Returns to Investment in Training of Agricultural Researchers

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Abstract: Returns to both graduate and continuous training programmes developed and carried out by EMBRAPA are estimated, following the standard social rate of return approach. Benefits were measured at the farm level and derived from adoption of new technologies associated with training programmes. Estimates of the internal rate of return are quite high for investment in such training programmes, even when compared with any other investment alternative, whether public or private. Those high rates of return were obtained by considering only the direct net benefits for farmers. The indirect net social benefits of the programmes, although not measurable, can be regarded as favourably supporting EMBRAPA's policy of investment in the development of human resources. Training programmes have produced important benefits for Brazilian agriculture, thereby contributing to the country's social and economic development.

Introduction

Through EMBRAPA, Brazilian society has been heavily investing in the development of human resources in agricultural research. In 1974, soon after EMBRAPA's establishment, 83 percent of its research staff had bachelor degrees and only 17 percent had attended graduate courses. Now, almost 80 percent of the researchers have masters or Ph.D. degrees. Up to 1983, 1,600 graduates had been formally trained and 13,000 persons informally trained through their participation in the Continuous Training Programme. The return on investment in training has been appreciated by EMBRAPA since its creation and has recently become an important priority, after the conclusion of a study on the evaluation of returns on EMBRAPA's investment in agricultural research (Cruz *et al.*, 1982).

This study evaluates training according to the standard procedure for estimating the social rate of return on investment. However, focussing on the social effects related to the main objectives of the corporation makes it unique. For the estimation of the rate of return, only the net benefits resulting from the technology developed were taken into account.

Human Capital and Its Depreciation

The state of arts according to Schultz (1973), continues to contain many out-of-date viewpoints. That a country must be endowed with natural resources to develop a modern economy cannot be supported by evidence, as illustrated by the cases of Japan, Denmark, and Switzerland. Schultz (1963) called attention to the investment approach as being necessary to obtain a complete and consistent explanation about the causes of modern economic growth. Therefore, one should not ask the traditional question: "What is the size of the land, the amount of labour, and the number of machines used to produce a given output?" but should instead ask: "What is the marginal increase observed in production from an additional amount of investment?"

In the modern world, investment in human resources has been stressed. On the one hand, education is a consumption good, insofar as it is desired as an end in itself or considered intellectually stimulating and rewarding. On the other hand, education is clearly considered to be a capital good or investment, in that those persons who acquire education can obtain a future stream of benefits from it.

The superior productivity of trained labour and consequently of developed countries can be analyzed by using the concept of the production function. For example, take two individuals of the same age, one of whom is a graduate and the other of whom has only achieved the compulsory minimum basic education level. The one with a higher educational level will obtain higher earnings; i.e., will be situated on a higher production function relative to the less-educated individual. Generally, the absolute earnings differential between persons with different education levels increases with age. Sheehan (1975) observed that individuals with higher education levels tend to achieve maximum earnings when they are older.

Also important is the depreciation or obsolescence of human capital: a reduction in the productivity of the individual at a particular point in time. Two processes of obsolescence exist: intellectual human capital and physical human capital. This study focusses on the first.

The depreciation of intellectual human capital has two dimensions: one absolute and the other relative. The absolute dimension refers to the loss of knowledge or memory, while relative depreciation corresponds to the stagnation or relative lack of progress. The depreciation of human

capital is responsible for the diminishing marginal productivity obtained by individuals at a certain age. Investment in education can not only avoid the depreciation of human capital, but those individuals who are able to acquire additional knowledge can consequently obtain higher earnings than they would otherwise receive without training.

Return on Investment in Human Capital

Returns on investments in education can be calculated from either the private or the social point of view. Private returns imply comparing costs and benefits of education for individuals, while social returns take into account costs and benefits for society. To estimate private returns, costs are measured by the expenditures on school fees, books, and other items and also by indirect costs, which are equivalent to the earnings foregone. Benefits are measured by the additional earnings that students can hope to obtain during their lifetimes.

The decision to study means that part of the time previously dedicated to leisure or to work is now allocated to educational activities. That implies a real cost, since leisure is probably desirable. Likewise, the work is rewarded by receiving salaries, and, if education means foregone employment opportunities, education also means a sacrifice of earnings. The value of the alternatives foregone is called the "opportunity cost." That cost is practically zero when education is compulsory, since the individual almost does not have any alternative. When "opportunity cost" exists, it is calculated in terms of the earnings foregone by students according to their age, training, and experience.

The private benefits are calculated in terms of the economic benefits produced by a given increment of education. According to Sheehan (1975), those benefits, from the point of view of investment, will consist almost entirely of extra earnings due to the additional education.

The private rates of return on investment in education have been calculated, especially for the secondary and graduate levels, in both developed and developing countries. The majority of the studies in developed countries refer to the USA, and among them can be mentioned the pioneering work of Walsh (1935) and the subsequent analyses of Mincer (1962), Hansen (1963), Schultz (1961, 1963, and 1967), Becker (1964), Hanoch (1967), and Johnson (1970). Blaug (1965 and 1967) did work on the UK. Sheehan (1975) refers to studies undertaken in Canada and Israel, as well as in developing countries such as India, Mexico, Chile, Uganda, and Kenya. In Brazil, Patrick and Kehrberg (1973) calculated private returns on investment in education in rural areas facing different levels of modernization.

The method used to estimate social returns on investment in education is generally similar to the one used for estimating private returns. The difference between the two procedures is accounted for by what is included in the structure of benefits and costs. The estimate of private returns includes the after-tax stream of earnings, whereas the social rate of return considers the pre-tax flow of earnings. Regarding the direct costs included in the measurement of social returns, all expenditures incurred by society, independent of their source of financing, are taken into account. Private costs constitute only a fraction of the direct social costs, since the largest proportion of the costs of education are financed from public funds.

To calculate the net stream of social benefits, indirect social costs should be taken into account. Those indirect costs, which are generally equivalent to the income lost by devoting time to education, are measured in the same way as the indirect private costs, plus taxes. The "opportunity cost" for society would then be the present value of the foregone earnings of the student.

Due to difficulties in measurement, the computation of social returns to education does not include the pecuniary external economies, which are the indirect spillover effects or those benefits that do not accrue to the economic agents who have generated them. Blaug (1975) stated that many economists, whatever approach they have adopted, have omitted external economies in the calculation of the social rate of return because of the great difficulty in quantifying them. Blaug also argues that the indirect benefits are likely to be less than the direct benefits, at least when benefits are considered from a strictly economic viewpoint.

Among those who have estimated the social return on investment in education are Becker (1964), Weisbrod (1962), Bowman (1962), Blaug (1967), and Hansen (1963). Those who have focussed on Brazil include Patrick and Kehrberg (1973), Langoni (1974), Castro (1973), Castro and Mello e Souza (1974), and Ribeiro (1979).

Because the additional social costs are higher than the additional social benefits, the estimate of the social rates of return are lower than the private ones. Becker (1964) estimated the private rates

of return on higher education to be 14.5 percent for a 1939 graduate and 13 percent for those who graduated in 1949. The social rates of return for the same graduates were 13 and 12 percent, respectively. Hansen (1963), Blaug (1967), Blaug, Layard, and Woodhall (1969), and Patrick and Kehrberg (1973) confirmed the higher private rates of return compared to the social ones in the cases of the USA, UK, India, and Brazil, respectively.

Estimates of Costs, Benefits, and Returns[2]

Salaries were included in the cost structure (including salary for a substitute), as were social benefits and direct expenditures during the training period, such as scholarships, health insurance, travelling costs, thesis preparation, books, and college fees. The social costs for EMBRAPA's training programme were calculated for the 1974-82 period. The Department of Human Resources estimated that, during 1983-86, training costs would be maintained at the same level as the 1981-82 average (Cr$4.2 million, at 1982 prices).

Direct benefits were measured in terms of the increased net income of the farmer (Cruz *et al.*, 1982) due to the adoption of a new technology and by estimating that part of net benefits due to training. In the first step, a survey was made of all the technologies developed by 1982 that were effectively adopted by farmers. Then, for each technology (and considering the contribution of the training programmes), an estimate was made of the net benefits to the farmer attributable to EMBRAPA's research in terms of Cr$/ha and Cr$/animal, at market prices. Annual benefits were calculated by multiplying the net benefits derived from training by the area harvested or by the number of farm animals that benefited from the adoption of the technology.

An assumption of seven years was made for the average time lag between the start of a training programme and the actual adoption of a technology by farmers. Since EMBRAPA's training programmes began in 1974, annual benefits thus were measured only from 1981, although some of the technologies had been yielding benefits since 1978. For the 1983-86 period, an estimate of benefits was based on forecasts regarding the adoption of those technologies made by extension workers and researchers. An estimate was made of the flow of long-term net benefits, which was long enough to calculate the returns on investments in EMBRAPA's training programmes using the standard internal rate of return method.

To calculate the internal rate of return, the stream of net benefits was extended to 1996[3] under the assumption that such a net benefit stream for the 1983-96 period will be maintained at the level estimated for 1982 (Cr$14.4 billion, at 1982 prices). The internal rate of return on EMBRAPA's training programmes was calculated as being 22.2 percent. In order to examine the degree of variability of the internal rate of return estimates, a sensitivity analysis was made, with costs and benefits parameterized as being 25 percent above or below the original values. In that sensitivity test, the internal rates of return varied from 13 to 32 percent.

Those rates show a high annual return on EMBRAPA's training programmes, even when compared to other investment alternatives. The economic development banks consider an average rate of return of 10 to 12 percent as being a reasonable return and as a condition for financing investment projects. Langoni (1974) estimated the rate of return on investment in education for 1969 and obtained average rates of return of 32, 19, 21, and 12 percent, respectively, for Brazilian investments in primary education, junior high school, senior high school, and higher education. Those rates are very similar to those found by other researchers, such as Castro (1973) for the same education levels and by Castro and Mello e Souza (1974) for junior and senior high school levels. The returns on investment at the senior high school level for Colombia (Schultz, 1968), Mexico (Carnoy, 1967), and India (Gounden, 1967) ranged from 12 to 27 percent, while, for higher education, those same authors estimated rates from 3 to 25 percent.

The majority of returns to training in the 1980-82 period have not yet been generated because of the time lag between the completion of a course and the adoption of the research result. Therefore, the internal rates of return for future years may reach higher values than those now being estimated.

Notes

[1]Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA).

[2]For more details on these estimates, see Avila *et al.* (1983).

[3]The choice of 1996 as the final year for the generation of net benefits, as any other date, is

arbitrary, as argued by Harberger (1965). However, the literature recommends 10-15 years, because, over that time period, no significant change occurs in the estimated values of the internal rates of return.

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Discussion Opening – *J. Gros*

Longmire and Winkelmann's paper contains numerous suggestions, but, to carry them out, one would need thorough knowledge of the technical data. To complete the work, we need institutions specialized by products. A centralized agency could hardly collect half the data to pursue Longmire and Winkelmann's suggestions. The first point of discussion could be the difficulties of estimating the benefits of technologies and the weight given to the changing priorities. As far as changing priorities are concerned, to give a weight is somewhat difficult and controversial, even if it is a desirable purpose. Another question is the estimation of the impact of a policy directed to encourage farmers. Coming from Europe (with its protectionist agricultural policy), I wonder what the results would be if we ever worked in this line. The problem emerges of the method and kind of policy: open or protective market? I would also like to consider the relationship between biological and economic research. To be in the forefront of research and to know one's research priorities is obviously advantageous. According to my experience, biologists frequently expect us to give monetary values from only technical inputs. So, my question is: Was the advice well received by technicians? Also, how important was their contribution to policy analysis in resource allocation?

On Norton's paper, we can begin by asking if a unique standard research system exists at all or if standards exist for each stage of development or for cross-country differences. Since we have different countries and different regions, a standardized research system could perhaps be established for each different situation. Then comes the obligation of every research centre to submit its work to be reviewed. The point arises of whether the review is only directed to nations receiving some sort of assistance, and only when asked for by the agencies that pay for this assistance, or whether it should be extended to all cases. Then, if public funds are used, we have to consider the necessity of reviewing the institutions and how to do it. We have to consider the linkage between national and international research systems and their orientation concerning research. Dealing with orientations by commodities or by farming systems, we must consider if international institutions should be organized by products and if national institutions should work mainly by farming systems, because the latter know the real physical conditions. With regard to field or station experiments, although not directly related to economics, I would like to ask if any agreement exists about which is better suited for each situation.

On Irias and Dias Avila's paper, we could discuss the differences between private and public investment in training, their various orientations, and their productivity. Then, when dealing with evaluation of benefits, we have to consider the cases (if any) in which it would be adequate to measure benefits through extra earnings due to additional education. As for direct evaluation (extra income for farmers), which was also a point in Longmire and Winkelmann's paper, problems exist with time to carry out calculations and the lag between start of training and adoption. When speaking about internal rate of return and particularly of a reasonable one for investment in training, what different ideas and opinions exist? With regard to the return to investment, we have to consider that it is influenced by the adequate priorities set by society and organizations of agricultural research systems; these were points developed in the first and second papers.

General Discussion – *Marshall A. Martin*, Rapporteur

Does the approach suggested by Longmire and Winkelmann actually help set research priorities? The focus should be on the comparative advantage of wheat and alternative costs and the returns and research costs for each. Salaries and promotions are sources of frustration for research managers in developing countries. Researchers in developing countries are often civil servants and better paid than others in their own countries but perhaps not as well paid as researchers in developed countries. Nonmonetary income or improved working conditions in developing countries might be a solution. Longmire and Winkelmann should consider resource costs and other criteria to allocate research resources. Moreover, they should recognize three levels of research policy decisions: general national policies, national agricultural research policies, and implementation of specific agricultural research programmes. If farmers pay part of the research costs, the analysis should identify returns to farmers as well as the social costs and benefits of agricultural research. The decline in the wheat area in Ecuador was a result of a price stabilization policy where nominal wheat support prices were held constant despite rapid general price inflation in the 1970s. Winkelmann was also asked to comment

on the appropriateness of the domestic resource cost approach to evaluate "future" or "new" research activities.

In response, Winkelmann noted two themes in the comments from the audience: the appropriateness of a static, limited domestic resource cost approach and futurology. Their study implicitly examined nonwheat crops. Research on tropical wheat must ask: What yields must be obtained for wheat production to be profitable? The Thailand study can provide some insights. Any careful evaluation of research investment decisions must include social and biological scientists, especially any review of future or new technology development.

The time suggested by Norton for a review team to spend in a country is too short adequately to understand the research activities and make appropriate recommendations. Norton was asked to comment on long-term training and setting research and development priorities and whether more attention should be given to specific ecological zones, especially in many African nations where the national boundaries are artificial and where sharing research results is difficult. We should not wait for a unifying theory of organizational behaviour to guide a review of a research system. Basic criteria to evaluate individual country or research station programmes are needed. Norton was asked whether a broader scope was needed for agricultural research evaluation. Should education and the agricultural extension system also be reviewed explicitly? A seven year time lag for research adoption seemed heroic. Moreover, although research findings are presented as packages, they may not be adopted or may be only partially adopted. Therefore, research evaluation should account for nonadoption or partial adoption. Farmers' views should be included in research evaluation, but that is difficult to do, especially where educational and communication skills are limited.

Norton agreed that farmers' views should be considered but that researchers with farmer backgrounds and grassroots experience are sufficient in a small research evaluation team. Also, whether a farming system or commodity specific approach is used, economists should use marginal economic analysis. Norton concurred that an international and a national market exist for agricultural scientists. Research managers may wish to give salary and promotion incentives to those who meet research objectives or make important research discoveries. Review time is always limited. Team members should prepare as much as possible (i.e., read reports and correspondence) prior to the site visit. The team leader may wish to make an advance visit. Each team member should interview different people. A draft of the report should be begun early during the review process and its contents discussed with those researchers whose work is being reviewed. Norton suggested the establishment of a national research foundation as a way to focus on long-term research priorities and projects. Such a foundation may help reduce inappropriate political intervention in the agricultural research system.

Participants in the discussion included R. Benalcazar, C. Bevinger, F.M. Cirio, W.H. Furtan, D. Green, M. Kamuanga, U. Koester, J.C. Martinez, A. Power, E. Tollens, and C. Zulberti.