RETURNS TO INVESTMENT IN AGRICULTURAL RESEARCH FOR TECHNOLOGICAL CHANGE

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Introduction

In this paper it is proposed to discuss and illustrate that technological change and the research behind it has an important role in our national economy. Historically, research has been instrumental in the technological revolution in farming which is responsible for such a high agricultural productivity and has contributed to the economic development of the United States. There is a wide-spread recognition among economists of the significance of technological improvement for economic growth and high returns to investments in research that has made this change possible.

Definition of Technological Change

Simply stated, technological change is shifting of production function. As stated by Schultz "Technological improvement is a superior resource that will produce for the economy a higher rate of return relative to its cost than will the (normal) established inputs employed in production." Technological change takes place when inputs yield proportionally more output. The quantitative measure of technological change would then be the ratio of the increase in output to the old output.


Technological Change, the Result of Research

Technological change is the most important force behind the increase in productivity of farm resources. However, technological advances in agriculture do not come about spontaneously. They are largely the result of scientific research. Some of the improvements may have resulted from chance, but by far most of them have come about through the conscious efforts of scientists. Research is responsible for the efficiency of present day agriculture. Our efforts thus need be directed towards meeting the research responsibilities of agriculture and to keep the technological advance progressing. Research could pay heavy dividends but research costs money, and proper allocation of scarce research resources requires that the various alternative uses be valued relative to their ability to satisfy the goals of society. Little research has, however, been completed that can be used by administrators in making decisions relative to optimal resource allocation for research.

Some Difficulties in Measurement

Investments in agricultural research have been found to yield good returns to society but empirical measurement of these returns is not easy. Economists, attempting to evaluate agricultural research returns, such as Heady, have concluded that “Society would have difficulty in finding many investment opportunities in either the public or private sector, which had greater promise of return to consumers in general, than this activity which has been embraced as an active public policy.” Mumford has also expressed a high marginal productivity of capital in investments for research. In few, if any, other ventures has the marginal productivity of capital been so great.

All available evidence indicates a high rate of return on research expenditures; however, it is extremely difficult to evaluate the input costs and the returns to research investments empirically. This difficulty in measurement stems from various factors and has been pointed out by several economists. Heady states that: “Difficulties arise in measurement because of problems in aggregation of commodities serving as inputs and outputs; in identifying research inputs and their outputs in both private and public sectors; in evaluating knowledge which would have been ‘self-generating’ and in others.” Schultz points out that there is a long lag between a particular research activity and the time when the contributions from such research become available and are adopted by farmers. If inputs could be accurately measured against lagged productivity, the social return to the public investment in research would be high. Another measurement difficulty stems from the fact that research often provides the basis for future research as well as the basis for action. Some worthwhile research cannot be valued in monetary terms. The improvement in human health resulting from the production of vegetables with desirable vitamin content is an example of an important non-monetary return to research.

There is an element of uncertainty about research results. Research on any one problem is a gamble. When a scientist experiments, he is seeking new knowledge. He is an explorer entering unmapped territory. Therefore, some of his experiments may fail. The Du Pont company estimates that only one in 20 of its research projects pays off. Nevertheless, a going research programme spread over a variety of subjects is usually a sure thing. Du Pont's one success has always produced enough profits to carry most of the other 19, and pay handsome profits in addition.\footnote{Science Serving Agriculture, Biennial Report of Oklahoma Agricultural Experiment Station, 1950-52, Stillwater, p. 10.}

**Returns to Research**

But while there can be questions about the exact and specific levels of returns, there is no doubt that it has been extremely high. This can well be demonstrated by few examples of measurements on research investments in United States.

As early as 1934, Secretary of Agriculture, Henry A. Wallace stated that: "a dollar of investment by the Government for scientific research in agriculture brought back a hundred dollars."\footnote{Anthony M. Tang in a recent study of inputs and output of Japanese agriculture for the period from 1880 to 1938 estimated the social rate of return to education, research and extension to be 35 per cent per year.} R. H. Ewell has estimated the national rate of return on all research and development to be 100 to 200 per cent.\footnote{R. H. Ewell, "Role of Research in Economic Growth," *Chemical and Engineering News*, Vol. 33.}

Zvi Griliches made the first systematic attempt to estimate the realized social rate of return, as of 1955, on public and private funds invested in hybrid corn research. He concluded, as of 1955, the rate of return to all past expenditures was virtually 700 per cent, or seven dollars of return for each dollar so expended in hybrid corn research. In the same study, he also estimated the rate of return on research expenditures on hybrid sorghum at about 400 per cent. In general, on all types of agricultural research, Griliches found that the lower limit of return to the total public and private expenditures on agricultural research was 35 per cent and the upper limit 171 per cent.\footnote{Zvi Griliches, "Research Cost and Social Returns : Hybrid Corn and Related Innovations," *Journal of Political Economy*, Vol. LXVI, No. 4, October, 1958, pp. 419-431.} Hybrid corn is one highly successful example. Other researches will have a lower pay-off. But even at returns around 100 per cent or even of 70 per cent, the social pay-off is large.\footnote{Earl O. Heady: *Op. cit.*, p. 601.}

Agricultural economists at Washington estimated that an improved strain of high yield, rust resistant wheat had brought a financial return to the wheat farmer in the state of Washington equal to the total sum of all state appropriations to the College since it had been organized. At Ames, Iowa, it has been reliably estimated that for each $1.00 spent for research in agriculture, about $30.00 or more has been returned to Iowa farmers.
Directors at Ohio State Agricultural Experiment Stations have profoundly claimed: "Historically, it can easily be shown that each dollar invested in agricultural research has been returned to the economy a hundred-fold within a decade or so. It is likewise a demonstrated fact that each additional dollar's worth of agricultural product generates three to five dollars' worth of economic activity in the area where it is produced."  

We could list other examples of the manner in which agricultural research has provided the real pay-off to agricultural industry and to the public as a whole in United States. While estimates on returns for agricultural research in India have not been worked out empirically, there is no doubt that the level of returns has been extremely high. Much of the progress of modern Indian agriculture today could be traced directly to research findings.

Conclusion

Technology is the most important force affecting the structure and income of agriculture and its role in the national economy. Every progressive nation has benefited from the technological change and research behind it. If India is to achieve within a reasonable length of time its food, feed and fibre production targets in the face of an increasing human and cattle population, agricultural research should be expanded at all levels. The nation's present agricultural research effort is too limited to meet our objectives. A programme adequate to meet them would require additional facilities and personnel. Professor Schultz has emphatically pointed out the importance of technological advance and research in farming for developing nations: "improving the quality of agricultural inputs and supplying them at a price that will make it worthwhile for farmers to acquire them and to learn how to use them efficiently, hold the key to economic growth from farming."  

This implies intensification of our research efforts in right directions to keep the technological advances progressing.

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