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## Rates of Return to R&D Investment in the Philippines

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Philippine Institute for Development Studies

## Rates of Return to R&D Investment in the Philippines

*Caesar B. Cororaton*

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

**RATES OF RETURN  
TO R&D INVESTMENT  
IN THE PHILIPPINES  
(FINAL REPORT)**

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# **Rates of Return to R&D Investment in the Philippines<sup>1</sup>**

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

## **Introduction**

The primary objective of this paper is to estimate the rates of return to investment in research and development (R&D). R&D is defined as any systematic and creative work undertaken in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this knowledge to devise new applications.<sup>3</sup> There are three major categories of R&D activities. These are: research, applied research, and experimental development.

Using a production function approach, the paper attempts to estimate the rates of return to R&D investments in three major sectors, namely (i) primary sector – which includes agriculture and mining industries; (ii) industry sector – which includes manufacturing, construction and utilities; and (iii) service sector – which includes transportation, trade, finance, and other services.

The secondary objective of the paper is to compare the rates of return to R&D investment in these sectors with other forms of investment like

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

physical capital includes fixed assets such as machineries and equipment, building and facilities, land, and etc.

### **Rates of Return to R&D Investment: A Brief Review**

Although the estimation techniques used to compute for the rates of return to R&D investment are far from perfect mainly because of data problems, the rates of return found in the literature for both developed and developing countries and for both agriculture and industry are encouragingly high. Evenson and Westphal (1995) surveyed results of 156 studies estimating the rates of return to R&D investments in agriculture and 40 studies in industries. They found that, indeed, the rates are very high, even higher than other forms of investment like infrastructure. Table 1 shows that of the public agricultural research conducted across different countries, more than half of the results of the studies surveyed show rates of return higher than 50 percent. Only few studies show rates of return estimates which are lower than 10 percent. It is also worth noting that in terms of the distribution of estimated returns, developing countries have higher estimated rates compared to developed countries.

There are fewer studies which report estimates of the rates of return to the private sector R&D investment in agriculture compared to the public sector. However, some studies would point to a similarly high rates of return to private sector R&D in agriculture.

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

In the Philippines, Librero (1997) surveyed studies on the rates of return to investment in agricultural research for selected countries and commodities. She found the same high pattern of estimates of rates of return. The estimated rates of return are shown in Table 2. In the Philippines, estimated rates of return are particularly high for sugarcane, mango, and poultry.

Higher rates of return to R&D investment have been recognized by policy makers in the Philippines as well. In fact, in the 1997 Agriculture Modernization Bill of the Philippine Congress, a rate of return to R&D investment in agriculture was placed at 35 percent. "Investment in research and extension aimed at improving agricultural productivity has an annual rate of return of at least 35 percent" (report of the Congress of the Philippines on Agricultural Modernization, 1997, page 90).

On the other hand, few studies have estimated returns to industrial R&D in developing countries. This is because "it is exceedingly difficult to measure directly the overall volume of technological effort related to technological change in the industrial sector. Generally, one can at most infer the results of such activity from estimates of productivity growth." (Evenson and Westphal, 1995). In spite of this, the limited number of estimates of rates of return to industrial R&D investments indicate similarly very high numbers.

In the Philippines, there are practically no estimates available on rates of return to industrial R&D, except for the study of Pack (1987, 1990) which focused on the computed potential returns from productivity enhancing expenditures on adaptive modifications and skills development in a sample of Philippine textile firms. His results indicate that more than 80 percent of the firms in the industry would realize higher returns from such expenditures than from alternative investments.

Among the possible reasons for these high returns to R&D investments is through the achievement of efficiency gains as a result of R&D. Evenson and Westphal claims that "Most LDC firms are well behind the local

production frontier and even further behind the frontier of international best practice. Given this evidence, the estimates suggest that there is tremendous potential for realizing high returns from investments that would enable the achievement of best practice.”

Another possible reason for the high rates of return to industrial R&D is the spillover effects of R&D results across different sectors and industries, including agriculture. Griliches (1991) and Nadiri (1993) have looked into a number of empirical estimates and found that R&D spillovers are of substantial importance, which provided evidence that social returns are considerably in excess of private returns.

### **R&D Effort in the Philippines**

There are two indicators of the level of R&D effort of a particular country. These indicators are: (a) R&D expenditure-to-GNP ratio; and (b) the number of scientists and engineers relative to total population. Cororaton (1998) surveyed UNESCO-based data on these indicators for 91 countries and found that the Philippines ranks very low in terms of R&D effort. Table 3 shows that out of 91 countries the Philippines is at the 73<sup>rd</sup> place in terms of the number of scientists and engineers per million population. It has only 152 scientists and engineers per million population. This is far below the maximum of 6,736 scientists and engineers per million population. In terms of R&D expenditure to GNP ratio, the Philippines is at the 60<sup>th</sup> place with a ratio of 0.2 percent in 1992. This is far below the maximum of 3 percent.

The low number of scientists and engineers is reflective of the general tendency of the educational system in the Philippines to produce non-technical graduates. Table 4 shows that while the Philippine educational system produces a very high number of tertiary graduates, the post-baccalaureate science and engineering students as a percent of post-baccalaureate students is very low. In column 6 of the table, the Philippines ranks the lowest in the list with a ratio of only 8.65. This is far from the second

lowest of 20.76 percent, which is for New Zealand. The highest is China with a ratio of 74.26 percent.

Furthermore, in a recent survey conducted by PIDS (Cororaton, et al 1998) on R&D personnel it was observed that a very high percentage of personnel with PhD degrees in the Philippines are not in engineering and technology but in social sciences (see Figure 1).

## **Framework of Analysis**

Different Approaches in the Literature. Empirical estimates of the rate of return to R&D investment have used three different approaches: (i) economic surplus approach; (ii) financial approach; and (iii) production function approach.

In the economic surplus approach, changes in productivity can be attributed to shifts in the supply function. Together with econometrically estimated demand and supply elasticities, the supply shifts are the basis for estimating changes in consumer and producer benefits (i.e., changes in consumer and producer surplus).

The conceptual basis of the financial approach for the private rate of return can be drawn from straightforward estimation of the internal rate of return to an investment by a firm. With an investment decision at time  $t$ , the firm could estimate the flow of benefits it received from the investment over time against the initial cost of the investment. The internal rate of return of the investment is the value of  $r$  which solves the equation:

$$(1) \quad C_t = \frac{B_{t+1}}{(1+r)} + \frac{B_{t+2}}{(1+r)^2} + \dots + \frac{B_{t+L}}{(1+r)^L}$$

where:  $B$  = flow of benefits;  $C$  = cost of investment;  $L$  = life of investment



For the special case where the flow of benefits is constant over time, (1) can be simplified as follows;

$$(2) \quad r = B / C$$

While this approach may well be appropriate to estimating private rate of return to R&D investment, it may be very difficult to adopt in estimating the social rate of return to such investment, which includes not only the private return to the technology developer but also to other sectors as well as to other members of the society. In other words, the spillover effects of private R&D activities cannot well be accommodated in this particular approach. The social return to a private research investment is usually higher than the private return to the firm.

Lastly, in the production function approach three statistical frameworks are used in the literature. In general, each of these frameworks involve the following procedure:

- (a). Total factor productivity (TFP) are estimated using output data and data on conventional factor inputs like labor and capital services. TFP results are then regressed against information on TFP-enhancing activities like investments on research, extension, schooling, infrastructure, etc.. These variable are called “meta” variables. Rates of return to R&D investment are obtained from the parameter estimates of the regression.
- (b) Direct estimation of production function wherein output variable is regressed against the conventional factor inputs and the meta variables. Rates of return to R&D investments are inferred from the estimated parameters. The production specification could be the simple Cobb-Douglas, or other more flexible specifications.
- (c) Profit functions or output-supply, input-demand systems are estimated using the conventional factor inputs and the meta variables. The theory on duality in production, together with the assumption of competitive markets are invoked to obtain

estimates of production function parameters. Rates of return to R&D investment are derived from these parameters.

In the present study, the second procedure of the third approach is adopted. In particular, item (b) of the third approach is used. The “meta” variable included in the production function estimation is the stock of R&D. There two types of R&D stocks used: R&D stock with no spillover effects, and R&D without spillover effects. The detailed discussion of the approach is discussed in the next section.

Approach Adopted in the Paper. A production function approach is adopted in the paper. Consider a Cobb-Douglas production function with three factor inputs<sup>4</sup>

$$(3) \quad Q_i = A_i L_i^\alpha K_i^\beta R_i^\gamma e_i^{\lambda t}$$

where  $Q_i$  is value added of sector  $i$ ;  $L_i$  is labor input;  $K_i$  capital input; and  $R_i$  R&D stock;  $t$  is time;  $A_i$  is a shift parameter and  $\alpha, \beta, \gamma, \lambda$  are production function parameters to be estimated.

Taking logarithm of (3), assuming constant returns to scale, and differentiating partially with respect to  $t$  will lead to

$$(4) \quad dT/T = \lambda + \gamma (dR/R)$$

Note that  $T = Q/(L^\alpha K^{1-\alpha})$  represents total factor productivity. Therefore,

$$(5) \quad dT/T = \lambda + \rho (dR/Q)$$

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<sup>4</sup> Based on the discussion of Jiann-Chyuan Wang (1998).

where  $\rho = dQ/dR$  represents the marginal output of R&D, or the rate of R&D contribution to value added. Also,  $dR/Q$  represents R&D intensity.

Equation (5) is usually called intensity model. Sometimes it is used to estimate the return to R&D investment. One advantage of using (5) to estimate the rates of return is that it can obtain results without having to estimate R&D stock. However, it has one major disadvantage. Since  $\rho$  is a function of  $Q$  and  $R$ , it cannot be considered as a constant in a strict sense. In fact, some studies have obtained  $\rho$  under that assumption that  $Q/R$  is constant. As such, it not be totally appropriate to directly employ (5) in estimating rates of return to R&D investments. A far more better approach is to estimate R&D stock and estimate (3) directly. This is the approach adopted in the paper. Furthermore, similar to Jiann-Chyuan Wang (1998), the analysis has been extended to incorporate inter-industry linkages to be able to capture the spillover effects of R&D activities.

A general form the estimator of R&D stock takes the following form

$$(6) \quad R_t = \sum_{i=1}^T \mu_i E_{t-i} + (1 - \delta) R_{t-1}$$

where  $R_t$  is R&D stock of period  $t$ ;  $E_{t-i}$  is R&D expenditure lagged period  $i$ ;  $\mu_i$  is parameter which captures the rate at which expenditure turns into R&D stock;  $i$  is the number of years for R&D expenditure to become an R&D stock;  $\delta$  is the rate of obsolescence of R&D stock. As in Goto and Suzuki (1989) Equation (6) can be simplified into a form which is similar to the perpetual inventory formula for capital stock estimation

$$(7) \quad R_t = E_{t-i} + (1 - \delta) R_{t-1}$$

Initial R&D stock can be estimated using the following formula

$$(8) \quad R_{t-1} = E_{t-i} / (g + \delta)$$

There are no available information on the average time R&D expenditure turns into R&D stock. In the present case the assumption was made that it generally takes about 2 years for R&D investment to be come a productive R&D stock, i.e.,  $i = 2$ . Similarly, there are no information related to the rate of obsolescence of R&D stock . However, obsolete R&D stock is a stock of current new knowledge and its depreciation rate should be very minimal. Given this, an assumption was made that  $\delta$  be equal to zero. The parameter  $g$  in Equation (8) can be estimated by the natural logarithmic growth of R&D expenditure.

R&D stock computed using Equation (7) is the stock of R&D without spillover effects. In estimating R&D stock with spillover effects, inter-industry linkages have to be taken into account. Inter-industry linkages are captured by the input-output (I-O) table. That is, R&D with spillover effects can be computed using the following formula

$$(9) \quad R_t = E_{t-i}^S + (1 - \delta) R_{t-1}$$

where

$$(10) \quad E_{t-i}^S = E_{t-i} (I - a_{ij})^{-1}$$

$a_{ij}$  is the I-O technical coefficient. The last bracketed term in Equation (10) captures the total effect (direct and indirect effects) of sectoral R&D investment.

I-O tables are not available annually, but in a span of four to five years. Thus, in the estimation the 1979 I-O table was applied for the years 1979 to 1982 sectoral R&D expenditure. The 1983 I-O table was applied for 1983 to 1984. For 1985 to 1989, the 1985 I-O table was used. Lastly, the 1990 I-O table was applied from 1990 to 1996 R&D sectoral expenditure table. The results are shown in Appendix A.

## **Empirical Results**

To derive the estimating equation of (3), the variables were expressed in per labor units (i.e., Q, K, and RD were expressed as ratios to L which is labor). Furthermore, the variables were converted into natural logarithmic form so that (3) becomes a linear relationship. With a linear relationship, ordinary least squares (OLS) can be directly applied. That is, the estimating equation is

$$(3') \quad q_{it} = a_i + \beta_i k_{it} + \gamma_i r\&d_{it} + \lambda_i t + \text{error}_{it}$$

where q, k, and r&d are the natural logarithm of the variables in (3) in per labor units. The last item in (3') is the usual error term. The estimated parameter  $\beta$  can be used to indicate the rate of return to other forms of capital investment, while the parameter  $\gamma$  is the estimate of the rate of return to R&D investment. The parameter  $\lambda$ , which is the coefficient of the time trend, can be used to indicate the average the total factor productivity (TFP) of sector i over the estimation period, 1982-1996.

The estimating equation (3') was estimated using OLS on data for the primary sector, industry, and the service sector. The period of estimation is from 1982 to 1996. The regression results are shown in Table 5.

Table 5 has 12 columns. Column 1 lists the name of the sector. Column 2 is q in Equation (3'). Column 2 is the estimated value of a. Column 4 is the estimated value of  $\beta$ . Column 5 is the estimated value of  $\gamma$  for r&d without spillover effects, while column 6 is the estimated value of the same parameter for r&d with spillover effects. Column 7 is the estimated value of  $\lambda$ . The value of this parameter is an indicator of the total factor productivity of the sector. Column 8 shows the correction for autoregression. Note that in time series data, the problem of autoregression will usually exist. If this exists, it will affect the efficiency of the parameter estimates. With the introduction of the variable AR(1) into the regression, this problem is minimized. This is

indicated by the improvement in the D-W statistics shown in column 10 after the AR(1) correction. The rule of thumb is  $D-W = 2$ . Thus, a movement of this statistics towards the value of 2 would indicate an improvement. Column 9 shows the “goodness of fit” of the estimated equation, while column 11 is the usual F-test. The last column shows the sample period. Moreover, the numbers in parenthesis “( )” show the t-test value. There are four sets of results per sector: two for r&d with no spillover (with and without trend variable) and another two for r&d with spillover (also, with and without trend variable).

Generally, the estimating equations do fit the historical data quite well. This is indicated by the high adjusted R squared in column 9 for all sectors.

**Primary Sector.** The TFP estimates for the primary sector is not statistically significant with a t-test value of less than 1. However, the coefficient is negative, indicating that the total factor productivity of the primary sector is declining by  $-0.2$  percent on the average. This indicates inefficiencies in the process of production in this particularly sector. That is, the production process of the primary sector cannot crank out enough output volume for a given volume of factor inputs because of production efficiencies. This is consistent with the TFP results of Cororaton and Caparas (1998) for agriculture using a different TFP measurement which is growth accounting method (Table 6). In that study, the agriculture sector, which captures the biggest part of the primary sector, has an average TFP of  $-1.3$  percent. However, the mining sector has positive TFP.

One of the interesting results of the regression is the high rates of return to R&D investment in the primary sector. For R&D without spillover effects, the results show estimates ranging between 54 percent and 60 percent. For R&D with spillover effects, the range increases between 57 percent and 62 percent. This is generally consistent with the survey of estimates discussed in the previous section which showed high rates of return to R&D investment in the agricultural sector across countries. However, in the

present estimates, the results show that there is a small effect due to spillover; only about 3 percent.

Another interesting set of results is that the rate of return to R&D investment is higher than the rate of return to other capital investment. The coefficients of capital in column 4 for the primary sector are lower than the coefficients of either column 5 or 6.

One should note that the relevant estimated coefficients (columns 4 to 6) are all statistically significant.

**Industry.** The estimated TFP for industry is positive and statistically significant. The coefficient of the trend variable shows an average TFP growth of +0.9 percent for the period. Again, this is consistent with the results of Cororaton and Caparas (1998) for the manufacturing and utilities industries, which capture the biggest share of the total industrial sector (Table 6).

However, the estimated rates of return to R&D investment in industry are relatively low, only about 10 to 12 percent. This range of estimates is almost similar to the results generated by Cororaton and Abdula (1997) in Table 7 wherein TFP of the manufacturing sector was analyzed against a host of determinants including R&D expenditure. The coefficient of R&D expenditure is 0.101 (or approximately 10 percent) almost similar to the coefficient derived in the present study using an entirely different approach and data base.

The two sets of coefficients are similar and comparable in the sense that both indicate elasticities. The results in Table 5 are coefficients of regression of variable in natural logarithmic form, while the coefficient of R&D expenditure in Table 7 are in first difference.

Furthermore, there is practically no spillover effects, as shown by the very small difference between the estimated coefficients of R&D with

and without spillover effects. However, the rates of return to other capital investment are very high, estimates ranging from 88 to 94 percent.

**Service.** Total factor productivity of the service sector has been declining at an average of -2.9 percent for the sample period. This is indicated by the coefficient of the time trend variable in column (7) of Table 5 for the service sector. Again this is consistent with the TFP results in Table 6 using growth accounting method wherein all the subsectors of the service sector registered negative TFP growth.

The coefficients of all the relevant variables are statistically significant. The rates of return to R&D investment in the service sector are high. The estimates range between 60 and 62 percent. However, the spillover effects are also very small. The difference between the coefficients of R&D (with and without spillover effects) range between 1 and 2 percent, indicating a small spillover effects.

Similar to the primary sector, the rates of return to R&D investment are higher than the rates of return to other capital investment. The gap is about 20 percent, in favor of R&D investment.

### **Sectoral Performance and R&D Allocation**

Table 8 presents some indicators of sectoral performance and allocation of R&D resources. Except for the period 1982-1985, both industry and service sectors performed above the primary sector in terms of growth. Over the same period, there were no significant structural changes. The share of the primary sector declined slightly from 25 percent in 1986-1990 to 24 percent in 1991-1996. The share of the industry sector remained at 33 percent over the same period. Thus, the slight decline in the share of the primary sector went to the service sector from 41 percent to 43 percent in 1991-1996. However, there were noticeable changes in the sectoral shares of employment. The employment share in the primary sector declined from 51



percent in 1982-1985 to 45 percent in 1991-1996. Both the employment share in industry and service sectors increased over the same period.

Results on total factor productivity (TFP) showed dismal performance. The TFP of the primary sector declined by  $-0.2$  percent on the average during the period 1982-1996. The TFP of industry increased marginally by  $0.9$  percent on the average over the same period, while TFP of the service sector dropped by  $-2.9$  percent on the average.

It has been established above that R&D positively affects productivity and growth. However, there was been a decline in the share of R&D expenditure to GNP from  $0.20$  percent in 1979-1984 to  $0.18$  percent in 1989-1992. The share of R&D expenditure that went to agriculture-related services increased from about  $32$  percent in 1979-1990 to  $43$  percent in 1990-1996. The share of engineering and technology declined from  $40$  percent in the period 1979-1985 to  $22$  percent in 1990-1996. The share of "others", which is generally comprised of service-related activities, increased from  $28$  percent in 1979-1985 to  $35$  percent in 1990-1996.

In terms of sources of R&D funds, a few changes took place. The share of government agencies declined from  $67$  percent in 1979-1984 to  $52$  percent in 1989-1992, while private increased from  $18$  percent to  $26$  percent. The share of higher education more than doubled over the same period.

### **Summary and Policy Implications**

**Summary.** For both the primary and the service sectors the rates of return to R&D investment is about  $60$  percent. The results also show that, for both sectors, the rates of return to other forms of capital investment are generally lower than to R&D investment. The difference is about  $20$  percent. However, the spillover effects, after taking into account the inter-industry linkages, are found to be small. For both sectors the impact of

spillover effects ranges from 1 to 3 percent. Also, TFP growth for both sectors are negative, indicating production inefficiencies.

The results for the industry are different. The rates of return to R&D investment in industry is only about 10 to 12 percent. These results are consistent with other estimates derived using different rates of return methodology. The rates of return to other form of capital investment are a lot higher than to R&D investment in industry. There are practically no spillover effects of R&D investment in industry. However, it registered a positive total factor productivity growth.

The impact of R&D activities and the rates of return vary across sectors. This therefore indicates that for R&D resources to better affect and impact on the overall efficiency of the economy in general, the resources would have to be allocated properly. One criterion which can guide better R&D resource allocation is the rates of return. Certainly, the sets of results derived from this paper can be used towards that end.

**Policy Implications.** The rates of return to R&D investment computed in the paper, as well as those found in the literature, are encouragingly high. Furthermore, productivity is positively affected by R&D activities. This therefore implies that R&D investment is not only important in the process of development, but also it has generally better payoffs than other forms of investment. For both primary and service sectors, the rates of return are about 60 percent, generally consistent with those found in other studies done in other countries. However, the rates of return to industry R&D are generally lower.

For purposes of policy, the following R&D-related issues are relevant:

1. There is a need to increase further R&D investment, especially in the primary sector which is dominated by the agricultural sector. Productivity is positively affected by R&D efforts in this sector and the rates of

return is encouragingly high. In most agricultural commodities, there are problems of how to appropriate the returns to R&D investments. Thus, this would require further government, well-focused, commodity-specific, initiatives.

2. There is a need to encourage private sector involvement in industry R&D for two major reasons: (i) it is not as difficult to appropriate the returns to R&D investment in industry as compared to agriculture for as long as institutional safeguards like patents and intellectual property rights (IPR) are well-functioning; and (ii) ideally, the private sector is supposed to be active in industry R&D activities as shown in Figure 2 where there is very high private sector participation in high growth and prosperous economies such as South Korea, Japan, Taiwan, Hongkong, and Malaysia. The Philippines belongs to countries with low private sector participation in R&D activities.

Furthermore, aside from institutional infrastructure that support R&D activities like patents and IPR systems, the private sector also respond to incentives. The Philippines offers incentives to the private sector for R&D undertakings through the Board of Investments (BOI). However, the results are not encouraging. In fact very poor, because only few companies avail of such incentives. Over the period 1990-1997, only 11 companies with a total of 13 projects were granted with incentives. This extremely poor track record can be attributed to institutional inefficiencies.

Based on a survey and company interviews conducted under the R&D study, Nolasco (1998) prepared a checklist of gaps related to the R&D incentive scheme in the Philippines. One of the major problematic gaps deals with the unfocused and not well-coordinated system of R&D prioritization in terms of R&D in different government departments and agencies. "The departmental backdrop is always loose and chaotic. NEDA has different set of strategic sectors. BOI and DTI have different concerns. Other departments have their own. In a certain nook, DFA and NEDA have conflicting interests with the BOI planners in terms of incentives granting. DOE is looking into the possibility of developing wind energy, while DOST is

eyeing the solar energy. The backdrop is so parochial, and are losing cadence.”

Another gap deals with the very limited support facilities available. “Support facilities like testing centers (either government-run or government subsidized), standardization institution, as well as support industries like casing and others are lacking or non-existent at all in the country”

Another deals with the system having a lack of outward “reach”, resulting in cases where only a handful of numbers firms, usually large ones, are able to benefit. Furthermore, the staff and people concerned in the incentives promotion are not well familiar with the system itself. For example, they are “not even aware of the: (1) the content of R&D incentive scheme LOPA; and (2) that R&D has existed for more than six years now. Most of those who are familiar with the scheme would only recall R&D being integrated to the IPP LOPA two years ago, when in fact, it was as early as 1991 that this has been included.”

There is a very weak link between the government and the private sector in terms of R&D activities. In fact, there is no respectable databases and information network on the latest technology that can be easily accessed by the firms.

These are few cases of institutional inefficiencies which prevent a great deal the private sector from participating in R&D activities.

## TABLES AND FIGURES

**Table 1. Estimated Rates of Return to R&D**

	Number of Studies	Estimate not Significant	Significant Estimates Range of Estimates (%)				Mean
			1-24	25-49	50-75 75+		
<b>Public Sector Agriculture Research</b>							
Africa	10	1	2	3	3	1	41
Latin America	36	2	14	22	13	13	46
Asia	35	2	7	20	23	25	56
All Developing Countries	85	5	23	45	40	44	80
All Developed Countries	71	5	21	54	26	29	48
<b>Private Sector Industrial Research</b>							
Developing Countries	5	0	0	3	3	2	58
Developed Countries	35	0	10	20	10	5	44
<b>Public Sector Agriculture Extension</b>							
Developing Countries	17	1	4	2	4	6	50
Developed Countries	6	0	1	0	3	2	63

Source: Evenson and Westphal (1995)

**Table 2. Rates of Return to Investment in Agricultural Research  
for Selected Countries and Commodities**

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

Source: Librero (1997)

**Table 3: Indicators of R&D Effort: The  
Philippines**

Variables	Maximum	Minimum	Rank of the Philippines	Level for the Philippines
Per Capita GNP (US\$, 1994)	34,630	80	68th	950
Scientists and Engineering per million population	6,736	8	73rd	152*
Gross expenditure in R&D/GNP (%)	3	0	60th	0.2*

\* 1992 level

Source of basic data: UNESCO

**Table 4: Tertiary Education Across Selected Pacific Rim  
Countries**

Country/Year	(1)	(2)	(3)	(4)	(5) (6)	
China (1991)	2,124,121	0.17	80,459	3.79	59,748	74.26
Japan (1989)	2,683,035	2.13	85,263	3.18	54,167	63.53
South Korea (1991)	1,723,886	3.83	92,599	5.37	28,479	30.76
Australia (1991)	534,538	2.92	92,903	17.38	26,876	28.93
Singapore (1983)	35,192	1.13	1,869	5.31	532	28.46
Malaysia (1990)	121,412	0.58	4,981	4.1	1,251	25.12
Thailand (1989)	765,395	1.24	21,044	2.75	4,928	23.42
New Zealand (1991)	136,332	3.78	13,792	10.12	2,863	20.76
Philippines (1991)	1,656,815	2.39	63,794	3.85	5,520	8.65

Column Definition:

(1) : Number of students at tertiary level

(2) : Number tertiary students as percent of population

(3) : Number of post-baccalaureate students

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

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

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

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

**Table 5: Rates of Return to R&D Investments, by Major Sectors**

Sectors	Dependent Variable	Constant	Coefficient of Capital-Labor Ratio	Coefficient of		Trend	AR(1)	Adj R <sup>2</sup>	D-W	F	Sample Period
				R&D Stock-Labor Ratio <i>No Spillover</i>	R&D Stock-Labor Ratio <i>With Spillover</i>						
Primary	GVA-Labor	2.221 (16.876)	0.481 (3.613)	0.542 (4.782)			0.516 (2.496)	0.989	1.486	434.909	1982-96
		2.030 (19.494)	0.459 (3.392)		0.568 (4.832)		0.529 (2.654)	0.990	1.482	464.673	1982-96
		6.326 (1.154)	0.434 (2.820)	0.598 (4.267)		-0.002 (-0.750)	0.469 (2.037)	0.989	1.371	310.626	1982-96
		6.091 (1.150)	0.415 (2.710)		0.621 (4.437)	-0.002 (-0.002)	0.479 (2.126)	0.989	1.373	332.077	1982-96
Industry	GVA-Labor	-8.798 (-0.009)	0.939 (15.359)	0.106 (2.083)			1.001 (8.166)	0.995	0.718	968.069	1982-96
		-1.473 (-0.596)	0.942 (15.502)		0.105 (2.109)		0.982 (8.027)	0.995	0.721	985.864	1982-96
		-20.040 (-5.845)	0.886 (14.415)	0.122 (2.208)		0.009 (5.232)	0.559 (2.010)	0.997	0.769	1144.111	1982-96
		-19.133 (5.804)	0.887 (14.628)		0.120 (2.206)	0.009 (5.205)	0.560 (2.02)	0.997	0.757	1136.466	1982-96
Service	GVA-Labor	-11.301 (-0.037)	0.420 (4.575)	0.607 (4.669)			0.998 (16.977)	0.946	1.344	82.655	1982-96
		-7.566 (-0.047)	0.416 (4.709)		0.614 (4.865)		0.997 (16.965)	0.950	1.384	89.393	1982-89
		50.738 (2.426)	0.419 (4.150)	0.600 (4.112)		-0.029 (-2.36)	0.789 (3.702)	0.947	1.265	634.000	1982-89
		53.944 (2.422)	0.410 (4.189)		0.621 (4.411)	-0.026 (-2.344)	0.753 (3.356)	0.952	1.248	69.744	1982-89

**Note: all variables are in natural logarithmic form**

**Table 6. Average Total Factor Productivity Growth  
Using Growth Accounting Method, 1980 - 1996**

Sector	TFP (%)
Agriculture	-1.3
Mining	1.56
Manufacturing	1.01
Construction	-5.88
Utilities	4.38
Transportation	-0.68
Trade	-5.53
Fiance	-6.84
Other Services	-1.81

Source: Cororaton and Caparas (1998)

**Table 7: Determinants of TFP Growth in Manufacturing**

Variables	Coefficients	t-tests
Constant	5.316	(27.267)
Exports(-1)	0.148	(8.581)
Imports(-1)	-0.519	(-18.522)
D(Tariff)	-1.74	(-33.438)
Wage	-0.126	(-9.353)
<b>DRD(-1)</b>	<b>0.101</b>	<b>(9.353)</b>
FDI(-2)	0.005	(-14.081)
INF	-0.153	(-14.081)
INF(-1)	-0.468	(-23.088)
Adjusted R2	0.997	
DW	0.65	
F-Stat	448.63	
Where:		
Exports(-1): real growth of exports, lagged one period		
Imports(-1): real growth of imports, lagged one period		
D(tariff): period differential of average nominal tariff rates		
Wage: growth of research and development expenditure as % of GDP		
lagged one period		
FDI(-2): foreign direct investment		
INF: inflation		
INF(-1): Inflation, lagged one period		

Source: Cororaton and Abdula (1997)



**Table 8: Sectoral Performance VS R&D Allocation**

**A: Average Growth (%) of Real Gross Value Added**

	1982-1985	1986-1990	1991-1996
Primary	-0.9	2.4	1.7
Industry	-6.3	5.4	3.1
Service	0.9	5.7	3.2

**B: Average Distribution of Gross Value Added (%)**

	1982-1985	1986-1990	1991-1996
Primary	24.7	25.3	23.6
Industry	37.1	33.4	33.4
Service	38.2	41.3	42.9
	100.0	100.0	100.0

**C: Average Employment Distribution (%)**

	1982-1985	1986-1990	1991-1996
Primary	51.1	47.5	45.1
Industry	13.9	14.2	15.4
Service	35.1	38.3	39.5
	100.0	100.0	100.0

**D: Average Total Factor Productivity Growth (%)**

	1982-1996
Primary	-0.2
Industry	0.9
Service	-2.9

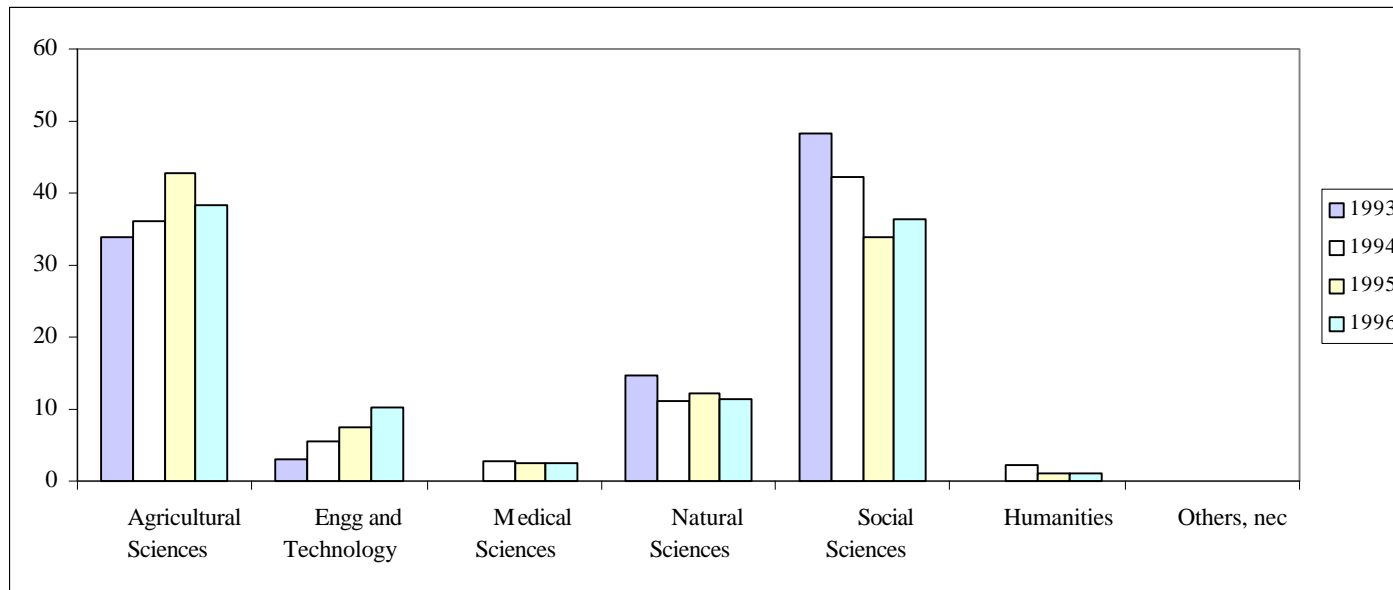
**E: Allocation of R&D Resources (% distribution)**

	1979-1985	1986-1990	1990-1996
Agriculture services	31.7	31.6	42.7
Engineering and Tech	40.3	24.2	22.2
Others	28.0	44.2	35.1
Total R&D	100.0	100.0	100.0

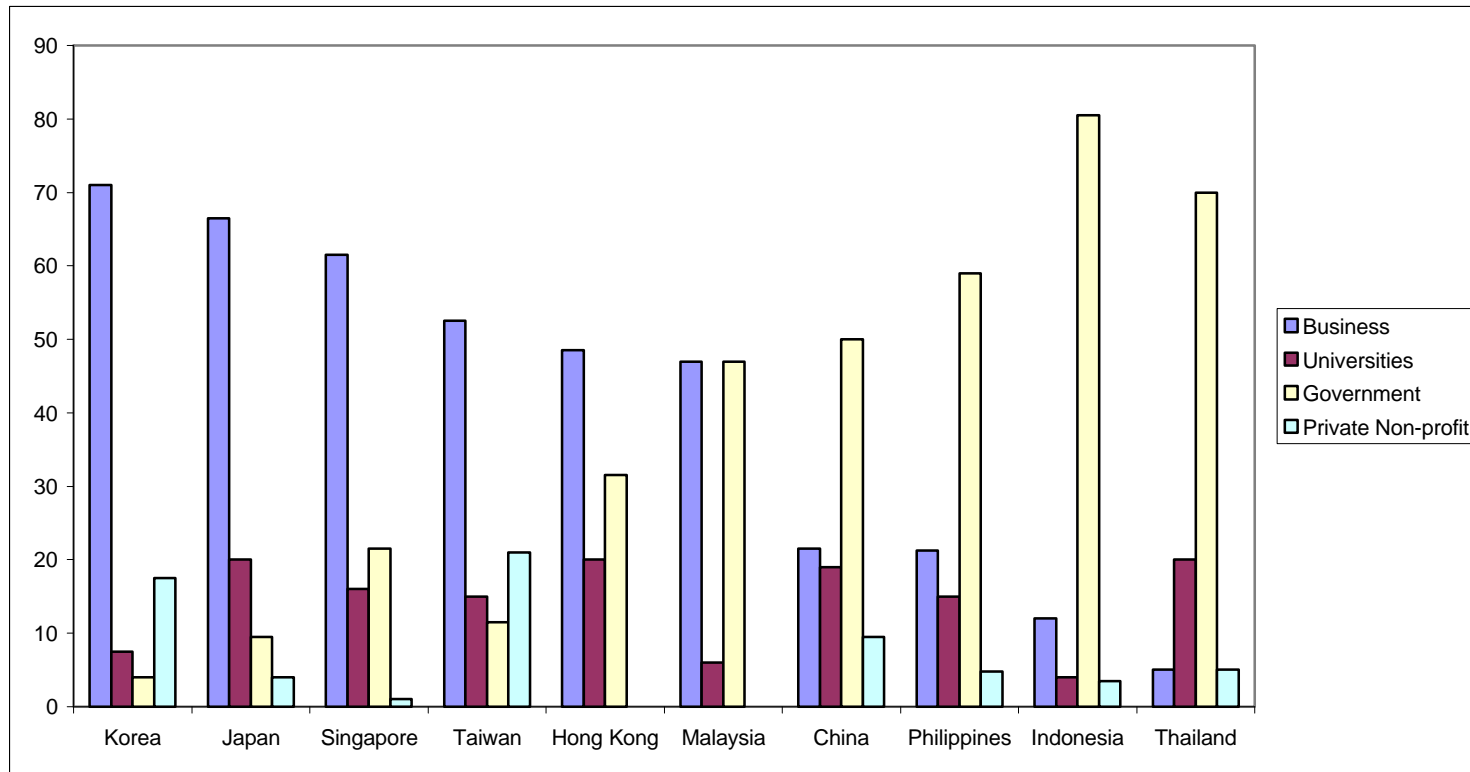
**F: Sources of R&D Investment (average % distribution)**

	1979-1984	1989-1992
Total	100.0	100.0
Govt Agencies	67.0	52.1
Private Industry	18.4	25.8
Higher Education	6.3	14.7
Non-Profit Institutions	8.3	7.3
R&D Spending/GNP (%)	0.20%	0.18%

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



**Figure 2. Percentage of R&D Expenditure by Sector of Performance**



## **APPENDIX A**

### **SECTIONAL R&D EXPENDITURE**

Historical data series on sectoral R&D expenditure is required in the rates of return analysis/framework adopted in this paper. There are three major sources of R&D expenditure which can be used to establish the required historical data. These are:

- (1) “Compendium of Available S&T Statistics”. S&T Resource Assessment and Evaluation Division. Planning and Evaluation Service. Department of Science and Technology. Bicutan, Taguig, Metro Manila, Philippines, June 1992.
- (2) “National Survey of Scientific and Technological Activities (NSSTA)” Integrated Report. S&T Resource Assessment and Evaluation Division. Planning and Evaluation Service. Department of Science and Technology. Bicutan, Taguig, Metro Manila, Philippines
- (3) “Survey of Activities in Research and Development” A Draft Report Submitted by the Philippine Institute for Development Studies to the Technical Working Group on R&D. June 30, 1998.

The first source contains data from 1979 to 1984. The second source from 1989 to 1992, while the last contains information on the survey conducted for government agencies and state universities on R&D activities for the period 1993 to 1996. Based on the available source of information, data series can only be established from 1979 to 1996. Furthermore, information from these sources are not complete to establish the required data series. Thus, a number of assumptions were applied to complete the data construction. The purpose of this appendix is to discuss in detail the assumptions applied.

Tables A1 and A2 present data taken from the first two sources. National R&D expenditure is broken down into four institutional sectors:

government agencies, private industry, higher education, and non-profit organizations (or NGOs). One can observe that there are no information from 1985 to 1988. There are also no information for the private industry and the non-profit organizations and private universities and colleges part of the higher education sector from 1993 to 1996.<sup>55</sup>

### **Total National R&D Expenditure**

The first assumption applied for those years with no estimate of total national R&D expenditures was to assume an R&D-GNP ratio of 0.15 percent. This is a realistic assumption given the historical ratio for the years 1979 to 1984 and 1989 to 1992. Given this assumed ratio and the actual data on gross national product (GNP) the total national R&D expenditure for the said years with no estimates can be derived. The derived expenditure estimates for these years are shown in Table A3. One can observe that with 0.15 percent ratio, the total R&D expenditure in 1996 amounts to almost P3.4 billion.

### **Institutional Sector Breakdown of Expenditure**

The next data problem encountered was how to break down the estimated total national R&D expenditure into institutional sectors: government agencies, private industry, higher education, and non-profit organizations for the years with no available information. A number of steps were taken to arrive at the breakdown:

- (a) Percentage distribution of total expenditure into these major institutional sectors were computed for the years when actual data are available, i.e., 1979 to 1984 and 1989 to 1992.

---

<sup>55</sup> The National Statistical Office (NSO) is currently undergoing a survey on R&D activities of the private industry and private higher educational institutions for the period 1993 to 1996. The Philippine Institute for Development Studies (PIDS) has preliminary survey results of government agencies and state universities and colleges on R&D activities for the period 1993 to 1996.

- (b) For the in-between years, 1985 to 1988, compound change formula was applied to estimate the share of each institutional sector. That is,

$$X_{t-1} \cdot (1 + g); \quad t = 1985, 1986, 1987, \& 1988$$

where  $X_{t-1}$  is the share of institutional sector  $i$  (government, private industry, higher education, and Non-profit organizations); and  $g$  is the compound change between 1984 and 1989, i.e.,

$$g = (X_{1989}/X_{1985})^{(1/5)} - 1$$

- (c) The third source of information from PIDS is insufficient to derive the shares for the years 1993 to 1996 because the survey only covers government agencies and state universities and colleges. Information on the other sectors are not available to estimates the shares. Also, the compound change formula cannot be used because of unavailability of an end-point, unlike in (b) information where 1989 as the end-point is available. Thus, a projection analysis using trend line of the shares was adopted. That is, a trend was fitted to the actual shares of each of the sectors. Given this trend, the shares for the years 1993 to 1996 were projected.

- (d) Given the derived shares and the estimated total national R&D expenditure, the breakdown of expenditure into sectors were derived.

### **Breakdown of Expenditure into Production Sectors**

The framework adopted in this paper uses a breakdown in terms of production sector. The usual production sector breakdown is agriculture, industry, and services. For purposes of this paper, the breakdown adopted include the following industries: (i) primary sector - which includes total agriculture and mining industries; (ii) industry – which includes manufacturing, construction, and utilities; (iii) service – which includes transportation, trade, finance and other services.

The data required for the analysis of rates of return to R&D investment is R&D expenditure according to this production sectoral breakdown. Unfortunately, this set of information is not available. What is available, however, is the breakdown of R&D expenditure into different fields of activities which include: agriculture services, engineering and technology; medical sciences; natural sciences; social sciences; humanities; and others.

The second major set of assumptions applied include the following: (1) that R&D expenditure on agriculture services go directly into the primary sector; (2) that engineering and technology into the industry sector; and (3) that the rest into the service sector. Table A2 shows information on R&D expenditure by field of activity and by institutional sectors. The 1984 data was taken from the first source, while the 1989 to 1992 from the second source. Data for 1993 to 1996 for the government agencies were taken from the third source, as well as the data for higher education (covering only state universities and colleges) during the period.

Percentage distribution was calculated based on these actual data. The 1984 percentage distribution was applied for the period 1979 to 1984. For the years 1985 to 1988 compound change formula, as in above, was applied to derive the percentage distribution. For the last period, 1993 to 1996, percentage distribution based on the PIDS survey was applied for the government and higher education. Since there are no information on both the private industry and NGOs, the average percentage distribution for the years 1989 to 1992 was applied to 1993 to 1996.

Based on these percent distribution, R&D expenditure of all institutional sectors were breakdown go into field of activities from 1979 to 1996. R&D expenditure on agriculture services of all institutional sectors were summed up to derive the total R&D expenditure on agriculture services. Similarly, expenditure on engineering and technology were summed up to derive the total, as well as on other field of activities. The derived data series is shown in Table A3 panel A. Panel B of the same table shows R&D expenditure by field of activity in

1985 prices. The price deflator used was the implicit price deflator for capital formation of the National Income Accounts.

Panels C and D show the derived R&D stock in case where there is no spillover effects and with spillover, respectively. Detailed discussion on this is shown in the main text.



**Table A1: National R&D Expenditure by Sector of Performance, 1979-1984  
& 1989-1992 (in million pesos)**

<b>Sector</b>	<b>1979</b>	<b>1980</b>	<b>1981</b>	<b>1982</b>	<b>1983</b>	<b>1984</b>	<b>1989</b>	<b>1990</b>	<b>1991</b>	<b>1992</b>
<b>Total</b>	563	690	528	634	515	613	1,639	1,655	1,969	2,941
<b>R&amp;D/GNP (%)</b>	<b>0.28%</b>	<b>0.28%</b>	<b>0.19%</b>	<b>0.20%</b>	<b>0.14%</b>	<b>0.12%</b>	<b>0.18%</b>	<b>0.15%</b>	<b>0.16%</b>	<b>0.21%</b>
Govt Agencies	399	471	332	418	338	419	904	706	1,020	1,728
Private Industry	90	129	105	104	104	119	393	511	523	642
Higher Education	22	24	38	55	42	38	211	275	290	433
Non-Profit Institutions	52	67	53	57	30	37	131	163	136	137
<b>Percent Distribution</b>										
<b>Total</b>	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Govt Agencies	70.8%	68.2%	62.9%	65.9%	65.8%	68.3%	55.1%	42.7%	51.8%	58.8%
Private Industry	15.9%	18.6%	19.8%	16.5%	20.2%	19.4%	24.0%	30.9%	26.6%	21.8%
Higher Education	4.0%	3.4%	7.2%	8.7%	8.2%	6.2%	12.9%	16.6%	14.7%	14.7%
Non-Profit Institutions	9.3%	9.8%	10.1%	8.9%	5.8%	6.1%	8.0%	9.8%	6.9%	4.7%

Source: (I) "Compendium of Available S&T Statistics" and "National Survey of Scientific and Technological Activities"  
DOST

**Table A2: National R&D Expenditure by Field of Activity  
and by Sector 1984 & 1989 to 1992**

	1984	1989	1990	1991	1992
<b>1. Government</b>	<b>419.23</b>	<b>903.50</b>	<b>705.91</b>	<b>1,019.63</b>	<b>1,728.35</b>
Agriculture services	146.49	188.36	229.01	352.57	426.39
Engineering and Tech	140.97	193.87	105.52	136.78	332.20
Medical Sciences	21.16	126.08	150.95	155.45	188.58
Natural Sciences	53.36	175.83	141.20	253.70	362.16
Social Sciences	55.12	163.21	72.53	105.37	289.37
Humanities	2.13	6.30	2.58	9.55	26.29
Others		49.87	4.11	6.21	103.37
<b>2. Private Industry</b>	<b>118.89</b>	<b>393.49</b>	<b>511.26</b>	<b>523.29</b>	<b>642.10</b>
Agriculture services	23.31	200.17	234.22	283.68	300.77
Engineering and Tech	90.05	102.75	139.52	154.97	188.00
Medical Sciences	0.07	21.04	24.50	26.17	30.43
Natural Sciences	-	69.02	108.85	51.85	112.86
Social Sciences		0.02	3.50	5.62	8.67
Humanities	5.30	0.00	0.01		
Others	0.16	0.55	0.68	1.01	1.38
<b>3. Higher Education</b>	<b>38.07</b>	<b>210.84</b>	<b>274.79</b>	<b>290.05</b>	<b>433.23</b>
Agriculture services	22.85	86.30	105.00	115.09	171.91
Engineering and Tech	1.84	17.47	20.29	22.72	33.94
Medical Sciences	0.37	4.20	5.36	5.71	8.53
Natural Sciences	3.59	46.93	62.49	65.25	97.47
Social Sciences	8.55	42.43	59.88	60.78	90.79
Humanities	0.87	10.99	17.69	16.90	25.24
Others		2.52	3.53	3.59	5.37
<b>4. Non-Profit Institutions</b>					
Agriculture services	4.13	16.34	20.62	23.43	36.99
Engineering and Tech	18.37	10.63	12.17	21.31	16.65
Medical Sciences	1.63	4.37	4.78	6.65	9.36
Natural Sciences	3.36	6.37	12.16	32.74	16.07
Social Sciences	8.44	80.64	102.57	40.66	45.17
Humanities	0.61	2.74	3.07	3.45	4.77
Others	0.66	9.79	7.41	7.47	7.86

Source: (I) "Compendium of Available S&T Statistics" and "National Survey of Scientific and Technological Activities" DOST

**Table A3: R&D Expenditure and Capital Stock**

A. Derived National R&D Expenditure by Field of Activity (Pmillion)																		
Sectors	1979 - 1984 actual						1985 - 1988 derived				1989 - 1992 actual				1993 - 1996 derived			
	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Agriculture services	176	211	165	206	167	197	260	274	307	358	491	589	775	936	1,100	1,209	1,295	1,546
Engineering and Tech	229	290	219	250	209	251	307	289	281	277	325	277	336	571	523	621	768	795
Others	158	189	144	178	138	165	260	319	410	538	823	788	858	1,434	628	775	876	1,052
Total R&D	563	690	528	634	515	613	827	883	998	1,173	1,639	1,655	1,969	2,941	2,251	2,605	2,939	3,392
B. Derived National R&D Expenditure by Field of Activity (Pmillion 85 prices) *																		
Sectors	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Agriculture services	471	480	354	419	293	222	260	267	278	297	367	392	439	501	528	536	569	626
Engineering and Tech	612	659	470	508	366	283	307	281	254	230	243	185	190	305	251	276	337	322
Others	423	429	308	362	241	187	260	311	371	447	615	525	487	767	301	344	385	426
Total R&D	1,506	1,568	1,132	1,289	900	692	827	859	903	975	1,224	1,102	1,116	1,573	1,081	1,156	1,291	1,374
* Converted into 1985 prices using IPI capital formation																		
C. Derived R&D Stock (without spillover effects, Pmillion 1985 prices)																		
Sectors			1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Agriculture services			10,470	10,950	11,304	11,722	12,015	12,237	12,497	12,764	13,042	13,339	13,706	14,098	14,538	15,038	15,567	16,103
Engineering and Tech			10,288	10,947	11,416	11,925	12,291	12,574	12,881	13,163	13,417	13,647	13,890	14,075	14,265	14,570	14,822	15,097
Others			14,678	15,107	15,415	15,777	16,018	16,204	16,465	16,775	17,146	17,593	18,208	18,733	19,219	19,986	20,288	20,631
Total R&D			35,435	37,003	38,135	39,424	40,324	41,016	41,843	42,702	43,605	44,580	45,804	46,906	48,022	49,595	50,676	51,832
D. Derived R&D Stock (with spillover effects, P million 1985 prices)																		
Sectors			1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Agriculture services			14,835	15,500	15,987	16,554	17,000	17,339	17,705	18,078	18,465	18,877	19,384	19,912	20,492	21,185	21,866	22,565
Engineering and Tech			16,587	17,658	18,424	19,267	19,997	20,560	21,087	21,590	22,069	22,534	23,061	23,474	23,901	24,532	25,036	25,580
Others			20,757	21,373	21,814	22,326	22,740	23,061	23,472	23,938	24,470	25,089	25,918	26,560	27,161	28,101	28,507	28,966
Total R&D			52,180	54,530	56,225	58,148	59,737	60,960	62,264	63,607	65,005	66,500	68,363	69,945	71,554	73,817	75,409	77,111

\*Note: The totals considered are at the high side, and therefore way above the ones reported in the Survey. The reason being that the totals reported in the survey only cover government agencies and state universities and colleges.

The numbers for other sectors with R&D activities are preliminary estimates since they are not covered in the Survey. Once the survey results of the NSO are in, the totals shown here shall be adjusted. This will result in changes in the estimates of rates of return. The high estimates here is the result of the assumption about the historical trend line of R&D expenditure-to-GNP ratio which is assumed to be at 0.15 percent during this period.

## **APPENDIX B**

### **DATA ON SECTIONAL GVA, EMPLOYMENT & CAPITAL STOCK**

As discussed in the main text, the framework adopted in this paper to analyze the rates of return to R&D investment is a production function approach. In the production function approach data on output and factor inputs are required to be able to estimate the production function parameters upon which the rates of return to investments in factor inputs are derived. Appendix A discussed the construction of one of the factors inputs, R&D stock. In present appendix, the methodology used in constructing data on sectoral gross value added, employment and capital stock is discussed. The discussion is based on the paper of Cororaton and Caparas (1998).

The paper of Cororaton and Caparas (1998) estimated total factor productivity (TFP) growth of the Philippine economy and of nine major production sectors: agriculture, mining, manufacturing, construction, utilities, transportation, trade, finance, and other services. The paper applied a methodology wherein data on gross value added, employment and capital stock were used. Except for output and employment, data series on capital stock is not readily available from the official statistics. Thus, the paper developed a methodology for constructing capital stock. For purposes of estimating rates of return to R&D investment, the same set of data is utilized in the present paper. Furthermore, as mentioned in the previous appendix, the production sectors considered in the analysis are the following: (i) primary sector – which includes agriculture and mining industries; (ii) industry sector – which includes manufacturing, construction and utilities; and (iii) service sector – which includes transportation, trade, finance, and other services.

Gross value added. The indicator of value of output used in the estimation is sectoral gross value added (GVA). GVA were expressed

in real prices using their respective implicit price indexes, which are also available from the NIA. The price indexes are in 1985 prices.

Labor. Data on employment sectoral level are published regularly. Thus, in the TFP estimation, the data series on the number of employment generated by the Department of Labor and Employment (DOLE) were utilised as labor factor input. In principle, labor service, not the level of employment, is the one that is relevant in the analysis. The common practise is to adjust the employment data with some information on average working hours. However, an adequate time series for the “weekly average hours work” is not available. Because of this problem, the employment data were not adjusted. For the time being, this presents one weakness in the estimation, which can be easily modified and adjusted after a good and consistent “weekly average hours work” time data series has been established.

Capital Stock. Usually, one of the major problems encountered in production function approach is the unavailability of capital stock series both at the sectoral level. In the Philippines, the problem is aggravated by the unavailability of sectoral investment data series. The procedure developed by Cororaton and Caparas (1998) started with the gross domestic capital formation GDCF (investment at the national level) which is available from the NIA. This GDCF series was distributed into sectoral investment using a set of derived sectoral investment shares computed using the sectoral gross additions to fixed assets (GAFA) from the Annual Survey of Establishment (ASE) of the National Statistics Office (NSO). The capital stock series were derived using perpetual inventory method. The depreciation rates that were utilized were derived from the the ASE also. The detailed procedure in capital stock series estimation is too long to be included in the present paper. Interested reader may be referred to the original paper.

Capacity Utilization Capital services are the ones needed in the analysis, instead of the level of capital stock. To arrive at this set of

information, the derived capital stock series were adjusted by capacity utilisation. In the study capacity utilisation index was derived using the peak-to-peak method on both real GDP and real sectoral GVA.

Tables B1 to B4 show the data on sectoral GVA, employment, capital stock and capacity utilisation, respectively.

**Table B1: Sectoral Gross Value Added**  
(P million, 1985 prices)

**Table B2: Employment ('000)**

Year	Economy	GVA , P`000 85 prices			Year	Primary	Industry	Services
		Primary	Industry	Services				
1980	609,830	151,130	237,348	218,040	1980	1,250	5,607	9,043
1981	630,674	157,563	248,509	221,951	1981	1,597	5,886	9,112
1982	653,434	158,751	254,762	236,835	1982	1,382	6,051	9,375
1983	665,723	153,581	259,105	250,736	1983	1,800	9,039	6,951
1984	616,964	152,205	228,823	235,421	1984	1,824	9,058	7,410
1985	571,883	152,447	188,655	230,781	1985	1,849	8,707	7,581
1986	591,440	157,790	192,707	240,110	1986	1,887	9,005	7,945
1987	616,937	161,347	201,433	251,762	1987	1,983	9,777	8,280
1988	658,576	166,885	219,750	268,050	1988	1,995	10,200	9,011
1989	699,451	171,336	236,741	284,353	1989	2,123	11,020	8,766
1990	720,704	171,819	243,677	297,611	1990	2,078	10,657	9,478
1991	716,506	173,703	237,581	299,909	1991	1,825	11,009	10,080
1992	718,953	174,557	235,714	302,514	1992	1,742	11,269	10,687
1993	737,155	178,077	239,545	310,737	1993	1,627	10,948	11,806
1994	766,284	181,156	254,717	316,627	1994	1,887	11,225	11,921
1995	802,867	182,423	272,914	327,687	1995	1,722	11,446	12,508
1996	849,517	187,209	290,310	344,724	1996	1,789	11,875	13,522

**Table B3: Derived Capital Stock (P  
million, 1985 prices)**

Year	Primary	Industry	Services
1980	19,418	1,996,806	108,386
1981	21,396	2,036,442	126,174
1982	22,321	2,084,364	147,720
1983	23,735	2,139,597	169,411
1984	23,328	2,142,844	170,331
1985	22,997	2,096,961	181,766
1986	22,850	2,060,838	193,253
1987	22,935	2,034,100	214,142
1988	23,052	2,024,330	234,192
1989	24,417	2,047,542	244,849
1990	24,504	2,061,324	288,088
1991	25,078	2,055,902	317,290
1992	24,459	2,045,141	363,006
1993	24,241	2,048,885	407,739
1994	24,064	2,063,297	450,256
1995	23,671	2,093,430	479,871
1996	23,457	2,103,417	556,972

**Table B4: Derived Capacity  
Utilization Index**

Year	Primary	Industry	Services
1980	0.978	0.942	0.951
1981	1.006	0.977	0.938
1982	1.000	0.992	0.972
1983	0.955	1.000	1.000
1984	0.934	0.875	0.914
1985	0.924	0.715	0.872
1986	0.945	0.724	0.885
1987	0.954	0.750	0.906
1988	0.975	0.811	0.942
1989	0.990	0.866	0.977
1990	0.981	0.883	1.000
1991	0.980	0.854	0.987
1992	0.974	0.840	0.975
1993	0.983	0.846	0.982
1994	0.989	0.892	0.982
1995	0.985	0.948	0.997
1996	1.000	1.000	1.031

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