessons: (1) accumulation of technological experience is extremely important, and in the case of Japan this has been started years before WWII through its pre-war industrialization policies; (2) key institutions which proved to be very crucial in the process were established (like the Science and Technology Agency, research institutions, labor unions, patent office, etc.); (3) industrial strategy pursued was seen as managing the process of technological change in order to achieve a dynamically efficient industrialization (this was quite evident in the phasing in and phasing out of priority industries and the rapid increase in R&D during the period when the technological gap with developed countries in Europe and America was closing); (4) the importance of importation, adaptation, assimilation of foreign technology; (5) the importance of incentives and subsidies to promote and encourage private participation, which in a neoclassical sense is inefficient but in reality is effective if granted in a competitive manner through a set of criteria laid out by the government; (6) manpower development through basic and formal education, vocational training, and company sponsored skills-enhancing programs; (7) sound macroeconomic management and stable economy (extremely essential for private participation); (8) political stability through strong leadership; and (9) shared development through the rapid expansion of the middle class.

The details of each this are discussed in Section II, but it is important to elaborate further two important issues that are particularly relevant to the Philippine case. These are the role of: (i) industrial strategy; and (ii) proper institutional arrangements.

The current debate in the economic literature puts the issue of industrial strategy that is along the arguments of Hirshman (1958) in the sideline. In fact, the issue of the day is globalization through "making prices right". While this may be justified by the failures of some countries which adopted import substitution policies through targeting like the Philippines, Brazil, India to name a few, "making prices totally right" may be unrealistic especially if technological change and innovation is at the heart of the growth 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 because of the factors outlined in Section I. The case in point is the Philippines. It has been exerting a lot of effort in implementing economic reforms that are consistent with globalization. While the ongoing set of economic reforms[19] are extremely important and necessary to overhaul the inefficient production structure of the economy, it lacks focus and provides no clear direction at all to where the

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

process of technological innovation should go. The recent S&T plan of the government lists down 23 industries as priority areas. They are just simply too many since the production lines of these industries are totally unrelated. The case of Japan, and to a great extent the case of South Korea, is very clear: the technological innovation strategy was attuned, synchronized and made consistent with the overall industrial strategy. This is 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, private sector would be unwilling or hesitant to come in and participate no matter how attractive government incentives are. In the Philippines, incentives have been made available to R&D-related activities since the early 1990s, but thus far there have been very few takers.

The second issue involves institutional arrangements. The review of S&T experience in the Philippines provides some clue that key ingredients for a technology-based growth strategy may be present already. While they may not be as comparable to that of Japan, the relatively long S&T experience, the institutions, the policies and, to a limited extent, the manpower are present. However, there is an institutional failure because of very weak institutional arrangements. Planning and budgeting exercises are uncoordinated resulting in very poor performance and project failures. There is also lack of focus, especially in attracting and getting the participation from the private sector, through for example the commercialization of some developed technologies.

The lessons discussed may have some important implications to the policy formulation exercises in the Philippines. However, they are general. There are equally relevant specific policy recommendations that are important to consider also. These include improvements in: (1) R&D investments; (2) R&D manpower; (3) incentive system; (4) institutional arrangement and S&T coordination mechanism; (5) R&D delivery system; and (6) statistical information and accounting system.

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 at the various sectoral levels. For example, Cororaton (1998) estimated a gap in R&D expenditure of 0.5778 percent of GNP at the national level. David et al (1998) also observed significant underinvestment in agriculture. Israel (1998) also found the same thing in the fisheries sector. Underinvestment in R&D is also very apparent in the private, manufacturing sector as observed by Macapanpan (1998) and Halos (1998). 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 to 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, to technological progress and finally to economic growth and prosperity. There is a huge body of literature that would support this.

The biggest issue at hand is: Who would fill in 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 (1998) argued that misallocation of public sector research funding is an equally important consideration as underinvestment. They cited specific examples. Using the congruence rule, they found that "relatively greater research budgets are provided to 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 regions in Luzon and to a lesser extent to those in 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 nor equity considerations"

Other manifestation of misallocation of resources is in the allocation of budgetary resources by type of expenditure. David et al (1998) also observed 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 (1998) mentioned this as one of the major concerns in the fisheries sector. "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 (1998) has recommended that DBM must 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 also, its effects would take a long time to be realized if ever reforms are successfully implemented. 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 (1998) estimated that the gap in the R&D manpower is about 197 scientists and engineers per million population. In agriculture, David et al (1998) observed that the R&D manpower is not so much in terms of the number, but 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 (1998) also observed a severe shortage of qualified personnel in the fisheries sector. The same is true in the private manufacturing sector (Macapanpan, 1998 and Halos, 1998). In fact, in the recent PIDS survey (Cororaton et al, 1988), it was observed that 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 number of graduates with science and engineering skills (Cororaton, 1998). There are a host of factors behind this. 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 non-technical 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 related courses because of their high laboratory requirement that is capital intensive. Non-technical courses are less laboratory intensive and therefore less capital intensive.

At the secondary or high school level, a substantial fraction of high school science teachers have no formal training in science and mathematics (Magpantay, 1995 and 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 out. 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 (1998) offered specific recommendations: (1) Strengthen S&T education at the elementary and secondary school level. The quantity and quality of elementary and secondary teachers of science and mathematics must be addressed in the Medium-Term Philippine Development Plan: 1999-2004; (2) A strong science and engineering program is also needed to support an expansion of science and engineering enrollment at the tertiary level. Expand the facilities of science and engineering institutions. Encourage the hiring of qualified faculty from abroad; (3) Intensify the effective recruitment of Filipino scientists and engineers working abroad by designing an incentive program that matches the cost of ESEP[20]; 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: (1) stable economy; (2) institutional protection; (3) access to capital and financing, especially by the SMEs; (4) good R&D infrastructure; and (5) 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 and etc. are kept at the 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 (1998), Halos (1998) and Nolasco (1998) observed 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

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

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 (1) a strengthened educational system which can produce a workforce with adequate R&D capabilities, good and updated data bases and information system; (2) wide and easy-to-access network on technology developments; (3) a mechanism whereby Filipino scientists and engineers working abroad can come back home to work; and (4) a mechanism whereby research results and output of research institutions and universities can be delivered to the end-users, among others.

Macapanpan (1998), Halos (1998) and Nolasco (1998) also noted that fiscal incentives are important in attracting the private sector to go into R&D activities. Cororaton (1998) listed down some of the major fiscal incentives in the Philippines and noted 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 (1998) noted that from 1991 to 1997, only 11 companies or a total of 13 projects were granted with incentives. Patalinghug (1998) therefore suggests that there is a 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 in a competitive basis through a set of performance criteria that may be defined by the government.

Other important incentive issues, which need attention, are discussed in Israel (1998). In particular, it was noted that in most cases, researchers conducting research using the funds of their own agencies are granted with minimal financial incentives. Remunerations from projects funded by other government sources have been incompetitively 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, would also indicate this trend (Cororaton et al 1998).

The Magna Carta for the Government Science and Technology Personnel (R.A. 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.

Furthermore, Patalinghug (1998) has additional recommendations that can improve the S&T incentives. These include: (1) allocation of an annual funding for the implementation of the Scientific Career System (SCS). However, entry into SCS should be limited by giving top priority on the target groups, natural scientists and engineers; 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.

Institutional Arrangement and S&T Coordination Mechanism

From all indications, 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 in technology in the overall development strategy. To address these problems, Patalinghug (1998) recommended the following reforms: (a) DBM must be involved with DOST in the S&T plan formulation stage so that S&T resources are available to implement the plan; (b) STCC must draft a Medium-Term Science and Technology Development Plan a year before the drafting by NEDA of the next Medium Term

Philippine Development Plan. An inter-agency joint committee must integrate the Medium Term Science and Technology Development Plan into the Medium Term Philippine Development Plan by decomposing them into annual budget plan, annual S & T plan, and annual economic plan, and then harmonizing its goals, projects, programs, strategies, resource requirements, and timetables; (c) 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 (d) 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 (1998) has a number of recommendations:

(1) 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.

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

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

(4) 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.

(5) 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. 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 is pilot testing. Demonstration of the technical viability of the technology in a semi-commercial 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.

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, normally, there are high risks involved in R&D investments (particularly the uncertainty in the outcome of an R&D undertaking), as well as there is 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, 1998). 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 their expertise in gathering information and their extensive nationwide network, so that regular information is generated and regular monitoring and analysis are conducted.

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Figure 1: Production Function

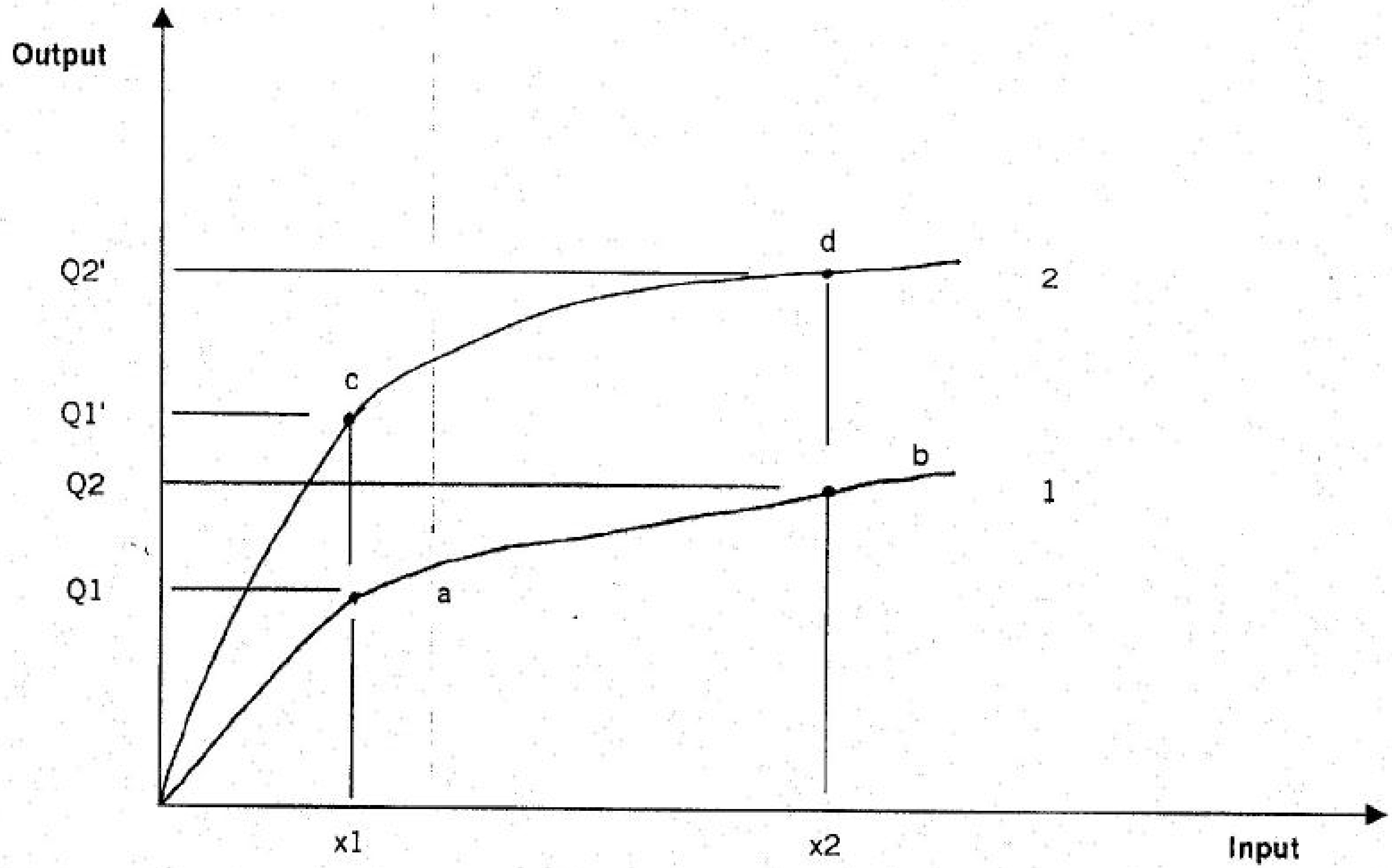
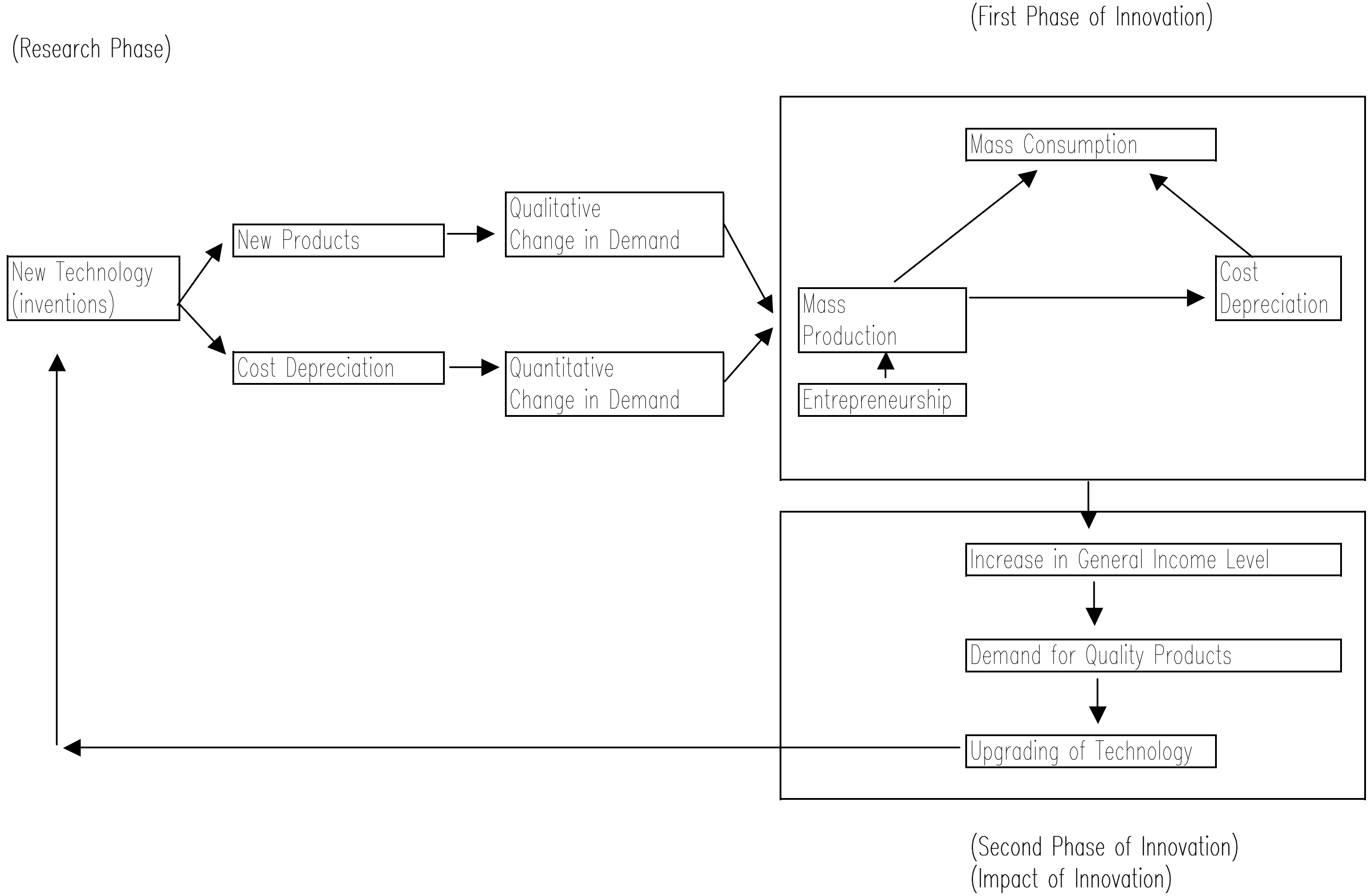


Figure 2: Technological Innovation Process



Source: Quoted from Choi (1983), but orginal source is Yamada (1964)

Table 1: Destruction of National Wealth in Japan (billion yen)

	Total Damage	Estimated Value of Undamaged State	National Wealth Remaining at War's End	Perentage of Damage	National Wealth in 1935 calculated at value of War's End
Gross value of national assets	64	253	189	25	187
Buildings and other structures	22	90	68	25	77
Industrial machinery	8	23	15	34	9
Ships	7	9	2	82	3
Electricity and gas supply facilities and equipment	2	15	13	11	9
Furniture and household effects	10	46	37	21	39
Production goods	8	33	25	24	24

Source: Quoted from Takafusa (1994). Original source is Economic Stabilization Board, Taiheiyo Senso ni Yoru Wagakuni Hokokusho (Comprehensive Report on Damage to Our Country in the Pacific War), 1949

Table 2: Average Annual Growth Rates (%) of Real GNP of Six Major Industrial Countries

Country	**1955-60**	**1960-65**	**1965-70**	**1970-75**	**1976**	**1977**	**1978**	**1979**
France	2.0	5.8	5.8	3.9	4.6	3.0	3.0	3.5
Italy	5.6	5.3	5.9	3.8	5.7	1.7	2.0	3.5
Japan	**8.9**	**10.0**	**12.1**	**6.8**	**6.5**	**5.2**	**5.8**	**4.3**
United Kingdom	2.7	3.4	2.4	2.3	2.3	1.6	3.0	2.3
United States	2.2	4.8	3.3	2.5	5.7	4.9	3.3	2.0
West Germany	6.6	5.0	4.8	2.2	5.7	2.6	3.0	4.0

Note: GDP growth for France, Italy, and United Kingdom

Source: Quoted from Hirono, 1980. Original sources: OECD, National Accounts of OECD Countries, 1955-75, and OECD, the OECD Observer, No. 96 January 1979, Table 2, p. 20

Table 3: Source of Economic Growth

Measures	Japan 1953-71	USA 1948-69	W. Germany 1950-62	France 1950-62	United Kigdom 1950-62
Standardized Growth Rate	8.81	4.00	6.27	4.70	2.38
Total Factor Input	3.95	2.09	2.78	1.24	1.11
Labor	1.85	1.30	1.37	0.45	0.60
Capital	2.10	0.79	1.41	0.79	0.51
Output per Unit of Input (Standardized)	4.86	1.91	3.49	3.46	1.27
Advances in knowledge & oth	1.97	1.19	0.87	1.51	0.79
Improved resource allocation	0.95	0.30	1.01	0.95	0.12
Economies of Scale	1.94	0.42	1.61	1.00	0.36

Source: Denison and Chung, 1976

Table 4: Savings and Investment in Japan

Year	Savings Proponesity[1]	Investment Rate[2]
1955	0.09	26.2
1960	0.16	38.7
1965	0.17	27.9
1970	0.2	35.5
1972	0.22	35.8
1974	0.24	33.3
1975	0.23	32.7
1977	0.23	31.2

Source: Hirono, 1980.

Notes: (1) savings propensity for worker household; (2) gross capital formation as percent of gross national expenditure computed using 1975 prices.

Table 5: Trends in Concentration Ratios for the Top Ten Firms in Manufacturing Sector of Japan, by Industry Groups1

	Food Processing	Textile, Pulp & Paper	Chemicals Petroleum & Ceramics	Metals and Metal Products	Machinery	All Manufacturing
1950	100.0	100.0	100.0	100.0	100.0	100.0
1952	104.7	82.7	99.5	97.9	89.9	97.6
1954	106.7	73.4	98.9	98.0	84.6	96.3
1955	106.7	69.0	98.3	99.5	91.9	96.4
1957	110.5	65.9	93.6	98.1	87.7	94.8
1959	115.3	63.0	92.3	99.3	85.3	95.2
1960	119.7	62.9	90.6	98.7	83.1	95.5
1962	124.9	62.7	89.4	99.5	90.2	97.1
1964	123.7	64.7	89.1	98.7	97.5	97.4
1965	126.2	63.0	89.0	98.9	99.7	98.0

Source: Hirono (1980). Original Sources: Fair Trade Commission, Nihon no Sangyo Shuchu (Concentration in Japanese Industries), 1963-66 and 1979.
1 Note: 43 industries are selected for the 5 industry groups; 11 for the food processing, 6 for the textiles, pulp and paper, 15 for the chemicals, petroleum and ceramics, 8 for the metals and metal products, and 3 for machinery groups. The concentration ratios are computed on the basis of output rather than sales, assets or employees

Table 6: Average Annual Growth of Exports and Exports as Percent of GNE of Six Major Industries Countries[1]

	Average Annual Growth Rate				Exports as Percent of GNE				
Year	1950-60	1960-70	1965-70	1970-76	1960	1963	1970	1975	1976
France	6.4	7.6		11.7	15.0	13.0	16.0	20.0	20.0
Italy	10.5	13.4		2.7	15.0	15.0	19.0	25.0	25.0
Japan	**15.9**	**17.2**	**18.0**	**14.3**	**11.0**	**9.0**	**11.0**	**13.0**	**14.0**
United Kingdom	4.8	3.0		0.6	21.0	20.0	23.0	27.0	29.0
United States	5.1	5.7	9.4	5.6	5.0	5.0	6.0	9.0	8.0
West Germany	16.6	12.6		15.1	19.0	18.0	21.0	25.0	26.0

Source: Hirono (1980), Original source: United Nations, UN Yearbook of Statistics 1977 and IBRD, World Development Report, 1978.
1.Growth rates of exports are in real terms, whereas exports as percent of GNE (gross national expenditure) are calculated on the basis of current market prices

Table 7: Quantum Indexes of Exports of Japan, by Major Commodity Groups

Year	Total	Textile Products	Chemical Products	Nonmetallic Products	Metals	Metal Products	Machinery	Misc.
1965	31.0	67.9	26.1	89.3	33.1	46.5	18.9	52.2
1970	62.5	95.5	73.2	101.7	61.7	85.7	49.7	96.5
1972	79.8	108.6	105.9	109.2	74.3	104.3	70.4	91.8
1974	99.7	95.8	95.3	93.3	113.2	103.9	94.8	103.9
1975	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1977	132.9	115.7	117.0	131.4	121.1	138.7	143.3	133.2

Source: Hirono (1980), Original Source: Bureau of Customs, Ministry of Finance, Foreign Trade Statistics, 1979

Table 8: Long-Term Foreign Capital into Japan (million US dollars)[1]

Year	Direct Investment	Portfolio Investment	Bank loans & bonds	Total Inflows
1950	2.6	0.6		3.2
1952	7.2	3.0	34.6	44.8
1954	2.5	1.5	15.3	19.3
1955	2.3	2.8	47.1	71.5
1957	7.3	4.2	124.1	135.6
1959	14.6	12.5	127.9	155.0
1960	31.6	42.5	137.5	211.6
1962	22.6	142.1	514.2	678.9
1964	30.6	54.2	827.9	912.7
1965	44.6	38.7	445.1	528.4
1967	29.8	130.0	687.9	847.7
1972	135.9	3,894.5	1,180.7	5,211.1
1974	133.7	1,455.5	2,304.3	3,893.5
1975	141.8	3,361.3	3,429.0	6,932.1
1977	192.6	3,028.6	2,744.1	5,965.3

Source: Hirono (1980), Original Source: MOF, Monthly Report on Financial Statistics, in EPA, Summary, 1969 and 1979

1. on approval basis

Table 9a : Labor Movement in Japan

	(10,000)				Percentage Distribution(%)			
	Farmers	Self-Employed	Employees	Total	Farmers	Self-Employed	Employees	Total
1948	1,586	598	1,274	3,458	45.9	17.3	36.8	100.0
1953	1,558	807	1,572	3,937	39.6	20.5	39.9	100.0
1958	1,422	850	2,050	4,322	32.9	19.7	47.4	100.0
1963	1,201	830	2,577	4,608	26.1	18.0	55.9	100.0
1968	900	950	3,148	4,998	18.0	19.0	63.0	100.0
1973	628	1,008	3,614	5,250	12.0	19.2	68.8	100.0
1978	560	1,041	3,800	5,401	10.4	19.3	70.4	100.0
1983	453	1,059	4,208	5,720	7.9	18.5	73.6	100.0

Source: Takafusa, 1994. Original Source: Labor Force Survey

Note: Farmers - self-employed operators of farms or forestry businesses and family-member employees

Self-employed - self-employed operators on nonfarming or forestry businesses and family-member employees

Figure 3: Labor Movement in Japan

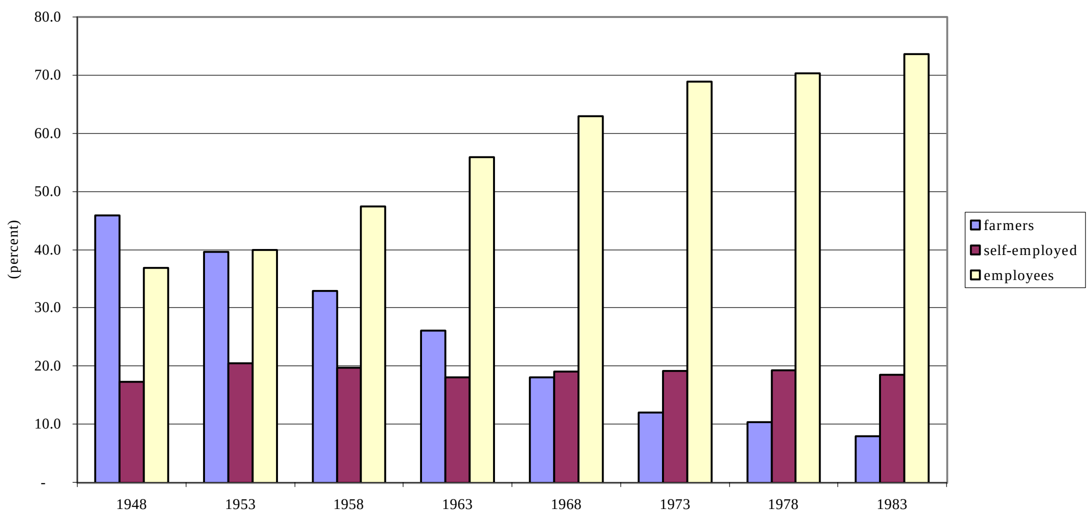


Table 9b: Employment in Japan, by Major Sectors

	Thousands of Persons						Percentage Distribution(%)					
	1955	1960	1965	1970	1975	1977	1955	1960	1965	1970	1975	1977
Primary Sector	16,111	14,240	11,738	10,060	7,354	6,137	41.0	32.6	24.6	19.3	13.8	11.5
Secondary Sector	9,220	12,762	15,242	17,651	18,098	18,697	23.5	29.2	32.0	33.9	34.1	35.2
of which: Manufacturing	6,902	9,542	11,507	13,442	13,236	13,797	17.6	21.8	24.2	25.8	24.9	25.9
Construction	1,783	2,679	3,403	3,993	4,729	4,772	4.5	6.1	7.1	7.7	8.9	9.0
Tertiary Sector	13,930	16,717	20,653	24,325	27,689	28,343	35.5	38.2	43.4	46.7	52.1	53.3
of which: Wholesale and Trade	5,473	6,910	8,563	10,014	11,381	11,622	13.9	15.8	18.0	19.2	21.4	21.9
Total	39,261	43,719	47,633	52,036	53,141	53,177	100.0	100.0	100.0	100.0	100.0	100.0

Source: Hirono (1980), Orginal source: BS / OPM, Population Census, in EPA, Summary, 1979, and BS / OPM, Japan Statistical Yearbook, 1978

Table 10: Improvement in Paddy Rice Productivity

	Man-hours per 10 acres	Yield (kg) per Per 10 acres
1952	196	325
1956	195	325
1960	174	368
1965	141	400
1970	121	431
1975	80	450
1977	75	455

Source: White papers of Japan, 1979-80

Table 11: Structure of Manufacturing Sector

	Trillion yen, current prices						Percentage Distribution (%)					
	1955	1960	1965	1970	1975	1977	1955	1960	1965	1970	1975	1977
Food, Beverage, Textile, Clothing	0.9	1.5	2.4	3.8	5.9	9.0	37.1	26.4	22.0	15.7	15.8	17.4
Wood, Furniture, Paper, Printng, leather, rubber	0.4	0.6	1.3	3.4	4.8	7.4	15.0	11.1	12.2	13.7	12.7	14.4
Chemical, coal, ceramics	0.4	0.9	2.0	3.9	6.6	7.8	15.6	16.8	18.4	16.0	17.5	15.0
Iron, nonferrous, metal products	0.3	0.9	1.5	3.9	5.6	7.2	12.0	15.6	14.2	16.0	14.8	13.8
Machinery, Electrical, Trans Misc	0.5	1.7	3.6	9.5	14.8	20.4	20.2	30.1	33.2	38.6	39.3	39.5
Total	2.4	5.5	10.7	24.6	37.7	51.8	100.0	100.0	100.0	100.0	100.0	100.0

Source: Hirono (1980), Original source: EPA, Annual Report on National Accounts, in JERC, Showa Roku Junen no Nihon Keizai (Japanese Economy in 1975), and BS/OPM, Nihon Tokei Neukan (Japan Statistical Yearbook) 1971, 1976,1978

Table 12: Structure of Production

	Trillion yen, current prices						Percentage Distribution (%)					
	1955	1960	1965	1970	1975	1977	1955	1960	1965	1970	1975	1977
Primary	1.6	2.1	3.1	4.5	8.2	9.3	18.5	12.6	9.3	5.9	5.3	4.9
Secondary	3.0	6.8	13.6	32.6	57.3	69.1	34.7	40.9	40.7	42.9	37.3	36.3
of which: Manufacturing	2.4	5.5	10.7	26.3	37.7	52.9	27.5	33.1	32.1	34.7	24.5	27.8
Construction	0.4	1.0	2.5	5.7	13.5	15.2	5.0	6.2	7.4	7.5	8.8	8.0
Tertiary	4.0	7.8	16.8	38.9	88.4	112.1	46.8	46.5	50.1	51.2	57.4	58.8
Total	8.6	16.7	33.5	76.0	153.9	190.4	100.0	100.0	100.0	100.0	100.0	100.0

Source: Hirono (1980), Original source: EPA, Annual Report on National Accounts, in JERC, Showa Roku Junen no Nihon Keizai (Japanese Economy in 1975), and BS / OPM, Nihon Tokei Neukan (Japan Statistical Yearbook) 1971, 1976,1978

Table 13: Structure of Export of Japan, by Major Commodity (percentage share)

	1955	1960	1965	1970	1975	1977
Heavy & Chemical Ind. Products	38.0	44.0	62.6	72.4	83.5	85.0
Metal & Metal products	19.2	13.8	20.3	19.7	19.2	14.2
Iron & Steel	12.9	9.6	15.3	14.7		
Machinery	13.7	25.3	35.2	46.3	57.1	65.2
Vessels	3.9	7.1	8.8	7.3		
Chemical Products	5.1	4.5	6.5	6.4	6.9	5.3
Light industry products	52.0	47.5	31.8	23.2	14.0	13.0
Textile products	37.3	30.0	18.7	12.5	5.8	5.2
Nonmetallic minerals	4.9	4.4	3.1	1.9		
Others	9.8	13.1	10.1	8.8		
Raw Materials	6.8	2.2	1.5	1.0	1.1	0.9
Foodstuffs	3.2	6.3	4.1	3.4	1.4	1.1
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: Hirono (1980), Original Source: MITI, Tasusho Hakusho (White Paper on International Trade)
in BS / OPM, Japan Statistical Yearbook, 1966 and 1978

Table 14: Completion of Electric Power Development Projects in Japan (10,000 kilowatts)

	1951-55	1956-60	1961-65	1966-70
Hydroelectric	247	384	378	390
Thermal	174	584	1510	2246

Source: Qouted from Takafusa, 1994. Original source: Nihon Kaihatsu Ginko Nijugonen Shi (A Twenty-Five-Year-History of Japan Development Bank), 1976

Note: In addition, 10,000 kilowatts of nuclear power were completed in 1961-65 and 1,320,000 kilowatts in 1966-70.

Figure 4: Electric Power Development Projects (10,000 kilowatts)

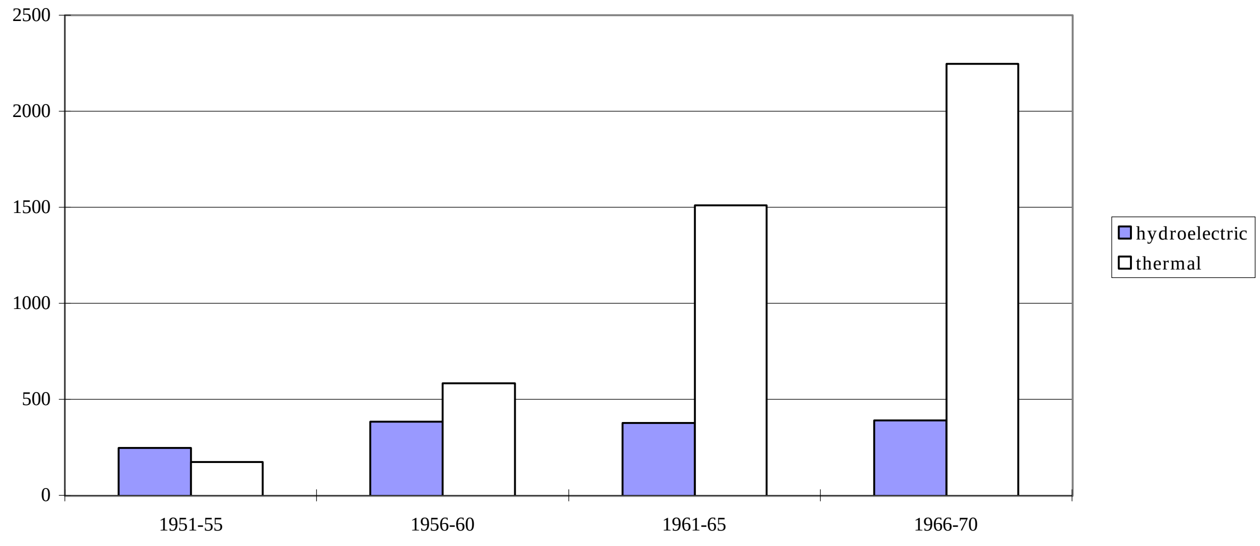
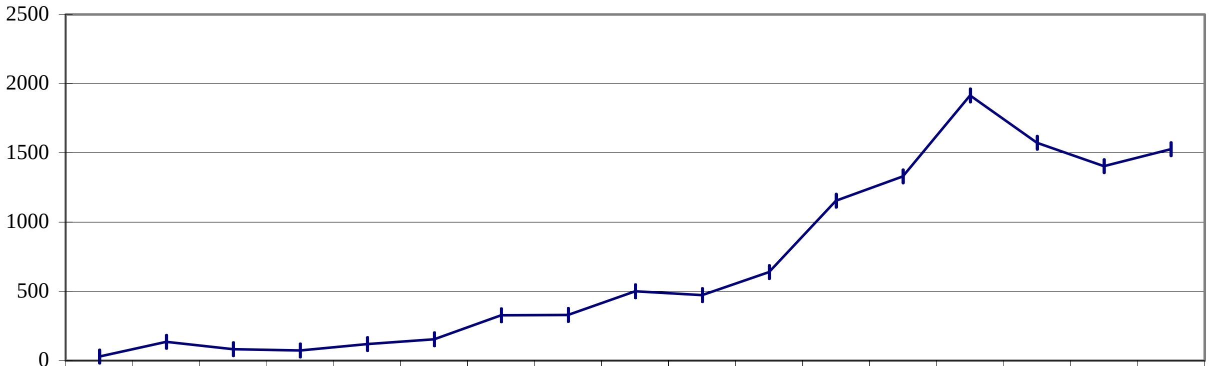


Table 15: Japan's Shipbuilding Program

	Number of Vessels	Gross Tons (10,000 tons)	Contract Price for Vessel by governmen (Y100 million)	Percent Financed
1947-50	164	69	581	57
1951-55	159	132	1,776	44
1956-60	140	136	1,654	50
1961-65	164	449	3,129	66
1966-70	290	1,136	6,921	69

Source: Quoted from Takafusa, 1994. Original source: Nihon Kaihatsu Ginko Nijugonen Shi (A Twenty-Five-Year-History of Japan Development Bank), 1976

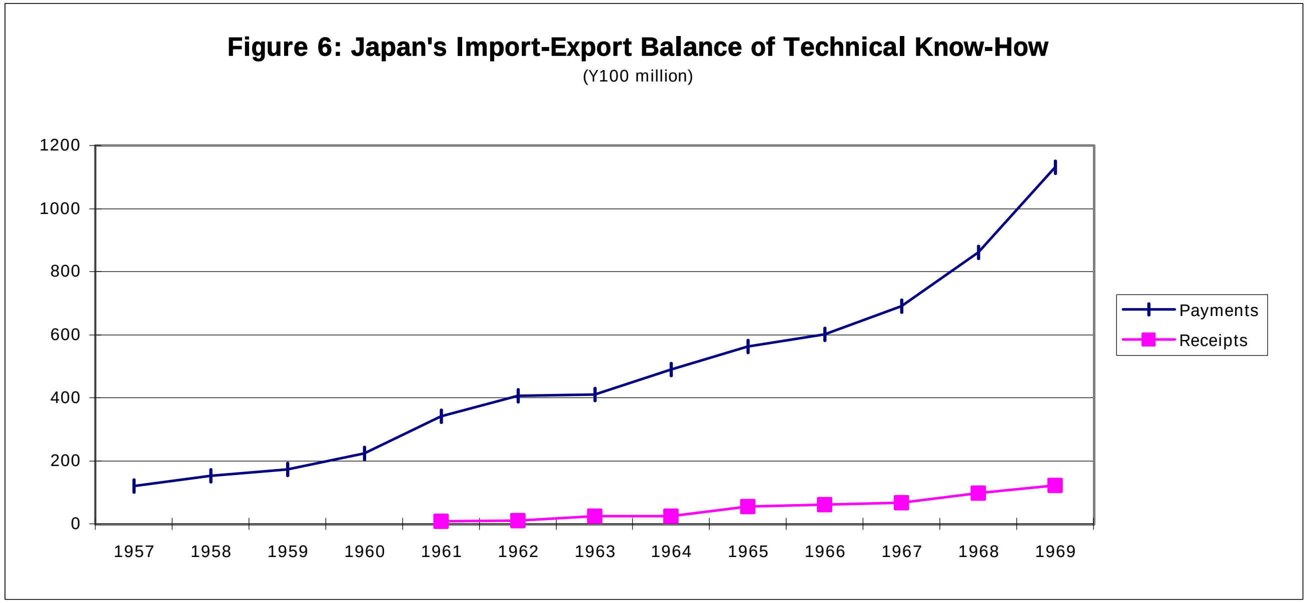
Figure 5 : Technology Inflow Into Japan



	1950	1952	1954	1955	1957	1959	1960	1962	1964	1965	1967	1969	1970	1972	1974	1975	1977
Series1	27	133	82	72	118	153	327	328	500	472	638	1154	1330	1916	1572	1403	1527

Source: Hirono (1980), Original Source: MOF, Monthly Report on Financial Statistics,

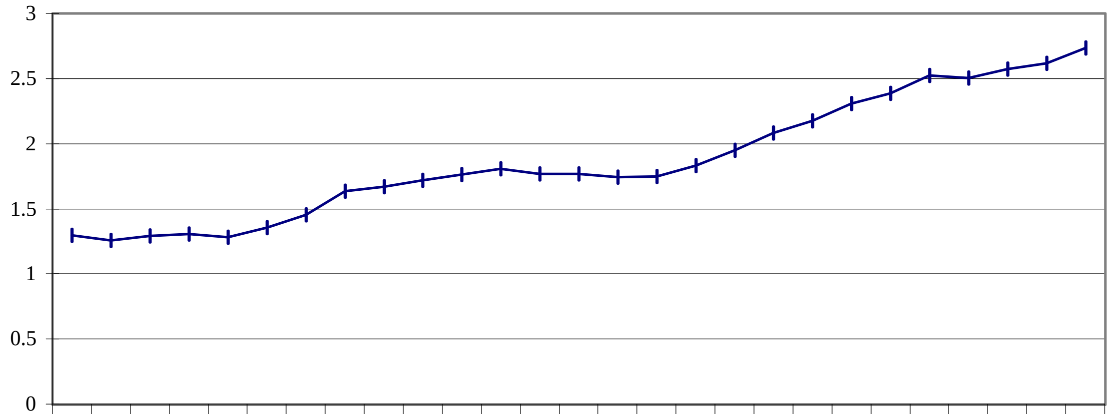
Note: technology inflows cover only those requiring the payment of royalty beyond one year in foreign currency



Source: White Papers of Japan, 1969-70

Payments and receipts of technical know-how, in Y100 million

Figure 7: R&D expenditure/GNP (%)



	1962	63	64	65	66	67	68	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89
R&D expenditure / GNP	1.3	1.3	1.3	1.3	1.3	1.4	1.5	1.6	1.7	1.7	1.8	1.8	1.8	1.8	1.7	1.7	1.8	2	2.1	2.2	2.3	2.4	2.5	2.5	2.6	2.6	2.7

Sources: Various issues of White Papers of Japan, Muta (1993), Ministry of Labor and Science and Technology Agency

Figure 8: Analysis of Appropriate Technology

Figure 8a

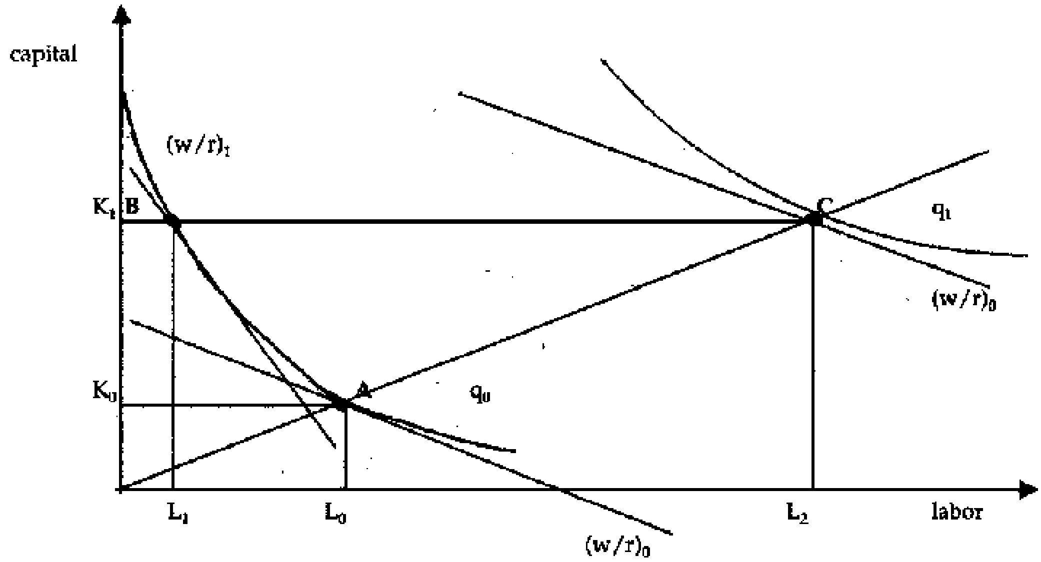


Figure 8b

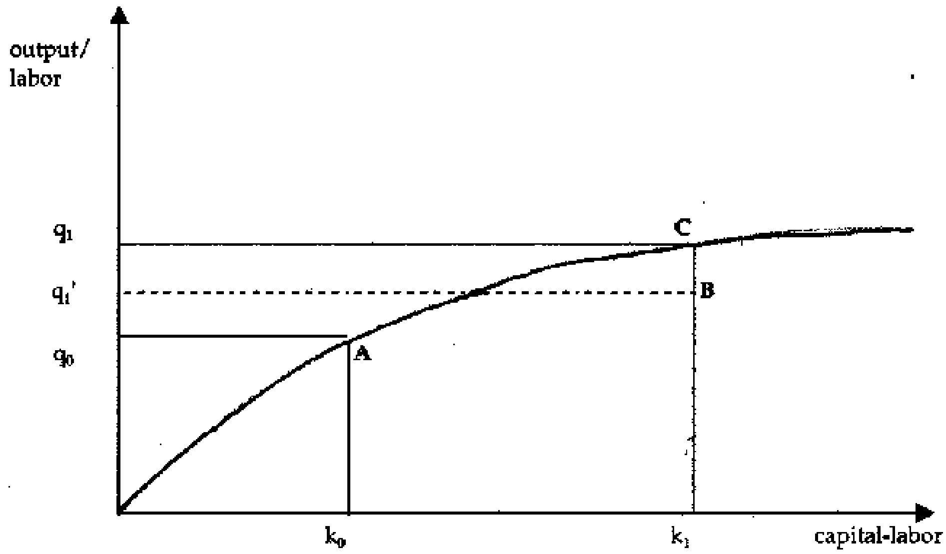


Table 16: Destination of Inflow of Foreign Technology into Japan, by Sector (Percentage distribution, %)

Sectors	1950-70	1971	1972	1973	1974	1975	1976	1977	1950-77
Textiles	4.9	6.5	9.1	12.2	11.6	12.3	13.4	13.1	8.5
Chemicals	21.0	19.1	15.4	13.9	16.7	13.4	11.5	13.9	17.5
Fibre	0.4	0.3	0.2	0.1	0.1	0.1	0.1	0.3	0.3
Pharmaceuticals	2.9	3.6	3.5	3.2	3.8	3.6	2.7	4.1	3.2
Organic & Inorganic	9.3	6.3	4.3	3.8	4.5	3.4	4.3	3.4	6.4
Plastics	4.8	4.7	4.7	3.6	4.3	2.7	1.2	3.5	4.1
Others	3.6	4.3	2.7	3.3	4.1	3.7	3.1	2.7	3.5
Coal & Petroleum Products	1.8	3.3	2.6	2.1	2.4	1.1	1.0	1.0	1.9
Ceramics & Clay Products	2.3	3.0	1.8	2.4	2.2	1.6	1.4	1.6	2.1
Basic Metals	5.2	2.8	2.7	2.3	2.1	3.2	1.3	1.5	3.5
Metals Products	3.2	2.7	2.7	2.2	2.7	3.6	3.0	3.7	3.0
General Machinery	28.0	27.4	24.7	24.4	22.4	22.8	24.8	22.7	25.8
Milling Machinery	2.8	3.4	3.3	2.4	2.4	2.2	1.3	2.2	2.6
Specialized Machinery	17.0	14.4	14.2	14.0	13.9	12.5	15.2	14.3	15.3
Other Machinery	8.2	9.6	7.2	8.0	6.2	8.1	8.3	6.1	7.9
Electrical Equipment	18.3	14.2	16.6	15.7	13.5	16.5	15.6	22.1	17.1
Power Transmitter	2.9	1.4	1.3	1.1	2.2	1.9	1.4	1.4	2.1
Communication Appliances	6.3	6.2	10.8	7.3	6.0	6.1	4.7	14.3	7.3
Eletronics Equipment	1.9	4.5	3.3	6.1	4.3	8.1	8.1	5.2	4.0
Other Equipment	7.1	2.1	1.3	1.3	1.0	0.4	1.4	1.3	3.7
Transporation Eqquipment	5.4	5.3	4.8	5.5	5.9	4.8	5.3	4.4	5.3
Precision Machinery	2.6	2.5	3.7	3.0	4.0	3.7	5.0	3.0	3.1
Miscellaneous	7.3	13.3	16.0	16.2	16.4	16.9	17.8	13.0	12.1
Total	100	100	100	100	100	100	100	100	100.0

Source: MOF, Monthly Report on Financial Statistics, in EPA, Summary 1979

Table 17: Imports of New Technology

	1963			1966			1967			1968		
	Total number licensed (a)	New technology developed (b)	(b) / (a) %	Total no. of licensed (a)	New technology developed (b)	(b) / (a) %	Total no. of licensed (a)	New technology developed (b)	(b) / (a) %	Total no. of licensed (a)	New technology developed (b)	(b) / (a) %
Machinery	274	175	63.9%	182	77	42.3%	189	86	45.5%	313	97	31.0%
Electrical Machinery	122	75	61.5%	83	30	36.1%	96	33	34.4%	192	26	13.5%
Metals and products	16	8	50.0%	43	23	53.5%	30	15	50.0%	56	13	23.2%
Chemistry	93	58	62.4%	140	55	39.3%	165	49	29.7%	229	91	39.7%
Atomic Energy	2	2	100.0%	3	3	100.0%	3	0	0.0%	5	3	60.0%
Others	57	48	84.2%	74	41	55.4%	71	15	21.1%	157	52	33.1%
Total	564	366	64.9%	525	229	43.6%	554	198	35.7%	952	282	29.6%

Source: White Papers of Japan, 1971-72

Table 18: Trends in Science & Technology Related Budget (Y100 million)

	Total Budget realted to Promotion of Science & Technology	Budget for Promotion of Science & Technology	Other Research Related Budget	Ratio to National Budget (%)
1963	906	366	540	
1964	1089	424	665	
1965	1323	466	857	
1966	1430	532	898	
1967	1678	607	1071	3.4
1968	1919	734	1185	3.3
1969	2214	916	1298	3.3
1970	2635	1142	1493	3.3
1971	3054	1338	1716	3.2
1972	3740	1684	2056	3.3

Source: White Papers of Japan, 1973-74

Table 18a: Breakdown of Total Budget Related to Science & Technology (Y100 million)

	Total Budget realted to Promotion of Science & Technology	Expenditure for National Universities	Subsidies	Expenditures for National Research & experiment Institutions	Administrative Expenses, etc.
1968	1,919	962	255	451	251
1969	2,214	1,056	347	500	311
1970	2,635	1,149	475	571	440
1971	3,054	1,280	595	665	514
1972	3,740	1,482	838	758	662

Source: White Papers of Japan, 1973-74

Table 18b: Breakdown of Budget for Promotion of Science and Technology (Y100 million)

	Budget for Promotion of Science & Technology	Expenditures related to Nuclear power	Expenditures for national research and Experimental Institutions	Subsidies	Expenditures related to space development	Adminstrative Expenses, etc
1968	734	208	306	160	41	19
1969	916	299	347	187	61	22
1970	1,142	390	394	212	119	27
1971	1,338	476	476	250	124	12
1972	1,684	562	521	361	206	34

Source: White Papers of Japan, 1973-74

Table 19: Fsical Incentives for Introduction of New Technology in Japan

Schemes		Fsical Granted
1. Abatement of Tax and Tariff		
	a. Income tax exemption for commercialization new important products (1923 - 66).	Tax on the income generated from the production of new products designed by the government was fully exempted for about four years. /A/
	b. Reduction of the withholding tax on external payment associated with important technical licensing (1953 - 67).	The withholding tax was reduced by 10% (later 15%)
	c. Import duty exemption for importing important machinery (1951 - 65)	Imported duties on machinery designated by the government were exempted. The eligible machinery were (1) new or highly efficient industrial machinery, (2) machinery difficult to be manufactured in Japan, and (3) machinery necessary for industrial development. /B/
	d. Income tax credit for the increase in expenditure for research and development (1966 - present).	If a firm's annual R&D expenditure exceeded the peak amount in the previous years, 25% of the excess was allowed as a tax credit. /C/ The credit was raised to 50% for the portion of the excess alone 15% of the amount spent in the previous peak year. The credit has been limited to 10% of the corporation income tax.
2. Accelerated Depreciation /D/		
	a. Important machinery (1951 - 61)	50% additional depreciation for the first three years, relative to the ordinary depreciation schedule.
	b. Machinery for rationalization (1952 -)	50 % depreciation in the first year.
	c. Machinery for testing and research (1958 - 65)	50%, 20% and 20% depreciation for the first, second and thrid year respectively.
	d. Machinery for commercializing new technology (1958 - 1965)	50% depreciation for the first year.
	e. Equipment produced for the first time in Japan (1964 -)	One third depreciation for the first year
	Machinery for the modernization of small and medium size industry (1963 -)	One third depreciation for the first three years

Source: Nagoaka (1989)

/A/ Before the revision of 1957, this scheme used to be applied not only to the commercialization of new products but also to the production of such products as minerals and coals.

/B/ The revision took place in 1960. The scheme was transformed to serving the prevention of industrial pollution, etc., from serving industrial development

/C/ Currently 20% of the excess can be counted as a tax credit.

/D/ Right hand column describes incentives applicable from 1958-60. Major curtailment took place in 1961 with some incentives integrated in the statutory schedule of depreciation.

Table 20: Major Incentive Schemes for R&D in Japan: Conditional Loan, Financial Assistance and Government-Sponsored R&D in 1960s and 1970s

Incentive Scheme	Type	Description
1. Conditional Loan		Fiscal support granted (around 50% of R&D cost) must be repaid, depending on the profit generated by the technology or on the success of the development project. Patents or any other research results belong to enterprises.
	a. Important technology in industry and mining (1950-).	Eligible R&D projects are chosen out of applications from industry on the competitive basis, according to criteria set by the government.
	b. Technology improvement for SMEs (1967 -).	The same scheme but eligibility restricted to small and medium enterprises.
	c. Computer development (1972-).	Targetted support for the development of computer and aircraft industry
	d. Aircraft development (1968 -).	
2. Financial Incentive		Below market interest rate loan to cover around 50 percent of project cost (financing period up to 15 years)
	a. Loan by the Japan Development Bank (1951 -).	Soft loan is provided to the commercialization of new technology, development of heavy machinery, and commercialization of new machinery
	b. Loan by Small and Medium Business Finance Corporation (1970 -).	Soft loan is provided to the commercialization of new tehcnology and to the prototype development of new machinery
3. Government-Sponsored R&D		The patents originated from research usually belong to the government and are available to any enterprises (i.e. nonexclusively), including a participating enterprise.
	a. Large-Scale project (1966 -)	The government identifies R&D projects, which cannot be undertaken by enterprises in spite of high social return, and sponsors their implementation (16 completed projects and 7 ongoing projects in 1987).

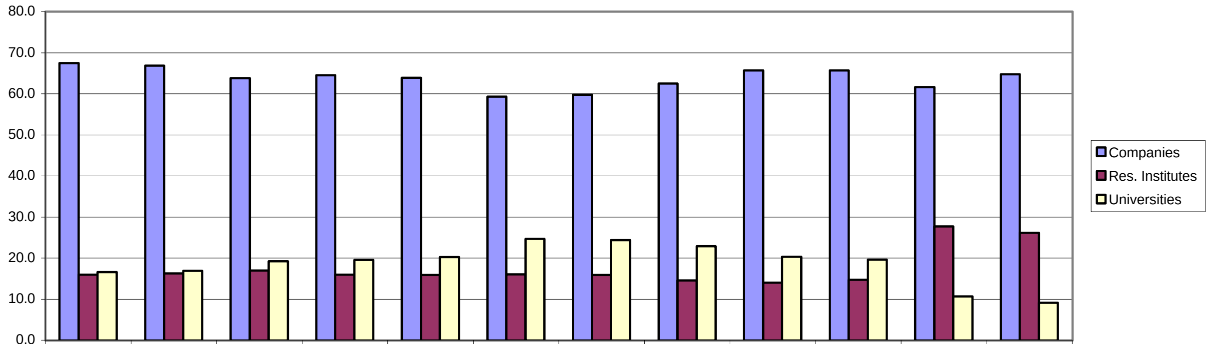
Source: Nagaoka (1989)

Table 21: Expenditure on Research and Development

	Expenditure (\billion)				Percentage Share			
	Total	Companies	Research Institutes	Universities	Total	Companies	Research Institutes	Universities
1960	18.4	12.4	2.9	3.1	100.0	67.4	16.0	16.6
1961	24.5	16.4	4.0	4.1	100.0	66.8	16.3	16.9
1962	28.1	17.9	4.8	5.4	100.0	63.8	16.9	19.3
1963	32.1	20.7	5.1	6.3	100.0	64.6	15.9	19.5
1964	38.2	24.4	6.1	7.7	100.0	63.9	15.9	20.2
1965	42.6	25.2	6.8	10.5	100.0	59.3	16.1	24.7
1966	48.9	29.2	7.8	11.9	100.0	59.8	15.9	24.3
1967	60.6	37.9	8.8	13.9	100.0	62.5	14.6	22.9
1968	76.8	50.4	10.8	15.6	100.0	65.7	14.0	20.3
1970	119.5	78.5	17.6	23.4	100.0	65.7	14.7	19.6
1975	262.2	161.6	72.7	27.9	100.0	61.6	27.7	10.6
1980	468.4	303.2	122.5	42.6	100.0	64.7	26.2	9.1

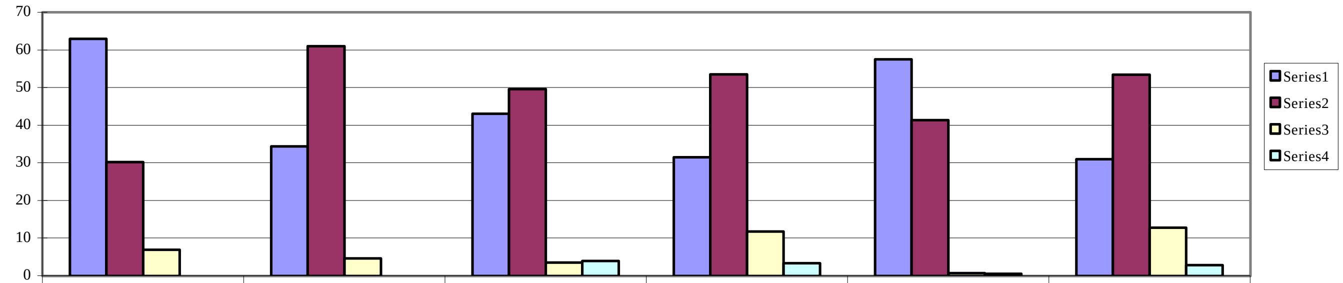
Source: White Papers of Japan (1969-70), and Hirono (1985)

Figure 9: Components of R&D Expenditures (%)



	1960	1961	1962	1963	1964	1965	1966	1967	1968	1970	1975	1980
Companies	67.4	66.8	63.8	64.6	63.9	59.3	59.8	62.5	65.7	65.7	61.6	64.7
Res. Institutes	16.0	16.3	16.9	15.9	15.9	16.1	15.9	14.6	14.0	14.7	27.7	26.2
Universities	16.6	16.9	19.3	19.5	20.2	24.7	24.3	22.9	20.3	19.6	10.6	9.1

Figure 10: Share (%) of R&D Expenditure by Organization in Major Countries



	Japan	USA	United Kingdom	France	West Germany	Canada
Series1	62.9	34.4	43	31.5	57.5	31
Series2	30.2	61	49.6	53.5	41.3	53.4
Series3	6.9	4.6	3.5	11.7	0.7	12.8
Series4			3.9	3.3	0.5	2.8

Source: White Papers of Japan, 1970-71

Series 1 Industry

Series 2 Government

Series 3 Non-Profit Organizations and Universities

Series 4 Overseas

Table 22: Type of Research by Organization (percent distribution of R&D expenditures)

		Fundamental	Applied	Development	Total
	Overall				
1970		23.3	27.6	49.1	100.0
1978		16.5	25.1	58.4	100.0
	Companies				
1970		9.2	27.2	63.6	100.0
1978		4.7	18.2	77.1	100.0
	Research Institutes				
1970		17.8	42.1	40.1	100.0
1978		17.6	38.7	43.7	100.0
	Universities				
1970		80.0	20.0	0.0	100.0
1978		57.3	37.3	5.4	100.0

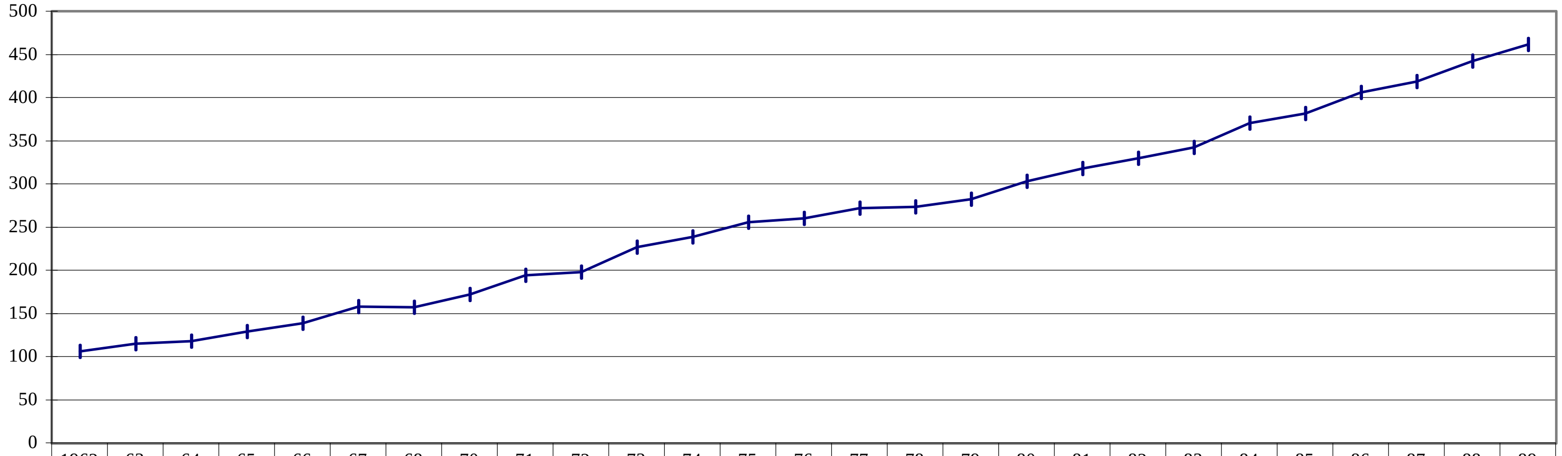
Source: White Papers of Japan (1971-72 and 1979-80)

Table 23: Trends in Objectives of Technology (by private sector)

	Better quality and performance	Convenience and comfort	Mass production	Environ-mental pre-servation	Safety	Labor saving	Resource conservation	Energy conservation	Total
1950	40	14	23	2	5	9	5	2	100
1960	38	15	19	4	6	10	5	3	100
1970	31	14	11	9	8	11	8	8	100
1980	23	11	8	7	7	8	18	18	100

Source: White Papers of Japan (1979-80)

Figure 11: Researchers per 1000 Persons



	1962	63	64	65	66	67	68	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89
Researchers per 1000 Persons	105.8	114.8	117.6	128.9	138.7	157.6	157.1	172	194.3	198.1	226.6	238.2	255.2	260.3	272	273.1	281.9	302.6	317.5	329.7	342.2	370	381.3	405.6	418.3	441.9	461.6

Sources: Various issues of White Papers of Japan, Muta (1993), Ministry of Labor and Science and Technology Agency, various issues

Table 24: Researchers

	Researchers per 1000 persons				Percentage Distribution (%)			
	Total	Companies	Research Institutes	Universities	Total	Companies	Research Institutes	Universities
1960	86.8	43.6	14.9	28.3	100.0	50.2	17.2	32.6
1961	90.9	46.1	16.5	28.3	100.0	50.7	18.2	31.1
1962	105.9	54.1	18.3	33.5	100.0	51.1	17.3	31.6
1963	114.8	60.0	18.4	36.4	100.0	52.3	16.0	31.7
1964	117.6	59.0	19.5	39.1	100.0	50.2	16.6	33.2
1965	128.9	65.4	19.9	43.6	100.0	50.7	15.4	33.8
1966	138.7	69.2	21.0	48.5	100.0	49.9	15.1	35.0
1967	157.7	81.7	21.7	54.3	100.0	51.8	13.8	34.4
1968	157.1	82.5	22.2	52.4	100.0	52.5	14.1	33.4
1970	172.0	91.5			100.0	53.2		
1975	255.2	143.4			100.0	56.2		
1980	302.6	170.3			100.0	56.3		

Source: White Papers of Japan, Various Issues and Hirono (1980)

Table 25: Specialization of Researchers (percentage distribution,%)

	Overall					Research Institutes				
	1965	1966	1967	1968	1969	1965	1966	1967	1968	1969
Grand total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Mathematics, Physics	7.5	6.8	6.9	7.0	7.7	6.5	6.1	6.2	6.1	6.2
Chemistry	23.1	22.1	22.9	22.7	21.3	15.9	15.6	15.6	15.6	14.7
Biology	1.7	1.5	1.5	1.4	2.0	2.8	2.8	2.6	2.4	1.9
Physical Geography	0.7	0.7	0.7	0.7	0.9	1.5	1.4	1.4	1.5	1.7
Civil Engineering, Construction	2.9	2.8	2.9	2.9	3.1	2.9	2.9	2.6	2.4	2.6
Machinery, Ship, Aircraft	13.6	14.3	13.2	13.8	15.1	7.8	8.0	7.9	7.3	7.4
Electricity, Communications	12.0	12.2	12.8	12.8	13.4	5.2	5.2	5.3	5.3	5.7
Mining, metallurgy	3.5	3.4	3.2	3.1	3.1	2.2	2.0	2.2	2.2	2.1
textile	2.4	2.7	2.2	2.6	2.3	4.7	4.2	4.2	4.0	3.8
Agriculture, forestry	7.0	6.5	6.7	6.0	7.4	26.5	27.3	26.6	27.2	30.1
fisheries	1.6	1.5	1.5	1.5	1.4	6.2	6.5	6.4	6.6	6.6
Animal husbandry, vet sci	2.2	2.0	2.0	2.1	2.0	7.6	7.3	7.7	7.6	7.6
medicine, dentistry	13.8	15.1	15.1	15.1	14.2	3.0	2.7	2.7	2.9	2.8
Pharmaceutics	3.4	3.3	3.4	3.1	3.3	2.8	3.0	2.9	2.9	2.9
Others incl. humanities & social sciences	4.7	5.1	5.1	5.2	2.8	4.3	4.9	5.5	5.9	3.9

	Companies					Universities				
	1965	1966	1967	1968	1969	1965	1966	1967	1968	1969
Grand total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Mathematics, Physics	6.3	5.6	5.6	5.9	5.6	9.7	9.0	9.2	8.9	11.3
Chemistry	33.3	32.0	33.6	32.7	30.1	11.3	10.3	10.7	10.5	11.0
Biology	1.0	0.9	0.8	0.9	1.1	2.2	1.9	2.0	1.9	3.3
Physical Geography	0.2	0.2	0.3	0.3	0.2	1.1	1.0	1.1	1.1	1.6
Civil Engineering, Construction	2.1	1.9	2.0	2.1	2.4	4.0	3.9	4.3	4.3	4.2
Machinery, Ship, Aircraft	20.4	21.7	19.4	20.5	22.1	6.3	6.2	6.6	6.4	7.9
Electricity, Communications	18.2	18.4	19.7	19.3	20.4	6.1	6.0	6.0	6.1	6.0
Mining, metallurgy	4.8	4.7	4.3	4.1	4.3	2.3	2.0	2.1	1.9	1.8
textile	2.8	3.6	2.7	3.6	3.1	0.6	0.5	0.5	0.5	0.6
Agriculture, forestry	1.9	1.6	2.4	1.7	2.7	5.0	4.3	4.2	4.1	5.6
fisheries	0.4	0.4	0.5	0.5	0.5	1.0	0.9	0.9	0.9	0.9
Animal husbandry, vet sci	0.8	0.7	0.6	1.0	1.0	1.7	1.6	1.4	1.4	1.3
medicine, dentistry	0.2	0.2	0.2	0.2	0.2	39.6	43.0	41.7	42.4	38.7
Pharmaceutics	4.0	3.9	4.0	3.3	3.6	2.7	2.6	2.6	2.9	3.0
Others incl. humanities & social sciences	3.6	4.1	3.9	3.9	2.5	6.4	6.6	6.7	6.9	2.8

Source: White Papers of Japan. Various Issues

Table 26: Number of schools, teachers and enrollment (May 1, 1991)

	Institutions	Teachers*	Enrollment		Enrollment Rate
Kindergarten	15,041	101,493	1,977,611		64.1 **
Elementary Schools	24,798	444,903	9,157,429		100.0 ***
Lower secondary schools	11,290	286,965	5,188,314		100.0 ***
Upper secondary schools	5,503	286,092	91,534		95.4 ****
Special schools for handicapped	960	47,393	33,623		
Technical colleges (1-3 grade)	63	4,061	33,623		38.2 *****
Technical colleges (4-5 grade)	-	-	20,075	a	55.5 ******
Junior colleges	592	20,933	504,087	b	
Universities	514	126,445	2,205,516	c	
Special training schools (college level)	3,370	33,512	658,150	d	
Special training schools (others)	-	-	176,563		
Miscellaneous schools	3,309	18,745	406,599		

Source: Muta (1993), original source was Minstry of Education, Science and Culture, 1992a

* Full time

** Kindergarten completed / first grade enrollment. Nursery school completed is not taken into consideration

*** Enrollment / school age population

**** Upper secondary school entrants / lower secondary school graduates

***** (a+b+c) / lower secondary gradutes three yeara ago

****** (a+b+c+d) / lower secondary graduate three years ago

Table 27: Public Education Expenditure by Government

	Total, period sum (Ybillion)	Percentage (period averages)	Provided by the National Government (%)				Provided by local government (%)		
			Sub-total	National Educational Activities	Subsidies to Local Government	Part of the Local Allocation Tax Grant	Sub-total	Prefectures	Municipalities
1960-65	5,919	100.0	49.1	13.2	21.5	14.4	50.9	30.5	20.4
1966-70	10,645	100.0	48.8	14.7	20.2	13.9	51.2	30.4	20.8
1971-75	27,711	100.0	46.0	12.2	19.7	14.1	54.0	29.9	24.1
1976-80	57,972	100.0	47.5	13.3	20.5	13.7	52.5	28.6	23.9
1981-85	78,633	100.0	45.0	13.7	18.7	12.5	55.0	29.9	25.2
1986-89	71,189	100.0	42.5	13.9	16.4	12.2	57.5	32.2	25.3

Source: Muta (1993), Original Source was Ministry of Education,Science and Culture

Table 28: Public Expenditure on education by level of education

	Total, period sum (Ybillion)	Percentage (period averages)	School Education (%)								Social Education (%)	Educational Administration (%)
			Kindergarten	Elementary School	Lower Secondary school	Special Education	Upper Secondary school	University and College	Special training college	Miscellaneous school		
1960-65	5,919	100.0	0.6	36.3	24.1	1.0	16.1	12.6	-	0.0	2.7	6.5
1966-70	10,645	100.0	0.8	36.8	20.5	1.4	16.0	14.0	-	0.0	3.7	6.7
1971-75	27,711	100.0	1.3	37.9	19.9	1.8	15.6	11.0	-	0.0	4.9	7.5
1976-80	57,972	100.0	1.3	37.1	19.0	2.3	14.9	10.6	0.0	0.0	5.8	9.0
1981-85	78,633	100.0	1.2	33.5	19.4	2.5	15.2	11.0	0.0	0.0	7.2	9.9
1986-89	71,189	100.0	1.1	31.3	18.9	2.7	15.4	11.7	0.1	0.0	8.3	10.2

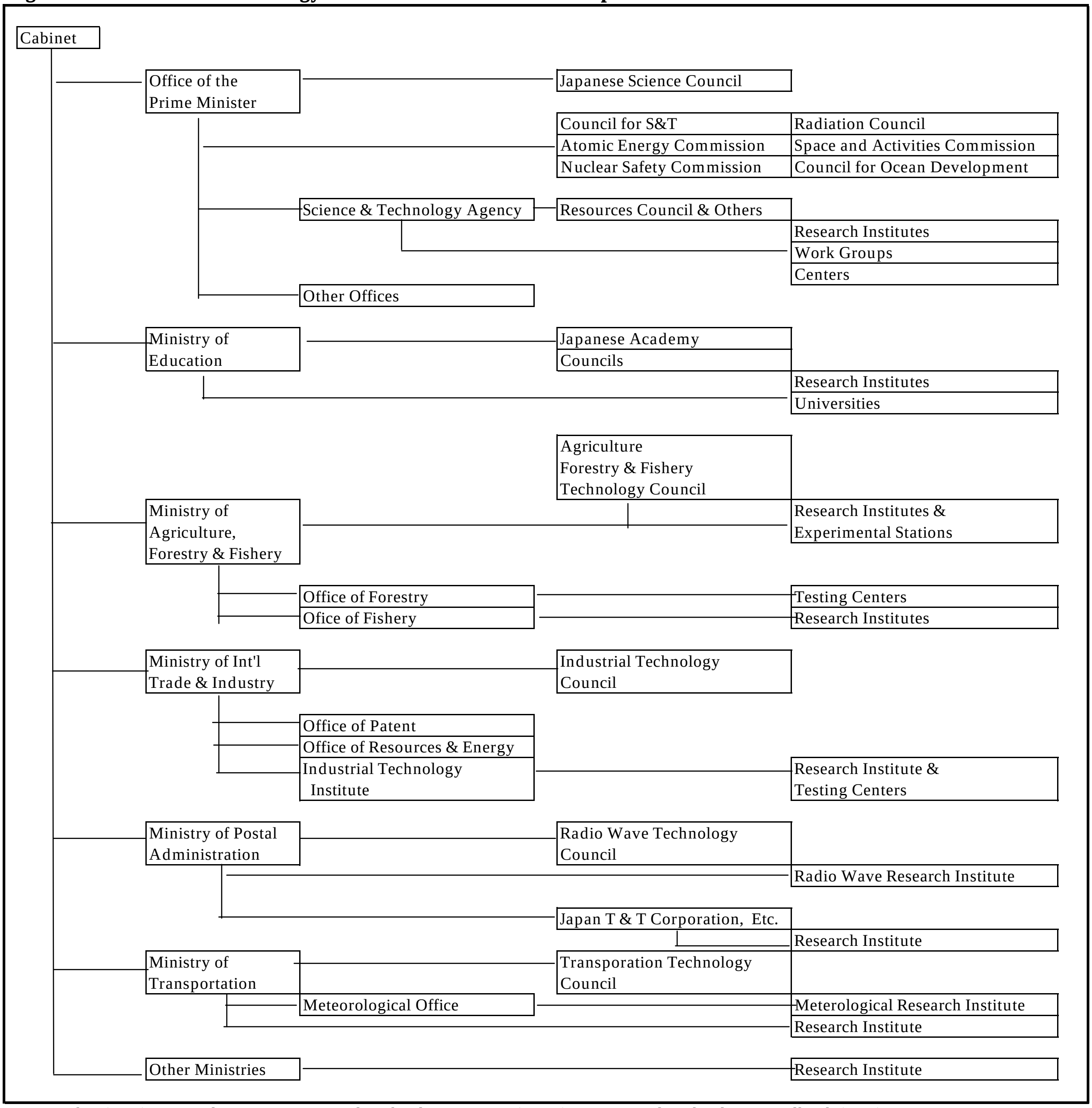
Source: Muta (1993), Original Source was Ministry of Education,Science and Culture

Table 29: Number of Private Schools, Students and Teachers (as of May 1, 1991)

	Number of Schools	Ratio of Private sector (%)	Number of Students	Ratio of Private sector (%)	Number of Teachers	Ratio of Private sector (%)
Four-Year University and College	378	73.5	1,610,135	73	65,310	51.7
Junior College	497	84.0	463,418	91.9	17,590	84.0
College of Technology	4	6.3	3,072	5.7	174	4.3
Upper Secondary School	1,316	23.9	1,575,432	28.9	65,415	22.9
Lower Secondary School	617	5.5	210,921	4.1	9,874	3.4
Elementary School	168	0.7	65,041	0.7	2,934	0.7
School for the Handicapped	17	1.8	891	1	262	0.5
Kindergarten	8,769	58.3	1,560,274	78.9	76,153	75.0
Subtotal	11,766	20.0	5,489,184	22.3	237,712	18.0
Special Training Schools	3,022	89.7	788,661	94.5	30,744	91.7
Miscellaneous Schools	3,221	97.3	399,805	98.3	18,303	97.6

Source: Muta (1993), original source Ministry of Education, Science and Culture, 1992

Figure 12: Science and Technology Administrative Structure of Japan



Source: Choi (1983); Original source: Science and Technology Agency (Japan) "Science and Technology Handbook (1979)

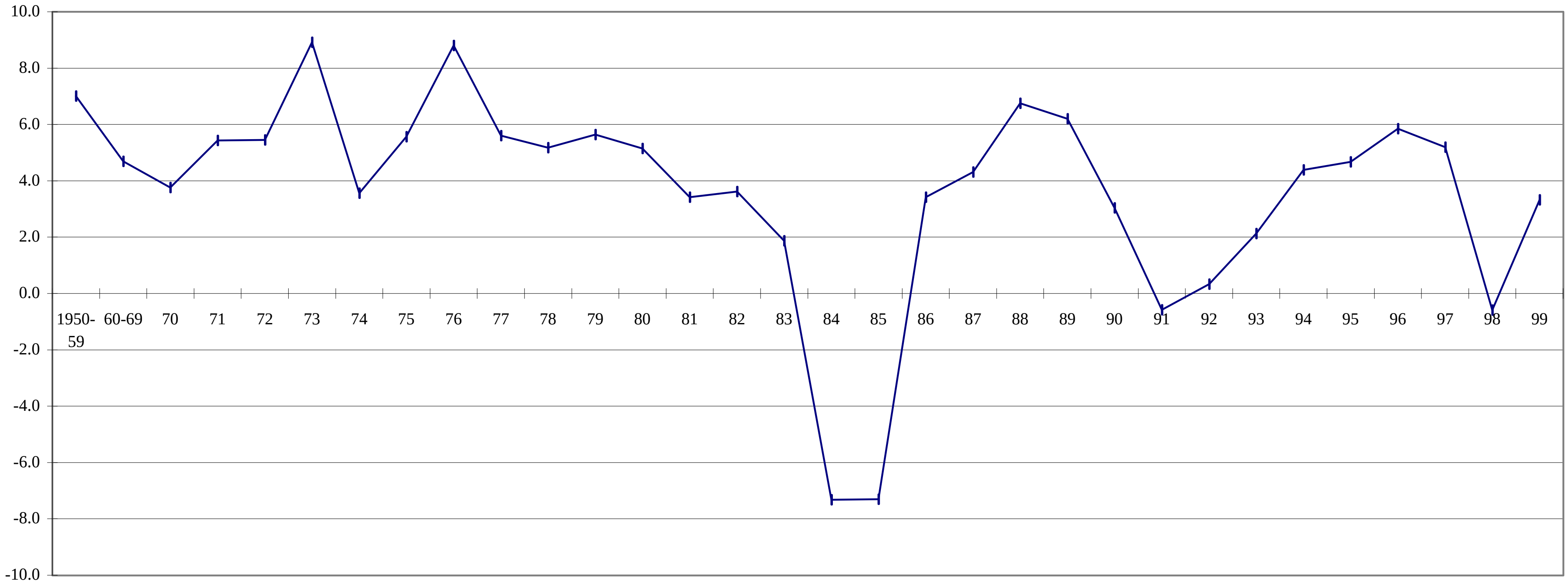
Table 30: Investments in the Philippines

	GFCF / GDP(%) /1/	Net Foreign Direct Investment (m US$)	Net Portfolio Investment (m US$)
1982	27.2	132	(115)
1983	28.9	221	(109)
1984	22.3	122	(105)
1985	16.5	49	(32)
1986	16.1	146	(6)
1987	16.5	362	(36)
1988	18.0	983	3
1989	20.6	559	284
1990	22.9	528	(48)
1991	19.8	529	125
1992	21.0	675	62
1993	22.4	864	(52)
1994	23.0	1,289	269
1995	23.0	1,361	248
1996	24.4	1,338	2,142
1997	25.8	1,113	(1,027)
1998	23.1	1,592	(1,003)
1999	21.9	871	449

Source: Selected Philippine Economic Indicators, various issues

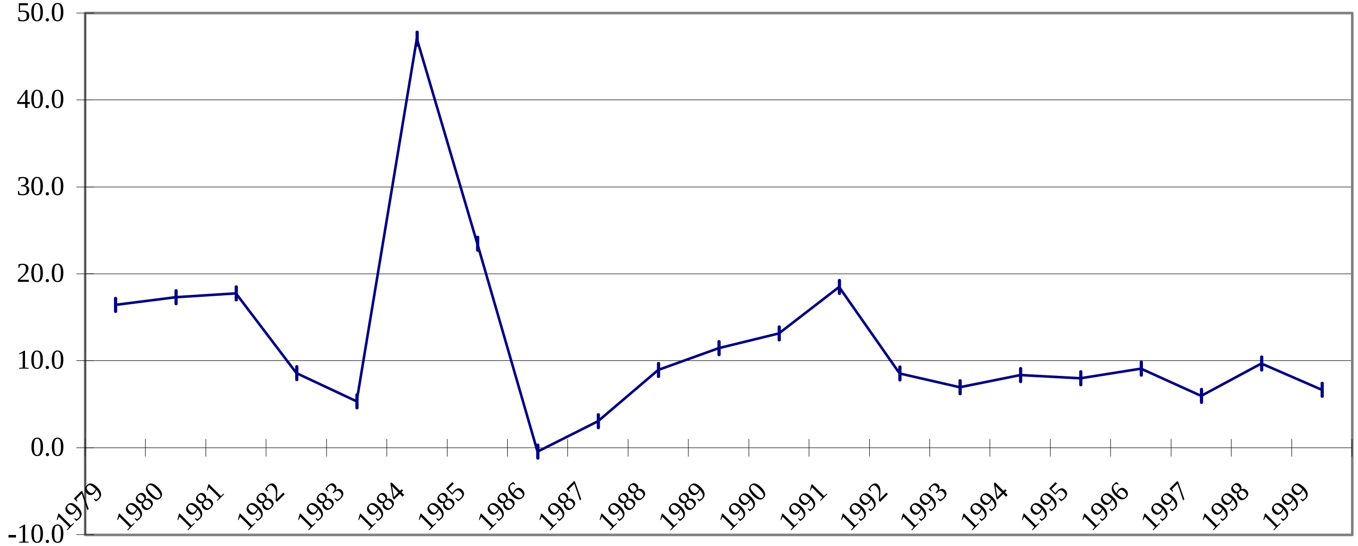
/1/ Gross Fixed Capital Formation / Gross Domestic Product

Figure 13: Real GDP Growth (%), Philippines



Source: Philippine National Income Accounts, various issues

Figure 14: Inflation in the Philippines (%)



Source: Selected Philippine Economic Indicators, vrious issues

Table 31: Philippine Sectoral Gross Domestic Product (Percentage Share, %)

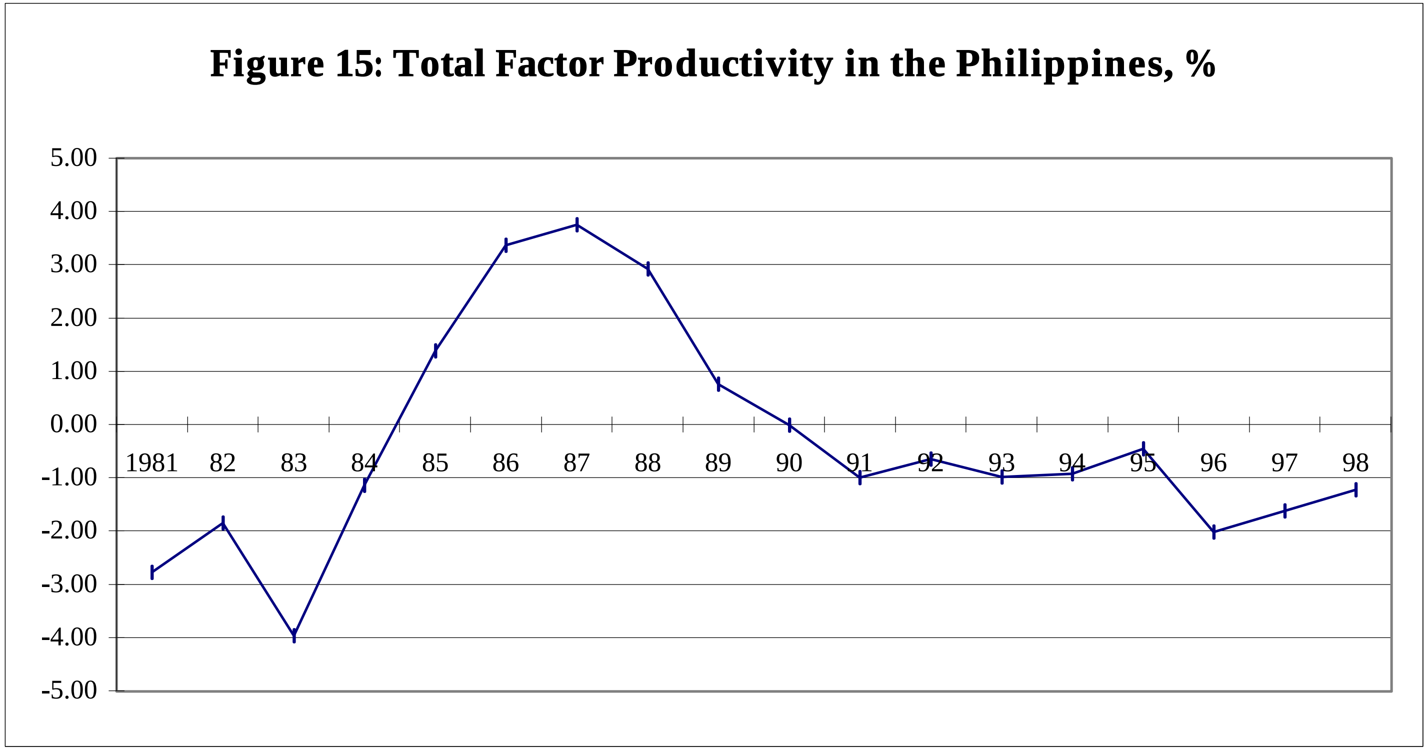
Sectors	1950	1960	1965	1970	1975	1980	1985	1990	1995	1998
Agriculture	34.7	26.5	27.2	29.5	30.3	25.1	24.6	21.9	21.6	17.4
Industry	27.1	31.3	31.1	31.9	35.0	38.8	35.1	34.5	32.1	31.3
Manufacturing	16.1	24.5	23.6	24.9	25.7	25.7	25.2	24.8	23.0	21.8
Services	38.2	42.2	41.7	38.6	34.7	36.1	40.4	43.6	46.3	51.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Economic and Social Statistics Office, National Statistical Coordination Board

Table 32: Philippine Sectoral Employment (Percentage Share, %)

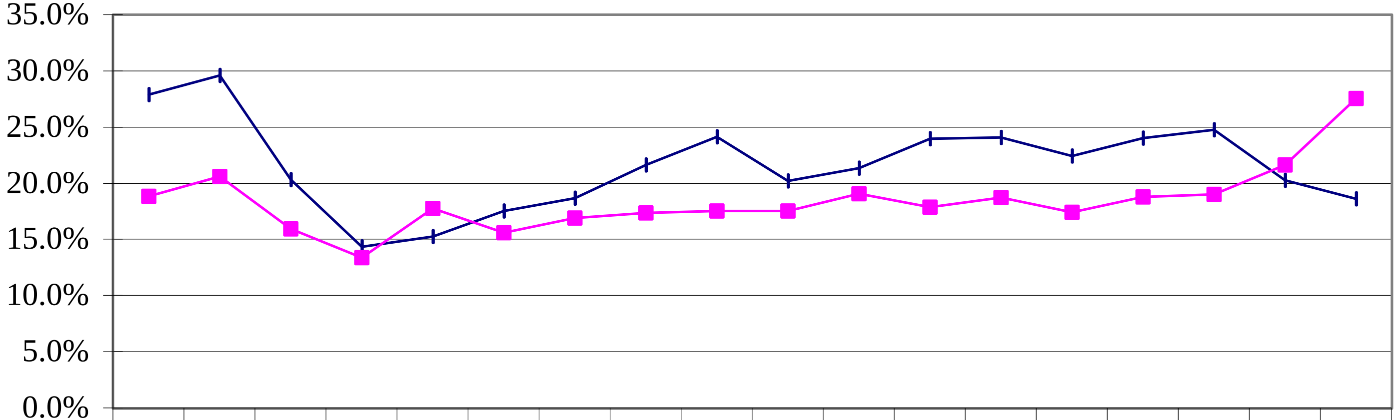
Sectors	1960	1965	1971	1975	1980	1985	1990	1995	1998
Agriculture	61.2	56.7	50.4	53.5	51.6	49.3	44.5	43.4	39.2
Industry	12.6	14.3	15.7	15.2	15.5	14.3	15.9	16.1	16.4
Manufacturing	12.1	10.9	11.5	11.4	10.9	9.7	10.5	10.2	9.7
Services	26.2	29.0	33.9	31.3	32.9	36.4	39.5	40.5	44.4
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Labor Force Survey, Department of Labor and Employment, various issues



Source: Cororaton and Cuenca (2000)

Figure 16: Investment and Savings Rates in the Philippines



	1982	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99
Investment Rate	27.9	29.6	20.3	14.4	15.2	17.5	18.7	21.6	24.2	20.2	21.3	24.0	24.1	22.5	24.0	24.8	20.2	18.6
Savings rate	18.8	20.6	15.9	13.3	17.7	15.6	16.9	17.3	17.6	17.5	19.1	17.9	18.7	17.4	18.8	19.0	21.6	27.5

Source of basic data: Selected Philippine Economic Indicator, various issues

Table 33: Philippine Exports (Percentage Share, %, of Major Items,)

	1970	1975	1982	1990	1999
Semiconductors & electrononic Microcircuits	0.0	2.0	19.0	17.2	48.3
Finished electrical machinery	0.0	0.0	0.0	0.0	7.5
Garments	3.4	3.8	10.9	21.6	6.4
Crude coconut oil	8.8	10.0	7.5	3.8	0.7
Bars, rods of copper	0.0	0.0	0.9	3.5	0.7
Gold from copper ores	0.2	3.4	2.5	1.1	0.6
Banana and plantains	0.4	3.2	0.7	1.8	0.7
Copper concentrates	16.7	9.4	0.0	2.6	0.1
Shrimps and prawns	0.0	0.3	1.4	2.7	0.4
Canned pineapple	2.0	1.5	1.5	1.1	0.2
Iron agglomerates	0.0	0.0	6.3	1.0	0.2
Centrifugal sugar	16.7	25.3	3.4	1.1	0.2
Copra oil, cake & meal	1.3	1.5	2.1	0.6	0.1
Others	50.5	39.6	43.8	41.8	34.0
Total	100.0	100.0	100.0	100.0	100.0

Source: Economic and Social Statistics Office, National Statistical Coordination Board

Figure 17: Growth of Semi-Conductor Exports

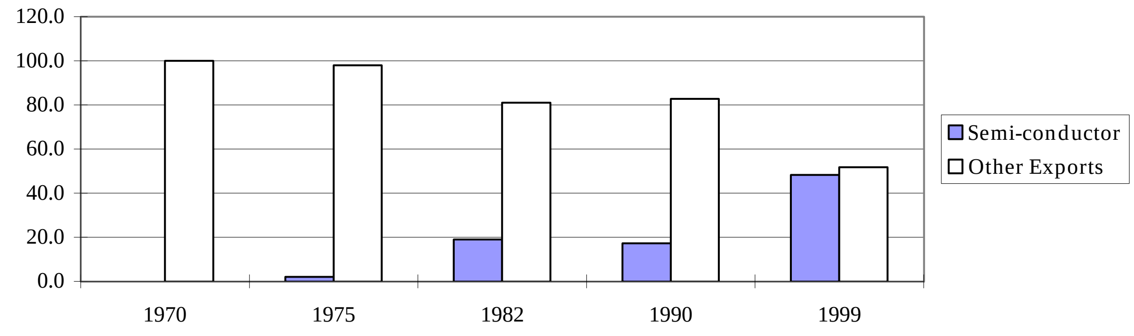


Table 34: Determinants of TFP Growth in Manufacturing

Variables	Coefficients	t-tests
Constant	5.316	-27.267
Exports(-1)	0.148	-8.581
Imports(-1)	-0.519	(-18.522)
D(Tariff)	-1.74	(-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	
DW	0.65	
F-Stat	448.63	

Where:
Exports(-1): real growth of exports, lagged one period
Imports(-1): real growth of imports, lagged one period
D(tariff): period differential of average nominal tariff rates
Wage: growth of research and development expenditure as % of GDP lagged one period
FDI(-2): foreign direct investment
INF: inflation
INF(-1): Inflation, lagged one period

Source: Cororaton and Abdula (1997)

Table 35: Determinants of Total Factor Productivity, 1960-1996

Dependent Variable: TFP Growth of Philippine Economy	Equation (1)	Equation (2)	Equation (3)
Constant	-0.016 (-0.69)	-0.018 (-0.76)	0.034 (0.53)
Share of Exports to GDP	0.005 (3.41)*	0.005 (3.31)*	0.008 (2.41)**
Share of Imports to GDP	-0.003 (-2.27)**	-0.002 (-1.99)***	-0.004 (-3.46)*
Tariff rate	-0.83E-0.4 (-0.07)	-0.015E-03 (-0.13)	-0.002 (-0.99)
Inflation rate	-0.002 (-4.62)*	-0.002 (-4.91)*	-0.002 (-5.46)*
Foreign Direct Investment (FDI)	0.12E-05 (-1.26)		0.33E-05 (2.14)
FDIt-1		0.11E-05 (1.01)	
FDI in Manufacturing			-0.11E-05 (-1.85)**
DW Statistics	1.94	1.89	2.09
Adjusted R2	0.53	0.52	0.67

Note: t-values are in ( ). *, **, and *** indicate significance at 1, 5, 10 percent levels, respectively.

Source: Austria (1997).

Table: 36 Determinants of TFP Growth in Manufacturing

Dependent Variable: TFP Growth of Manufacturing	**Results: Coefficients and Test of Significance**
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 DW = 0.65 F-Stat = 448.63 Where: **Exports(-1)**: real growth of exports, lagged one period **Imports(-1)**: real growth of imports, lagged one period	**D(tariff):** period differential of average nominal tariff rates **Wage:** growth of research and development expenditure as % of GDP, lagged one period **FDI(-2):** foreign direct investment **INF:** inflation **INF(-1):** Inflation, lagged one period

Source: Cororaton and Abdula (1997)

t-values are in ( ).

Table 37: 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

No.	Country	Per Capital GNP (US$)	Scientists/ Engineers per million population	Gross Expenditure on R&D / GNP (%)	Year
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).

Table 38: 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	4.1	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

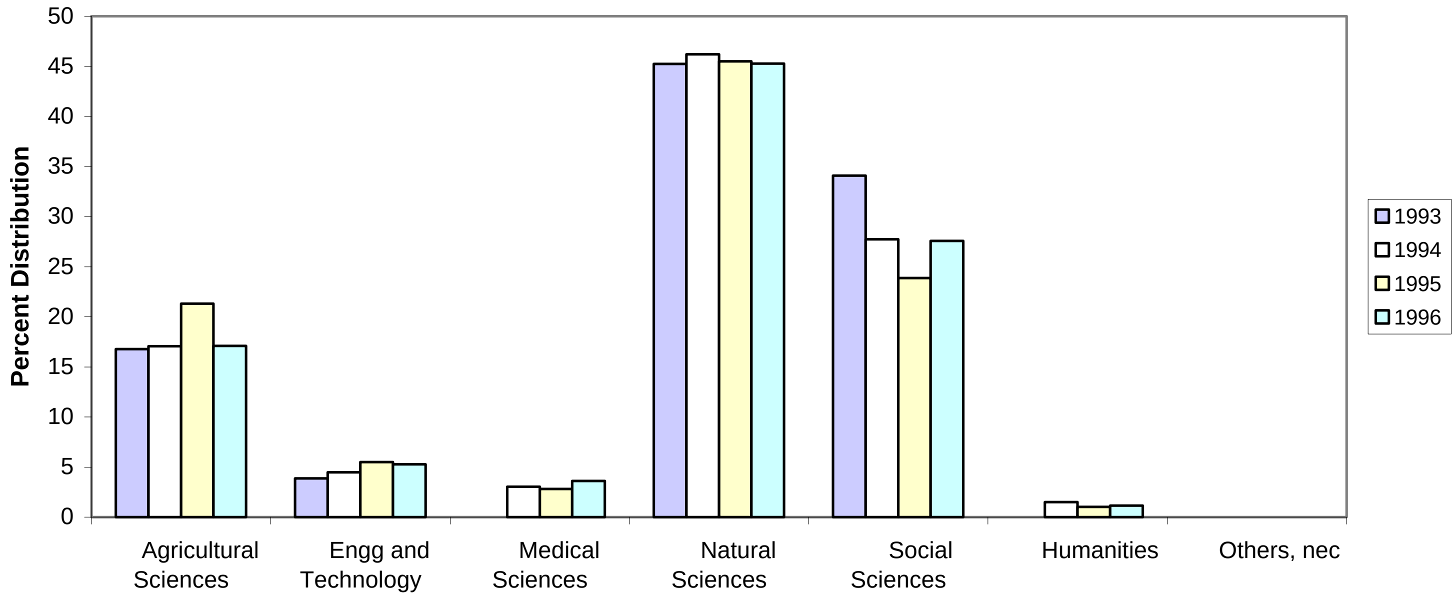
(4) : Post-baccalaureate as % of Tertiary Students

(5) : Number of post-baccalaureate science & engineering students

(6) : Post-baccalaureate science & engineering as percent of post-baccalaureate students

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

Figure 18: Phd Personnel (Full-Time), Field of Activity
(all respondents, percent distribution)



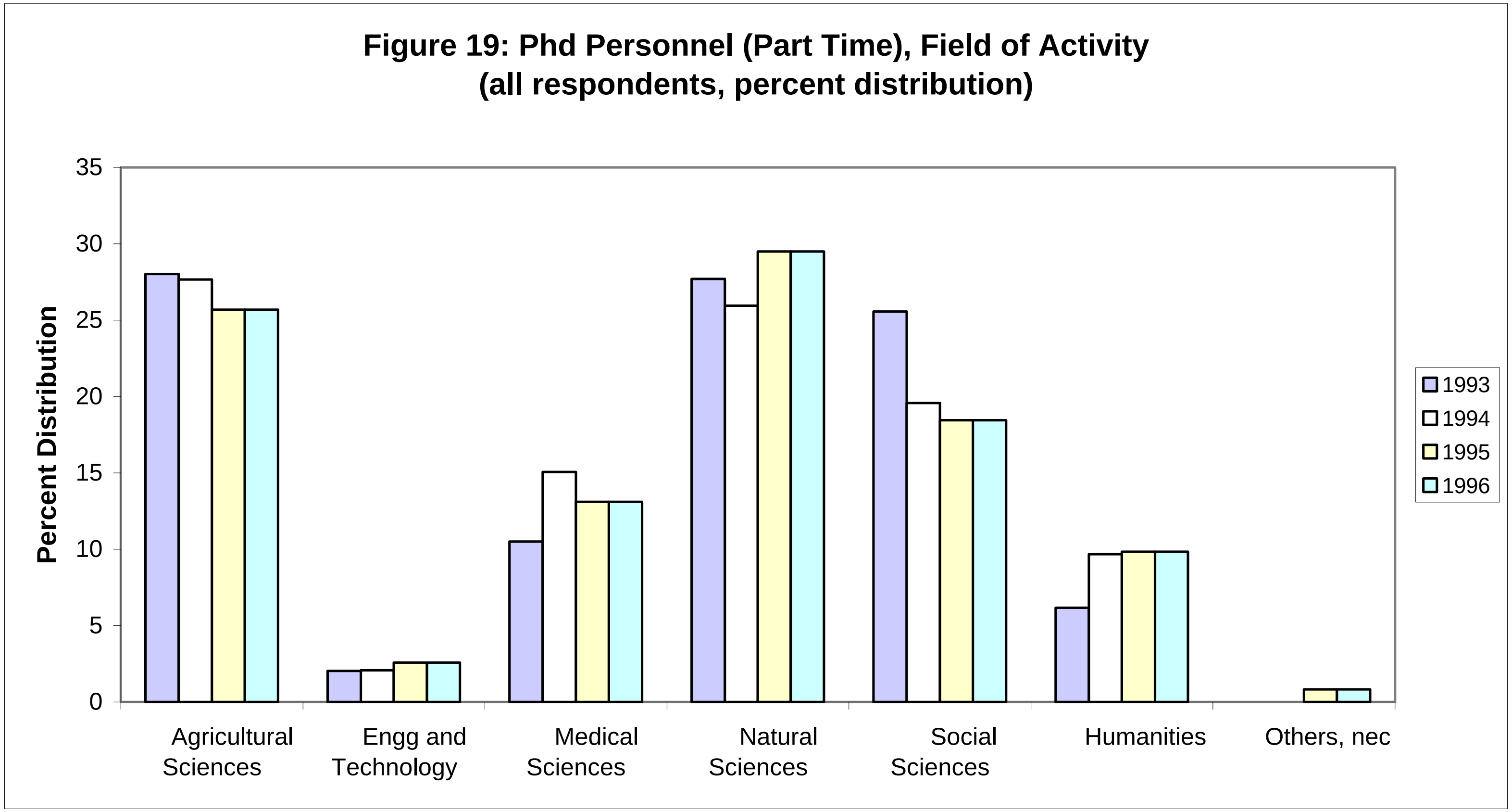


Figure 19: Phd Personnel (Part Time), Field of Activity
(all respondents, percent distribution)
Percent Distribution
35
30
25
20
15
10
5
0
Agricultural Sciences
Engg and Technology
Medical Sciences
Natural Sciences
Social Sciences
Humanities
Others, nec
1993
1994
1995
1996

Table 39: 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 40. 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 41. 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	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 42: 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 43: Distribution of public expenditures for agricultures 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
Other	17	15

Source: David (1998)

Table 44: 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]					
a. w/out 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:

Refers to direct budgetary outlay. Figures in parenthesis refer to total research expenditure, including external grants from local and foreign

Source: Israel (1998)

Table 45: 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	913.9	na
	(501)	(524)	(696)	(842)	(1030)	(na)
DENR	68.98	78.6	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	2.6	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	127.1
	(62)	(84)	(99)	(123)	(168)	(180)
PCAMRD	9.6	11.01	10.96	9.09	18.61	19.4
	(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	3.7	3.7	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	1.9
	(18)	(3)	(17)	(7)	(6)	(7)
Other major univ	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 w/out 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

Table 46: Agency-Funded Fisheries R&D Porjects of NARRDS Institutions

INSTITUTION	No. 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-Region1	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)

Table 47: Agency-Funded Fisheries R&D Projects of NARRDS, 1996

INSTITUTION	No. 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-Region1	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)

Table 48: 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	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 49 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
	Sub-total	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
	Sub-total	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
	Sub-total	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
	Sub-total	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: PIDS survey, 1998.

Table 50: Distribution of Manpower for Fishery R&D

Agency	PhD	MS	BS	ASSOC	Total	%
Zonal Area for Northern Luzon (Region I, II. III. And CAR)	11	57	25	-	93	12.33
Zonal Area for Southern Luzon (Region 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 (Region 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 51: 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 Proirity Areas	14,837,104	1,500,000	16,337,104
Total	60,522,046	4,605,190	65,127,236

Source: Israel (1998)

Table 52: 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: PIDS Survey, 1998.

Table 53. 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	3.5
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	4.5
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.

Sources: Israel (1998)

Table 54: R&D Expenditure for Fisheries

Year	R&D in Fishery (Pm) (1)	GNP (Pm) (2)	GVA Forestry & Fisheries (Pm) (3)	GVA Fisheries (Pm) (4)	(1)/(2)	(1)/(3)	(1)/(4)
1982	14.52	313,544	74,055	14,084	0.005	0.02	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	0.01	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)