SCIENCE AND TECHNOLOGY AND ECONOMIC DEVELOPMENT

by

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by

Mario B. Lamberte, Ph.D.*

I. Introduction

On a 24-hour basis, from the time we wake up in the morning to the time we wake up the next morning, we are enjoying the fruits of scientific research. Yet we hardly notice it. Last summer, I had the opportunity to go home to my hometown after being away for ten years. I observed marked changes in the way the townsfolk live, and technology has something to do with it. With the presence of electricity, piped water system and some mechanical and electronic gadgets, household chores that were supposed to be done only by young people can now be done by older ones because of the relative ease in doing them. Likewise, types of farm work that used to be incompatible with time-consuming household chores are now made compatible.

Over at the farms, changes in relationships of economic organizations are taking place. Whereas before, the landowner

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*Vice-President, Philippine Institute for Development Studies. This paper was presented at the Science and Technology Congress held in Davao City, 9 December 1988.

The views in this study are those of the author and do not necessarily reflect those of the Institute.

had to deal individually with his hired workers, now he has to deal only with one person, i.e., the manager of a "thresher"[1/]. "Threshers" have work contracts throughout the year owing to the fact that most farms in the town and its neighboring places are irrigated.

My uncle owns six hectares of farmlands and he has been harvesting 120 cavans of palay per hectare for the past ten years. Thanks to the high-yielding varieties of rice and the new methods of farming. But he is still using a carabao to plow his fields. Six years ago, he bought a tractor by borrowing from a bank which was then aggressively promoting the highly subsidized loan under the farm mechanization program of the government. Later, though, he found out that the tractor was too big for his farm and that the spare parts were available only at a distant city at very high prices. Thus, he decided to go back to the use of a carabao even as he is still paying his loan until now and his tractor is lying completely unused in his yard. He now laments: "Not all technologies offered to us are appropriate given our resource endowment and objectives in life. More often, however, we realize it only after we have adopted them. And government policies can certainly color our assessment of the appropriateness of technologies."

1/ A "thresher" is a group of farm laborers hired by the manager. Most "threshers" own their farm implements, such as thresher, hand tractors, etc.

This paper deals with science and technology and economic development. In the next section, we will describee the relationship between technological capability and degree of economic development. Section III will briefly analyze the structure of the Philippine economy and the structural changes that have taken place since 1970. It will also look into the impact of economic developments and technological advances in other countries on the Philippine economy. Section IV will then discuss the impact of macroeconomic policies on technology choice. Finally, the last section will discuss possible research collaboration among PIDS, DOST, and regional research organizations.

II. Technological Capabilities and Economic Development

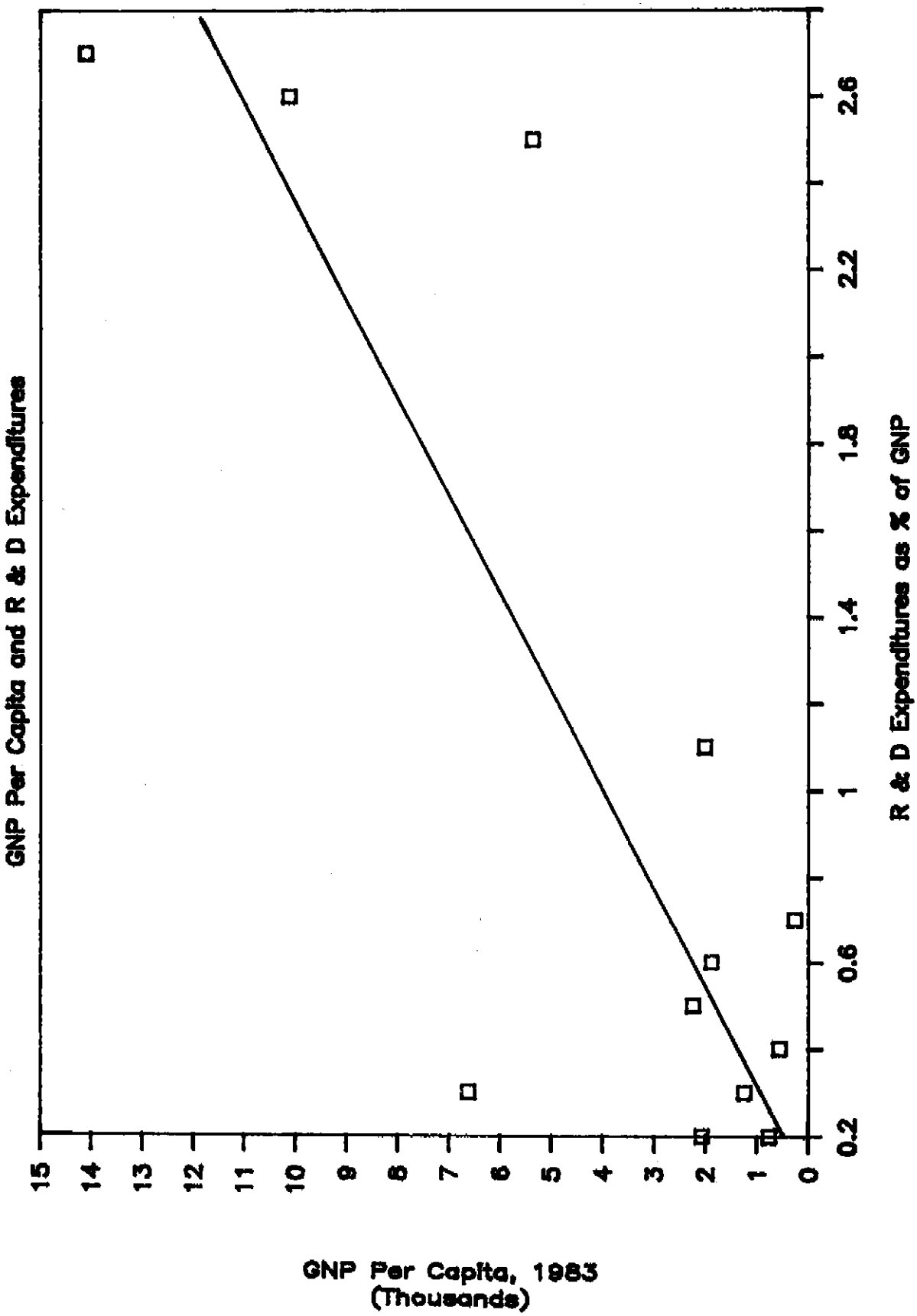
This section tries to describe the relationship between technological capability and economic development of a country. The terms "technological capability" and "economic development" are indeed broad concepts that are difficult to quantify or to be represented by a few indicators. For the sake of brevity, we are going to use some rough (and incomplete) indicators of such terms. Specifically, the degree of economic development of a country is measured in terms of income per capita while technological capability is represented by two indicators, namely R & D expenditures as a percentage of GNP and the number of scientists and engineers engaged in R & D.

Figure I depicts the relationship between GNP per capita and R & D expenditure as a percentage of GNP (see also Annex A). As expected, there is a positive association between these two variables, that is, countries which allocate more of their income to R & D tend to have higher per capita income. Note that we are merely stating here a positive association between the two variables, not causal relationship. Intervening variables have to be sorted out before one can have a firm basis for identifying and measuring causal relationships. One such intervening variable is managerial skill or the extent to which a country makes efficient use of its resources. For example, the Philippines and Argentina have practically the same shares of R & D expenditure to total GNP, yet the latter has achieved a higher income per capita relative to the former probably because of other intervening factors. Meanwhile, India ranks fifth in terms of R & D expenditures but last in terms of income per capita.

Figure 2 shows the relationship between income per capita and the number of scientists and engineers engaged in R & D per million population. The figure suggests a positive relationship between the two variables. Again, we refrain here from stating causal relationships for the same reasons mentioned above. It is indeed surprising to see that the Philippines which has one of the highest literacy rates has a very shallow manpower base doing research and development.

We can draw some general conclusions from the findings above, taking into consideration the crudeness of our

Figure 1


GNP Per Capita and R & D Expenditures
R & D Expenditures as % of GNP
GNP Per Capita, 1983
(Thousands)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
0.2
0.6
1
1.4
1.8
2.2
2.6

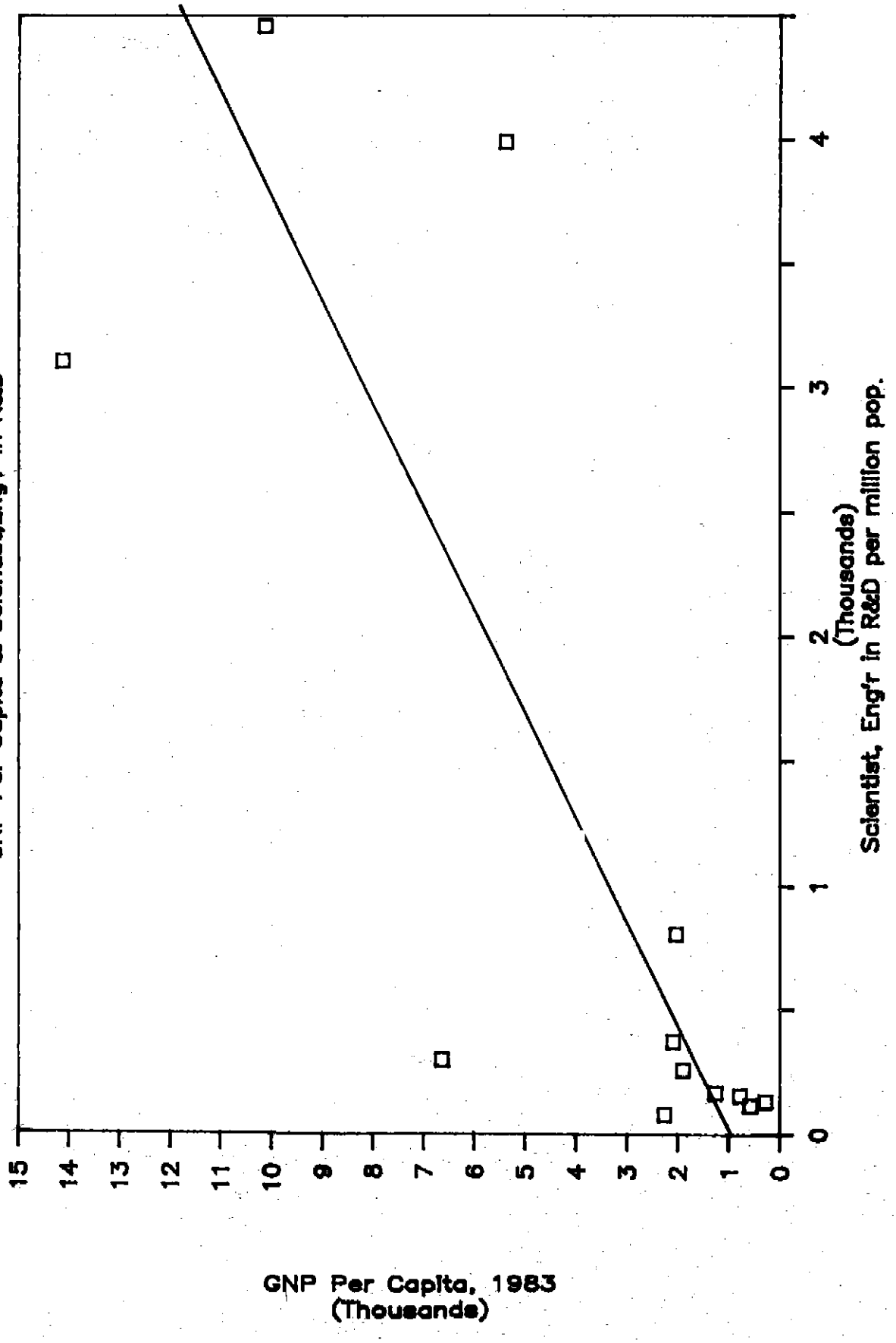

GNP Per Capita & Scientist,Eng'r in R&D
Scientist, Eng'r in R&D per million pop.
(Thousands)
GNP Per Capita, 1983
(Thousands)
0
1
2
3
4
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15

Figure 2

measurements. We can more or less say that the technological capability of a country is one of the important ingredients of economic development. Needless to say, though, technological capability alone cannot spur economic development.

In the context of Philippine development, the role of science and technology is best expressed in the Medium-Term Development Plan. When the new government took over, it vowed to adopt an employment oriented agricultural and rural based development strategy. This is a big shift in strategy for alleviating poverty and reducing unemployment, considering the fact that the previous regime emphasized an urban-based industrialization anchored on large-scale industrial projects. Corollarily, S & T activities have been geared up towards addressing the requirements of the various sectors of the economy and the provision of support for the newly-adopted development strategy.

The specific objectives of S & T sector are the following:

a. To generate and upgrade technologies appropriate to the needs of the production and social services sectors;

b. To utilize indigenous and imported technologies to help increase the growth and productivity of the production and social services sectors;

c. To improve the selection, assimilation, adaptation and diffusion of appropriate imported technologies;

d. To develop and upgrade the national scientific and technological manpower, financial, informational and institutional capabilities; and

e. To develop the national infrastructure for advanced science and technology and ensure the country's economic viability and technological competitiveness in the 21st century.

It is necessary to point out some of the important dimensions of the policies and strategies of the S & T sector. First of all, they are devoid of any rhetorics usually aired by extreme nationalists. Instead, a pragmatic approach towards technology development is adopted. Thus, imported technology whether modified or taken in toto, may be promoted so long as it is consistent with the resource-endowment of the country. Second, the development of appropriate technology (AT) is greatly emphasized. Here, AT is defined according to the specific-characteristics approach.[2/] And lastly, greater attention is given to technologies that have immediate commercial use.

Considering the pressing problems the economy is facing at present, the policies and strategies announced by the S & T sector seem reasonable. However, there seems to be a

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2/ In the context of LDCs, a more appropriate technology is defined according to the specific-characteristics approach as: more labor-using in comparison with a less appropriate technology; making more use of local materials and resources; not environmental damaging, fitting in with socio-economic structures and producing a more appropriate product (see Stewart [1987]).

tentativeness on the part of the government in providing adequate support to the S & T sector. As may be seen from Table 1, the targeted percentage share of R & D expenditures to GNP has been substantially reduced in the Updated-Medium Term Philippine Development Plan, 1988-1992. This implies a much slower improvement in our technological capabilities. The consequences of this in the face of rapid technological advances in other countries will certainly be felt in the intermediate term.

III. Structural Change in the Philippine Economy

We begin our analysis of structural change in the economy in 1970. This is the beginning of the period when the government adopted "an outward-looking development policy at the same time that it increased substantially its role in the regulation of various sectors of the economy." (Bautista [1988], p.6).

In 1970, agriculture and industry had almost the same contribution to total output (gross domestic product) while the services sector contributed 40 percent to total output (see Table 2). By 1980, the contribution of the industry sector to total output moderately improved at the expense of both the agriculture and services sectors. This is a result of the industrialization effort exerted by the country. But this proved to have been unsustainable. By 1987, the shares of the three major sectors were back to almost the 1970 levels. This is a classic case of unsuccessful industrialization take-off. The protectionist policies that encouraged

Table 1

GNP GROWTH RATES AND R & D EXPENDITURES

Year	GNP Growth Rates (%)			R & D Expenditures as % of GNP	
	Actual	Original	Updated	Original	Updated
1986	2.0	1.1*	-	0.12	0.12
1987	6.4	6.5	-	0.20	0.16
1988	7.54**	6.9	6.4	0.32	0.23
1989		6.7	6.7	0.45	0.35
1990		7.0	6.5	0.61	0.50
1991		6.9	6.3	0.78	0.72
1992		6.7	6.5	0.90	0.90
Average		6.8	6.5	0.48	0.42

* Estimate

** First Quarter

Sources: Medium-Term Development Plan, 1987-1992.
Updated Medium-Term Development Plan, 1988-1992.
National Statistics Coordination Board.

Table 2

STRUCTURAL CHANGE IN THE PHILIPPINE ECONOMY

Item/Sector	1970	1980	1985	1987
A. Output				
Agri	29.2	25.6	29.2	28.5
Industry	30.7	36.2	32.3	31.8
Services	40.1	38.3	38.5	39.6
B. Employment				
Agri	53.7	51.4	49.0	47.8
Industry	16.5	15.5	14.2	14.6
Services	28.2	33.0	36.8	37.6

Source: (1) NSCB, National Income Accounts (various years)

(2) NEDA, Philippine Statistical Yearbook (various years)

substituting industries have largely contributed to this failure. Specifically, the industries being promoted seem to be inconsistent with the resource endowment of the country. As may be gathered from Table 2, the share of employment of the industry sector had been declining, implying that the sector failed to absorb the growing labor force. This is contrary to what has been expected of the industry sector which received substantial protection and subsidy from the government.

The extent of inefficiency of import substituting industries may be gleaned from Table 3. The ratio of domestic resource cost to shadow exchange rate (DRC/SER) is used here as a measure of efficiency. A firm is said to be efficient if the ratio is less than one, and inefficient if the ratio is greater than one. Most firms are observed to be inefficient. It is noteworthy that the extent of inefficiency varies among industries and even among firms belonging to the same industry. Only flour-producing firms seem to have shown a marked improvement in productivity between 1980 to 1984.

With protection and less competition, firms' R & D activities have focused mainly on product diversification rather than cost reduction (cf. World Bank Report [1987]). Our economy is replete with examples of firms which have large market shares in their respective industries, introducing low quality products for low-income consumers instead of reducing the price of their high quality products.

Table 3

DRC/SER BY FIRM AND INDUSTRY

Industry	Firm	DRC/SER/a 1980	1982	1984	
Flour	1	0.44	3.11	0.9	
	2	1.99	1.23	0.78	
	3	4.25	2.96	0.6	
	4	0.98	0.85	1.16	
	5	0.62	0.96	0.79	
	6	0.38	0.5	0.49	
	7	1.47	1.48	0.77	
	(P)	0.86	1.19	0.74	
		1.37	1.54	0.78	Mean of firms 1 -7
		1.20	0.91	0.19	Standard deviation of firms 1 - 7
Home Appliances	1	2.36	1.28	0.55	
	2	*	*	-	
	3	2.27	0.59	1.32	
	4	-	*	1.17	
	5	1.5	5.63	25.21	
	(P)	2.53	2.16	0.78	
		2.17	2.42	6.97	Mean of firms 1, 3, 5
		0.40	1.94	10.54	Standard deviation of firms 1, 3, 5
Paper	1	2.07	*	*	
	2	*	*	*	
	3	4.2	*	24.2	
	4	*	*	*	
	5	*	*	0.9	
	6	-	-	*	
Textiles (Fabrics)	1	*	*	1.55	
	2	0.59	0.18	0.34	
	3	1.25	1.05	-	
	4	3.42	2.4	-	
		1.75	1.21		Mean of firms 2, 3, 4
		1.21	0.91		Standard Deviation of firms 2, 3, 4
Textiles (Yarns and fibers)	1	*	*	-	
	2	1.35	0.42	1.1	
	3	*	*	1.84	
	4	19.63	6.09	1.47	
	5	1.75	0.93	1.42	
	(P)	5.27	1.88	1.23	
		7.00	2.33	1.31	Mean of firms 2, 4, 5
		7.45	2.23	0.15	Standard deviation of firms 2, 4, 5

/a DRC/SER - actual capacity.
* DRC/SER - negative foreign exchange earnings.

(P): Refers to a particular representative product the firm produces.

Source: Power and Medalla (1986), Table 6.

Meanwhile, the outward-looking development policy has produced desirable results. The value of exports grew from $1 billion in 1970 to $5.7 billion in 1987. However, this growth cannot compare with those realized by other Asian countries, notably Korea and Thailand.

The structure of exports has changed considerably since 1970. The share of non-traditional exports has markedly increased from 8 percent in 1970 to 73 percent in 1987, with non-traditional manufactures substantially contributing to this growing share (see Table 4). Equally important is the fact that the change in the structure of commodity exports has been accompanied by a greater market diversification. Specifically, the share of exports going to traditional trading partners (i.e., U.S. and Japan) declined while that of new trading partners grew.

There are important international developments that impinge on the country's efforts to stage a sustainable economic growth. The appreciation of the currencies of the so-called newly-industrializing economies (NICs) is a welcome development to the Philippines since it makes our exports more competitive than theirs. In addition, the currency appreciation coupled with rising cost of labor may prod NICs to transfer their industries, especially those that are labor-intensive, to developing countries. This is a favorable development for the Philippines especially since more capital inflow is needed to service the external debt. In addition, the new industries can help absorb

Table 4
STRUCTURE OF PHILIPPINE EXPORTS

	1970	1980	1985	1987
A. COMMODITY GROUPS				
I. Traditional Exports	91.53	53.01	28.13	23.90
Coconut Products	19.60	14.01	9.92	9.81
Sugar and Products	18.46	11.35	4.00	1.24
Forest Products	26.18	7.34	4.30	4.25
Mineral Products	20.43	15.86	5.25	3.92
Fruits and Vegetables	2.45	1.92	2.94	2.62
Abaca Fibers	1.41	0.47	0.37	0.21
Tobacco Unmanufactured	1.32	0.50	0.52	0.31
Petroleum Products	1.60	1.55	0.84	1.54
II. Non-Traditional Products	8.00	45.78	70.75	73.37
Non-Traditional Manufactures	6.78	34.64	59.73	63.67
Non-Traditional Unmanufactures	1.22	11.14	11.02	9.70
III. Special Transactions	0.00	0.57	0.26	0.12
IV. Re-Exports	0.47	0.64	0.86	2.60
TOTAL	100.00	100.00	100.00	100.00
B. MARKETS				
ADB Developing Member Countries	7.50	16.60	21.40	18.50
European Economic Community (EEC)	8.70	16.70	13.60	18.50
United States of America	41.50	27.20	35.70	34.60
Japan	39.60	26.50	18.90	17.20
Others	2.70	13.00	10.40	11.20
TOTAL	100.00	100.00	100.00	100.00

Source of basic data: Dept. of Economic Research, Central Bank of the Phils.

the growing labor force and also facilitate transfer of technology.

There are, however, other developments that could deny the country from enjoying the benefits of currency appreciation and rising labor costs in the NICs as well as in developed countries. One is the growing protectionist attitude of the Philippines' major trading partners. So far, the response has been to shift emphasis from quota to non-quota export commodities and to further intensify market diversification. The other is the slowdown in the growth rates of the Philippines' major trading partners. Even if protection is dismantled, so long as the absorptive capacity of major trading partners is limited, the growth of the Philippine exports will be severely constrained.

Still another factor, which is very much related to the topic of the Conference, is the rapid technological development taking place in developed countries and the NICs.[3/] The increasing use of computer-based technology has greatly reduced the share of the wage bill to total production costs. This makes exports of the NICs and even products of major trading partners more competitive again even as they continue to experience rising labor cost. Thus, the expected transfer of industries from developed countries and the NICs to developing countries would sharply slow down, if not completely halt.

3/ See Junne (1988) for a more detailed discussion on this issue.

Advances in biotechnology in developed countries have also worked against exports of developing countries. Specifically, biotechnology improves productivity and gives rise to new synthetic products that replace traditional commodities. For example, sugar production and refining in EEC has been greatly improved, thus making EEC an important exporter of sugar. Enzyme technology makes the extraction of high fructose corn syrup from maize possible, thus replacing sugar as the most important sweetener. The impact of these developments on our sugar industry is already well known.

These new international developments should be taken into consideration in designing science and technology policies and strategies.

IV. Macroeconomic Policies and Choice of Technology[4/]

Technologies are developed for use by micro-productive units. Micro-productive units include organized firms and household producing units. In the case of firms, they may be publicly- or privately-owned. In the most recent past, publicly-owned firms sprouted as a result of the eagerness of the previous government to go into production of commodities. Privatization and re-privatization are now one of the biggest tasks the present government is doing.

4/ This section draws heavily on Stewart (1987), Ranis and Stewart (1987) and Bautista (1988).

Micro-productive units are responsible for choosing technology. Their choice of technology depends on their objectives (O), resource availability (R), markets (M) and technology (T). However, these factors, are to a large extent, conditioned by macroeconomic policy environment. Hence, we now turn our discussion to how macroeconomic policies affect these factors.

Under a perfectly competitive market, firms would be maximizing profits. Unprofitable firms will be eased out of the market. More specifically, firms that adopt inappropriate technology cannot survive in this environment. However, policies can change firms' objectives. For example, if government limits the number of participants in the industries, the small number of firms exercising oligopoly power may pursue a satisficing objective rather than a profit-maximizing objective. Under this situation, firms usually have a tendency towards using inappropriate technology. Most of the import-substituting industries have behaved this way.

A more liberal policy on foreign-owned corporations is another case in point. Multinational corporations usually maximize global profits. They can save on costs by bringing in their own technology which is typically capital-intensive rather than developing a new one in the developing country where they would like to operate.

Government policies have huge impact on resource availability and cost. Ceilings on interest rates and subsidized

credit programs of the government in the past greatly benefitted large firms while small firms and household-producing units (farm households) remained outside the purview of the formal financial system. With cheap credit, producing units tended to adopt capital-intensive industries. Mejia (1979) estimated that the low-interest credit reduced the cost of capital by 9 to 35 percent. Guarantees provided by the government to privately-contracted foreign loans contributed to the emergence of capital-intensive industries. Interestingly, the present BOI-incentives also have a large capital cheapening effect.

Government policies can affect the types of products that will be produced and the direction of the flow of these products. Pushing for the export markets almost invariably promote labor-intensive goods in LDCs where comparative advantage exists. Favoring urban consumers by instituting price controls on basic food commodities does not encourage farmers to invest on new, efficient technology. Where markets for products produced in the rural sector are limited due to inadequate physical infrastructure and transport system, small-scale techniques are deemed appropriate.

Since the government controls relatively large resources devoted to R & D and possesses some regulatory power, it can influence the development and diffusion of technology. Where information about existing technology is not available to producing units, their chances of choosing an inappropriate technology are great. Technology diffusion is therefore an

important activity of the government. Where resources are scarce, the government has to make a choice as regards what type of technology must be given priority. In the context of the agriculture, rural-based development strategy of the present government, developing technologies that would promote greater linkages in rural areas could yield a very high pay-off. According to Ranis and Stewart (1987):

> "Linkages occur where expansion in agricultural output leads to expansion in other activities and, conversely, where additional non-agricultural activity in the rural areas provides opportunities and incentives for raising agricultural productivity. These linkages may take a number of forms: first, consumption linkages, where incomes generated in agriculture lead to consumption of output produced locally; second, production linkages, which may be backward or forward. Backward linkages occur where production in one sector uses inputs produced in other sectors -- for example, machinery or fertilizer. Forward linkages occur where production in one sector provides inputs for productive activities in other sectors, for example, food supplies for food processing."

Available evidence examined by Ranis and Stewart showed that the strongest linkage of agricultural growth is with consumer good industries in the rural areas. Indeed, consumption-linkage activities have contributed significantly to rural, non-agricultural employment. Accordingly, the elasticity of non-agricultural employment with respect to growth in icultural output is greater than one.

The magnitude of rural growth linkages is d ined by a number of factors. One is labor intensity agricultural production. This is in turn influenced by policies on

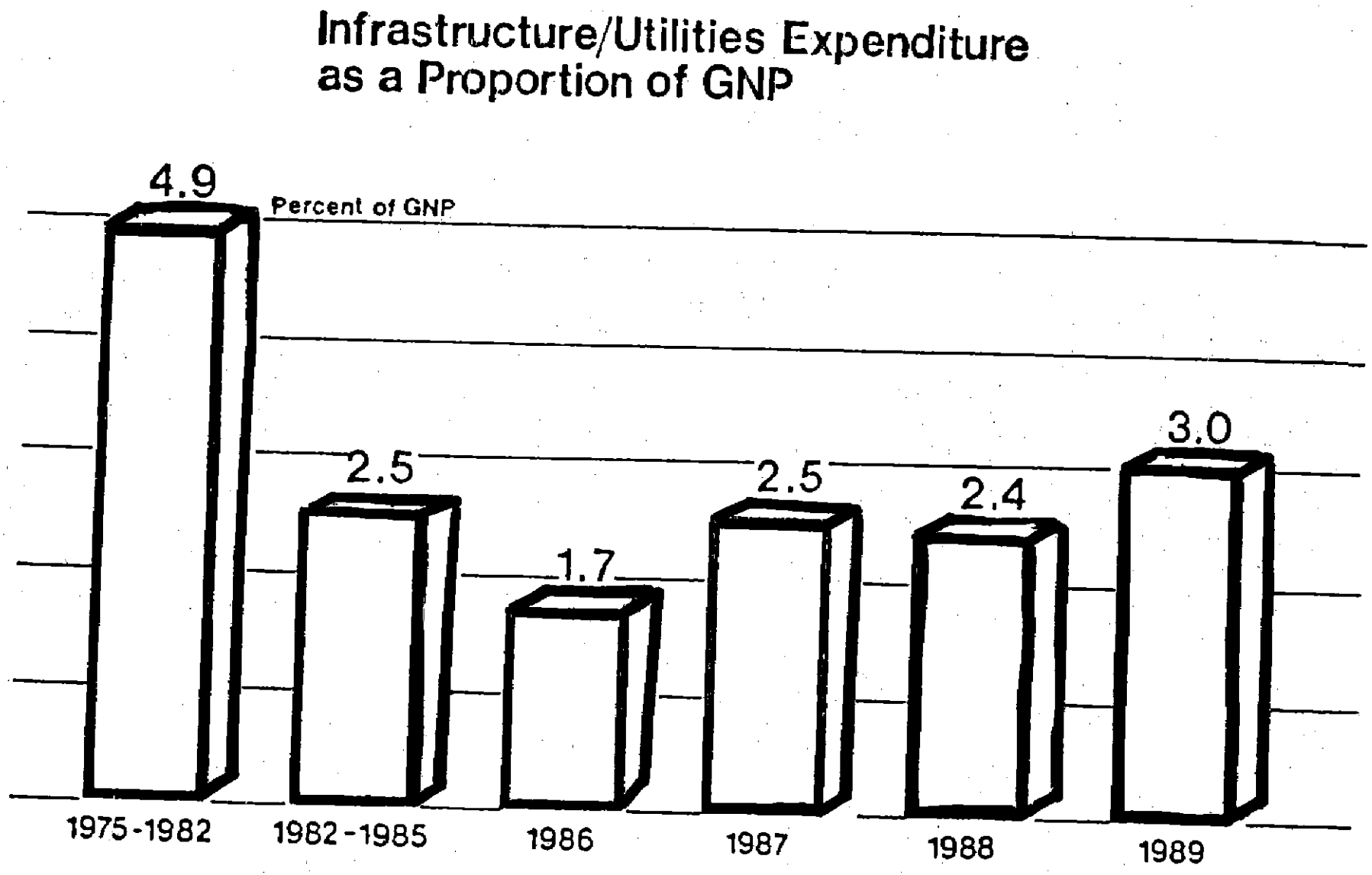
mechanization, land reform, agricultural wages and prices. Another factor is rural infrastructure. Although the Philippines and Taiwan had more or less the same initial conditions in 1960, the latter has, however, successfully developed its rural industries. The differences in rural industrialization between the two countries can be accounted for by differences in rural infrastructure. Provision of rural infrastructure in Taiwan has been substantially greater than in the Philippines. The recent crisis must have accentuated this difference. As may be shown in Figure 3, the ratio of government expenditure on infrastructure/ utilities to GNP substantially dropped during the crisis period. The 1989 budget still shows a much lower ratio compared to the pre-crisis period.

Based on these major points which we have discussed, the need for more policy-oriented researches on Science and Technology becomes imperative. This is where the role of our institution, the Philippine Institute for Development Studies, may come in.

V. Possible Research Collaboration

The Philippine Institute for Development Studies (PIDS) is a non-stock, non-profit government research corporation. Its specific objective is to undertake long-term policy-oriented research.

Figure 3


Infrastructure/Utilities Expenditure
as a Proportion of GNP
Percent of GNP
4.9
2.5
1.7
2.5
2.4
3.0
1975-1982
1982-1985
1986
1987
1988
1989

The research studies completed by PIDS have provided significant inputs to the government's policy formulation. Among the recently completed research projects are: the "Economic Recovery and Long-run Growth: Agenda for Reforms" which provided the framework for the Medium-Term Philippine Development Plan, 1987-1992, drawn up by the government; the "Agenda for Action for the Philippine Rural Sector," the policy recommendations of which were adopted by the Department of Agriculture; the "Macro-Econometric Model" which was extensively used by NEDA not only in planning and policy formulation but also in the simulation exercises required for the conduct of external debt negotiations with the country's creditors; and studies related to Trade Liberalization which provided valuable information and significant policy recommendations to the Tariff Commission's Tariff Reform Program. The financial autonomy of the Institute has enabled it to maintain its tradition of independent policy research relevant to government planning and policy decisions.

The preparation by the Institute of its research program and its annual research agenda involves the conduct of consultation with planners and policy makers in government, researchers from the academe, and private research institutions, and representatives from the private sector. Their participation in the process of program development helps ensure that the Institute's research is responsive to contemporary and anticipated needs and augurs well for the eventual adoption of research findings and recommendations. Currently, we have

research collaborations with the Department of Health, Agricultural Credit Policy Council (Department of Agriculture), Tariff Commission, Housing and Urban Development Coordinating Council, and NEDA.

And in view of the important role played by Science and Technology in economic development, we thought of formulating a policy-oriented research program in this area. Admittedly, this is something new to our Institute and expertise has yet to be developed.

We hope to arrange a research collaboration with the Department of Science and Technology. To ensure the utilization of research results, the users (i.e., DOST, other government agencies, and private sector) and producers (researchers) are expected to contribute to the formulation of policy-oriented research agenda on Science and Technology.

With decentralization being seriously pursued by the government, there is a need to improve the capability of Regional Development Councils to formulate and implement policies. In this regard, the Institute intends to establish and strengthen linkages with regional research institutions. We hope that the relationship the Institute has with policy making bodies at the national level can be replicated by regional research institutions with policy making entities at the regional level. In particular, we hope and expect to see more regional research institutions engage in researches that could serve as inputs to

policy making and planning at the regional level. It is in this area where we hope to be able to share the experience and technical expertise of our Institute with regional research institutions.

We hope that we can invite more views and suggestions on this from the audience during the open forum afterwards or even perhaps in some future dialogues.

On this note, we wish to thank you for giving us this opportunity to share our views on science and technology development.

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ANNEX

GNP PER CAPITA, R & D EXPENDITURES AND NUMBER OF SCIENTISTS AND ENGINEERS IN R & D

COUNTRY	GNP/CAPITA 1983 (US$)	R & D Expend as of GN	Scientists and Engineers in R&D per million population
Indonesia	560	0.4	116
Korea	2010	1.1	804
Philippines	760	0.2	156
Singapore	6620	0.3	296
India	260	0.7	132
Israel	5370	2.5	3991
Turkey	1240	0.3	167
Argentina	2070	0.2	369
Brazil	1880	0.6	256
Mexico	2240	0.5	80
US	10120	2.6	4458
	14110	2.7	3107

Sources: (1) The World Bank, World Development Report (1985)

(2) The World Bank, The Philippines: Issues and Policies in the Industrial Sector (1987)