Translations and Reprints No. 18

THE UNEVEN PROSPECTS FOR GAINS FROM AGRICULTURAL RESEARCH RELATED TO ECONOMIC POLICY

Theodore W. Schultz

CENTRO INTERNACIONAL DE MEJORAMIENTO DE MAIZ Y TRIGO
INTERNATIONAL MAIZE AND WHEAT IMPROVEMENT CENTER
Londres 40 Apartado Postal 6-641 México 6, D. F., México

THE UNEVEN PROSPECTS FOR GAINS FROM AGRICULTURAL RESEARCH RELATED TO ECONOMIC POLICY*

Theodore W. Schultz
University of Chicago

We have gathered here to share our insights on the organization, the performance and the production effects of a new international network of agricultural research activities. This network, which has been developed during the last three decades, serves many countries, and in this sense, it is an international enterprise. Although it is international in scope. It was not launched by governments. It began as a venture of a rare breed of research entrepreneurs who knew from experience the requirements of the agricultural sciences and who at the outset were financed by private foundations. It now consists of a wide array of inter-related research enterprises located in various low income countries throughout the world. It is clear that the function of this network of research activities is to employ the knowledge and talents of agricultural scientists as a means of increasing the productivity of agriculture in low income countries.

This international approach to agricultural research is now well established. It is robust and we see that it is capable of dealing with changing circumstances and that it is successful in taking advantage of new opportunities. But there are many low income countries that could have benefited from this research but have failed to do so. Others have benefited somewhat, but much less than they could have. Among them are countries that have the natural endowment and the potential economic capacity to greatly increase their agricultural production. We have not, in my view, given adequate attention to the factors that account for these failures. It is my contention that unless these factors are altered for the better, the uneven prospects for gains from agricultural research that are related to the economic policy of the respective countries will continue to thwart the potential success of this international approach to agricultural research.

I shall begin with a comment on aspects of the anti-science "movements" with special reference to the new popular misconceptions and criticisms of agricultural scientists that prevail despite the recent acute shortages of food in parts of the world. I shall then concentrate my remarks on economic issues pertaining to the future value of agricultural research, with special references to economic policies that account for the uneven prospects already referred to.

I. The Utility of Science in Being Debased

The role of agricultural research in maintaining our faith in the utility and legitimacy of the Sciences is stated imaginatively by Andre and Jean Mayer in their recent essay, "Agriculture: The Island-Empire."[1]

> Few scientists think of agriculture as the chief, or the model science. Many, indeed do not consider it a science at all. Yet it was the first science --the mother of sciences; it remains the science which makes human life possible; and it may well be that, before the century is over, the success or failure of Science as a whole will be judged by the success or failure of agriculture.

---

* For the conference on Resource Allocation and Productivity in International Agricultural Research, Airlie House, Virginia, January 26-29, 1975 sponsored by The Agricultural Development Council, Inc. (Agricultural Economics, Paper 75:1, revised, Univ. of Chicago). Reprinted under permission.

1 An Essay in "Science and Its Public: The Changing Relationship," Daedalus, Summer, 1974, 83-95. See, also, the excellent essay by Edward Shils, "Faith, Utility and Legitimacy of Science," in the same issue of Daedalus.

If agriculture is the mother of sciences, motherhood is being treated rather shabbily these days. Be it the current food deficit in India or the approaching doomsday, there is a lot of rhetoric proclaiming that agricultural scientists are to blame. The effects of science on agriculture are deemed to be bad; it follows, of course, that agricultural scientists are responsible for the inordinate appetite of modern agriculture for energy and for chemicals that pollute our soil and that contaminate our food supply. It is also being said that they are making agricultural production more vulnerable to changes in weather and that they cause much unemployment. In the United States during the sixties, agricultural scientists were blamed for the then mounting agricultural surpluses. Some critics even proclaim that the Green Revolution only confounds the excess population growth, and worst of all it is popular to say that it is unjust to poor people. Nicholas Wade in his December 20 and 27 papers in Science tries to present a balanced view but he leaves his readers with a very dismal picture of the Green Revolution. [2]

Agricultural scientists have good reasons for feeling ambivalent about the treatment they receive. Although our major private foundations have been generous and successful in building international agricultural research centers, U.S. aid in support of agricultural scientists over the years, beginning with Point Four, has been much more uneven and undependable than the Canadian performance through CIDA and IDRC. Our prestigious National Academy of Sciences in its foreign activities (department) has failed to understand the role and requirements of agricultural scientists, and in its domestic committee pronouncements have tended to look upon agricultural scientists as a lowly breed who are in general out of touch with the real physical and life sciences. The environmental movement has added to their woes. Agricultural scientists also are stung by the statements of those economists who claim that agricultural scientists are contributing to the inequality in the personal distribution of income inasmuch as they have failed to develop types of wheat, rice and other crops that would solve the equity problems in low income countries. I shall return to this issue.

The view that I shall take rests on two propositions: 1) advances in the agricultural sciences are one of the necessary conditions for agriculture to succeed as the primary supplier of food, and 2) optimum economic incentives for agriculture (farmers) are one of the necessary conditions in determining the full possibilities for the useful advances in the agricultural sciences. I shall contend that we have not given sufficient attention to the second of these two propositions. In support of my view, I shall comment briefly on parts of the papers and then turn to a consideration of an economic approach that is more general than has been our want in analyzing the real economic value of agricultural research.

II. With Respect to the Papers

In line with the plan of this conference, the papers that were at hand before we met, fall into three groups: 1) the organization, funding and the decision-making process of this international network of agricultural research activities; 2) the economic studies of the production effects of this research during the recent past in particular countries including estimates of costs and returns; and 3) a set of economic models that may prove useful in undertaking future research. Judging from the quality of discussion and its fruitfulness, the plan and the papers must be given a high mark.

1. The papers devoted to organization, funding and decision-making give a rich account of what has been learned from experience. We see it clearly as an international enterprise from Crawford's advantageous position. Wortman stresses the fact that the critical decisions come down to "considered judgments"; I strongly concur. These decisions entail risk and uncertainty and other considerations that are beyond precise measurement. Each of the papers in this set adds appreciably to our insights on how this research complex is operated, how it is evaluated, and how it is adjusted to changing perceived opportunities. Three things, however, are missing.

---

2 Nicholas Wade, "Green Revolution (I)" and "Green Revolution (II)" in Science, December 20, 1974, Vol. 186, pp. 1093-1096, and December 27, 1974, Vol. 186, pp. 1186-1192.

First, no doubt out of modesty, the authors are reluctant to discuss the very important function of research entrepreneurship in the success of this enterprise. I would like to know what are the essential qualifications of research entrepreneurs. It is more than a talent for management and administration. It is undoubtedly a rare talent. There is in this area a lot of experience to draw upon. The generation of research entrepreneurs who launched and who have been successful will soon be replaced by a new generation. Are they being recruited, acquiring experience, and being tested? I see no evidence that this is occurring. Our discussion convinced me that the functions of the research entrepreneur are not adequately understood and that the value of their contributions in the success of this research complex is vastly underrated.

Secondly, there is no systematic treatment of introducing and taking advantage of market competition in the organization of this activity. On the contrary, the appeal by some is to ever more complex systems of communication to provide information and to integrate the decision-making process. The implied assumption of this approach is that the market is at no point as efficient in providing such information as an extensive non-market communication system. It is, in my view, a false assumption. There are many points at which market competition is far more efficient in this respect. We see it in the production and distribution of high yielding food and feed grains. Private firms, subject to competition, have demonstrated their comparative advantage. Sehgal's analysis bears on this point. Once we begin to look for ways of taking advantage of market competition in shaping the organization of this research, we will find that it can serve us efficiently at many points. One further point with regard to competition. I have on other occasions expressed concern about the increasing centralization in the allocation of resources to agricultural research. It implies less competition; it assumes general indivisibility among research activities; and it constrains the research choices of individual agricultural scientists. I confess I am biased in favor of competition. What would the considered judgments of those who have inside experience tell us about the role and limits of competition in this area?

The third missing thing pertains to the inherent difference in research possibilities among various crops both in the short and long run. A good deal must be known from experience and from the state of our scientific knowledge. There are no doubt many variables that must be reckoned with in arriving at considered judgments. What are these variables and to what extent is each subject to uncertainty? What weight do research entrepreneurs give to the anticipated research effort that will be required, the time it may take, the yield effects, and the risk and uncertainty that is involved? Economists are woefully uninformed with respect to the research possibilities that agricultural scientists and research entrepreneurs are up against.

2. To see the second set of papers as I do, the choice of language and concepts is important. In the allocation of resources, agricultural research is fundamentally an investment in future returns. It obviously is not a leisure activity to please and to enhance the welfare of agricultural scientists. The concept of research capital formation is useful in guiding our economic thinking. It leads us to look at the different forms of such capital, e.g., banks of genetic materials, laboratory facilities, experimental fields, and various mixes of scientific skills. I am attracted to Wortman's definition of "scholarly capital"; it is succinct, cogent and useful. Each form of research capital has its own rate of depreciation and when the genetic yield reaches its maximum, as illustrated by Kislev's genetic cow, all further research would consist of maintenance research. In the production of research capital forms, the concept of scale and the optimum combination of research inputs serve to guide us in distinguishing between less and more efficient organizations. The concept of a general economic equilibrium is always, as it should be, in the back of our minds, although the observable behavior of people including research entrepreneurs reveals their perceptions, decisions and actions to regain equilibrium. It is my contention that we grossly neglect the extension of theory to analyse these equilibrating processes. Factor prices obviously matter but so do farm product prices. Although farm product prices are in serious disarray throughout the world, the papers in this group are virtually silent on the implications of these price distortions for the optimum contribution of agricultural research.

The empirical studies that trace the diffusion and that estimate the research costs and returns from the new high yielding grain varieties in selected low income countries, represent a major contribution. They tell a consistent story, i.e., the realized rate of returns relative to the costs of the research is much higher than the rate of return from most alternative investment opportunities in these countries. The results from Dalrymple's approach are for all practical purposes the same as those from Evenson's production function approach. Although data limitations abound and specification biases are ever present, the results are so robust that they must be taken seriously. The endeavor by Evenson to distinguish between applied and scientific research in this context is sufficiently important and promising that it should be placed high on our economic research agenda. With respect to developments in

Colombia, Hertford's study adds two new insights: 1) the strong adverse effects of P.L. 480 wheat on the farm price of wheat in Colombia and as a consequence the pay-off from the wheat research in Colombia has been very low [3]; and 2), in the case of cotton, yields nearly quadrupled mainly since 1958 in response to the favorable price effects resulting from the exchange rate reforms in that year, and Colombia became an exporter of susbstantial amounts of cotton. But in this particular success story, "no significant, positive benefits were derived from the Colombian cotton research program." I venture that a careful look at the evidence pertaining to Mexico's success in cotton would reveal a similar story. Analytically, what is noteworthy in Hertford's study is the fact that he took account of both wheat and cotton farm prices. His study is not limited to changes in factor prices.

The two papers on Brazil come closest to dealing with the dynamics of economic development, including the reduction in barriers to the export of farm products, and with the resulting favorable farm price effects. The implications for agricultural research are strongly positive. According to Pastore and Alvers, one of the main reasons for the recent large increases in federal support for agricultural research is "to gain sizeable slices of the international market." The approach of the Castro and Schuh is useful in interpreting the Brazilian experience.

3. There are a few papers that consist of models with no empirical analysis to show that they may be useful. I take a jaundiced view of such papers. It became evident in the discussion, however, that the authors had applied them. It is my hope that their empirical applications will be included when these papers appear in our published proceedings. In organizing the 1962 JPE Supplement on human capital,[4] I held firmly to the decision that no paper would be acceptable unless the author could show or had shown that he had used his model in empirical analysis. The models in that supplement have been widely applied and I am convinced that this occurred because the authors demonstrated that they were in fact useful. My experience with two more recent JPE Supplements, devoted to the economics of fertility,[5] strongly supports the position I took. Our economic literature is plagued with an abundance of unused (seless?) models.

I am puzzled by the fact that these three groups of papers are mute to the economic policies of those low income countries that thwart the gains to be had from agricultural research. I know that international research entrepreneurs are reluctant to openly criticize the policies of governments. It is obviously a very sensitive issue. But the issue must be faced if the production of food is to be increased, as it can be, to serve the needs of the people in these countries. The fact that the papers by economists say so little bearing on this issue, is odd indeed.

III. Economic Policy Matters

We have not allowed ourselves to see the effects that governmental policies have on the economic value of agricultural research. If we did, as we should have, we would find that in many low income countries, these effects are highly adverse to the attainment of the optimum benefits from both international and national agricultural research enterprises. We find it convenient not to see these consequences because the economic policy of any government, other than our own, is a very sensitive issue. We play it safe by proclaiming that it is improper for us to criticize such policies. This uncritical view of what sovereign countries do, leads us into a serious inconsistency. Our endeavor to help solve the food problem in these countries tends to be under such circumstances inconsistent with their sovereign behavior. In my view, a large part of the poor performance of agriculture in many low income countries is a consequence of bad economic policies. In this context, it is a mistake on our part not to take a carefully considered, critical view of such policies, granted that in doing so, we would enter upon some very sensitive issues pertaining to sovereignty.

---

3 The study by Leonard Dudley and Roger J. Sandilands, which Hertford cites, is now published; see, "The Side Effects of Foreign Aid: The Case of Public Law 480 Wheat in Colombia," Economic Development and Cultural Change, 23, January, 1975, 325-336.

4 "Investment in Human Beings," Journal of Polical Economy, 70, Supplement, Part Two, October, 1962, 157 pages.

5 "New Economic Approaches to Fertility," Journal of Political Economy, 81, Part II, March/April, 1973, 299 pages; and, "Marriage, Family Human Capital, and Fertility," Journal of Political Economy, 82, Part II, March/April, 1974, 233 pages.

I shall restrict my remaining remarks to three such issues: 1) the gains that consumers derive from agricultural research, 2) the effects of such research on the personal distribution of income, and 3) the adverse effects of farm product price distortions on the optimum contribution of agricultural research.

1. We are remiss in not showing the extent to which consumers gain from agricultural research. To merely say that there may be a consumer surplus is not sufficient. To contend, as we do, that farmers as producers are the real beneficiaries of agricultural research, is far from true. Farm families as consumers may gain and, under special circumstances, would derive the full gain. Suppose that the costs of producing rice were reduced significantly by means of new variety, and suppose further that the small rice farmers who adopt this variety are wholly self sufficient in what they produce and consume. In this special case, all of the benefits would accrue to the farm family as consumer gains. The real income of the family would be increased. The transfer of these gains from a reduction in real costs is much more complex in a market economy under competition. The event that leads to a reduction in costs in the first instance creates a disequilibrium. Farmers make adjustments to regain equilibrium. The rate at which and the extent to which the gains are transferred to consumers depend on the elasticity of demand and the shift in demand during the full adjustable period. If all of the product were exported, it would be the consumers in the importing countries who would gain and the extent to which they did would depend upont the effects that the additional exports of the country have on the world price. Although there are various possibilities, general economic theory tells us that the gains in agricultural productivity derived from research are, in general, transferred overtime via competition to consumers. Farmers cannot hold on to these gains for long, although these who are among the first to reduce their costs profit for a time and until competition has had its say. Farmers, of course, benefit in their capacity as consumers.

We know from Peterson's Ph.D. research that the marked decline in the price of meat from poultry was in considerable part a consequence of agricultural research. [6] Between 1910-14 and the 1971 crop year, "the real price of food grains declined by 37 percent."[7] I wish we knew how much of this consumer gain was derived from agricultural research. Prior to World War I, the price of a ton of wheat was substantially higher than that of rice. Since the mid-fifties, however, the price of wheat has in general been about one half of that of rice. My guess is that agricultural research over this period was much more effective in reducing the real cost of producing wheat in the world than it was in the case of rice. How much is to be credited to research and how the many equilibrating processes in agriculture have performed is still to be determined. There is, however, the reduction in the costs of producing poultry, wheat and of many other farm products. This being true, the possibilities of reducing these costs further in the future should enter as a basic consideration in making economic policy.

2. Although we know all too little about the factors that alter the personal distribution of income, we nevertheless know enough about the income distribution effects that are associated with the history of agricultural modernization to correct some of the widely held misconceptions with respect to this issue. I shall restrict my remarks to consumers, landlords and farmers.

(1) The primary research effects on income inequality occur as a consequence of the gains in agricultural productivity that are transferred to consumers. Accordingly, any reduction in the real costs of producing farm products benefits the consumers, and the real income of high income families. We know that a sales tax on food is regressive, by the same economic logic the research effects, here under consideration, are

---

6 Willis Peterson, "Returns to Poultry Research in the United States," unpublished Ph.D. dissertation in Economics, University of Chicago, 1966.

7 D. Gale Johnson, "World Food Problems," unpublished Agricultural Economics Research Paper No. 74:8, July 10, 1974.

progressive in the way the benefits are distributed among poor and rich families. Lower farm-food costs, therefore, are important in reducing the inequality in personal income. There is much evidence which shows that the primary accumulative effects of agricultural modernization, including agricultural research, has not been unjust to poor people, on the contrary, it improves their lot more than it has that of the rich. We owe our agricultural scientists a great deal in this connection.

(2) Another income distribution effect occurs as a consequence of changes in factor shares. It is widely observed that the share of income of farm landlords declines as the modernization of agriculture proceeds. It is my contention that agricultural research accounts for a considerable part of this decline in the economic importance of farm land as a factor in production measured in terms of the fraction of the income that accrues as land rent. We fail to see this process because our analytical approaches rest on Hicks' Law. No one has been more cogent than Professor Jan Pen[8] in showing the limitations of Hicks' Law in analyzing the historical decline in farm land rents as a share of income. Some of the credit for the fading away of this landlord class belongs to our agricultural scientists, because they come up with substitutes for farm land and because they increase the human capital that is required.

(3) The effects of agricultural research on the distribution of personal income among farm families is an issue that is dominated by confusion. They may gain as consumers and in this context, as Hayami and Herdt[9] have shown, that small rice farmers tend to benefit more than the large rice farmers. To the extent that farmers are owners of farm land, the rent that assures to them will tend to decline over time. As modern farming becomes more complex and as the adoption of new research results becomes more important in farming, the human capital of farmers becomes increasingly important. Under such dynamic conditions, the better educated farmers, in terms of their acquired human capital, win out under competition.[10]

Contrary to much that has been said about the bad effects of the high yielding wheat varieties on the distribution of personal income in Indian Agriculture, there are now two studies in depth[11] that show that in fact the income inequality has been somewhat reduced. These effects could not have been predicted; we had to wait for the evidence to find out. Under other economic conditions, the results could be otherwise. Important as it is that economic policies not by-pass and not discriminate against small farmers, agricultural scientists, who are endeavoring to develop more "efficient" plants (animals, too) in terms of their genetic capacities, and chemists who are engaged in developing cheaper and better chemicals, should not be placed under the constraint that the fruits of their research be applicable only to small farms.

3. Lastly and most important on my agenda, is the pricing problem. In my view, the distortions in farm product prices greatly reduce the potential economic value of agricultural research. But we have not come to grips with this problem, except for the distortion in wheat prices in Colombia and its adverse effects on wheat research and in an awareness of the importance of export prices in Brazil. The countries of Western Europe and Japan over price farm products, and as a consequence the economic value of research is thereby overvaluated. The high internal price of rice in Japan and of wheat in France are misleading indicators in determining the real value that agricultural research adds to income. The success of research in Japan must be discontinued substantially for this reason. The effects of over pricing in Western Europe are much more serious in the sense that they reduce the farm price incentives in some of the low income countries.

---

8 Jan Pen, Income Distribution: Facts, Theories, Policies, translated by Trevor S. Preston, Praeger Publishers, New York, 1971. See especially pp. 208-214.

9 Yujiro Hayami and Robert W. Herdt, "The Impact of Technological Change in Subsistence Agriculture on Income Distribution," presented as a workshop paper at the University of Chicago, January 30, 1975.

10 I deal with this issue in considerable detail in "The Value of the Ability to Deal with Disequilibria," unpublished human capital paper, No. 74:1, revised December 20, 1974, University of Chicago.

11 K. Satyanarayana and M.A. Muralidharan, "Impact of New Farm Technology on the Economy of Cultivator Households in Punjab," Indian Agricultural Research Institute, New Delhi, 1974. 109 pp. unpublished manuscript. Katar Singh, "The Impact on New Agricultural Technology on Farm Income Distribution in the Aligarh District of Uttar Pradesh," Indian Journal of Agricultural Economics, Vol. XXVIII, No. 2, April-June 1973.

Our primary concern, however, is to improve the organization of and to increase the investment of agricultural research as a means of increasing the supply of food in low income countries. But the persistent, serious, under-pricing of food and feed grains in most of these countries greatly reduces the potential possibilities of achieving this objective. None of the recent rhetoric on shortages of food grains has dealt with this basic issue, namely that the cheap food policies of most of these countries not only hampers, but keeps agriculture far below its optimum production. In my view, it is the task of outside economists to provide the analysis that will determine the extent to which low income countries are themselves responsible for their shortages of food. It is this implied interaction between agricultural research and production that we have not faced throughout this conference. To take the internal prices of these countries as given is to dodge our analytical responsibility.

Hard as it is to ascertain the real farm product prices in these countries, the prices that I have at hand[12] tend to support the following economic inferences:

(1) The state monopoly marketing boards throughout West and East Africa have been and are pricing their best farm crops to death; by best, I mean the crops in which these countries have a real comparative advantage. If these marketing boards had been established for the sole purpose of reducing the economic incentives to produce these crops, it would be difficult to see how they could have accomplished that purpose more successfully. To give an example, last March while I was in Senegal, I observed that the farm price for groundnuts was decidedly less than one half of the real export price. The marketing board was collecting revenue and the farmers were being discouraged further by the marked rise in the price of fertilizer. The implications for research on these key crops in these parts of Africa are obvious.

(2) The economic potential of the Argentine as a major supplier of wheat and corn has been greatly impaired by the underpricing of these crops within that country. The farm price incentives have long been one-third and more below the real value of these crops. Is it any wonder that yields have benefited so little from wheat and corn research?

(3) In the production of rice, I see Thailand and Burma as having a very large unrealized economic potential. But it is not forthcoming. The economy of Burma is in serious disarray; and, in Thailand, the politically convenient export tax on rice has long been the means to keep the price that rice producers receive, a third to two-fifths below its real economic value. The new high yielding dwarf rices and their costly complement, i.e., investments to control the water, continue to remain uneconomic. In contrast, the pricing, the use made of research, and the impressive gains in the production of corn in Thailand is a story of real economic success.

(4) Another view of farm price distortions is evident when one looks at the prevailing internal relative prices. I take as my standard that the real economic value of rice is about twice that of wheat per ton and that of corn is somewhat less than for wheat. In India, the farm harvest prices of rice has tended to be somewhat below that of wheat. The implication seems obvious: if the farm price of rice were twice as high as that of wheat, the incentive to modernize rice production would turn sharply in favor of rice. To return to Thailand, the wholesale price of rice in Bangkok has been virtually the same as that for corn. In seven of the years between 1960 and 1973, the price of corn was actually higher. Yet the real economic value of rice is more than twice that of corn; whereas the price of corn is in line with its real value, rice, the key crop, is vastly underpriced.

To summarize, we have learned a lot with respect to the organization of agricultural research. It is true that the basic decisions come down to "considered judgments." It also is true that research entrepreneurs and competition are important but they were omitted in the several useful papers on organization. We now have robust evidence that the pay-off on investment in agricultural research has been very high. But there is more to be said on the interactions between agricultural research and the economy. The gains from research over time benefit primarily consumers. As consumers benefit from lower costs of farm foods, low income families gain relatively more than high income families, and to this extent, the inequality in income is reduced. The economic importance of the landowner class declines in part as consequence of the contributions of agricultural scientists. Within agriculture,

---

12 Christine Collins of Economic Research Service, U.S.D.A., has been most generous of her time in helping me with data on prices. It would require a major paper to interpret fully the prices that I have from her along with those I have had at hand. She is, of course, not responsible for what I say in the paragraphs that follow.

the income distribution effects in low income countries are not necessarily adverse to small farmers. From a policy point of view, however, what is important is that there are appropriate economic policies for reducing the inequality among farm families; it is a mistake to burden agricultural scientists with this particular inequality problem for the reasons I have presented. The neglect of the farm product pricing problem between and within countries is, in my view, the most serious omission. The existing distortions in these prices greatly reduces the potential economic value of agricultural research. I realize that it is a very sensitive problem, in all probability too sensitive an issue for those who are inside to enter upon. Nevertheless, solutions must be found if in fact many of the low income countries are to succeed in producing enough food to satisfy their demand.