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PHILIPPINE INSTITUTE FOR DEVELOPMENT STUDIES
AND THE
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R&D GAPS IN THE PHILIPPINES
(FINAL REPORT)

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Introduction

The objective of this paper is to determine and to estimate the gaps in research and development (R&D) in the Philippines. 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.[3] R&D activities include basic research, applied research, and experimental development. On the other hand, gaps are defined in the context of productivity. The basic idea is based on the chain of causality which starts from R&D to innovation, to productivity and technological progress, and finally to economic growth and prosperity. There is strong empirical evidence that countries with high level of effort in R&D normally have high productivity, which in turn have high economic growth performance.

Cororaton and Abdula (1997) investigated some of the major determinants of productivity, in particular total factor productivity (TFP) of Philippine manufacturing. One of the factors which was found to be significant is R&D investment. Cororaton (1998a) investigated the rates of return to R&D investment in three major sectors in the Philippines. The sectors are (i) the

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[3] 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

primary sector – which includes agriculture and mining industries; (ii) the industrial sector – which includes manufacturing, construction and utilities industries; and (iii) the service sector – which includes transportation, trade, finance and other services. The rates of return to R&D investment are significant in both the primary and the service sectors, in particular, about 60 percent. These rates of return are higher than other form of investments like capital equipment and machineries, building and other fixed assets. Evenson and Westphal (1995) surveyed estimates of rates of return to R&D investment in other countries and found that indeed the rates of return are significantly high both for agriculture and industry, as well as for developed and developing countries. However, in the case of the industrial sector in the Philippines the rates of return to R&D investments are much lower, only about 10 percent. Admittedly, there are no well-identified and well-documented reasons behind this, but the closest one pertains to the severe lack of R&D personnel in industry which in turn leads to very low technological capability. Thus, with low R&D manpower capable of R&D work, any R&D investments cannot turn into productive results as desired.

While the rates of return to R&D investment are high, there are indications the Philippines has been underinvesting in R&D. Cororaton (1998b) showed that in terms of two broad indicators of R&D activities, i.e., expenditure on R&D and the number of scientists and engineers, the Philippine ranks very low. Based on UNESCO data, Table 1 shows that out of 91 countries the Philippines is at the 73rd place in terms of the number of scientists and engineers per million population. It has only 152 scientists and engineers per million population. This is far below the maximum of 6,736 scientists and engineers per million population. In terms of R&D expenditure to GNP ratio, the Philippines is at the 60th place with a ratio of 0.2 percent in 1992. This is far below the maximum of 3 percent.

The economic costs of underinvesting in R&D may be substantial. Cororaton (1998b) surveyed some indicators of productivity in the Philippines, and found that the productivity performance has not been very encouraging. In fact, TFP has been declining. The declining productivity trend over the years is

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installing new processes, systems and services, and to improving substantially those already produced or installed.

borne out in a number of productivity studies done at the macro level. Table 2 shows some of the estimates of total factor productivity (TFP). For example, Willamson (1969) estimated a declining TFP from 55 percent in the period 1947-55 to 15 percent in 1955-65. The results of Sanchez (1983) and Patalinghug (1984) showed relatively constant TFP growth in the 1960s up to the early 1980s. However, the results of Austria and Martin (1992) showed a big drop in TFP growth in the period 1950-87 of -11 percent. According to the authors, this drop in productivity growth can be explained by the inability of the country to allocate its resources efficiently because of policies that intervened in the process of resource allocation.

In a more recent productivity paper, Austria (1997) found that for the period 1960 to 1996, TFP of the entire economy declined by -0.4 percent. However, in a more recent period, in the last 4 to 5 years, productivity improved (see Figure 1). Austria (1997) attributed this improvement to the favorable efficiency effects of the economic reforms.

The overall declining productivity trend is also seen at the manufacturing sector. The results of Hooley (1985), showed that "over the period 1956-80, TFP decreased by 0.15 percent annually. Since 1975, TFP has been declining at an alarming rate of 2 percent or more per year. For the manufacturing sector as a whole, the data paint a very clear picture: one of slow TFP growth during the late fifties and sixties, unmistakable retardation after 1970, with rates of advance after 1975 assuming significantly larger negative dimensions. When certain additional adjustments for labor quality improvements are made, the average rates are uniformly lower for the entire period as well as for all subperiods."

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

In a more recent study, Cororaton (1998) found that for the period 1981 to 1996, TFP of the primary sector (which includes agriculture and mining industries) declined by an average of –0.2 percent. Industry TFP improved marginally by an average of 0.9 percent over the same period, while the service sector TFP declined by an average of –2.9 percent.

The relatively poor productivity performance in the Philippines is one of the key reasons why it has not been able to sustain its growth process. In fact, the Philippine economy performed poorly over the last three decades compared to its Asian neighbors. It grew an average of 2.5 percent per annum over the period 1980-1996, far below the growth performance of Singapore (8.0 percent), South Korea (8.2 percent), Thailand (8.0 percent), Malaysia (8.2 percent), and Indonesia (7.6 percent).

Aside from the issue of underinvestment in R&D, there are also convincing indications of institutional inefficiencies in the national science and technology system in the Philippines which may have resulted in (i) very weak delivery system from technology generation to adaption, use and commercialization; (ii) inefficient allocation of R&D resources; and (iii) a complex and bloated system in the Department of Science and Technology. However. while both underinvestment and institutional inefficiencies are critical issues in the technology sphere, the paper will only delve into the former. The point of interest in the paper is captured in the following question: If indeed the causality chain runs from R&D to innovation, to productivity and technological progress, and finally to economic growth and prosperity, by how much would the Philippines have to increase its investment in R&D? In the paper this is referred to as the investment gap. It will attempt to estimate the gap using a growth regression model involving TFP of different countries, on the one hand, and R&D expenditure and R&D manpower, on the other. The growth regression model allows one to construct some kind of a “world TFP frontier”. On the basis of this frontier, the R&D investment gap in the Philippines is computed. The advantage of using this type of analysis in examining the investment gap is that one is able to incorporate the experiences and performances of other countries with regard to the issues of concern through the computed world frontier.

The Model

The paper uses a growth regression model to compute for the TFP frontier. The growth regression model is calculated using data of different countries, thus capturing each ones' experiences and performance through time. As such, it provides a good basis for computing the R&D investment gaps in the Philippines.

The model is given by the following equation

(1) TFP = f(R&D investment, R&D manpower)

where TFP is total factor productivity. The basic idea in (1) is that R&D investment results in innovations, which in turn results in higher productivity. However, this investment cannot turn into real outcome if there are not enough R&D manpower to do R&D work. Thus, R&D manpower, in particular scientists and engineers, is important.

The Data

As discussed in the previous section, the model requires TFP data of different countries to be able to compute for the TFP frontier. Initially, the paper started with data of 93 countries and computed for TFP of these using the growth accounting approach. The data set, which was sourced from the World Bank, covers the period from 1960 to 1990. In particular, the following country data were used in computing for the TFP of the different countries:

(a) Purchasing power parity (PPP) adjusted gross domestic product (GDP) at 1987 prices. This is the indicator for output.

(b) Gross domestic fixed investment (GDCF) at 1987 prices. This was used to compute for the capital stock series needed in the growth accounting formula. The capital stock series was computed using the perpetual inventory approach. Capital stock is considered as the capital input. Note that there was not adjustment for capacity utilization.

(c) Working population between ages 15 and 64. This is the indicator of labor input. Again, there was no adjustment for labor utilization rate.

Annual TFP of the 92 countries were computed from 1960 to 1990 using the following growth accounting method:

(2) $TFP_{it} = GGDP_{it} – (w_l*GN_{it} + w_r*GK_{it})$

where $GGDP_{it}$ is the growth of GDP_{it} of country i at year t, GN_{it} growth of employment, and GK_{it} growth of capital stock, w_l employment weight, and w_r capital weight. The computed annual TFP of the countries were averaged into three sub-periods: (i) 1960 to 1969; (ii) 1970 to 1979; and (iii) 1980 to 1990.

The second set of data required to compute for the frontier are R&D expenditure and the number of scientists and engineers. The R&D expenditure indicator used was the ratio of R&D expenditure to gross national product (GNP) of the different countries which appeared in the various issues of the UNESCO Statistical Yearbook. On the other hand, the indicator for the number of scientists and engineers was the ratio of the number of scientists and engineers to the population, which also appeared in the UNESCO Statistical Yearbook. Unlike the GDP, employment and investment data, these two indicators do not appear regularly on an annual basis in the UNESCO Statistical Yearbook. To remedy this problem, all ratios available for the decade of the 1960s were averaged. Similar procedure was done for the 1970s and 1980s. These average ratios were then set side-by-side with the average country TFP for the corresponding periods. When this process was done, it was observed that out of the 93 countries in the World Bank data base only 33 countries have all the information in all the three decades. Thus, in the growth regression model only 33 countries were included in the actual estimation. The countries included are shown in Appendix A.

Empirical Results

Estimated Equation. The equation below is a result of an ordinary least squares (OLS) regression on pooled data for 33 countries. The figures in parentheses () are t-statistics.

$$(3)\quad TFP = \underset{(-2.169)}{-0.032763} + \underset{(1.868)}{1.677E\text{-}3 * R\&DEXP} + \underset{(2.096)}{7.730E\text{-}6 * S\&E} + (a_i * DUM_i)$$

$R^2 = 0.276$

number of observations = 99

where TFP is total factor whose indicator is derived using (2), R&DEXP is the ratio of R&D expenditure to GNP (expressed in percentage), S&E is the ratio of the number of scientists and engineers to population, DUM_i is the country dummy variables to capture country differences, and a_i is the corresponding estimated coefficients (note that these coefficients have been generated using the OLS, but it's too long to write them here since there are 32 of those).

The coefficient of R&DEXP is significant at 6.6 percent level, while the coefficient of S&E is significant at 4 percent. Considering that the regression is on pooled data, the R2 statistics of 0.276, which is a measure of goodness of fit of the estimated equation, is not too bad.

Evidences of Increasing Returns. The estimated equation was used to generate Figures 2 and 3. These figures show the partial effects of each of the regressors on TFP. For example, Figure 2 shows the effect of R&D expenditure on TFP growth, with all other factors affecting TFP held constant. Similarly, Figure 3 shows the effect of the number of scientists and engineers on TFP growth, holding all other factors constant.

One can observe that TFP increases faster at higher ratios of both R&D expenditure and the number of scientists and engineers. This would clearly indicate increasing returns to investment in technology, R&D, innovation and other knowledge-based activities. These results support the general conclusion of Evenson and Westphal (1995) on high rates of return to R&D investment. Furthermore, the results are in line with the argument in the recent development in growth economics called "Endogenous Growth Theory" (Romer, 1986 and 1990 and Lucas 1988). Increasing returns in these areas has been the center of argument in the endogenous growth theory and has been the major focus of recent debate in economics both in academic-theoretic and policy circles. The importance of these knowledge-based investment and activities is well summarized in a recent book on endogenous growth theory (Aghion and Howitt, 1997)

> "We do not just have more of the same goods and services; we have also new ones that would have been unimaginable to someone in the eighteenth century. The knowledge of how to design, produce, and operate these products and processes had to be discovered, through succession of countless innovations. More than anything else, it is these innovations that have created the affluence of modern times. "
>
> "Innovations are created by human beings, operating under the normal range of human motivations, in the process of trying to solve production problems, to learn from experience, to find new and better ways of doing things, to profit from opening up new markets, and sometimes just to satisfy their curiosity. *Innovation is thus a social process; for the intensity and direction of people's innovation activities are conditioned by the laws, institutions, customs, and regulations that affect their incentive and their ability to appropriate rents from newly created knowledge, to learn from each other's experience, to organize and finance R&D, to pursue scientific careers, to enter markets currently dominated by powerful incumbents, to accept working with new technologies, and so forth*."
>
> "Thus, economic growth involves a two-way interaction between technology and economic life: technological progress transforms the very economic system that creates it. The purpose of endogenous growth

theory is to seek some understanding of this interplay between technological knowledge and various structural characteristics of the economy and the society, and how much such as interplay results in economic growth."

<u>Gaps</u>. The primary goal of the paper is estimate the investment gap in the Philippines using the estimated growth regression model. The following procedure was applied to derive the gap in R&D expenditure and the number of scientists and engineers relative to the frontier derived from the estimated equation:

(a) The residual between the frontier and the TFP for the Philippines was calculated for the decades of the1980s. This calculated residual serves as the basis for the investment gap computation.

(b) To compute for the R&D expenditure gap the estimated equation was utilized. Thus, the left-hand side of the equation was set to the residual as computed in (a). In the right-hand side of the equation, S&E was set to zero, while R&DEXP was made a variable to be solved. All the estimated coefficients were retained. The resulting R&DEXP gap is **<u>0.5778</u>** (expressed also in percentage). This means that R&D expenditure-GNP ratio would have to increase by 0.5778 for the Philippine TFP to reach the TFP frontier. The average R&D expenditure–GNP ratio during the 1980s was 0.1667 percent. Thus the total R&D expenditure-GNP ratio needed to reach the frontier is 0.1667 + 0.5778 = **<u>0.7445</u>**. This is a sizeable increase from the current level, but lower than what has been proposed in S&T Bill (House Bill no. 2214) of 1 percent of GNP. Applying this to the 1997 GNP of P2,527 billion will result in a total R&D expenditure of roughly **<u>P18.8 billion</u>** (i.e. P2,527 billion GNP in 1997 x 0.7445%). It should be noted that this total R&D expenditure, which, in principle, should come from both the government and the private sector. In other countries, particularly those which are technologically aggressive, high growth economies, the bulk of this investment comes from the private sector (Figure 4).

(c) Similar procedure as in (b) was applied to compute for the gap in manpower. The result show a gap of **197** scientists and engineers per million population. The average ratio for the decades of the 1980s was only 108. For the Philippine TFP to reach the gap it should need R&D manpower of 108 + 197 = **305** per million population.

Some Policy Insights

The results derived from the paper have important broad policy implications. Some of these include the following issues:

(1) R&D Investment. The Philippines has been underinvesting in R&D. The economic cost of this in terms of productivity is substantial. The results indicate that a substantial increase in R&D investment is needed for the Philippines to move up to the frontier. In particular, it needs **0.7445** percent of GNP. Based on the average ratio for the 1980s of 0.17 percent, the gap amounts to 0.6 percent. But the question is: In what sector and who is going to be the major investor?

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 (Cororaton, 1998). 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.

However, there is a need to encourage private sector involvement in industry R&D for two major reasons: (a) 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 (b) ideally, the private sector is supposed to be active in industry R&D activities as shown in Figure 1 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.

But there are high risks involved in R&D, particularly because the outcome of R&D is uncertain. Given this, private sector participation can be encouraged only if the institutional structure of the entire national science and technology system is well functioning, including proper incentives, right protection and etc. In the Philippines there seems to be a substantial gap in this area. For example, in the area of incentives, the track record is rather poor because only few companies avail of incentives related to R&D activities. Over the period 1990-1997, only 11 companies with a total of 13 projects were granted with incentives. The Philippines offers incentives to the private sector for R&D undertakings through the Board of Investments (BOI).

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.

(2) R&D Manpower. R&D investment can turn into real outcome if there are enough manpower to do the activities in R&D. The number of scientists and engineers in the Philippines is not enough. In fact, for the Philippines to move up to the frontier, it requires an additional 197 scientists and engineers per million population. If the average level in the 1980s was 108, it would therefore need a total of **305** scientist and engineers per million population. This presents a real challenge to the educational system in the Philippines which, at present, is producing less technical-related graduates. Table 3 shows that while the educational system has a huge number of students at the tertiary level, the number of students taking science and engineering courses is low relative to some countries.

Sachs (1998) observed that the supply of skilled manpower is low. This is a result of poor S&T educational system. "In particular, there is a severe shortage of science teachers at the school level. The quality of science education at the college level is also poor. A substantial fraction of high-school science teachers have no training in science and mathematics (but rather have degrees in education). High-school math and physics curricula are badly in need of reform. A World Bank funded engineering and science education project has provided scholarship for maters and doctoral training in science and engineering but the scope of the project is limited. In general, there is a lack of capacity to do research, which will become particularly problematic in the future when forms will have greater demand for adapting and innovating existing technologies. Increasing the supply of science and technology education is probably the most crucial investment in science and technology that needs to be made *now.*”

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TABLES AND FIGURES

Table 1. 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 2. Distribution of the Sources of Growth in the Philippines, Various Studies (%)

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

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

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

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

Table 3. Tertiary Education Across Selected Pacific Rim Countries

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

***Column Definition*:**
1) : Number of students at tertiary level
2) : Number tertiary students as percent of population
(3) : Number of post-baccalaureate students
(4) : Post-baccalaureate as % of Tertiary Students
(5) : Number of post-baccalaureate science & engineering students
(6) : Post-baccalaureate science & engineering as percent of post-baccalaureate students

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

Figure 1. Annual TFP Growth Rate, Philippines, 1960-1996

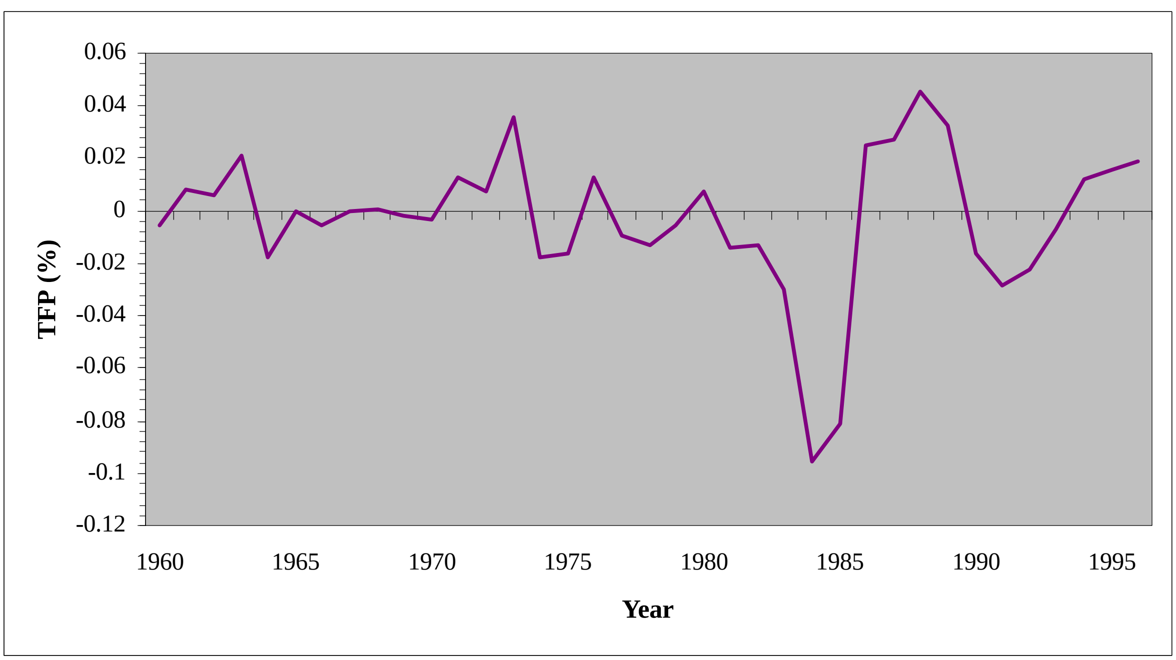

Figure 2. TFP vs Ratio of R&D Exp/GNP

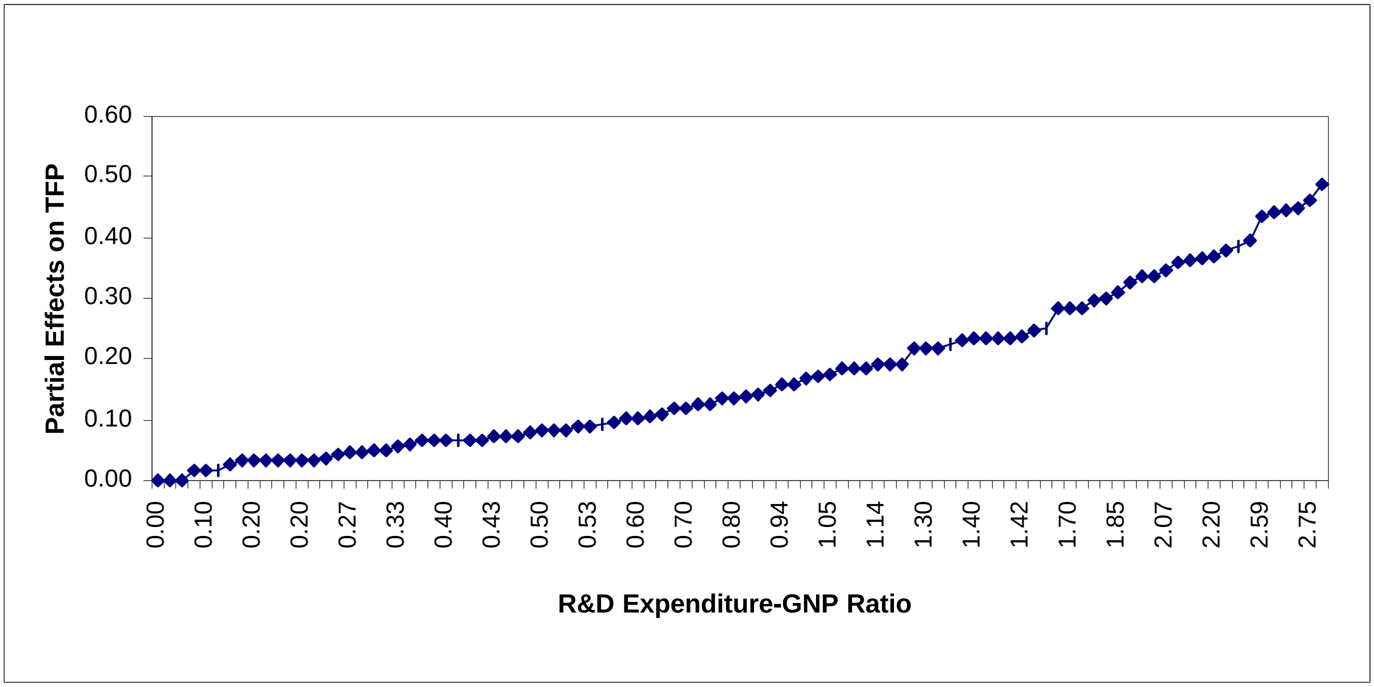

Figure 3. TFP vs Ratio of S&E/Pop