RETURNS TO INVESTMENT ON AGRICULTURAL RESEARCH IN THE PUNJAB

Karam Singh*

With a national budget of about Rs. 150 crores on research and development, and over one million persons qualified in the various disciplines of Science and Technology (2), there is a definite need to measure the returns to massive investment on agricultural research and particularly highlight the organizational structure which has promoted/hindered the pay-off on research activity.

Education, research and development should not be considered as overheads for socio-economic development but they should be regarded as active agents (or factors of production) for any developmental scheme, at the micro/macrol level. Here lies the importance of estimating the productivity of agricultural research and development.

The results of research improve inputs either directly, as with new crop varieties, insecticides, etc., or through information improving the labour skills and management. Extension effort is a source of quality change largely through the labour input. The results of research and extension, particularly in agriculture, are mostly the social goods which spread through society without having to pass market barriers. Their economic evaluation, therefore, means evaluation from the viewpoint of scarcity involving a balance of inputs of scarce goods which have to be withdrawn from alternative uses against the outputs in the form of creation and diffusion of new knowledge, technology and information(14).

PRODUCTION FUNCTION APPROACH

That part of the aggregate production which should be attributed to research can be determined by including research as an input in the aggregate production function analysis.

The aggregate production function studies are, in general, based on a cross-section of nations or specially defined geographical regions on the premise that there is a relationship between the research undertaken inside an area and the effect of research on production in the same area. Since there is a flow of research results from one area to the other, the above premise may not be valid, and one may even conclude, as Latimer and Paarlberg (10) did, that in the U.S.A., a single state could curtail its outlay for research and education without substantial injury to the level of farm income in that state, provided that other states and the federal government would continue their research programmes. But the second presumption that the inflow and the outflow of the research results balance to some extent meets this contradiction.

* Farm Economist, Department of Economics and Sociology, Punjab Agricultural University, Ludhiana (Punjab).
For a single region, where the expenditure on research is allocated for the whole region and there is no possibility of the split up of this expenditure for the smaller areas, which could be treated as cross-sectional observations for all variables except research (for instance, the districtwise data for a State for all variables, except the expenditure on research which is available for the State only), the inclusion of the expenditure on research as a variable in the aggregate production function becomes a problem. One alternative is to combine time-series data with the cross-sectional one and use research variable common for all the sub-regions (either as expenditure for different years or some dummy variables to represent the cross-sections of time).

**APPROACH OF THIS STUDY**

Basically, the approach adopted in this study consists of identifying the factors that determine the level of aggregate agricultural productivity of the region. This comes close to the approach adopted by Griliches to account for the 'measured productivity growth' of U.S. agriculture with the production function estimated on the U.S. cross-regional data \([3,4,5]\). Another study of this nature is by Hayami who explored the 'sources of agricultural productivity gap among selected countries' by estimating the aggregate production function of world agriculture on the basis of cross-country data \((6)\).

Aggregate agricultural production functions of the unrestricted Cobb-Douglas type, based on the cross-district and time-series data, were estimated for the pre-technology (1960-65) and post-technology (1969-72) periods for the Punjab. The pooled production function for the two periods incorporating a dummy variable to represent the technology was also obtained. The fitted functions are given in Table I.

**Table I—Regression Coefficients in Different Aggregate Agricultural Production Functions, Punjab, India**

<table>
<thead>
<tr>
<th>Period</th>
<th>N (Intercept)</th>
<th>Log &lt;x&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Labour (man-years per thousand hectares)</td>
<td>Fertilizer (kg. nutrients per hectare)</td>
</tr>
<tr>
<td>1960-65</td>
<td>22 2.5068</td>
<td>0.9440***</td>
</tr>
<tr>
<td></td>
<td>(0.385)</td>
<td>(0.0440)</td>
</tr>
<tr>
<td>1969-72</td>
<td>33 2.2305</td>
<td>1.0421***</td>
</tr>
<tr>
<td></td>
<td>(0.2772)</td>
<td>(0.0810)</td>
</tr>
<tr>
<td>1960-72</td>
<td>55 2.5065</td>
<td>0.9750***</td>
</tr>
<tr>
<td></td>
<td>(0.1872)</td>
<td>(0.0616)</td>
</tr>
</tbody>
</table>

***, ** and * denote significance of coefficients at 1, 5 and 10 per cent level respectively. 
α denotes that in the F-test, the statistic for the respective regression turned out to be significant at 1 per cent level.

1. Since there are wide fluctuations in production (gross returns) from year to year depending on goodness or badness of weather and other exogenous factors, one should work out with few selected years so that the effect of weather, etc., is the minimum. The year 1960-61 was selected as the base year, it was good agricultural year; the year 1964-65 was, again, a good agricultural year. These two years constituted pre-technology period. During 1969-70 to 1971-72, the production was fairly stable in the Punjab economy and these were normal weather (for Punjab) years. These years constituted the post-technology period. See \[(9)\].
The analysis of covariance for comparing the pre-technology and post-technology production function with the pooled production function yielded a significant F-ratio. This indicated that the technology changed the output elasticities of different factors significantly.

SHIFT IN THE PRODUCTION SURFACE AND CONTRIBUTION OF RESEARCH

The coefficient of technological dummy was 0.3305 in the pooled regression and was significantly different from zero at 1 per cent level. This indicated that the production surface for 1969-72 period has significantly shifted upward by about 33 per cent. This increase in the production surface within a decade is of an unprecedented magnitude in the history. Also, the shift was non-neutral to scale because the output elasticities of different factors changed significantly over this period.

This "shift" of the production surface can be used to approximate the returns to investment on research because the increased production over time is a result of the increased use of inputs, the institutional developments and the technology by research. The shift in the production function due to technology which is to be attributed to investment in research is caught by the dummy variable in the pooled regression. But this shift in the production surface was not neutral to the level of inputs; as the response coefficients changed significantly over this period, the pooled function, in which the technological dummy variable was included, therefore, cannot be used. The alternative is to use the increase in the estimated output from the function for 1969-72 period over that estimated from the function for 1960-65 period at a given level of inputs. Since the mean level of inputs at which the functional analysis explains the best (7, p. 231) were different during the two periods, the problem arises of which level of inputs should be used for the analysis. Various approaches that are suggested in this respect are debated in the following paragraph.

Consider the Figure 1, in which $I_1I_1$ and $I_2I_2$ are the production surfaces for the pre-technology and post-technology periods, respectively. The mean levels of inputs during these two periods correspond to the co-ordinates A and D, respectively. As regards the estimation of the increase in production which is to be attributed to research, the following alternatives are suggested.

(i) Production at the optimum level of input in $I_2I_2$ minus production at the optimum level of inputs in $I_1I_1$ minus cost of the additional inputs.

(ii) Increase in production estimated from the two functions at the respective mean levels of inputs and deducting the cost of the

2. Another study reported the shift in the production surface (of new wheat over old wheat) by the magnitude of 22.85 to 28.04 per cent (12, p. 51). But whereas the shift reported in this study was neutral to scale, that found in the present study is of non-neutral type.
additional inputs, i.e., comparing the co-ordinates D and A, viz., QD—PA—cost of the PQ inputs.

(iii) Increase in production at the average of the two mean levels of inputs, i.e., average of OP and OQ which is equal to OR. This GH increase in production is to be attributed to research.

(iv) Average of the increased production at the mean levels of inputs i.e., average of AB and CD.

The estimation at the optimum level of inputs seems to be the best approach. It also overcomes the danger of reaching the third stage of the production plateau, which means declining total production, at the post-technology level of inputs in the pre-technology production function. But this approach assumes, heroically, that the farmers operate at near the optimum level of inputs, which is far from the real situation even in the region of the study which is a very progressive one. For instance, take fertilizers alone, its use in the aggregate was so low that even its coefficient was not significant. Above all, to work out the optimum the price of the inputs had to be assumed which makes the analysis still more susceptible to minor changes.

So far as deducting the additional cost of inputs is concerned, both in the case of estimation at the optimum level of inputs and at respective mean level of inputs, i.e., comparing the co-ordinates D and A, it assumes that the additional factor inputs account for production just equal to their cost which is also not logical.

3. For more evidence, see (8), p. 4.
When the increases in production due to the shift in the function at different levels of inputs are averaged, it accounts for the additional costs of the inputs. Taking the inputs at the mean levels, at least the corresponding function is best explained (7, p. 231). This amounts to averaging of AB and CD; at A, the pre-technology function explains the best and at D the post-technology function explains the best. But in the case of the alternative approach of estimating the increase in production at the average of the two mean levels of inputs, i.e., GH, none of the functions is best explained. Also, these two approaches will yield little difference. The former approach was, therefore, followed.

The estimated output from the two functions at the respective mean level of inputs for the two periods and the estimate of the returns to investment on research are given in Table II.

**Table II—Estimation of the Returns to Investment in Research**

<table>
<thead>
<tr>
<th>Estimating function</th>
<th>Mean level of inputs of the period</th>
<th>Estimated output (Rs. per hectare)</th>
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<tbody>
<tr>
<td>1960-65</td>
<td>1960-65</td>
<td>506.70</td>
</tr>
<tr>
<td>1969-72</td>
<td>1960-65</td>
<td>743.09</td>
</tr>
<tr>
<td>1960-65</td>
<td>1969-72</td>
<td>590.30</td>
</tr>
<tr>
<td>1969-72</td>
<td>1969-72</td>
<td>880.30</td>
</tr>
</tbody>
</table>

1. Increase in productivity during 1969-72 over 1960-65 at:
   1960-65 mean level of inputs = Rs. 239.20 per hectare;
   1969-72 mean level of inputs = Rs. 290.00 per hectare;
   Average increase in productivity = Rs. 264.60 per hectare.

2. Aggregate expenditure on research = Rs. 9.24 per hectare.

3. Returns to investment in research = Rs. 28.64 per hectare.

The increase in productivity during 1969-72 over 1960-65 period at 1960-65 level of inputs was Rs. 239.20 per hectare and at 1969-72 level of inputs was Rs. 290 per hectare. The average of the two situations was Rs. 264.60 per hectare and this increase is due to the technology generated by research. Assuming that this increase in productivity of Rs. 264.60 per hectare per year during the three years 1969-70 to 1971-72 was due to all research during 1960-68, the estimate of the returns to investment in research was obtained. The total expenditure on research in Punjab has been estimated by Mohan, Jha and Evenson (11). This was discounted to 1960-61 level at 9 per cent rate of interest, because the output estimate was at 1960-61 prices. Table II shows that every rupee spent on research in Punjab has yielded a return of Rs. 28.64. This is quite an encouraging estimate to justify the huge expenditure incurred so far and to warrant still higher allocations for research in the future.

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4. The lag in returns from investment in research has been estimated to be about five and a half to eight and a half years by Peterson (1). The lag considered in this study was eight years.

5. This estimate compares favourably with that obtained by Kahloun and Singh through a different approach which was Rs. 21.80 per rupee for the Punjab (9). Compare it too with that of Evenson's of Rs. 40 per rupee spent on sugarcane research in India (13).
REFERENCES


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RETURNS ON INVESTMENT IN RESEARCH AND EXTENSION:
A STUDY ON INDO-SWISS CATTLE IMPROVEMENT PROJECT,
KERALA*

P. Kumar, C. C. Maji and R. K. Patel†

An attempt has been made in this paper to estimate the returns on investment in cattle improvement programme of the Indo-Swiss Project in Kerala by computing the benefit-cost ratio, the external and internal rates of return. As the research and extension activities of the project involves public investment, this study designed to throw light on the economic viability assumes great significance.

* The basic data for this study were obtained from R. K. Patel, V. Voegele, P. Kumar, et al.: Economics of Cross-Bred Cattle (Report of a Survey): A Study of the Cattle Breeding Programme of Indo-Swiss Project, Kerala, National Dairy Research Institute, Karnal, 1976.

† Division of Agricultural Economics, Indian Agricultural Research Institute, New Delhi and Division of Dairy Economics, Statistics and Management, National Dairy Research Institute, Karnal (Haryana), respectively.