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Beyond 2000: An Assessment of the
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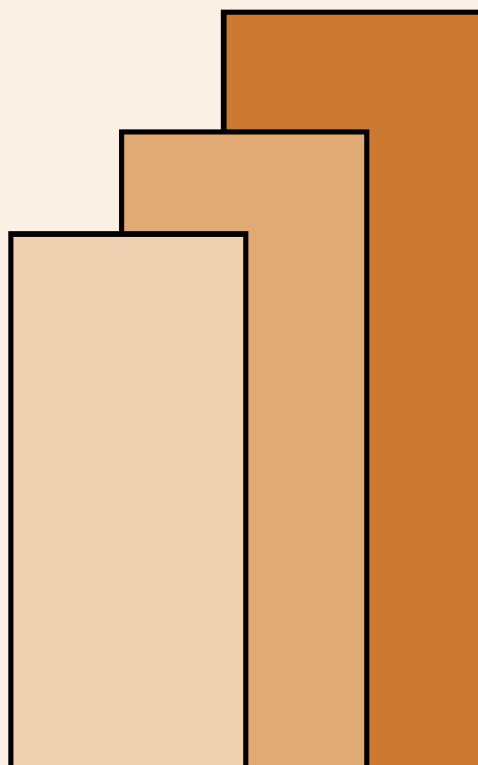
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**Beyond 2000: Assessment of the Economy
And Policy Recommendations - Social Sector
Dealing With Technology Policy**

Jose A. Magpantay

I. Introduction

The events since July 11 of this year put more into focus the raging debate on the sustainability of the country's economic growth. The believers of sustainable growth, and they are mostly in government, argue that since our GDP grew by an average of 4.2% during 1993-96, inflation has been controlled to single digit levels during 1992-97, exports have grown by an average of 15.4% annually during 1992-96 [data taken from the paper of de Dios et al], then the country's economy is now growing sustainably. The non-believers on the other hand point out that although indeed our GDP growth is now respectable because it is higher than the world average, it is not really something to crow about because it is much lower than the growth rates of most Asian economies [ADB data quoted in Hamada's paper]. Furthermore, our non-traditional export performers (semiconductors and electronics) are not really ours while those that we can truly call ours (the so-called export winners such as fruits, fancy jewelry, car parts, etc.) are mostly low value adding. Finally, our trade deficit is widening, our industry is stagnating and our savings rate is the lowest in the region [de Dios et al]. Given these facts, the skeptics are justified in claiming that the country's economic growth is not really based on very sound "fundamentals".

Unfortunately, worrying about the "fundamentals" during a crisis is a useless exercise unless it spurs the country to begin a long term corrective program to make the economy competitive. However, given the prevailing culture in the country, in particular, "ningas cogon", "manana" and "hot pandesal", the prospect of the country consistently implementing serious long-term reforms is quite bleak. But the country does not have a choice, we have to start implementing important reforms, because the 21st century will be an era of fast changes due to globalization and technological developments. Maybe the realization that we have our backs against the wall will make us realize that quick fixes will not do us any good and we have to get our "basics" right.

But what do we mean by "fundamentals" or "basics"? For government officials, especially those in finance and economic planning, the "fundamentals" are inflation, employment, fiscal balance and GDP growth. Thus for finance people and economists, positive trends of these indicators mean sound economic fundamentals.

But do these economic indicators really represent the "fundamentals" of an economy? In physics, fundamental particles refer to the indivisible constituents of matter (of course the fundamentality of a particle is an experimental question) and fundamental principles are not based on other principles or laws. If we translate this concept of fundamentality to economics, the economic indicators mentioned above cannot be considered "fundamental" because of two reasons.

First, positive trends of these indicators do not necessarily reflect

fundamental strength of an economy. GDP growth, especially if the economy started from rock bottom (remember we came from a period of political instability and energy crisis) can be a “bounce” effect and nothing more unless the trend persists for an extended economic period. At this stage it is still too early to say that the growth we are experiencing is not a “bounce” effect.

Fiscal balance may just be due to government selling its crown jewels and not because it is practicing fiscal restraint. And indeed this is true in our case - privatization of some GOCCs brought in revenues and got rid of unnecessary expenditures - but we failed to streamline the bureaucracy. There will come a time when government will have nothing to sell. And when this time comes and government has not learned to restrain its spending and has not passed the important tax reforms, then we will have negative fiscal balance again.

A decrease in unemployment is a welcome development but more important is its underlying reason. If the decrease in unemployment is due to increase in overseas placement of Filipino domestics, laborers and entertainers, then this can hardly be considered a positive development and growth is definitely not sustainable. If the increase is due to increase in employment of skilled workers, engineers and other professionals, then the growth is more likely sustainable. Thus, we have to find out first where the improvement in unemployment figures comes from before we can make any statement about sustainability.

The second reason why the above mentioned economic indicators do not represent economic fundamentals is that they are dependent on prerequisites like macroeconomic stability, desirable investments, improving productivity, high value adding exports and equity (this is the framework used in this study). On the other hand, there are others (see for example Magpantay’s report to NEDA and IDC) who consider the quality of human resources (people after all are the fundamental building blocks of a society), the competitiveness of the national innovation system (which measures the cohesion and symbiotic relationship of the building blocks), the existence of stable political, social and economic institutions (which provide the mechanism for the cohesion and symbiotic relationship), and environmentally-safe and ecologically-sound industrial practices, community programs and individual actions (to guarantee that the building blocks have a place to live in) as the conditions for sustainable growth. In any case, regardless, which of the two frameworks is used, science and technology is an important consideration in the sustainability of growth.

Among the reforms that must be undertaken but often neglected are those that deal with science and technology policies. There are several reasons for this neglect, among them, our failure to appreciate, beyond motherhood statements, the deep role of S&T in sustainable development. Another reason is that S&T requires long-term commitment and investment while our culture puts a premium on the short term.

In the past ten years, development planning slowly changed for the better. The DOST prepared its first ever Science and Technology Master Plan in 1990.

The project on streamlining the bureaucracy in 1993 considered reforms in the S&T sector. And two recent planning exercises, the preparation of the Industry Development Plan by the Industry Development Council and the drafting of the first Long Term Plan of the country by NEDA, emphasized the important role of S&T in achieving sustainable development.

The important concern today is implementation. Brilliant plans are easy to write but the inertia of old practices and established policies will make their implementation difficult. This is where the political will of the top leadership comes in. A determined and consistent (but not dogmatic) implementation of reforms and programs for a number of years is needed before we will see a marked improvement in our “fundamentals”. When that happens, the country can focus on specific responses to speculative attacks on our currency. And then we can effectively use the exchange rate mechanism for improving the competitiveness of our products and services in the world market.

This paper is concerned about technology policies. To put into perspective the technology policies of the country and those of others, we will discuss in Section II the theoretical framework and the general features of technology policies. Section III will summarize the country’s technology policies (and programs) during the past ten years. Section IV will discuss the technology policies employed Korea. Important lessons will also be highlighted in this section. Section V will discuss specific policy recommendations and Section VI will cover the specific programs needed in restructuring Philippine industries and in making the country’s economy competitive in the 21st century.

II. S&T Policy - General Features

Science and technology policy is defined by UNESCO as “the principles and methods, together with the legislative and executive provisions required to stimulate, mobilize and organize the country’s scientific and technological potential”. From this definition, it follows that S&T policies are the general principles and methods that govern the five levels of S&T activities. At the first level are policy making, planning, evaluating, budgeting and financing. At the second level are promotion and coordination. At the third level are R&D execution, education and technology acquisition. The fourth level is comprised of S&T services and technology diffusion. The fifth level is advocacy and is the concern of non-government organizations and professional associations.

The principal role of science and technology policy is to make a country’s national innovation system dynamic and competitive. This means that the principles and methods that apply to the activities at the five levels must be able to stimulate the S&T community (found in both the public and private sectors) to new heights of activity and creativity and to enhance cooperation between government, academe and the private sector so that we can face the competition and challenges of the 21st century.

At the first level, the role of S&T policy is to link the activities of the S&T sector to the country’s overall development agenda and economic program. The

country's science and technology policy should never be disjointed from the policies, plans and programs of the economic sectors (agriculture, industry and manufacturing, and services) because these sectors are important components of the national innovation system. The important policy issue here is the role of supply push and demand pull strategies in developing S&T.

Similarly, when a country reviews its programs, the evaluation of the S&T sector's performance should never be carried out in isolation from the rest of the country's programs and policies.

As for budgeting and finance, the S&T sector's allocation should be viewed as an investment for the future and not an immediate cost to be minimized. Although direct accounting of returns on S&T investment is not easy to do, it does not mean that S&T activities do not produce economic benefits. Economists like Solow (who computed that about 85% of increased output per capita of the US during the first half of the 20th century was due to technological change), and Mansfield (who argued that the "rate of technological change is perhaps the most important single determinant of a nation's rate of economic growth") have shown that indeed S&T expenditures reap economic benefits. Unfortunately, less developed countries (LDCs), which must invest more on S&T, find it difficult to do so and thus are trapped in a vicious circle of low level of S&T and economic underdevelopment. Since there is no way out of this problem but to break the circle by making an initial investment (not just for one year but for many years) on S&T, LDCs must carefully select the areas they will go into and spend the money wisely. Thus the need for a well thought out investment program which must be based on a technology plan.

At the second level of activities, the object of a technology policy is the development of a scientific culture and an engineering tradition. This is particularly important for LDCs that never had a scientific tradition (there are LDCs, India for example, that have a strong science tradition). Since instilling a culture of "doing things right" and a scientific orientation in society involve fundamental changes in outlook, the efforts of media, the schools, non-government organizations and professional associations must be well coordinated. It would be good if science concepts are also discussed in children's comics and cartoons to reinforce the lessons taught in schools. Professional associations would do well to conduct information campaigns to inform the general population of their role in society and to inspire children to enter the science and engineering professions.

However, the promotion of S&T should not only be focused on the general population. It is important to have firms and businesses develop a technology orientation in the management of their operations. Worldwide, the emerging best industrial practice shows the principal role of technology in achieving competitiveness. Firms that can technologically innovate are capable of making simultaneous improvements in quality and production cost. The role of technology policy in this case is to effect a change in the outlook of top management people towards technology and its uses and impact on various aspects of the firms operations.

The third level of S&T activities involves the hard work that measures the productivity of the S&T sector (R&D), guarantees the continuity of the country's S&T activities (education) and makes local industries productive and competitive (technology acquisition). The role of policy-making in this case is to determine the institutions to be set up, the incentive schemes to attract practitioners and motivate them to work hard, and the budget and other support in line with the priority programs. As for education, the goals of policy are (1) to ensure that basic science and math education at the primary and secondary levels are done properly, (2) that science and engineering education at the tertiary level are comparable with the best in the region if not the world, and (3) that graduate education in the sciences, engineering and advanced technologies are competitive in the sense that graduates produce new knowledge (publications in refereed reputable journals).

As for R&D and technology acquisition, the important policy issues are what technology to develop in-house (or in the country), and what technology to acquire and from whom to get it. Technology acquisition involves such issues as the mode of acquiring particular technologies from foreigners (joint ventures, licenses or direct purchases) and how to ensure that foreign (joint venture) partners transfer technology. The point of technology acquisition is to make the technology ours in as little time as possible. This means internalizing the technology which can only be done by using and improving the technology. But in the longer time frame, technology development requires serious R&D, starting from the result of reverse engineering, technology licensing or outright purchase, and even the basic science foundation.

The fourth level, S&T services and technology diffusion, covers activities for improving the country's overall productivity. The activities relate to technology's immediate application, be it for industry (calibration and standards laboratory, consultancy services, adoption of existing technologies, etc.) or for the benefit of the general public (weather monitoring and prediction, earthquake-safe standards for structures). The objective of policy-making in this case is to guarantee that the appropriate services are available to both industry and the general public, and that technologies are widely disseminated to users.

Finally, there is the level of advocacy, which is particularly relevant today because of the growing awareness on sustainable development. Non-government organizations are independent fiscalizers of official programs. For these organizations to be effective, however, they should be knowledgeable about science and technology. They should be able to advance their concerns and proposals based on solid science foundation. The role of S&T policy-making in this case is to open the lines of communication and cooperation between the government, the private sector and NGOs/POs. The adoption of Philippine Agenda 21 (in spite of its shortcomings) is a good example of this cooperation. It may even be worthwhile for the government to undertake training programs that will help educate NGOs/POs on specific science and environment topics.

Finally, it is important to point out that although science and technology policy is generally considered as a single instrument, it actually has two distinct components, science policy and technology policy. The two components differ in

their objectives, main types and scope of activities, accessibility to planning and time frame [Sagasti]. The differences between science policy and technology policy are summarized in the next Table.

III. The Country's Present Technology Policies and Programs

The S&T policies (implicit and explicit) and programs (starting with those defined by Secretary Follosco) of the government during the past ten years will be reviewed in this section.

A. Explicit Policies

The fundamental science and technology policies of the country are laid down by the 1987 Constitution. The relevant provisions are:

• *“The State shall give priority to research and development, invention, innovation, and their utilization; and to science and technology education, training and services. It shall support indigenous, appropriate, and self-reliant scientific and technological capabilities, and their application to the country's productive systems and national life”.*

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

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

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

These provisions reflect a utilitarian view of science typical of a developing economy that never had a scientific culture. Science, for developing economies, is primarily a tool for economic and national development (sustainable development is not yet a byword then) and secondarily an interesting and intellectually challenging human activity. But even within this utilitarian philosophy, one cannot help but think that the provisions are hollow and mere motherhood statements. In the past ten years, the government never gave priority to R&D (priority is debt servicing). If government gave incentives to scientists and gifted people, they were too little (research honoraria that is much less than the minimum wage) and often too late (due to bureaucratic rules). And the state did not really promote the adaptation of foreign technology (the BOT law does not have any provision on technology transfer).

There have been several S&T legislation passed by Congress. In line with the Constitutional Provision, Republic Act 7459, which is also called the "Inventors and Invention Incentives Act of the Philippines", provides exemption from duty or taxes, incentives, rewards, loans and guarantees to inventors to speed up the commercialization of their inventions. Republic Act 7648, also called the 1994 Science and Technology Scholarship Act, specifies that "two deserving students in the undergraduate and graduate levels from each municipality and at least ten from congressional districts without municipalities will be granted scholarships and other incentives to study in any DECS-accredited schools here and abroad". The program was piloted in the 19 poorest of the poor provinces with funding coming from the DOST and PAGCOR. Republic Act 7917, which amended Section 8 of RA 7227 allocated 2% of the proceeds of the sale of the military bases in Metro Manila to finance DOST's scholarship programs.

Earlier this year, Republic Act 8248, which created the Human Resource Development Council, was signed into law by President Ramos. The Council is tasked to formulate the country's science and technology human resource development plan for the mid and long terms. The Council is headed by the Secretary of DOST with cabinet rank members from CHED, DECS, DBM, the director general of TESDA and the President of PASUC.

The Magna Carta for Scientists, Engineers, Researchers and other S&T personnel provides for a system of incentives and special salary scale for S&T personnel. This law is important for it can be used to effect the exemption of research scientists and engineers from the salary standardization law. The only problem now is the money, the law did not allocate any for implementation. If UP, for example, is to implement this program, it has to look for its own resources.

RA 8496, which was passed February 4, 1998, established the Philippine Science High School System. This law will integrate the existing four PSHS in Diliman, Eastern Visayas, Western Visayas and Mindanao in a single system to "ensure uniformity in quality standards and systematize operations". Hopefully, this will not lead to uniformity of mediocrity.

Aside from Constitutional provisions and legislation directly related to S&T, there are other government policies that are important in the development of technology. These are the BOT law, the Investment Priorities Plan of the Board of Investment and the Foreign Investments Act of 1991. The BOT law is important as a negative example. It failed to include a provision on technology transfer, thus impairing our technology acquisition effort.

The Investment Priorities Plan of the BOI lists down industries and businesses government considers crucial to our development, thus, to be given incentives. The list is amended every year and considers R&D and technology development conditions for inclusion in the list. In this regard, the BOI enlists the help of the DOST in determining the eligibility of a firm for grant of incentives.

The Foreign Investments Act of 1991 instructs NEDA to formulate a list of "strategic industries" which by definition satisfy (1) "are crucial to the accelerated

industrialization of the country, (2) require massive capital investment to achieve economies of scale, (3) require specialized or advanced technology, (4) have strong forward and backward linkages with most industries, (5) generate substantial foreign exchange savings through import substitution and collateral foreign exchange earnings through exporting of the output.” Had NEDA taken this task seriously and targeted industries for acquisition, joint venture, or direct foreign investment (with corresponding incentives from BOI), then our industrialization program will be more directed.

B. Implicit Policies

Government practices and policies that strongly affect the S&T sector unintentionally are called the implicit policies.

The most insidious implicit policy is our mendicant approach to development. We make plans and programs without corresponding allocations (as in the Education for All Program and the Science and Technology Education Program of Philippines 2000) hoping that either the public sector or the NGOs/POs will be able to convince foreign governments and funding agencies to provide the financing. This is the reason why there are so many NGOs/POs in the country and most, if not all, of them funded externally. Today, we have taken the mendicant attitude to the hilt because, where as before we at least make the plans and look for external funding to implement them, today, we also wait for external funding to make the plans. NEDA could not even provide the funds for this long term planning exercise and had to wait for funding from CIDA.

If we do not beg for our development programs, we routinely make plans just to satisfy bureaucratic requirements because planners and heads of agencies have become jaded with the process. Why make plans when they will not be implemented at all? And worse, why work very hard to make rational plans, and get paid very little for it, when government hires international consulting firms when there is external funding available for the plans? And foreign consultants, who get paid hefty salaries, only stay for a short period, pick the brains of the locals, and then write the report.

The second implicit policy is the confusing planning and allocating process, where NEDA plans but DBM allocates primarily based on historical budget. This dichotomy between planning and allocating caused serious problems in the early stage of the implementation of ESEP. And it will cause problems every time we implement a new development program, specially if the two agencies do not see eye to eye.

The third implicit policy is the tenure requirement of the Civil Service Commission, which makes it very easy for government employees to become permanent. This policy is the cause of the low educational level of the DOST R&D Institutes. The effect is the Institutes are not capable of carrying out state-of-the-art researches as shown by their very few international publications and patents (local or international).

The fourth implicit policy is the red tape in the bureaucracy which makes

research unnecessarily difficult. These include the approved guidelines for research honoraria (below minimum wage), the COA rules and guidelines on supplies and equipment and the rules and regulations of the Customs Bureau. Getting imported equipment from the Bureau of Customs has always been a nightmare for researchers.

C. Programs

1. Science and Technology Master Plan

Former Secretary Ceferino Folloso is credited for having the first integrated plan for the science and technology sector. This is the Science and Technology Master Plan, which was initially an indicative plan when proposed in 1990 and has been fleshed out since then by the two succeeding Secretaries (Gloria and Padolina). Its major strategies are:

- *“Modernization of the production sectors through massive technology transfer from domestic and foreign sources”,*
- *“Upgrading of research and development capability through intensified activities in high priority sectors”,*
- *“Development of S&T infrastructure including institution building, manpower development and development of an S&T culture”.*

Since 1990, various activities in line with the three general strategies have been undertaken. For example, in 1995, the DOST reported that their Comprehensive Technology Transfer and Commercialization Program, which is the main implementing program of the first strategy, resulted in the commercialization of 7 new technologies and 73 existing ones by 5,852 adaptors throughout the country. Some of the technologies are soya ice cream making, sambong tablets, cassava chips processing and production of hydrogenated oil.

For the second strategy, the DOST focused its R&D support to priority areas classified under STAND (see succeeding paragraphs). These are the projects listed in Section V B.

As for the third strategy, the DOST organized the group called Samahang Agham Para sa Masa at Bayan (SAMBAYANAN), a multi sectoral group that aims to promote and popularize science and technology. The Engineering and Science Education Project (ESEP), the implementation of the S&T Scholarship Act are also examples of activities under the third strategy.

The general strategies laid down by former Secretary Folloso are the correct responses to the problems faced not only by the S&T sector but also by local industry. Note that it combines the two general approaches of S&T policy, the supply push and the demand pull strategies. The first strategy, modernizing production sectors through technology transfer is primarily a demand pull strategy because we start from the present industries and the market requirements and improve the industries' productivity so they can be competitive and respond

better to the changes in the market. The third strategy is more of laying down the foundation for the long term and is not a response to immediate market needs. Thus, it is a supply push strategy because it is hoped that by investing now in the sciences and the advanced technologies, we will be creating a demand for them in the future.

The second strategy can either be demand pull or supply push, depending on how it is implemented and what we consider as high priority sector. DOST is implementing the second strategy by concentrating on the export winners of the STAND Program, thus, in line with the demand pull strategy. This is unfortunate because the export winners (marine products, fresh and dried fruits, fashion accessories, gifts, toys and housewares), even if their production and exports are tremendously increased, will not make us technologically capable in the long term. The export winners' technological requirements are not advanced and will not lead to important processes that will be of much use in the long term. The DOST should have let the private sector, in particular, the exporters, to solve their technological requirements by themselves. After all, the exporters should know better their technological problems and they will be forced by the market to solve them.

Instead, the DOST should use the second strategy to push for the advanced technology areas, thus more in the direction of supply push because there are not too many businesses in these areas. Partly, they are doing this by supporting some projects in information technology (computer-based instrumentation and advanced software). But there are other advanced technology areas that have commercial and industrial applications even in the short term. Biotechnology is one, sensor technology is another. Besides, researches in these areas not only lead to new products, but also produce new processes that have better chances of being important in the long term.

2. STAND Philippines 2000

The science and technology component of Philippines 2000 is the STAND Program. STAND is a "market-oriented, private sector-led and short to mid term program". The identified areas of intervention are (1) export winners, (2) basic needs, (3) support industries, (4) coconut industry. Most of DOST funded projects are in line with the STAND Program.

The first thing wrong with STAND is that it supported a program, Philippines 2000, that is based on a wrong premise and understanding of NIChood. The government led the people to believe that NIChood is attained if our per capita income reaches \$1000. This is clearly a case of misrepresentation and lowering of standards so that the goal can be met (and was easily met because our per capita income when Philippines 2000 started was about \$800) because the internationally accepted per capita income of a NIC is \$2000.

NIChood also requires that manufacturing should have a bigger share of the economy. In our case, agriculture, real state and the property sector, and overseas contract work are the biggest contributors to our economic growth. As a matter of fact, manufacturing is having problems in spite of the much touted influx

of foreign money. And according to the Asian Development Bank, the country had the slowest and lowest GDP growth during 1990-1995 in Asia (see reference 1).

More importantly, the key word in NIC is “industrializing” and that means developing and learning technological capabilities. From the survey made by the Federation of Philippine Industries in late 1996 where they cited the low level of technology and the absence of R&D as major contributory factors to the country’s uncompetitiveness, and the fact that these problems have been around since the 1950s, it is obvious that we are not acquiring, learning and developing technological capability. How then can we conclude that we are industrializing?

The second thing wrong with STAND is that it was too conservative with the programs identified for support. DOST, as argued already, should have left the exporters of fruits, fashion accessories, gifts, toys and housewares to solve their technological problems by themselves. At most, DOST’s help should be in terms of setting up a calibration and standards facility and providing access to technology data bases, technology support services that can also be used by other industries.

Third, and this is not DOST’s shortcoming, STAND Programs will not really make a difference without other (and more crucial) government programs. For example, DOST may provide all the money for coconut research but until CARP settles what to do with coconut plantations, our coconut based industries, like the oleochemicals, will be in limbo not knowing whether they will still have their coconut inputs in the future. The other STAND areas also suffer from similar problems. The export winners’ competitiveness, as voiced out by the Federation of Philippine Industries, depends on the removal of red tape in key agencies like the Bureau of Customs, Department of Trade and Industry, etc., among other factors. As for the basic domestic needs like steel and other metals, and support industries like plastics, they will not survive without tariff protection. These programs are beyond the control of the DOST.

Had the DOST concentrated primarily on the advanced technologies, areas that depend more on know-how than capital and efficient bureaucracy, the success of their programs will not rely too much on the external factors. Maybe it is not yet too late to redirect STAND because DOST intends to invest in emerging sunrise technologies such as biodegradable plastics, engineering ceramics and natural and synthetic polymers. And we should have more of these industries as soon as possible.

The points raised above take us to the major shortcoming of a “market-oriented and private sector-led” science and technology program of a developing economy. Our colonial and neocolonial history left us in a vicious circle of underdevelopment and low level of science and technology. The key people in the economic sectors, the big landowners, the owners and CEOs of industries and manufacturing sectors and the owners of commercial centers, generally have a conservative outlook on technology and more so on the sciences. They look at technology as a cost to be minimized and not as a resource and investment to be managed. Thus, they will not invest on S&T, will not carry out R&D, and they

want others to spend for their technological requirement which are not very sophisticated and not important in the long term. If we allow the private sector to determine primarily our science and technology program, it will not be a forward-looking program. Also, such a program will make the private sector more dependent and uncompetitive.

The other extreme, a purely supply push program, is also not desirable because of the backward state of our industry. The science and technology sector is also found in the industrial and manufacturing sectors and their problems must also be addressed. DOST's strategy of modernizing the production sectors is the best approach to this problem. The implementation of this program, however, must involve the **private sector in the primary role**, specially, when it comes to **funding their modernization and R&D activities**.

To summarize, a combination of demand pull and supply push strategies is the correct approach in making a science and technology program. However, DOST's meager resources should be spent primarily on the supply push side - on laying down the foundation for the basic sciences and advanced technologies, investment on business opportunities in the advanced technology areas. DOST's support to STAND identified areas should only be limited to technology support services and not direct funding of the private sector's technological needs and R&D activities.

3. ESEP

ESEP is part of DOST's supply push strategy. It aims to lay down the foundation of a competitive economy through human resources development and institution building. It deserves support and must be continued after 1997-98 inspite of implementation problems.

The main criticism against ESEP is that it forgot to include reforms on the compensation package of the scientists. If this is not remedied soon, we will have well equipped National Centers of Excellence but severely undermanned at the PhD level. The project will go to waste.

It must be made clear that the compensation package for researchers is not DOST's principal responsibility, it belongs to the mother units of the centers of excellence, in this case, the University of the Philippines System. But DOST should have insisted for a much higher research honorarium rates than the present measly P3,000 per month, not even minimum wage. If DBM and COA do not agree, then DOST should take the issue to Congress or the President.

ESEP should be evaluated soon so that all aspects of its operation can be improved before the next phase is implemented. Its impact on secondary science and math education, a very important component, should be studied before a wider and bigger program is drafted.

4. Recent Proposed Programs

There are some innovative programs being undertaken by the S&T sector and there are few more being proposed. Let us begin with DOST's programs.

PCASTRD and the Information Technology Foundation's National Search for Product Excellence in Information Technology will encourage the country's IT businesses to move away from the labor-intensive to the more knowledge-intensive aspect of the business. This program should be continued even if there are questions regarding some winners in the first search. Eventually, we will see really excellent product champions that will not only do the country proud but will also bring economic benefits.

The Manufacturing Productivity Extension (MPEX) program, which assists SMEs improve their productivity through the establishment of technology support facilities, is another excellent program. It is in line with helping SMEs help themselves and making them more responsible for their own technological requirements.

In the agricultural sector, the counterpart of MPEX is the Consultancy in Agriculture for Productivity Enhancement (CAPE) Program. This program will facilitate the transfer of technologies to the farmers. Improved agricultural productivity, specially in the era of global free trade, is the main objective of this program. This program should be continued, hopefully reaching the stage where the farmers should be able to shoulder the cost of the consultancies and the transferred technologies.

The Philippine Engineering Village sponsored by UNESCO and Philippine Network Foundation, Inc., aims to establish a national engineering information resource system. Now that access to the Internet is very common and not very expensive, this project will help local industries and SMEs in searching for engineering research and data resources, state of the art products and technologies, patents, business opportunities and government laws and policies.

The UNDP supported GAINEX Program aims to provide technological support to three export industries (metal fabrication, marine and fruit industries). Apparently, this is an experiment to "demonstrate the feasibility of demand-driven technological interventions". Considering that the project cost is \$6.5 M, this is an expensive experiment with the wrong subjects. If these three industries, with exports running in hundreds of millions of dollars (metals at \$586.7M in 1995, fruits at \$270M in 1996), are not willing to spend for their own technological requirement, then we should just allow them to sink or swim in the global market. The money is better used as venture finance seed money for SMEs in the advanced technology areas.

In the area of environment, the country recently finalized its commitment to a sustainable development program through the document Philippine Agenda 21. The science and technology component of this document says that the country will promote the use of renewable energies, lower green house gas emissions, adopt the use of environment-friendly and clean technologies.

In line with science and math education at the primary and secondary level, the Institute for Science and Mathematics Education Development (ISMED)

of the University of the Philippines is proposing its reorganization into a national center of excellence to be called the NISMED. NISMED's goal is to improve the quality of basic science and math education in the country. NISMED's performance can easily be gauged by looking at the performance of our schoolchildren in the International Mathematics and Science Study.

The College of Engineering of UP Diliman wants to put up the National Graduate School of Engineering. This proposal will address the problems of (1) lack of research engineers in the country, (2) very few engineers enrolling in graduate school, (3) dilapidated and outdated equipment of the College, and (4) almost non-existent research output of the country in engineering fields.

The last two programs are part of the pole vaulting strategy discussed in the recently held National Development Summit. In particular, they belong in the "must do program" for the country to become the "knowledge center in the Asia Pacific". They are discussed separately from the National Development Summit (which is discussed in the next subsection) because these two programs are the correct responses to particular problems and realistic.

5. National Development Summit

After calling Philippines 2000 a success (which is to say the least debatable), the government raised its sights to give advanced countries, like the US and Britain, a run for their money by aiming to be competitive in the high value added services. The government now thinks that industrialization is no longer sufficient. We must pole vault to the 21st century by becoming the knowledge center, energy exporter, finance center, shopping center, medical center, Tourism, Telecommunications and Transportation (T3) hub, etc., in the Asia-Pacific region.

By what great leap of faith did the government arrive at this goal? The existence of some capabilities in information technology, medicine and agriculture, the country's geographical location, the presence of beautiful sites and the erroneous analysis that we are now in the service economy led some planners to think that we can pole vault into the high value added services, if we carry out some crucial reforms. Let us discuss each of the points.

Serafin Talisayon is the guru of the leapfrogging (current jargon is pole vaulting) to the service economy strategy. He argued that since the service sector has been the biggest employer and contributor to our GDP during the last ten years and that our export is now shifting towards services, then we are now, defacto, a service led economy, just like some advanced countries like the USA and England. Since our economy is now service-led, why draft a development program that will emphasize industry and manufacturing. Cute, but wrong!

First, let us look at the kind of services we offer the global community. We are primarily the domestic helpers, the construction workers and the entertainers (singers, dancers, strippers, guest relation officers in nightclubs) of the world. Are

these high value added services? Are these Third Wave Services? Definitely not. If our domestic economy is dominated by the service sector (which includes the bloated public sector), it is only because our agriculture and manufacturing are in such a sorry state and not because we are now in the high valued added services. Our per capita income of \$1000 per annum reflects the kind of service economy we have.

What Talisayon misses is that all sectors of the economy, whether agriculture, manufacturing and services can either be a First Wave, Second Wave or Third Wave (Toeffler's classification). The competitiveness of the economy is not whether it is agriculture led, manufacturing led or service led. Competitiveness is determined primarily if the economy is First Wave, Second Wave or Third Wave! The service economies of the US and England are dominant in the world because they are Third Wave services. Japan's manufacturing is dominant in the world because it is Third Wave manufacturing. And Israel's agriculture is able to feed its people in spite of the harsh desert conditions because it is Third Wave agriculture.

If we accept this framework, the next question is "Can we pole vault to high value added services in ten years or less (the time frame of NDS)"? The manpower requirement of these areas will tell us that this is simply not possible (see discussions on human resources). As for the selected service fields identified by Talisayon in his leapfrogging strategy, we can develop niches in some areas in the mid-term but to become the leader in the Asia-Pacific region is simply not realistic. Others, who have much better programs and have better initial conditions than us, are not even making such grand claims.

In the field of medicine, the plain fact is (as we will show in the next section using indicators), we are not the leader. Our doctors are not competitive in producing new knowledge. We may have some specialists with good reputation, but so do other countries. But when it comes to publishing in reputable, refereed, international journals, our doctors still have a long way to go. If the best in the country are not producers of knowledge, we cannot become the medical center of the Asia-Pacific region. Add to this the fact that we do not also produce the medical instruments and other specialized equipment, then the more we conclude that the dream of becoming the medical center of the Asia-Pacific region is not realistic.

More importantly, why aim to become the medical center of the region when the country's requirement is more basic - public health. Because of poverty, many of our people are malnourished and we have recurring epidemics of cholera, typhoid, dysentery and H-fever. And we want to cure the cancer, heart problems, kidney and other rare illnesses of affluent foreigners? There must be something wrong with our priorities. However, to the credit of the doctors who attended the NDS, when it came to prioritizing programs, they put public health at the top of the list.

The dream of becoming the telecommunication hub in the Asia-Pacific region is based on the wrong premise that it is dependent on geographical location. It is not, it depends on who owns and controls technologies such as

satellites (geosynchronous and the new Iridium project), geographic positioning systems, microwaves, computers, fiber optics, internet, etc. We do not own these technologies, we are only users of them. Thus, the telecommunication dream will not be a pleasant experience, it will be a nightmare.

As for the dream of becoming the tourist center, we will only say that our environmental and waste management practices are the biggest stumbling blocks.

The goal of becoming an energy exporter does not have a basis. Our fossil fuel reserve is clearly insufficient, our exploitable geothermal is only rated at most to six or seven thousand (?) Mwe. The riptide computation is unrealistic because it does not differentiate between **energy and harnessable energy**. When we harness energy, many factors such as engineering design, environment, economics have to be considered. Presently, all these factors point to the conclusion that riptide energy is not competitive to fossil fuel and geothermal-generated electricity (cost of factor of three). Setting up a 1 Mwe riptide power plant, one of the energy projects identified, is a good experiment. Let the riptide proponents prove their claim first before we embark on a big project like the proposed 540 Mwe plant.

As for the dream of becoming the financial center, Tokyo could not even displace New York, our currency is too vulnerable to speculation, the country's number one bank is only rated three hundredth in the world, our stock market is too miniscule, and we dream of becoming the financial center? Even with a liberalized banking sector, none of the big banks have put up their central office here but only small branches. So how can we become the financial center of Asia?

But what takes the cake is the dream to become the knowledge center in the Asia-Pacific region in less than ten years. We cannot even properly teach math and science to our primary and secondary students and we dream of educating the Asia Pacific region? We need not say more here, the discussions in the next sections will show that this goal is, to use Posadas' description, a hallucination.

IV. Lessons From Korea

Considering that Korea successfully industrialized and is now competitive in the world in certain areas, its government must have implemented some policies and programs right. This section is devoted to the technology policies of Korea.

The Korean government played a direct role in the development of their industry and economy. The government not only invested heavily in education at all levels (the share of education budget to the total budget grew from 2.5% in 1951 to 22% in the 1980s) and employed fiscal and monetary policies to promote savings (relatively low taxes, manageable inflation and balanced budget) but also picked winners, penalized poor performers and rewarded good performers (steel

and shipping industries were targeted, successful exporters were provided interest rate subsidies while non-performers had their favored status revoked). In other words, the government also employed industrial policy to the hilt.

Korea's technology policy supported its industrialization program. The focus is on technology acquisition and sustained technology development. The strategies for technology acquisition are not based on hard and fast rules but practical and appropriate to the industry goals. But the strategy for sustained technology development is firmly rooted in getting the basics right - strengthening basic science and mathematics education, fast growth in the number of research scientists and engineers, establishing and fully supporting specialized centers in all fields of science and technology, and promoting research and development not only in the public sector but more importantly in industry. Thus, regardless of how a technology was initially acquired (reverse-engineered, licensed, or purchased), Korea can make any technology its own because they have institutions and human resources that can develop the technology.

As stated already, Korea employed various strategies in acquiring technology. For industries that are capital intensive, need specialized design capability and produce highly differentiated products (example, shipbuilding and application specific machineries), the Koreans relied on formal technology transfer mechanisms like licensing and consultancy services. For capital intensive industries that produce less differentiated products in large production volume (electronics and cars), the strategy is primarily importing "packaged" technologies (assembly operation, production know-how, product specifications, personnel training, etc.).

For capital intensive industries that use continuous processes that are well known but proprietary (steel, chemical, etc.), the strategy is primarily turn-key purchase. But regardless of the initial arrangement for technology transfer, the Koreans institute incremental changes like replacing foreign personnel by a local, substituting local engineering for foreign engineering, doing forward and backward integration of the industry, etc. This desire and persistence to understand, internalize and improve technology differentiates Korea from most East Asian economies.

Science and technology planning in Korea is led by the President, a practice that was started by Park Chung Hee. The President regularly meets with industry leaders and technical people to determine the industries and technologies the country will develop. Because the top leadership is actively engaged in planning, decisions on programs and funding are easily made and implemented. Also since the leaders are technology literate and have a good understanding of the role of technology in development, Korea was able to move from resource-based industries to knowledge-based industries in less than three decades. Today, Korea has a well-funded and active research programs in the advanced technology areas [Abrenica].

The coordination of science and technology activities in Korea is a responsibility of the Ministry of Science and Technology (MOST) which is the first ever ministry level S&T body in all developing countries [Kim]. MOST has to make sure that the S&T activities of the various ministries are consistent with the

overall economic plan of the country, which is prepared by the Economic Planning Board (EPB). But even the EPB has a section in charge of technology and this is the Division of Technology Management. Thus, even the main economic planning agency (the counterpart of our NEDA) in Korea is cognizant of the role of technology in development planning. As a matter of fact, it was this division that prepared Korea's first Human Resource Development Plan.

To promote cooperation between the various public R&D centers, MOST put them together in the Daeduk Science Town [Kim]. Aside from KIST, the other institutes relocated at Daeduk are the Korea Advanced Institute of Science and Technology (KAIST), Korea Institute of Defense Analyses (KIDA), Korea Science and Technology Information Center and the Atomic Energy Research Institute. It is expected that as many as 50 institutes for research and education will be located at Daeduk by the year 2000.

The most important promotion of science and technology made by the Korean government was providing high salaries to scientists and engineers employed by KIST during the 1960s. The traditional value system in Korea then looked down at engineers and technicians [Nam]. Through this simple act, Korea was not only able to attract expatriate scientists and engineers but also changed the country's culture and perception of scientists and engineers.

Education is a central focus of Korea's development strategy. Basic science and mathematics education was given emphasis and it resulted in Korean children consistently performing well in international tests. Korea paid special attention to tertiary and graduate level education. This is important because the generation of knowledge, crucial in sustained technology development, begin at the graduate level. Korea put up specialized institutes such as KAIST which is a research-oriented graduate school, aside from strengthening the sciences, mathematics and engineering departments of the Universities. The Korean government makes it a point to send their local PhD graduates abroad for post-doctoral training to make sure their research capabilities are strengthened. Thus, it is not surprising that Korea's publications in international journals increased from 1,047 in 1981-82 to 4,255 in 1994-95 [Lacanilao].

The government used several policy mechanisms to improve the practice of R&D. The first fiscal incentive used by the government to make the private sector do R&D is the "Technology Development Allowance System". This system "required firms to reserve some amount of funds for technology development" [Kim]. The government also provided tax incentives and preferential financing to firms that will set up laboratories. R&D personnel are also exempted from the compulsory military service [Kim]. Another innovative program carried out by Korea was to provide direct subsidy to R&D programs in high-risk advanced technology areas that the government wants developed. These areas are covered by programs such as the "National R&D Project" and the "Industrial Base Technology Development Project". The subsidy actually served as catalyst for private sector participation.

The Korean government also made use of the procurement policy to

induce the private sector to do R&D. There are two kinds of procurement systems implemented - the "Procurement with Prior Notice System" and the "General Tendering System". In the first, government agencies announce the items they will need in the coming number of years and firms have to show their technology development plans to meet the requirement and standards. For the second, the firms will have to compete in price and quality and prove as well their technological competence to meet the government requirement. Apparently, these systems work (it is easy to think of ways of prostituting these systems) in Korea and contribute to the practice of R&D.

Given these policy mechanisms, it is not surprising that Korea's R&D expenditure improved from a measly .32% of GNP in 1971 to 1.93% in 1987. Also, the ratio of public to private sector participation in R&D improved from 68:32 in 1971 to 20:80 in 1987. And the number of corporate R&D centers increased exponentially, from 1 in 1970 to 122 in 1983 to 604 in 1987 [Kim].

What lessons can we learn from Korea's experience? There are many but the most important is the need for the top leadership in both the public and private sectors to understand fully the role of science and technology in development and for them to develop a technology orientation (note, not technology fix). If this is satisfied, then correct programs will be drafted, implementation will be consistent and creative, problems will be solved as they arise and the country will eventually develop a scientific culture and an engineering tradition.

The second lesson is the importance of getting the basics right in sustained technology development. If our students do not have strong basic science and mathematics foundation and our tertiary and graduate schools do not produce new knowledge, then our technology development cannot be sustained.

Third, culture can be changed. This is important because it is a major stumbling block in the country's S&T efforts. The high regard Korea have for engineers and technicians is relatively a recent culture. It began only when the Korean government gave scientists and engineers high salaries. This induced the expatriates to come home and inspired these people to practice their profession instead of going to sales and management. This also started a scientific culture and an engineering tradition.

Fourth, technology acquisition strategies have to be flexible. We can beg, steal, borrow or buy technologies (foreign grants for training and equipment, reverse-engineer, technology license or outright technology purchase) but these activities should only be the start of our technology development efforts. We should have a clear and definite program to move up the ladder of technological capability, from the lowly operative stage to the highly desired creative stage.

Fifth, we should do everything to improve R&D tremendously. There is no reason why our scientists cannot be as creative as the Koreans. There is no reason why our private sector should not spend for their R&D (they spend for advertisements and marketing but without R&D they will not have their own

competitive product to sell). The whole point is to get these industries started on R&D. The Koreans did it by providing all sorts of incentives. We can do the same, and maybe it will not be necessary to provide as much incentives because the private sector knows that free trade is just around the turn of the century and they will not survive if they do not do R&D.

Sixth, we should learn to take business risks that have promise of improving our technological capability in the long term. Korea competed with Japan in producing the 256 K DRAM knowing fully well that they will lose because of Japan's superiority. But they argued that the experience and know-how they will learn even if they lose will make them capable of beating Japan in the future. And indeed, by working hard and learning well, they beat the Japanese in the production of the 4 megabyte DRAM in less than ten years.

V. Specific Policy Recommendations

A. Planning, Budgeting and Financing

The public sector should experiment with the rational planning and allocation of the budget. If this were implemented, the S&T sector would draft realistic, implementable programs because these are guaranteed of funding. This would be much better than the present practice where government planners tend to plan arbitrarily regardless of the plan's implementability, because they are not sure how much they will get anyway (if they are lucky enough to get a budget that is more than their operating expenses). One reaction to this problem is the recommendation of Senator Orlando Mercado that our R&D expenditure (in terms of percentage of GDP) should be comparable to those of other countries. However, this is not realistic because if implemented, the S&T sector will not be able to sensibly use the money in the first few years. The funds may just end up being a source of corruption, and worse, the S&T sector will look bad because of its failure to sensibly utilize the money.

The problem is how to justify this proposal to the legislature. What makes the S&T sector so special that it must be afforded special treatment in the budget process? This problem can be solved in three ways. First, the executive can simply use its "influence" with the legislators to arrive at a modus vivendi that will effectively facilitate the budget request of the DOST and other agencies as far as R&D is concerned. However, considering the nature of checks and balances in a democratic (and feudal) system, there is bound to be a legislator who will throw a monkey wrench at this approach.

The second solution is to raise the proposal to the level of a law. But this will be debated upon endlessly in Congress and well-meaning people will raise the valid question of why the sciences alone deserve rational planning. On the other hand, if we were to do rational planning and allocating for everybody, we would have to do the nightmarish zero-based budgeting. Again, the needed reform in the S&T sector will get bogged down in the process.

The third solution is to adopt the practice of having a guaranteed development budget at the start of every mid-term development plan. This is

practiced in Malaysia. This means that if the development programs of an agency are accepted in the mid-term plan, then that agency will receive its usual allocation (determined historically plus the usual additions for inflation) and an additional budget to implement the development programs. When these development programs are regularized in the agency's operation, the development allocation gets incorporated into the usual budget. The agency again proposes another set of programs for the next mid-term plan and the cycle is continued.

This third solution has a better chance of succeeding than the other two. It is rational, it does not open a can of worms, so to speak, and everybody has a chance to put in their development programs. For the science and technology sector to benefit from this arrangement, the DOST secretary must be a fighter and have the support of the President.

The next policy recommendation is for the country to target the four advanced technology areas (microelectronics, materials science, information technology and genetic engineering) for immediate development. The development will be in terms of human resource development, R&D in the universities, putting up SMEs inside S&T Parks, and encouraging the private sector to put up large-scale business ventures that will make extensive use of these technologies.

As for R&D and human resource development, the DOST should define specific areas that Universities should get into not only in the four advanced technologies but also in photonics, robotics and micromachines. The DOST should do this by funding institutions (such as centers of excellence and even the science and engineering departments of private schools) rather than wait for proposals from individual scientists. If R&D support is guaranteed for five years, then these institutions can consistently work on their areas for an extended period, which will enable them to develop expertise and perhaps find niche applications.

In fewer than ten years, the private sector will compete in an almost open global market with a uniform tariff at 4%, and in a completely open global market in fewer than twenty years. The local industries must therefore plan for these two events by drafting their strategic business plans (SBPs). Just like the SBPs of most competitive firms in the world today, the SBPs of our local firms must include a technology plan. This means our local firms must learn and start practicing activities such as technology assessment and technology forecasting.

More important is research and development. Local firms or at least industry groups must start doing and internalizing R&D. If the firms and industries allocate money for ads and marketing, they must also regularly allocate money for R&D (see programs for a specific mechanism). If local industries do not learn to do R&D, they will not survive the competition in the second decade of the 21st century.

The role of the public sector in the foregoing activities of the private sector can be interventionist or supportive. The role is interventionist when government

requires, through legislation, the collection of an R&D tax from all firms. The tax will be used to finance the operation of R&D institutes that cater to industry needs. Exemptions from this tax will only be given to industries or firms that put up their own R&D units.

The role is supportive when government provides incentives or even support facilities for R&D. Government, through the Industry Development Council, can try to convince the private sector that it is to their best interest to prepare for the competition in the 21st century. But whether the private sector responds or not is their own lookout.

Which approach is better? The interventionist role was employed by Taiwan and judging from its current economic condition, it has worked. But this approach is not consistent with present trends in our society. Thus we should first experiment with the supportive role. If the private sector still does not respond positively in, say, five years time (2003), then the government can either let it go and accept our role in the international division of labor, or adopt an outright interventionist role.

B. Evaluation

The very first thing we must do is clean up the data of CHED, DOST and other government agencies. The evaluation of technologies made in the third report was not done properly because of the unreliability of the data provided by these agencies. Then we should develop indicator-based assessment procedures. Time series plots of these indicators should be developed so that we can at least do trend extrapolation (under assumption of business as usual).

The evaluation procedure to be developed must be able to relate the performance of the S&T sector to that of the entire economy. This way, policy makers and our leaders will have a clear understanding of the role of S&T in development rather than a vague or motherhood view of S&T as part of the common good.

For the public sector, the adoption of five-year R&D support for institutions rather than individual scientists will simplify the monitoring/evaluation procedures of projects. Today, the evaluation/monitoring is done quarterly by DOST Councils' whose personnel do not always understand the project. They visit the project proponents and gather data that are not very relevant to the success of the project. And since the release of project funds is often delayed, the proponents are not happy being asked about the current status of their research.

In the new funding scheme, the DOST will define the areas to be developed and their expectations (minimum number of publications and/or patents, new products and processes, technologies transferred to the private sector). The R&D institution, for its part, will have leeway in the implementation of the project. Monitoring in this case is going to be done once a year (the institute submits a progress report) and evaluation will be carried out by a group of experts towards the end to find out if the project is successful, needs renewal, or if the project is better undertaken by another institution.

For tertiary institutions, the system of accreditation must be started. This is the best way to guarantee the quality of our university education.

For the private sector, benchmarking should be institutionalized in order to encourage local industries to be competitive. It may also encourage local firms to do R&D.

C. Coordination

Today there are various S&T-related coordinating bodies that link the public, academe and private sectors. These are the Science and Technology Coordinating Council (STCC), Human Development Council (HDC), Eminent Persons Group (EPG), NEDA's Technical Working Group (TWG) and BOI's Industry Development Council (IDC). The EPG and TWG are ad hoc bodies while the STCC (created by President Aquino), the IDC and HDC (created by President Ramos) are more permanent and have the force of a law or presidential support (HDC was created by a Republic Act, STCC by an Administrative Order and IDC by an Executive Order).

These organizations are more than sufficient to coordinate the country's activities in S&T. Over coordination must be guarded against. What is required at present are hard work and the implementation of the good ideas proposed by these bodies.

As for environmental concerns, the drafting of the country's commitment to Agenda 21 by the Philippine Council for Sustainable Development is a good start. We should be able to attract more environmental NGOs/POs to participate in the country's environment and ecology programs. The government, through the DENR and DOST, should upgrade the NGOs/POs scientific and technical knowhow so that misunderstandings due to science misconceptions can be minimized.

D. S&T Promotion

We should come out with a policy paper on S&T promotion that will elucidate the Constitutional provision which says "The state shall encourage the widest participation of private groups, local governments, and community-based organizations in the generation and utilization of science and technology". The policy paper should emphasize the promotion of S&T at the grassroots level. It should also guide activities like the creation of more science TV programs; translation or dubbing of foreign programs like "Future Quest", "Discovery", "Newton's Apple" in Filipino (if we dub programs like Marimar and other telenovelas, there is no reason why we cannot do the same for educational programs); use the Agila satellite to broadcast S&T programs to benefit schools in far-flung rural and upland communities; and put up a mobile science exploratorium that will go around the country the whole year round.

Equally important is the development of a technology orientation among Filipino entrepreneurs and top management. If our business leaders have a

technology orientation, then the private sector will do R&D and undertake technology planning. At this time, it is not clear to the author what policy instrument to employ in order to promote a technology orientation in the business sector.

E. Education

The country should come out with a policy statement that basic science and mathematics education be taught in the language used in the region. This way, the student can learn these subjects even in grade one. The shift to English should only be done when students have taken enough English courses and when they have assimilated mathematics and science concepts. This should not be a problem since students learn better in the language used at home. The consequence of this practice is the appropriation of math and science by our students as part of our culture.

Some resistance to this proposal is expected, however. Opponents will cite the lack of teaching materials and the unnecessary cost of producing new books and teaching aids. But these difficulties are temporary and once overcome will enrich the educational system. The benefit is undoubtedly long term. Students properly trained in basic mathematics and sciences will be excellent starting material for our technical and tertiary institutions.

Another important policy issue is changing the degree requirement to teach high school science and mathematics from BSE to BS. The BSE program is short on content and heavy on the traditional method of teaching. Given the pervading situation in our country where the least intelligent in the family is encouraged to take education, our high school students get their science and mathematics education from teachers who are most likely not qualified to teach these subjects. And indeed this is true as discussed in Section III.

This policy will receive stiff opposition from the many education schools in the country for they will not be able to handle the BS programs. They will lose students to schools like UP, Ateneo and De La Salle. Unfortunately, however, these schools are in no position to immediately absorb the increased enrollment. But we cannot afford not to undertake this reform because the present system is precisely the cause of the poor performance of our students in science and mathematics. Besides, in many countries in the world, a first degree in science and mathematics is the minimum requirement to teach in high school. Thus the reform has to be implemented. But it needs to be implemented deliberately using a well thought out plan.

At the tertiary level, we need to institute an accreditation system to ensure the quality of our universities. There are too many universities and most of them are not able to offer quality undergraduate degree programs in math, engineering and the sciences. If we allow this situation to continue, not only are we shortchanging college students and their parents. We are also perpetuating a system that produces degree holders who cannot practice their profession and thus end up doing something else. Many domestic helpers have education degrees for example, engineering graduates of schools other than the top

schools in Metro Manila end up as construction workers abroad.

Stiff opposition to this reform is also expected more likely from the SUCs and the many private schools. But CHED has to start implementing this reform for we have dilly-dallied enough on this problem. Accreditation is practiced worldwide and it is the counterpart of benchmarking in business.

The policies on hiring, promotion and tenure requirement of faculty members are better left to the universities. However, the government, through CHED, should emphasize to the universities that they should upgrade their policies every five years or so. This way, there will be a clear improvement in the faculty profile of tertiary institutions.

F. Research and Development

The policy on R&D should not only clearly delineate the responsibilities and areas of each sector but promote an R&D agenda that will make us competitive in the 21st century. If this point is clearly understood, then the responsibility for developing the advanced technologies will rest primarily with the public sector and the academe while private sector takes care of its own technological requirement. This policy shift has important consequences for DOST, the centers of excellence and the tertiary school system (see programs).

The compensation scheme for research work should be rationalized. Despite the many complaints by the science sector (coursed through the DOST), the Commission on Audit still insists on a research honoraria of P3,000 per month. This policy is decimating the ranks of researchers in the centers of excellence. Soon, we will have well-equipped laboratories with no senior people. A simple policy statement that allows research honoraria to go as high as the basic pay provided it is determined by the productivity of the researcher as measured by publications and other creative work will vastly improve the situation in the centers of excellence.

During the initial period of this long-term program, from the first up to the middle of the second mid-term plan, the government should provide incentives for reverse engineering and technology development. The reason is to induce the private sector to do R&D and also because the local firms will still need support for these activities. The incentives should be determined by the BOI.

But in the long run, the private sector should take care of its own technological requirement. At most the government should only provide the common facilities (engineering and technical data bases, calibration and standards laboratory and maybe even an analytical services laboratory). But R&D funding should be the responsibility of the firm and or the industry group.

To facilitate the transfer of advanced technologies developed in the centers of excellence and public R&D institutions, the government should issue a policy statement that will allow the easy transfer of the scientific products of these institutions to the private sector, including SMEs in S&T Parks. This policy will go a long way in upgrading the technologies of the private sector, from the present

low technology to the advanced technologies in fewer than two mid-term planning periods.

The private sector should refrain from long-term technology licensing agreements and technology purchases in areas where the country has the capability. This way SMEs (even in high tech fields) that offer engineering and technical services to large firms will be established. Note that this will be difficult to do at the start because of the sketchy track record of local support industries and the colonial mentality of the general population (people go for foreign brand names). But this practice has to be curbed, if not completely stopped, if we are to move away from technological dependence. What is the role of the public sector in this micropractice reform of firms and industries? The BOI, through the Industry Development Council, can influence local firms and industries to adopt the reform by tying it to the provision of incentives (during the first up to the middle of the second mid-term plan) and the provision of support facilities (in the long term).

The BOT law should also be revised to include a technology transfer provision because the transfer of technology is the important first step in a developing economy's drive for technological self-reliance. The country should not be afraid of imposing technology transfer because this is normally done by less developed countries in dealing with advanced economies. Besides there is a big market out there of technology suppliers to choose from.

The private sector should be encouraged to practice "mirroring" in their joint ventures with foreign companies. Again, this is a micropractice reform that should be suggested by the government to the private sector through the Industry Development Council. To entice compliance, the incentives cited previously should also be tied to this reform.

G. S&T Services

There is a major policy change required regarding DOST R&D institutes that cater to the needs of the private sector (examples are ITDI and MIRDC). This is the privatization of these institutes so that they can be more responsive to the needs of the industries they serve and at the same time make the industries responsible for their own technological requirement. However, reorganization should not be done abruptly because it will not accomplish the intended goal and may well lead to dissatisfaction and unemployment of personnel if carried out irrationally. The details of how this is to be implemented should be discussed carefully by the agencies and the industries concerned but a suggestion is discussed in the section on programs.

Government should convince international funding bodies like the World Bank, Asian Development Bank and OECD agencies to hire local consultancy firms for feasibility studies of local projects. This will save the government money (local consultancy firms do not cost as much as international firms) and will develop the expertise of local firms so that they can compete in international market. After all, already today, some local consultancy firms do a much better job than international consultants.

Since the environment should be given serious attention, the front line agency in dealing with environment issues, the Environment Management Bureau, should be upgraded. The EMB, especially its regional offices, should be staffed by people trained in the sciences and engineering so that they can measure pollution correctly and monitor compliance with standards authoritatively.

VI. Programs

The programs will implement the proposed policies discussed in Section III. The main feature of the proposed programs is continuous improvement in the country's capability in the advanced technologies starting from our present situation. This is to be done by using the following general strategies:

- Lay down a strong foundation in math, sciences and engineering.
- Encourage and support researches in the modern sciences and advanced technologies.
- Induce the private sector to modernize their production by using the advanced technologies.
- Establish SMEs in the advanced technology areas.
- Target industries that will make extensive use of the advanced technology areas.
- Make use of and acquire the knowhow in clean, cleaning and efficient-use-of-resources technologies.

We will present the programs in terms of a series of mid term plans (six year time frame).

A. First Mid Term Plan

The first mid term plan will start from our present condition and try to set the stage so that we can make the initial leap to the advanced technologies during the second mid term plan.

A.1 Improving Basic Education

The Regional Science Teaching Centers (RSTCs) should undertake the upgrading of the present math and science teachers in the elementary and high school levels. The upgrading should include an extensive discussion of the subject matter, new methods of teaching, and simple laboratory equipment and exercises that can be fabricated by the teachers themselves using the machine shops in their schools. The NISMED should support the RSTCs by providing teaching modules and lecturers. In six years, the teachers must have attended at least two upgrading programs.

By the end of the first mid term plan, DECs should have worked out the implementation of the shift from BSE to BS as a requirement to teach in high school science and mathematics. The science departments of tertiary institutions like UP, Ateneo, Dela Salle, MSU-IIT, UST and a few others should be able to handle the increased enrollments. The National Institute of Physics, in particular, has to change its BS Physics and BS Applied Physics programs. Presently, all physics students do an undergraduate thesis (and some are really excellent for they get published in international journals). With the increased enrollment, the NIP faculty will not be able to guide all the students in their thesis work. And it is not realistic to expect that all the students are capable of research. Thus, the NIP has to start offering two types of Baccalaureate degree, the five-year honors class (with thesis for the really smart students) and the ordinary four-year degree for those who just want to teach in high school or get a job right away.

DECS should also start working for the approval of the language policy during this period. The NISMED and the RSTCs should help DECS prepare for the implementation of the language policy. Textbooks and teaching materials should be prepared by the three agencies. By the end of the first mid term plan, the language policy should have been approved and ready for implementation.

We should connect all the high schools to the Internet. This means putting up the necessary infrastructure (telecommunication) and providing enough computers to all schools. There should be a high school course on surfing the net (it goes without saying that the school administration and the parents should discuss the issue of “cleaning” the web sites that the school computers can access).

A.2 Improving Tertiary Education

The policy recommendation calls for the implementation of an accreditation system for universities to ensure quality in tertiary education. But this cannot be implemented immediately, there are just too many institutions to be affected (100 SUCs and more than a thousand private universities). The first step then is to assess and evaluate science, engineering and math departments. Norms of faculty profile, laboratory facilities, curricula and course offerings should be established. The time frame for the schools to meet the norms should be spelled out. Beyond the time limit, schools that do not meet the norms should be converted to community colleges, vocational schools or even high schools.

All tertiary institutions must have a program for improving the policies for hiring, promotion and tenure. Towards the end of the first mid term plan, an MS from UP or an equivalent institution should be a sufficient requirement for hiring in many private schools (except Ateneo, DLSU and a few others that already have PhDs in their faculty) and SUCs. But recent hires should be subject to stricter tenure policies, a PhD, so they will be forced to go back to school before they get too comfortable and complacent with their teaching careers.

All universities must start promoting scholarship by providing incentives for research. Rewarding international publications should be a common practice in tertiary institutions. This is the only way to promote the culture of research and

scholarship in the country's educational system. Later on (hopefully by the start of the third mid term plan), when publishing in international journals becomes common, the rewards should be given for exemplary publication, i.e., a publication that receive hundreds of citation the world over.

The old proposal called the "Sunset Program", which will allow retired professors from UP and other good schools to continue their service in SUCs, should be implemented. In the US today, there is no retirement age for professors, while in Japan (where this idea was patterned after), professors who transferred to private schools can teach till their 70. This program will boost the science, engineering and math departments in the provinces to the point that they can offer quality undergraduate programs. These universities can then help train the teachers required in high schools.

A.3 Research and Development

The academe and public R&D institutes (ASTI) should focus on the sciences, mathematics and advanced technology areas for their R&D. At the end of the first mid-term plan, the engineering departments of the top schools should have started programs similar to those found in Japan and other advanced countries.

Some may question why emphasize only the basic sciences and the advanced technologies when the technological requirement of local industries is not that high tech? If we follow the demand-pull strategy, focusing on high tech is certainly the wrong response. But as discussed already in the assessment report, for a country that does not have a scientific culture and an engineering tradition, the demand-pull strategy is the wrong response to its problem of backward S&T. This is more true today because we are facing a high technology, global free trade era in less than two decades. The public sector must invest in the basic sciences (to lay down the foundation for sustained technological development) and advanced technologies (so that the three economic sectors will be improved in the immediate future). Today and in the first mid term, the private sector will not invest in these areas because they are not relevant to them.

However, it does not mean that the technological requirement of the private sector will not be addressed. They will be addressed, but it should be the private sector that must address them primarily! After all, it is their business that is at stake and firms all over the world address their own technological requirement. So why should the local private sector be any different?

Local firms and industries should then start doing R&D. Many of these industries will be doing R&D in Second Wave Technologies and only a few will be into the advanced technologies at the start. But towards the end of the first mid term plan, there should be a clear movement towards application of the advanced technologies in more firms and industries.

A.4 Human Resource Development

The ESEP should be assessed (by 1998) and plans should be made for its

next phase. There should be a big budget for post-doctoral work for the faculty of the University of the Philippines and other schools. This is the only way to correct the problem of inbreeding in the College of Science of UP Diliman.

UP is suffering from the problem of PhDs abroad not wanting to return for obvious reasons. The solution is the implementation of the policy that will rationalize research honorarium (see policy recommendations).

The in-house training of UP faculty members should be avoided. UP should send its faculty abroad for PhD and post-doctoral training. UP should train the faculty of SUCs and others.

We should aim for growth rates of PhDs comparable to that of Korea's. The computation of the growth rates under various initial conditions and target years to attain the critical mass is shown at the end of this section.

There are many foreign nationals, specially in Eastern Europe, that have specialized skills and education that we can hire or even entice to migrate. Unfortunately, our country gives preference to people with money instead of know-how. But people with money are footloose, they can easily go to another place where they can enjoy their wealth and health (our reputation for kidnapping drives away these people faster than we can attract them). And rich immigrants generally do not contribute much to the long-term growth of a nation. Just look at the US experience, hardworking immigrants who have know-how made the country rich (recent most famous example is Andy Grove of Intel). Singapore is also following the same policy, it is attracting scientists and engineers. We should reconsider our immigration policies.

In this connection, we have two models to consider. The American experience as already pointed out assimilated the immigrants and made them Americans. The Japanese model on the other hand did not assimilate foreigners into their system (Japanese society is a very tightly knit and closed). They were treated as foreign workers, paid well for their services and employed until the locals took over. Which is the better system for us? Most likely, the American way because ours is quite an open society.

A.5 Institution Building

For firms that cannot put up their own R&D units, they should join with others to put up an industry-wide R&D unit. In this connection, some of the present DOST R&D Institutes can be divested to the private sector to be their R&D unit. This should be done carefully, making sure that the intended goal, for the private sector to do R&D, will be realized.

Here, we suggest one possible way of privatizing some DOST R&D Institutes. In the first year of this plan, industry and DOST should meet to find out if they have common R&D interests. If privatization is possible, then it should be implemented within five years. During the five-year period, the government will be slowly removing its allocation to the R&D unit with the private sector slowly taking over the budget requirement. The private sector and the government must sit

down to work out the exact arrangement of the turnover of responsibilities. The government should just consider the money allocated during the transition period as part of the technology safety net to help prepare the private sector face future competition.

The controversial Commonwealth 101 should just be converted to a Science and Technology Park where only SMEs in the advanced technology areas (priority for the four areas that rated high in the evaluation, see third report) will be allowed. This site is ideal for it is near UP, Ateneo and PNRI, sources of scientists and engineers with advanced degrees and expertise. Also, this particular use of Commonwealth 101 is consistent with the nature of a University (source of knowledge) and will not exacerbate the traffic problem (low-density use unlike high rise constructions and shopping malls).

The College of Engineering of UP should be converted to the National Graduate School of Engineering (NGSE) to solve the problem of very few engineers going to graduate school.

UP's ISMED should be converted to NISMED and give it the responsibility to solve the problem of basic science and math education, specially during the first three mid term plans when the BS requirement to teach in high school has not fully replaced all the teachers.

A.6 Basic Industries and SMEs

We should attract foreign and local investors (joint ventures) in basic industries that will use extensively the four advanced technologies (Microelectronics, Materials Science, Genetic engineering and AI/IT). Incentives, to be determined by the BOI, should be provided not only to these industries but also to the support SMEs so that the industry cluster can be formed and made competitive.

SMEs that plan to export their products and services abroad should be encouraged to shift to the advanced technology areas as early as possible. This is the strength of Germany, it has an unusually large number (around 300,000) of SMEs in the high tech areas doing niche products and services for the world. Unlike the US and Japan that have more than 300 companies each in the top 1000 corporations, Germany only has 30. But the German economy is consistently the third largest in the world and it is primarily there because of its SMEs, the so-called "Mittelstanders".

B. Second Mid Term Plan

The second mid term plan will continue some of the programs of the first (with substantial improvements) and will start new ones.

B.1 Improving Basic Education

The BS requirement to teach high school science and mathematics should be implemented by the fourth year of the second mid term plan (we would have

enough graduates to replace those who will retire if the good universities modified their programs to accommodate increased enrollment).

Towards the middle of this planning period, we should be fully implementing the language policy on basic science and mathematics education. NISMED should be able to provide the teaching modules and innovative experiments.

Towards the end of this planning period, all high schools must now be wired to the Internet. We should start wiring some of the elementary schools at the beginning of this planning period to the Internet.

B.2 Improving Tertiary Education

UP and other schools must now require post doctoral training for hiring and have a stricter promotion and tenure policy. The other universities should now consider imposing a PhD requirement for their hiring policy.

At the start, science and mathematics departments of UP and other top schools must now be in a position to accept the increased enrollment because of the BS policy.

The accreditation system of CHED should now be in place and at the end of this period, we should now start converting some universities to vocational schools, community colleges and even high schools.

The “Sunset Program” should now be fully implemented. SUCs and private universities in the provinces should fully welcome the “oldies but goodies” so they can upgrade their undergraduate programs.

ESEP II should be nearing completion and should be assessed. We should start the preparation for ESEP III.

B.3 Research and Development

The present National Centers of Excellence should now be spawning specialized centers of excellence in specific advanced technology areas. For example, the present National Institute of Physics should give birth to a Materials Science Center, an Applied Optics Center, a Photonics Center, a Liquid Crystal Center, a Plasma Physics Center and a High Energy Physics Center.

The productivity of the research scientists and engineers of the National Centers of Excellence and the NGSE should now be at the level of their counterparts in the National University of Singapore. We should now be aiming for a higher productivity.

The science and mathematics departments of SUCs and other leading private schools should now be publishing at the level of UP’s productivity.

We should start putting up an international journal in the advanced

technology areas (not at the same time, we begin in a field that we can sustain ourselves).

The R&D Centers put up by industries should now be doing research in the advanced technology areas. By the middle of this plan, they should be able to stand on their own.

B.4 Human Resource Development

Continue the growth of advanced personnel at the desired rate (see Table 1). The science, engineering and math departments of private schools and SUCs should now be similar to the profile of schools like Ateneo and DLSU. And they should now be aiming for a faculty profile similar to UP's (about 50% PhD) for the Third Mid Term Plan.

B.5 *Institution Building*

Diliman S&T Park should now have more tenants, all in the advanced technologies providing support to local and international industries.

Basic industries should now start putting up their own schools where they will train their personnel. College education should be viewed by big industries merely as a high pass filter for trainable personnel.

B.6 *Basic Industries and SMEs*

The previously established basic industry should now be moving in the direction of competitiveness without government incentives. Its supporting SMEs should also be in the same level of competitiveness. For the second mid term plan we should consider putting up another basic industry with its cast of supporting SMEs.

C. *Quantitative Trends*

It is difficult to go beyond twelve years in providing the details of an S&T Program. Most likely, even the first six years will not be implemented as planned.

Also, notice that the First Mid Term Plan is quite detailed while the Second is already quite sketchy. Thus, we will not list down the detailed activities for the Third and Fourth Midterm Plans. **The important lesson is simply to continue good programs, raise its level and standard, and implement new ones that are called for by the future.**

Instead, we will give quantitative trends to our growth pattern. Unfortunately, the lack of reliable baseline data and historical trends seriously limit the feasibility of an accurate projection. Because of this, we cannot do curve fitting to make projections. Fortunately, curve fitting is not the right approach because precisely the object of the planning exercise is to intervene so that we will achieve a desired growth. Thus, we will compute in the next sections the growth requirements so we can achieve targets in specified number of years.

C.1 Human Resource Development

The baseline data on number of PhDs should be cleaned up to determine by how much we should grow to attain the critical number of PhDs in either 12 or 18 years (two or three Mid Term Plans). The growth rate is given by the following formula:

$$r = e^{[(1/x)\ln(N/N_0)]} - 1,$$

where x is the number of years (either 12 or 18), N is the critical number (540) and N_0 is the initial number of PhDs (to be determined properly). In Table 1, we list down the values of r assuming specific values of N_0 and x.

Table 1: Growth rates to achieve the critical number of PhDs in 12 and 18 years.

	r for 12 years	r for 18 years
$N_0 = 5$	47.7%	29.7%
= 10	39.4%	24.8%
= 15	34.8%	22.0%
= 20	31.6%	20.1%
= 25	29.2%	18.6%
= 30	27.2%	17.4%
= 35	25.6%	16.4%
= 40	24.2%	15.6%
= 45	23.0%	14.8%
= 50	21.9%	14.1%

Table 1 shows that we can attain the minimum number of PhDs in genetic engineering (N_0 is approximately 50 if we remove the PhDs in related fields) in 12 years if the PhDs grow by about 22% or in 18 years if we grow by about 14.1%. The growth rate for the other areas can be determined accordingly.

We can do a similar analysis for the growth of the number of RSEs per 10,000 population. The 1997 data is around 1.38 per ten thousand. Suppose we aim for a number similar to Singapore's RSEs today (28) in 12 or 18 years from now, then we should be growing at the rate of 28.5% (for 12) and 18.2% (for 18). This means that if the number of our RSEs grow consistently by 28.5% for twelve years, then by that time, we will be where Singapore is today. Let us be more ambitious, let us target Taiwan's number which is 43. To attain this level in 12 or 18 years, we will have to grow consistently by 33.2% and 21.1% respectively. By that time, Taiwan would have moved to somewhere close to Japan's current number which is 87.

To translate these numbers in terms of absolute number of RSEs, we have to take into account our population growth. And since this is quite high, about

2.3%, the absolute number will also be quite high. We will have to spend a lot of our money on human resource development.

C.2 Productivity

The publications per PhD is not difficult to improve (unless of course we accept that we are inferior to the Singaporeans and other nationalities). From the present .25 publication per PhD, we can easily increase this by an order of magnitude if we provide incentives and change the hiring, promotion and tenure policies. We can project the impact of these interventions if we can do a causal model or even if we have a correlation model between productivity, and incentives and strict policies. But we do not, so at this point we just conjecture that productivity can easily be increased, even in less than five years, with the right intervention.

As for productivity in terms of patents, the first step, for the private sector to do R&D, has to be hurdled first before we can make projections on how it will grow.

C.3 Growth in R&D Spending

Since the policy is to practice rational planning and allocating and the objective of this planning exercise is to seriously plan the country's S&T development, we cannot use the historical growth of R&D expenditures to determine the growth during the next few years. But it is expected that it will not immediately reach the 2% expenditures of the advanced countries. Our experience during the next few years should give us sufficient data for later years extrapolation.

C.4 Growth in Institutions

At present, we have only about ten Centers of Excellence and a few more math, engineering and science departments that can do relatively decent research and teach quality undergraduate courses. In the private sector, there must be very few firms and industries that have R&D units (there is no baseline data on this) because historically, the private sector always point to the problem of lack of R&D as one of the reasons for their lack of competitiveness. During the next twelve years, we should count these institutions so we can correlate their number to the S&T policies and the macroeconomic environment.

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