Investment in International Agricultural Research: Some Economic Dimensions

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INVESTMENT IN INTERNATIONAL AGRICULTURAL RESEARCH:
SOME ECONOMIC DIMENSIONS

This paper addresses two closely related issues. It first examines, ex post, the socio-economic impact of agricultural research, particularly that carried out by the international centers. It notes that the high-yielding variety (HYV) cereal production technologies introduced in the mid-1960s significantly increased the total supply of basic foods and resulted in lower real food prices than would have been the case without such technologies. Major beneficiaries therefore have been low income consumer groups. The paper points out that widely-adopted agricultural technologies will at best leave relative income distribution unchanged among producers, but will widen absolute income disparities when productive assets are inequitably distributed. Although such technologies may increase the demand for rural labor, and therefore produce some income gains for the landless, the introduction of new technology is in general not an effective means to redistribute incomes among rural groups.

The paper then addresses, ex ante, the "optimal" level of international investment in agricultural research. This is done using a conceptual framework to capture some of the more salient features of investment in research, using a research production function, supply and demand curves for research-generated agricultural production and discounted cash flow analysis. The model, though tentative, suggests that international investments in crop research could be significantly expanded from present levels without pushing the economic rate of return to unattractive levels.

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SUMMARY

i. This paper addresses two closely related economic aspects of agricultural research. First, it examines ex post, the impact of agricultural research, particularly that carried out by the international agricultural research centers, on several socio-economic variables including output growth, income distribution, employment and nutrition. Second, using a preliminary model it makes an assessment of the economically-optimal investment in international agricultural research. The paper also includes a 529-item bibliography of various reports and studies relating to the extent, limitations and consequences of investment in agricultural research.

Impact of Investment in Agricultural Research

ii. A major impetus to expanding international investment in food crop research came in 1971 with the establishment of the Consultative Group for International Agricultural Research (CGIAR). Subsequent years have seen a remarkable growth in the number of donors to the CGIAR, the size of its budget and the number of constituent institutions. The budget for 1979 of nearly US$100 million comes from a wide variety of bilateral and multilateral sources and will support a research program which embraces all major food crops and livestock in developing countries which account for more than 70% of the world's population.

iii. This rapid growth in national and international research expenditure has heightened interest among economic policy makers and research planners in the overall effects of such investments. A wide range of carefully-conducted studies demonstrate that in both developed and developing countries economic returns to research are frequently in excess of 50% per annum and rarely fall below 20%. But most of these represent only one dimension of social accounting, vis., economic efficiency. In the past decade it has been increasingly recognized that the efficiency criterion must be supplemented by explicit attention to distributional effects in assessing the impact of agricultural research. These concerns mark the work of the international agricultural research centers as well. Both in their mandates and the structure of their research programs, these centers have recognized the need to address both the efficiency and equity goals.

iv. Research expenditure in developing countries, while still low relative to that in developed countries, grew by nearly 600% in 1951-74. Some of this expenditure resulted in the development and introduction of high-yielding fertilizer-responsive varieties (HYVs) of wheat and rice after 1965. Twelve years later (1976-77) over one-third of the total area under these crops in Asia, Africa and Latin America was planted to these varieties. On average, an additional 4.5 million ha have been planted to high-yielding wheat and rice each year since 1965-66. This is expected to slow as the land areas suitable to these technologies are depleted.
Several studies suggest that HYV yields of wheat have on average been about 100% greater than (i.e., double) yields of varieties they replaced. A similar comparison for rice suggests an HYV yield superiority of about 40%. Estimates of this type are complicated by the inherent complementarities of the HYVs with other inputs such as fertilizer and water. But it is clear that the introduction of HYV wheat and rice has accelerated average annual growth in production of these two crops (to 4% and 2.4%, respectively, in 1967-75, compared with 2.4% and 0.9% in the early 1960s) in the developing market economics (DMEs). But almost all of this acceleration occurred in Asia. Elsewhere the rate of growth of rice and wheat output declined or remained unchanged. At the same time, rate of growth of coarse grain production declined in all DMEs.

Returns to investment at the international centers has been high. Roughly estimated, the economic rate of return to rice research through 1977 by IRRI was about 80%. This is roughly similar to the return to rice research in Colombia by CIAT and national programs. Continued investment in wheat and rice research at the international centers is likely to be highly profitable even under pessimistic scenarios regarding adoption and technology decay. Several international centers have not yet been operating sufficiently long to have perceptible impacts on production.

Because most HYVs perform well in favorably-endowed agricultural areas with good water control, but poorly elsewhere, their introduction has greatly exacerbated interregional income disparities. Data for India suggest that HYV production gains have been largely confined to the northwestern wheat states, with some progress in isolated rice areas. Areas dominated by other cereals and dryland agriculture have made little headway. Interstate disparities in the growth of Indian agricultural productivity are also explained by differences in research investment at the state level.

Most discussions of technical change in agriculture have addressed the question of influence of farm size and tenure on adoption of HYVs. Evidence from a broad range of studies suggests that in areas to which HYVs are suited neither farm size nor tenure has been a major impediment to adoption of these varieties. In these areas the large farmers tend to be the earlier adapters of the new technology, frequently because of lower risk aversion, easier access to credit and knowledge of these varieties. Small or tenant farmers have typically lagged in their adaption, but after this initial period few if any differences remain in adoption rates across farm sizes.

Any meaningful analysis of the impact of the HYVs on income distribution must disaggregate the question into several separate issues: (1) the distributional impact among producers in a given region; (2) distribution between landholders and labor; (3) distribution between regions; and (4) distribution between producers and consumers. Because large farmers are generally the first to adopt cost-reducing technologies, they capture many of the early gains to producers. This results in a temporary worsening of the relative income distribution which is corrected as adoption by small
farmers catches up. However, while the relative distribution of income between small and large farmers may eventually be unaltered, absolute income differences will widen as a result of the existing inequality in the distribution of productive assets.

x. Less is known of the distributional consequences of technical change between owner-operators and tenants and between landholders and laborers. Some evidence suggests that the spread of HYVs has been contemporaneous with a decline in the area under tenancy and an increase in the gross product paid as rent. The influence of relative factor prices confounds the analysis of the impact of the HYVs on incomes of landholders and laborers. But typically returns to landholders tend to rise more than returns to labor, the supply of which is more responsive to higher prices. Absolute returns to both landholders and labor increase but relative income disparities widen to the advantage of landholders. In general, investment in productivity-enhancing research is not an effective means to alter the relative distribution of incomes between landholders and landless laborers. The principal impact on employment lies in off-farm employment.

xi. The distributional impact of the HYVs as between producers and consumers depends on which groups are the predominant consumers of these products and the manner in which demand responds to changes to price. Where demand is not very responsive, as in the case of many HYV cereals, increased supplies push prices lower and consumers capture the largest economic gains. And because low income consumers spend a higher proportion of their total income on food, they gain the most from price-reducing production technologies. Nutritional effects of the HYVs tend to be favorable on balance. Work at ICRISAT suggests that the higher cereal production which ensues generally results in a greater production of protein and calories than would otherwise have been the case, even if it is assumed that some of this production occurs on lands previously planted to high-protein pulses.

Preliminary Model of Optional Investment in Agricultural Research

xii. This section of the paper describes a simulation model to address the question of the optimal level of international investment in agricultural research in the DMEs. The model is disaggregated into three components: (1) a research production function; (2) a supply and demand analysis; and (3) a discounted cash flow analysis. In the research production function the percentage growth rate of agricultural output in these countries is a function of the ratio of investment in research to the value of agricultural output. The supply/demand analysis relates to commodities, expressed in tons of wheat equivalent, included in the research portfolio (excluding livestock) of the international agricultural research centers. Under particular assumptions regarding shifts in demand from population and income growth and supply shifts from investment in agricultural research, social benefits from this investment are estimated. The cash flow analysis combines the flows of benefits and costs and generates the internal rate of return from investment in international research.
The model was run, using "most likely" values for the variables, to estimate the alternative levels of investment which would result in rates of return of 10%, 15% and 20%. The resulting values (1976 US$) of $179 million, $75 million and $26 million respectively, can be compared actual expenditure by the international centers on crop research in 1976 of about $45 million. Alternative simulations explore the effects of different values of key variables on the size of investments consistent with the above rates of return. Even with relatively pessimistic assumptions regarding the relationship between growth of agricultural output and research investment, the investment level corresponding to a 10% return did not fall below $125 million. Rates of return were moderately sensitive to assumptions regarding the time lag between availability and adoption of a technology, a finding which highlights the importance of the technology diffusion process. The overall results of this analysis, which should be viewed as a preliminary attempt at quantification of these relationships, supports the general view that expenditure on crop research could be significantly expanded without depressing rates of return to unacceptably low levels.
I. INTRODUCTION

1.01 The narrow focus of maximizing the growth of GNP that characterized much of the post-war thinking and policies related to economic development has been substantially altered since the mid-sixties. More recent views encompass multiple goals, and often explicitly address the distributional consequences of alternative economic development strategies. An important aspect of these evolving views concerns the role of the agricultural sector.

1.02 Until the sixties, industrialization formed the cornerstone of economic development policy in much of the developing world. Western countries were seen to have generated an increasing proportion of their economic activity in the industrial sector, with a simultaneous decline in the importance of their agriculture. In an attempt to mimic the experience of the developed economies, nations embarked on a deliberate policy of industrialization. An expanding industrial base was seen as a route to rapid economic growth, and to the absorption of apparent surplus labor in the agricultural sector. To achieve their development goals, policies were established which favored industrial expansion, often at the expense of the agricultural sector, frequently denying the relevance of comparative advantage. In both market oriented and centrally planned economies, heavy infusions of capital were made in the industrial sector. While some of this investment was met from public and private capital inflows, much was needed from internal sources. As the agricultural sector was the predominant sector of the economy, it became obligatory that resources be transferred from agriculture — in fact, the agricultural sector became viewed as a reservoir of resources from which could be extracted the flows of labor, capital and foodstuffs needed to sustain non-farm economic growth.

1.03 Many and varied policy instruments were, and continue to be employed in pursuit of this transfer. Taxes on agricultural exports, land taxes, cheap food policies, multiple exchange rates and protective industrial tariffs represent only a sampling of the devices used to capture the surplus of agriculture and use it as a stimulus to industrial growth.

1.04 In large measure this strategy failed. It did not induce broadly based, pluralistic economic growth. Instead a small, highly capital intensive industrial sector emerged, depending for its existence on direct and indirect subsidies and employing little of the expanding labor force. The additional income streams were largely captured by an urban elite whose expenditure patterns did little to stimulate demand-induced linkages to the remainder of the economy. Agricultural productivity tended to stagnate, lending credence to the view that the sector was tradition-bound and unresponsive to prices.

1.05 An obvious question arises: was the failure due to faulty conception of the process of economic growth or rather to a missing element? The paradigm itself seems plausible. Sustained economic growth from time immemorial has been typified by a declining importance of the agricultural sector. And rapid increases in real income per capita in Western economies have occurred contemporaneously with a rise in the importance of the industrial sector. However, in every case, technological change in agriculture