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SOURCES OF DIFFERENCES IN RATES OF RETURN TO  
AGRICULTURAL RESEARCH BETWEEN COUNTRIES:  
SOME GENERAL OBSERVATIONS\*

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Sources of Differences in Rates of Return to  
Agricultural Research Between Countries:  
Some General Observations\*

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Differences in rates of return to agricultural research between countries can be attributed to three major factors. The first is the production elasticity of research when research is viewed as a separate variable in an agricultural production function. Or if one wishes to evaluate research by the "consumer surplus" approach as in Griliches hybrid corn study it is the "k" value. Other things equal, the larger the production elasticity or "k" value, the more productive the research and the greater its rate of return.

The second factor is the value of agricultural output that is influenced by the research. In the context of a Cobb-Douglas production function, this factor is the average product of research--dollars of associated agricultural output per dollar of research. Using the consumer surplus approach, it is the absolute value of the associated agricultural output (the PQ in the formula developed by Griliches) in relation to the expenditures on research. Other things equal, the larger the average product, or the PQ in relation to research expenditures, the larger the rate of return to investment in research.

These two factors determine the VMP of research. If we want to convert the VMP into a rate of return then we must take into account the lag between research and the corresponding increase in output. Other things equal, the longer the lag, the lower the rate of return to research.

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Although these three factors can be helpful in organizing our thoughts on the question, a full understanding of the sources of differences in rates of return can be obtained only by asking why do these factors differ between states, regions, or countries (if they do).

Differences in the production elasticity (or  $k$  value) of research can be attributed to a number of variables. Perhaps most obvious is the skill or competence of scientists. This in turn depends both on inherent ability and acquired skills. For differences between nations, the latter is likely to be most important. In regard to this point it ought to be mentioned that the way in which research effort is measured likely will influence its production elasticity or  $k$  value. If research is measured by scientific manyears unadjusted for quality differences, we should expect to observe more differences in the productivity of research between states or countries than if effort is measured by monetary cost. The labor market for scientists is not likely to be completely oblivious to differences in quality. The better ones likely earn more than the poorer ones, although differences in pay probably doesn't reflect the full difference in productivity. There is a related question of how to measure the scientific input in monetary terms in a cross-country production function where there are large differences between countries in the average level of salaries. When inputs or output are measured in value terms, one should use constant prices (adjusted for quality) cross sectionally as well over time for the purpose of estimating the coefficients in a production function. Then one can compute the VMP of scientific effort for individual countries by using internal prices say to

determine average products in the Cobb-Douglas framework. It seems to me that the greatest problem of estimating a cross-county production function is to measure input quality differences between countries.

The production elasticity of research also can vary because of differences of supporting facilities (computers, etc.) and personnel and by differences in administrative organization and size of the research units. For example, it has been argued that scientists are more productive when research is combined with teaching, particularly at the graduate level. And if there are economies of scale to research the production elasticity of research should be larger for larger research units. One shouldn't neglect to mention the adverse role of politics or ideology on scientific output if it reduces freedom of inquiry or exchange of information. The level of complementary inputs, such as the effect of basic research on the output of applied scientists, no doubt is important in determining the productivity of scientists. One should include here the likely effect of private R & D of the farm supply industries on the research done by public institutions. If we only include public research in the production function, its coefficients should be higher in countries where private R & D is above the mean of the group or sample. Related to this is the import of scientific information. One might expect nations which are net importers of information and do primarily adaptive research to exhibit a larger production elasticity of research than nations which produce knowledge from "scratch".

It also should be recognized that the productivity of scientists, at least as measured by the production elasticity of research in an aggregate agricultural production function or by its "k" value, is in

large part dependent on the profitability of the farm supply industries and of agriculture. If it doesn't pay the farm supply industries to produce or farmers to buy complementary inputs which increase the VMP of research, the new knowledge may not have an observed effect on agricultural output. For example, yield increases of new varieties are likely to require the use of more fertilizer and chemicals. Indeed the research which makes possible the production or use of these new high pay-off inputs may not even be done if they are not profitable. Instead the scientific efforts may take the form of refining old techniques or trying to make good farmers out of poor ones. Historically these efforts have had a relatively small impact on agricultural output.

Although education of farm people has been thought of primarily as a means of speeding up the adaption of new technology, it is possible that it can also affect the production elasticity of research. For example the level of schooling not only of farmers but also of farm supply industry personnel probably limits the kind of knowledge that can be utilized from other countries.

The production elasticity or "k" value of research also can be influenced by differences in the difficulty of the problem being worked on. For example, it is easier to produce hybrid corn than hybrid wheat.

Many of the above factors which can affect the production elasticity of research are likely to average out between research organizations within a given country. Indeed we could find no significant difference in the production elasticity of research

between U.S. experiment stations when grouped by levels of their average products (of research). However because of rather large differences between countries in the level of inputs which are complementary to applied agricultural research as well as large differences in organizational, political, and economic factors, one would be surprised to find the same thing in cross country observations. Off hand, one might think that the production elasticity would be higher for the DCs than the LDCs because of better training of scientists, higher farm prices, more complementary inputs from the farm supply industries, more freedom of scientific inquiry, better communications and research facilities, and a higher level of education of farm people and farm supply industry personnel. One offsetting factor would be the net import of knowledge by the LDCs.

Turning now to the second major factor affecting the rate of return to agricultural research, namely its average product or dollars of related output per dollar of research, we can say that if research is subject to diminishing returns, then other things equal the greater the investment in research in a given country the lower its VMP and rate of return. It seems reasonable to believe that in the short run particularly for narrowly defined research areas diminishing returns set in. It is not so clear over the long run especially for agricultural research in the aggregate. In this case the production of complementary inputs to current research, mainly past discoveries, may increase its production elasticity thereby offsetting a declining average

product (if research is increasing faster than agricultural output). At any rate if the VMP of research declines as its level increases, one might expect on the basis of this factor that the marginal rate of return to investment in agricultural research would be higher in the LDCs than the DCs because of the lower level of research expenditures in the latter countries.

It is interesting to note that there appear to be substantial differences in the VMP of agricultural research both within and between experiment stations (states) in the U.S. because of large differences in the average products of research. However, in this case the smaller average products tend to be associated with smaller levels of research (Table 1).

According to the Boyce and Evenson data the above relationship does not appear to hold true between geographic groupings of nations. As shown in Table 1, the simple average of average products for Western Europe and North America is about \$89 whereas the comparable figure for the remaining regions is \$109, although there are substantial differences between regions. One observes regions containing primarily LDCs which exhibit figures that are both above and below the values for Western Europe and North America. Of course prices of both agricultural output and research inputs have a great deal to do with the average product figures. Considering the depressed level of agricultural product prices in most LDCs, one might expect their average product figures to be substantially higher if world market prices were to prevail in these countries.

Table 1. \*Dollars of Agricultural Output per Dollar of Public Agricultural Research, 1969, Selected States

	<u>Dairy</u>	<u>Cash Grains</u>	<u>Poultry</u>	<u>Livestock</u>
Ohio	\$295	\$305	\$154	\$160
Indiana	234	356	312	324
Illinois	170	979	207	389
Wisconsin	1037	65	138	126
Minnesota	946	320	298	763
Iowa	307	259	183	607
Kansas	124	274	42	529
Arkansas	79	484	1089	86
Oklahoma	195	180	179	245
Wyoming	39	58	13	113
Washington	213	241	72	92
California	379	150	317	184
U.S. Average	261	200	221	196

Source: Computed from Maury Bredahl and Willis Peterson, "The Productivity and Allocation of Research: U.S. Agricultural Experiment Stations" AJAE, Nov. 1976, Table 7 p. 690.

Table 2. \*Dollars of Agricultural Product Per Dollar of Public Agricultural Research, 1974.

Northern Europe	\$76	North Africa	\$139
Central Europe	100	West Africa	89
Southern Europe	100	East Africa	61
Eastern Europe	87	South Africa	69
USSR	66	West Asia	120
Oceania	24	South Asia	322
North America	79	S.E. Asia	204
Temperate So. America	78	East Asia	32
Tropical So. America	97		
C. America & Caribbean	141		

\*Source: Computed from James Boyce and Robert Evenson, Agricultural Research and Extension Programs, ADC, New York, N.Y. 1975, table 2.7, p. 46.

Of course, even if LDCs were to exhibit substantially higher average products of research, their VMPs need not be higher if the production elasticities or "k" values of their research are lower. Indeed even if the VMPs and rates of returns are higher for the LDCs than the DCs, one still must consider the rates of return to alternative investments in the LDCs before concluding that they should increase investment in agricultural research. Rates of return to agricultural research should be equalized between nations only if the rates of return to all other investments are equal.

Even if it turns out that the rate of return to agricultural research in the LDCs are higher than alternative investments, one must also face the problem of availability of resources. Taking into account differences in per capita income and population per hectare of agricultural land, the allocation of resources to public agricultural research does not appear to be significantly smaller in the LDCs than in the DCs.<sup>1/</sup> Therefore, it does not seem likely that we are about to observe large increases in LDC agricultural research investment. At the present time bringing prices of output and inputs (particularly fertilizer) in the LDCs to the levels that exist in the DCs would seem to offer greater hope for increasing agricultural output in these countries than achieving an equilization of rates of return to agricultural research.

The third factor affecting the rate of return to agricultural research, namely the lag between the research inputs and agricultural

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<sup>1/</sup> Willis Peterson, "International Farm Prices and the Social Cost of Cheap Food Policies" Forthcoming AJAE, February 1979.

output, probably is not a major source of differences in rates of return to research between countries, although this statement borders on a sheer guess because of the absence of any international measurements of lags.