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Hans P. Binswanger
Joachim von Braun

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TECHNOLOGICAL CHANGE AND COMMERCIALIZATION IN AGRICULTURE
The Effect on the Poor

Hans P. Binswanger
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Do the economic gains brought by technological innovation and commercialization in agriculture work their way through to the poor? The prevailing optimistic view is that they do. But this view is not universal: some hold that these forces for change can interact with, or even induce, institutional and market failure, with adverse consequences for the poor.

Adherents of the pessimistic view point to real-world instances in which the poor have failed to reap the benefits, or even have lost, from the technological change or commercialization. Where these effects have occurred we find that they are mostly attributable to inelastic demand or adverse institutional features; often, when technology or commercialization has been blamed for the decline in income of the poor, other—not necessarily connected—policies have in fact been responsible for the damage.

This article contends that the optimistic view is, by and large, correct: normally, technology and commercialization stimulate agricultural growth, improve employment opportunities, and expand food supply—all central to the alleviation of poverty. The evidence does not offer much encouragement to an extension of this view—that through "social engineering" the benefits from technology and commercialization can easily be targeted toward the poor; the limited opportunities for such targeting should of course be seized.

There are conflicting views on how technological change and commercialization can affect the poor. (By the poor we mean the absolute poor: households and individuals that cannot earn enough to meet their basic

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needs.) As Mellor points out, "One of the most important theoretical and empirical findings in analysis of Western economic growth is the identification of technological change as a major form of growth" (1986, p. 76). Those who see technological innovation as a principal source of growth maintain that there is a good chance (though admittedly no guarantee) that this general growth will bring corresponding growth in the income of the poor. In the same way commercialization, as part of the expansion of domestic or international trade, or both, is seen to raise income levels in general via specialization based on comparative advantage and economies of scale. Again, there is no guarantee that commercialization will enhance the income of the poor, but the presumption is that a general increase in incomes will usually improve the incomes of the poor, and thereby their food consumption.

It is often assumed that the poor in low-income countries are subsistence oriented, detached from crop technology, and little integrated into market transactions. This notion is incorrect. The poor are usually well integrated in the rural labor market: whether hired workers or small farmers, they participate in the exchange economy and, despite the high share of income allocated to food, their cropping patterns and crop-livestock mixes show large involvement in markets. This fact is important for the spreading of effects of commercialization and technology in the economy.

The view that technology and commercialization play a major role in stimulating agricultural growth and alleviating poverty is now widely accepted, but there is also a tenacious tradition of pessimism about technology and commercialization, whose adherents claim that both of these movements may bring adverse consequences for the poorest. (For a comprehensive review of this literature related to technological change in cereals, see Lipton and Longhurst 1989; and for a critique of the literature on adverse effects of commercialization of subsistence agriculture, see von Braun and Kennedy 1986.) Proponents of this view adduce instances in which the poor were unable to participate successfully in the adoption of new technologies during the green revolution in Asia, or in which poor farm workers were displaced by machinery. They are also concerned about the possible effect of commercialization on the food consumption of the poor who produce for markets; for example, they maintain that milk marketing schemes in India induced milk-producing households to sell their milk instead of feeding it to the household's children. They fear that households that produce cash crops will not have access to purchased foods if their cash crops fail, or if cash crop prices collapse.

A third point of view extends the optimistic position. It holds that technology and commercialization can and should be "engineered" in such a way that the poor can participate in the growth: technology must be directed toward crops produced or consumed by the poor and must be easy for the poor to adopt; rural development projects must provide marketing assistance and credit to smallholders and poor farmers so that they can more easily participate in commercialization.

In this article we look first at the evidence of benefits of technological innovation and commercialization in the context of an open economy (that is, economies open to trade and capital flow). The assumption of an open economy means that technical change in a small country will not depress the price of the commodity. We then explore scenarios under which the poor might lose absolutely or relatively from the changes, particularly through price effects (which would arise in a closed or partially closed economy) and other second-round effects. Finally, we examine the opportunities for deliberately targeting technological and commercial change toward the alleviation of poverty.

Positive Effects of Technological Change and Commercialization

This section discusses conditions under which technical change and commercialization, or the combination of the two, have positive effects for the poor, and provides examples of where these positive effects have materialized.

Technology in the Lead

As land becomes less and less available, growth in agriculture depends more and more on yield-increasing technological change. Increased output per hectare contributed 70 percent of the production increase in major food crops of developing countries in the 1960s, 80 percent in the 1970s, and still more in the 1980s (Paulino 1986). When a new technology, such as a green revolution variety, is introduced into a region, higher farm profits initially accrue to all producers who adopt it, including poor farmers. If demand is elastic, a supply response to the higher profits will usually lead to sufficient expansion of production so that demand for agricultural labor increases. Demand for purchased inputs and marketing and transport services will also lead indirectly to expansion of employment. Consumer spending out of the higher profits will fuel demand for rural home goods and also expand the demand for labor. Rural wages will rise and workers may migrate from poorer areas to take advantage of expanded opportunities. The green revolution, for example, in the Punjab of India (Bhalla 1983), in the MUDA irrigation scheme in Malaysia (Bell, Hazell, and Slade 1982), and in the Laguna Province of the Philippines (Herdt and Ranade 1976) expanded farm output, nonfarm output, employment, wages, and immigration. Many of the effects of new technology in agriculture on employment are indirect. The direct effect—increased use of labor per hectare in crop production—appears to have diminished in the second phase of the green revolution after large creation of employment in the first phase. Kikuchi, Huysman, and Res (1983) show this pattern for rice villages in the Philippines.

Commercialization in the Lead

Commercialization, in the same way as technology, can be the prime impetus for poverty-alleviating growth. Many regions in the developing world that produce commercial crops for domestic or export markets are better off than regions that are under subsistence production. The poor in the commercial regions are frequently better paid and have more secure jobs. Opposite findings are, however, reported: interregional comparisons of sugarcane-growing areas with other rural areas in Kenya, for instance, imply that cash cropping may have an adverse effect on nutrition (Hitchings 1982). Then again, Kennedy and Cogill (1987), in their comprehensive analysis of the issues, find no adverse effects of sugarcane growing on nutrition.

That the poor are often better-off in commercial regions is not sufficient to establish a causal link between commercialization and poverty, either in improving or worsening the lot of the poor. A superior agroclimatic endowment, rather than commercial production, could account for the greater wealth of the commercialized regions. The cross-regional comparisons, therefore, are inconclusive; examples of positive effects observed over time afford more convincing evidence of the causal link between commercialization and improvement in the income or nutrition of the poor. In Guatemala, the opening up of new export marketing channels for vegetables boosted production of high-valued labor-intensive crops. Favorable agroecological conditions, basic infrastructure (roads), cooperative arrangements, and farmers' know-how in traditional vegetable production helped create a success story. Small farmers (with an average farm size of 0.7 hectare) realized large gains in income from specialization, and employment in agriculture increased by 45 percent (von Braun, Hotchkiss, and Immink 1989). The small farmers that joined the commercialization process also adopted yield-increasing technology on their now reduced maize and bean fields. In this environment of risky markets for outputs and factors, and absent insurance markets, farmers insure against risks to food security by maintaining some self-sufficiency in food production. Thus they may fail to capture the maximum short-term gains from specialization.

Another example of commercialization, rather than technological change, taking the lead may be seen in the rapid expansion of cassava production in Northeast Thailand as a result of policies that opened up opportunities for trade with the European Community in the 1970s and 1980s (Konjing 1989).

Commercialization in Tandem with Technological Change

Low-income countries that shift their crop mix toward marketed and (internationally) traded crops also showed accelerated growth of yields per unit of land in their staple food crops (von Braun and Kennedy 1986). True, different crops compete for scarce resources, but cash crops can also stimulate the pro-

Table 1. *Effects of Increased Income from Technological Change and Commercialization on Food Consumption and Nutrition*
(percentage increase)

Location of survey areas	*Affected crop*	*Effect of 10 percent increase in income*[a]	
		On calorie consumption of households	*On weight-for-age of children*[b]
The Gambia	Irrigated rice	4.9	1.9
Rwanda	Potatoes	4.7	2.5
Guatemala	Vegetables for export	3.5	1.1

a. Total expenditure, including value of home-produced foods approximating permanent income, is used in the respective models. All changes are computed at a level of annual income of US$100 per capita.
b. Z-score values of weight-for-age.
Source: von Braun 1989.

duction of staple food if channels for the supply of inputs and the marketing of outputs are opened up and if rural financial institutions are improved in connection with cash crops. Such complementarities between commercialization and technological change in staple food were strong in Sub-Saharan Africa (Lele, van de Walle, and Gbetibouo 1989). At the same time, hindering the commercialization process impedes technological advances in production of food crops.

The complementarities between yield-increasing technological change in staple foods and commercialization of agriculture can be exploited to help alleviate poverty. Specialization in labor-intensive crops, by stimulating the adoption of new technology in staple foods, can create employment on the one hand and reduce food prices on the other. Labor-intensive cash crops can also provide employment for the landless. Household food security is maintained—beyond the income effects of cash crops—through improved use of technology in staple foods by farm households that have moved into cash crops. This in turn can dampen potential rises in local food prices. The case of vegetables for export in Guatemala, referred to earlier, revealed precisely this pattern of complementarity (von Braun, Hotchkiss, and Immink 1989). Similarly, in a case of sugarcane expansion in the Philippines, sugar farmers had higher maize yields on the reduced area for maize crops and maintained significant amounts of maize production for subsistence. They consumed much less maize, however, than did specialized maize farmers, because sugarcane-growing households preferred to buy more rice in the market (Bouis and Haddad 1990). In a Kenyan case of sugarcane production, farm households expanded their maize area into fallow land at constant yield levels to maintain subsistence (Kennedy and Cogill 1987).

Gains in real income from technical change or commercialization translate into food consumption of the poor and nutritional welfare of children. In three cases studied in the Gambia, Guatemala, and Rwanda, a 10 percent increase in income from a level of US$100 per capita translated into a 3.5 to 4.9 percent

increase in households' food energy consumption and a 1.1 to 2.5 percent increase in anthropometric measures of nutritional status of children (table 1). A large proportion of the households below the US$100 cutoff point fall below accepted calories per adult equivalent.

Scenarios under Which the Poor Might Lose

In the following, we test against empirical research seven scenarios of technological change and commercialization under which the poor might lose absolutely or relatively. The scenarios range from inherent consequences of technological change and commercialization that policymakers have to be aware of (such as the agricultural treadmill effect) to failure of policy (for example, coerced production).

Scenario 1: Declining Agricultural Prices

When final demand is not infinitely elastic—as was assumed in the open economy scenarios discussed so far—the expansion of production made possible by technical change will lead to price declines. Such declines reduce the gains from technical change of producers and have secondary effects on consumers and on other regions or countries.

CONSUMERS VERSUS PRODUCERS: THE AGRICULTURAL TREADMILL. How the gains from technology and commercialization are distributed between agricultural producers and consumers has been a matter of considerable debate. The basic conclusion of partial equilibrium models is that under perfectly elastic demand, producers can capture all the gains from technology, but under inelastic demand consumers gain and producers may either gain or lose. In other words, since price elasticities for many agricultural commodities are low, farmers work in a treadmill in which the fruits of improved technology forever elude them and are instead enjoyed by consumers.

The treadmill hypothesis is persuasive, but the treadmill effect on rural income distribution is not as stark as the partial equilibrium models predict. First, producers can cushion the impact of declining prices on farm profits by moving into other crops—that is, by substituting or diversifying. Second, declining prices of food have a positive impact on the income distribution in the nonfarm sector: poor people spend much of their budget on food, so that when food prices fall their real income rises proportionally more than that of the rich. Third, even in rural areas the poor may benefit from the price decline as consumers, while they lose farm profits in their role as producers. Finally, poor workers and poor farmers are also affected by the impact of technology on demand for labor and wages. To measure the effect of technical change on incomes, therefore, more complex methods of assessment are needed, methods

that take into account the substitution response, the effect on consumers, and the effect on employment and wages.

Quizón and Binswanger (1986a) used a general equilibrium model that includes these three effects to assess the impact of the green revolution on rural and urban incomes in India. They computed a reference path of the real incomes of rural and urban income groups in India from 1960 to 1981 (table 2).

For the period as a whole, the figures show agricultural production growing—rapidly at the beginning of the green revolution (1965–70), stagnating from 1970 to 1973, and resuming its rise from 1973. Agricultural terms of trade rose before the green revolution, stayed fairly constant until 1973, and then dropped substantially by the end of the period. Employment in agriculture grew by about 20 percent over the period; wages declined by about 5 percent. The total real wage bill for the period therefore rose by about 15 percent.

1960 to 1970. Seriously depressed in the first half of the 1960s, farm profits moved dramatically upward in the early stages of the green revolution (1965/66 to 1970/71) as a result of technical change and improved agricultural terms of trade. Rural income rose along with profits: the rapid gains in production,

Table 2. *Simulated Indexes of Income Distribution and Income Sources in India, for Selected Crop Years, 1960–81*
(1970/71 = 100)

Endogenous variable	*1960/61*	*1965/66*	*1970/71*	*1973/74*	*1975/76*	*1980/81*
Total actual agricultural output	79.3	81.2	100.0	99.4	107.1	119.6
Actual prices (agricultural + nonagricultural goods)	89.8	97.2	100.0	97.7	91.6	76.3
Real residual farm profits	64.2	67.9	100.0	86.0	85.1	76.4
Agricultural employment	98.2	100.1	100.0	112.3	118.8	118.5
Real agricultural wage bill	91.2	95.3	100.0	101.4	104.9	105.4
Rural income						
Aggregate	92.9	92.4	100.0	93.6	92.9	94.9
First quartile (poorest)	101.0	99.0	100.0	95.9	97.4	107.0
Second quartile	96.9	95.8	100.0	94.6	94.8	99.9
Third quartile	93.8	93.5	100.0	93.8	93.3	96.3
Fourth quartile (richest)	88.5	88.6	100.0	92.4	90.7	88.8
Urban income						
Aggregate	89.4	102.3	100.0	99.4	102.2	136.7
First quartile (poorest)	91.9	100.4	100.0	98.1	100.7	136.0
Second quartile	90.9	102.8	100.0	99.3	102.6	141.9
Third quartile	90.2	102.7	100.0	99.7	102.5	139.3
Fourth quartile (richest)	87.6	102.3	100.0	99.8	102.2	133.5

Source: Quizón and Binswanger 1986a.

used by the government largely to replace imports, were associated with rising prices and thus translated into advances in income. The distribution of rural income shifted drastically from the wage bill to profits toward the end of the 1960s.

1970 to 1980. The subsequent decade saw a marked decline of profits: to 86.0 percent of their 1970/71 level by 1973/74, and to 76.4 percent by 1980/81. Once self-sufficiency in food production was assured, increased output was no longer needed to replace imports; the surplus grain production had to be absorbed domestically. The gains in production during the late 1970s, therefore, were not reflected in further advances in rural incomes, because the prices of agricultural products fell. Instead, the productivity gains were transmitted to consumers by way of declining prices.

During the 1970s urban groups were the principal beneficiaries of the combination of rapid growth outside the agricultural sector with the declining agricultural terms of trade. Urban incomes in the aggregate rose by about 34 percent during the late 1970s. But the rural poor also gained: within the rural sector the incomes of the poorest quartile rose by about 10 percent during the late 1970s (in contrast to those of the richest quartile, which declined slightly—about 2 percent).

Several effects interacted to achieve this outcome. First, the gains of the rural poor as consumers outweighed the decline in their incomes as producers or wage earners. Second, the effect of falling wages was partially offset by rising agricultural employment and by some participation in the growth of farm profits. Third, the incomes of the rural poor from the rural nonfarm sector also rose substantially.

In sum, the treadmill was clearly in operation. Once prices started to fall, many of the gains from the green revolution were transmitted to the urban areas. The mechanisms of adjustment to the price declines were not sufficiently powerful to prevent this outcome. However, none of the rural groups lost in absolute terms, and the poorest groups experienced an income increase of 6 percent over the period. The large farmers (the richest quartile of the rural income distribution) gained least—they found their per capita incomes back at about the same level as in the early 1960s, having lost the production and income gains of the late 1960s and early 1970s to population growth and urban groups. Despite the shift in income distribution from wages to profits during the late 1960s, by the end of the period rural income distribution was very similar to its starting point.

REGIONAL DISTRIBUTION. Can technical change hurt if it is confined to certain regions? Often, environment or geographic location dictate whether a region can adopt technical change—for example, the green revolution has largely been confined to irrigated zones with good water control.

Partial equilibrium analysis of the distributional consequences of unequal regional access usually describes two regions supplying an inelastic demand in

a national market. Should region A increase supply as a result of technical change, prices will drop. Region B will lose because its production is no greater, input costs remain the same, but the selling price has fallen.

The gains in region A will be distributed among landowners and workers. In region B, farmers will lose, and labor demand and wages will fall. The largest share of the losses will be borne by the factors in most inelastic supply: the immobile factors of production. Land prices will decline more than wage rates if some labor can migrate to the gaining region (and contain the rise in the wage rate there).

This partial equilibrium model, however, again ignores consumer gains and cannot quantitatively assess the effect of labor mobility. Moreover it ignores the ability of farmers in region B to take up production of crops which are displaced in region A by the technologically dynamic crops. Quizón and Binswanger (1986b) extended the general equilibrium model for India discussed above to include regional effects. The model allows for migration to respond to regional wage differential. Four regions supplying the same national market were analyzed. Two regions benefited massively from the green revolution, while the other two were less able to adapt to technology, owing either to poor water control or to lack of rain. From simulations of the increases in rice yields arising from the green revolution in the technology-adopting regions, Quizón and Binswanger estimated that large farmers in the regions that did not adopt technology lost as the price of rice fell, and their farm costs and yields remained the same. But in the same regions the poorest of the two quartiles of the rural income distribution gained at least as much from lower food prices as they lost in farm profits and ended up with a gain overall, or, at worst, no net loss.

When the simulation was extended to include wheat as well as rice yields, the figures pointed to urban groups and net purchasers of food in rural areas as the beneficiaries. Farm profits rose in the two technology-adopting regions and fell in the other two—but, again, the poor in the latter regions gained from the lower food prices.

Thus scenarios can be modeled in which the poor can lose from technological change. But the inbuilt advantages of falling food prices often outweigh the disadvantages of falling farm profits. Treadmill effects can also be ameliorated by diversification to and commercialization of other crops. And the government can limit price declines by eliminating or reducing export restrictions where these still exist.

THE INTERNATIONAL TREADMILL. Individual regions and countries can ameliorate or escape the treadmill effect by changing policies that constrain exports or by investing in infrastructure to reduce the cost of exporting, but the constraints of worldwide demand cannot be avoided. Prices of agricultural commodities are well known to have experienced a declining secular trend

associated with expanded production capacity, whose main source has been technical change.

The obvious way for a country to avoid losses imposed by more rapid cost reduction or technical change in other countries is to accelerate technical change beyond the rate of cost reduction elsewhere. Otherwise, loss of cost competitiveness leads to increased pressure on the balance of payments and faster depreciation (or slower appreciation) of the exchange rate. The loss of income associated with loss of competitiveness thus not only will fall on the producers of the commodity but will be widely shared among consumers of tradable commodities.

If worldwide technical change occurs rapidly in commodities consumed widely by the poor in the developing world, such as rice, wheat, and maize, the ensuing decline in real prices will be to the advantage of the poor in low-income countries. But this would not happen if, as often, the country reacts to a loss of competitive advantage by increasing the protection of domestic staples (Krueger, Schiff, and Valdés 1988). (It may also not happen if the country is a major producer of the commodity so that an appreciation of the real exchange rate compensates for the decline in international prices.)

The poor derive little, if any, of the consumer benefit from technical change in commodities (such as tropical beverages) for which final demand is inelastic, and which are consumed mainly by the developed world. Producers in developing countries impose losses on each other by expanding production. International commodity agreements, such as the international coffee agreement, have generally failed to control output.

When competitive advantage in a crop is reduced, intercrop substitution or diversification is once more an avenue for avoiding some of the losses. The extent to which this option is available depends on agroclimatic conditions and on infrastructure for production, marketing, and trade in the alternative commodities.

Scenario 2: Commercialization of Nonfoods Driving Up Local Food Prices

Regionally concentrated adoption of cash crops may raise food prices in both adopting and nonadopting regions of a country. When production of staple food for local consumption is displaced by nonfood cash crops, net food exports of the region may decline, or a net exporting region may even become a net importer. Resulting differences in the cost, insurance, and freight (CIF) prices as opposed to free on board (FOB) prices for the region will be larger the more deficient the transport infrastructure is. If income gains resulting from the switch are not locally accrued by the poor, the poor may lose to the extent that they are net purchasers of food. Most of the poor even in rural Africa are net purchasers of food. The effects on prices for nonadopting regions depend

on market infrastructure, and possibly on the response of trade policy. With free trade, imports of food will substitute for domestic production and food prices will not rise beyond levels determined by the CIF price. But if trade of an export crop is controlled and foreign exchange is channeled through a system of government controls, allocation of foreign exchange for food imports may be constrained, food prices would rise, and the poor would suffer.

In a case study of Benin, von Oppen (1989) shows that expanded cotton production in the north of the country reduces food crop exports from the north to the south. It then depends on effective demand of households and appropriate government response to translate the increased export earnings from cotton partly into food imports to forestall reduced availability of food at household and country levels. No case studies exist that evaluate how policy has actually responded in such situations. Although potentially relevant, this scenario, therefore, remains hypothetical.

Scenario 3: Late Adoption of Technology

The speed with which tenants and small farmers—a large proportion of the poor in many countries—adopt new technologies has been intensely studied since the green revolution. An early review of the literature on the adoption of high-yielding seed varieties (Ruttan and Binswanger 1978) suggested that neither farm size nor farm tenure has been a serious constraint on adoption. Although different rates of adoption by farm size and tenure have been observed, the available data implied that, within a few years of introduction, the lags in adoption due to size or tenure usually disappeared. Of course the nonadopters will have forgone the potential gains of early adoption and may already have suffered as a consequence. These conclusions have not been altered by more recent research.

Unlike that of seeds, the cost of fertilizers, herbicides, and other yield-raising inputs can significantly impede adoption by small farmers. Typically, small farmers use fewer of these inputs per unit of labor than do large farms, but not necessarily fewer per unit of land, depending on the steepness of the negative relation between farm size and productivity.

The adoption is not just an issue of factor ratios, however, but an issue of the overall efficiency of use and the relative speed of growth in production. A survey by Berry and Cline (1979) shows that the use of inputs by small farmers is as efficient as by large farmers or more so. Econometric evidence from the Indian Punjab (Sidhu 1972) indicates that new wheat technology was not strongly biased in either a labor-saving or a capital-saving direction. Small and large farmers achieved approximately equal gains in efficiency. Data from the Pakistan Punjab and the Philippines indicate that although small farmers face more constraints on obtaining irrigation and credit than large farmers, these constraints are not large enough to cause any significant differences in yields between the two categories of size (Ruttan and Binswanger 1978, p. 388).

The pattern of late adoption of cash crops and new market channels is similar to that for new production technology and staple foods. Of the smallholders in Guatemala referred to earlier (von Braun, Hotchkiss, and Immink 1989) who started producing vegetables for export, disproportionately more of the larger farms (larger than 1.5 hectares) were early adopters; the smallest trailed behind. Similarly, smallholders in Kenya and the Philippines were significantly slower to adopt sugarcane (Kennedy and Cogill 1987, Bouis and Haddad 1990).

Trailing behind in the adoption process is not necessarily a problem for efficiently allocating resources and ensuring the income security of the poor. For one thing, it avoids the risks of early adoption. But waiting too long can mean being shut out of the opportunity when market channels have bottlenecks related to organization or capacity. Capacity of an established sugarmill, for instance, may be filled up rapidly by the (bigger) early adopters. The export vegetable cooperative in Guatemala has effectively closed enrollment of new members because of concerns about bottlenecks in handling and capacity for cold storage.

The instruments usually advocated for accelerating adoption by small farmers are extension and credit. Reform of extension and credit policies to remove discrimination against the poor would go a long way toward alleviating the adverse effects of economies of scale in the use of technology.

Scenario 4: The Trap of Committed Expenses

Committing capital to perennial crops or other long-term investment such as milch cattle, crop-specific irrigation, or housing reduces the capacity to adjust to technological breakdown, price risk, or disruption of markets. When returns to capital do not materialize, the fixed capital resources (invested, for instance, in tea bushes or coffee) cannot be switched to new productive tasks. These risks are highest for the poor, but the empirical evidence shows that the poor rarely specialize completely. Smallholders in Guatemala, for instance, maintained about half of their crop land for staples, as did smallholder sugarcane-producing households in Kenya.

The same sort of risks as those of committed expenses arise when a project for technological change and commercialization attracts households to migrate to a new area and the project then collapses. In the Gambia the collapse of a rice irrigation project led to disinvestment in housing and community services and even to increased divorce rates (Webb 1989).

Scenario 5: Implications for Women and Children

New production technology and new marketing opportunities in agriculture can have profound implications for control of resources and division of labor in rural households. Evaluating the effect of technology and commercialization on poverty from the perspective of households in the aggregate does not cap-

ture the intrahousehold and gender-related effects. Both the burdens and the benefits of technological change and commercialization need to be assessed at the household level to judge the effect of gender, and both gender and child welfare are relevant in this respect (Leslie and Paolisso 1989). The effect on poor women will be more complex the more dramatic the change, the sharper the division of labor and labor markets according to gender, and the greater the separation of control over farm resources.

A comparative analysis of commercialization in five cases (in the Gambia, Guatemala, Kenya, the Philippines, and Rwanda) showed a much reduced role of women in the new technologies or commercialized crops, even if they were important contributors to farm production before the change (von Braun, Kennedy, and Bouis 1989). Two examples (from the Gambian and Guatemalan analyses) highlight the conflicts and tradeoffs. These argue, in opposition to the new conventional wisdom, that there is considerable income pooling within the household, so that women gain, though less than proportionally, from the increased income of men.

In the Gambia, where rice was a traditional women's crop, the study found that women's access to new technology for rice irrigation was hampered because it was harder for them to hire the necessary labor. Their work burden increased more than that of men. At the same time, technological change resulted in increased household income, despite women's relative—in some subgroups, absolute—loss of personal income (von Braun, Puetz, and Webb 1989). The increased household income in turn brought increased caloric consumption and reduced seasonal fluctuations in weight for women.

In the Guatemalan export vegetable cooperative, households' food consumption—including women's—improved despite largely male control of incremental income. The effects on child welfare illustrate the complexity of some of the tradeoffs: on the one hand, the expanded employment resulting from the changes increased seasonal use of child labor to such an extent that local communities became concerned about school participation, and changed school schedules and the timing of vacations. On the other hand, effects on income permitted communities to invest in schooling and the improvement of child welfare under a cooperative system (von Braun, Hotchkiss, and Immink 1989).

Scenario 6: Eviction of Tenants and Effects on Land Markets

The profitability of new crops or of crops grown with improved technology may increase the landowners' incentive to evict tenants and move to owner operation of farms. An example fostered by administrative ruling is found in an area studied in the Philippines where contracts for sugarcane growing were not given to tenants but only to landowners. As a result, landlessness expanded and the status of tenants deteriorated in an area around the sugarmill (Bouis and Haddad 1990).

The green revolution made farming in Pakistan more profitable. A failure of land rents to adjust immediately to higher profits may have been instrumental in the increased self-cultivation by landowners and the increases in farm size that followed. Results of surveys and censuses show that tenant cultivation declined sharply during the green revolution. Between the 1960 and the 1980 censuses, the number of pure tenant farmers declined from 2.0 million to 1.1 million, while the area under tenant farms declined from 19 million acres to 10 million acres.

Two other things accelerated the decline of tenant farming in Pakistan. First, aggressive subsidization of mechanization increased purchases of tractors and other technology.[1] The tractors made large farms less dependent on bullock drivers or tenants, or both. A very large decrease in tenant labor hours is reported by McInerney and Donaldson (1975) in a "before and after" study of tractorization. The World Bank financed loans for the purchase of large tractors at substantial subsidies to farmers. Land ceilings or tenancy laws in Pakistan either did not exist or were ineffective, and the 202 farms surveyed grew on average from 18.2 to 44 hectares. Of the additional land acquired, 32.3 percent came from reduction in land rented out, 28.6 percent from increased renting, 26.2 percent from reclamation and improvement, and 13 percent from purchases. Each tractor replaced an average of 4.5 tenants.

Changes in land tenancy legislation in 1959 and 1972 were the second impetus to the decline of tenant farming. The new laws were increasingly adverse to landowners (Nabi, Hamid, and Zahid 1986) so that renting out land became less profitable and more risky. The decline in tenancy was thus brought about by a combination of technological change and bad policy. It is hard to assess how much each contributed to the trend in this particular instance; the relation is easier to disentangle in two similar examples from Africa. The first is a case of extensive eviction of land users in Sudan as a direct result of promotion of large-scale mechanized sorghum production (Elhassan 1988). The government decided to allocate land in large sizes to farmers who were prepared to invest in mechanized farming. For a rural population dependent on wages, this meant declining employment with little opportunity to provide for household or community food security. The effects were worst for the poorest: rates of child malnutrition in these areas were found to be significantly higher than in the traditional rain-fed sector (Sudan 1988). Here the eviction, which took place *before* the new technology was introduced, can convincingly be attributed to bad policy. A similar instance, in which the tenants were evicted *after* the new technology was in place, is the case of CADU (a program for promotion of improved agricultural inputs and market integration launched in the late 1960s in Ethiopia). Here the outcome is attributable not to bad policies but to the absence of good supplementary policies. Almost all the tenants in areas under CADU were evicted once the new technology was disseminated to large producers and landowners (Cohen 1975). Policies and programs to provide tenants

with access to technology and to protect their tenancy rights have been lacking in these areas.

Scenario 7: Coerced Production or Forced Procurement

One of the worst outcomes of commercialization is associated with coerced production. Governments or powerful monopsonistic procurement partners may respond in this way in an attempt to shift losses from an ill-designed scheme for commercialization to farm producers, or when the monopsonistic procurement agent is trying to capture excessive profits. Since the poor usually hold a very weak position in the political arena, they are particularly vulnerable to such perverse policy.

One such case of coerced production evolved out of an unsuccessful tea production scheme in northwest Rwanda (there are several successful schemes in the country). Smallholders were talked into producing tea that did not turn out to be profitable for them. Supply was therefore not forthcoming, and the processing capacities established for the scheme were underutilized. To increase capacity utilization, the parastatal tea factory then expanded its tea plantation by expropriating small farms in the vicinity of the factory (von Braun, de Haen, and Blanken forthcoming). Schemes for area allotment with procurement regulations that result in coerced production are widespread. Examples include cotton and rice schemes in Egypt and cereal programs in parts of China.

The opposite side of the coin of enforced production is exclusion from production opportunities. In colonial times, bans on cash crop production by local small farmer populations were ubiquitous. Export crops were specifically reserved for settler farmers in Kenya, Tanzania, and other East African colonies. Even when cultivation of cash crops was not explicitly prohibited, extension, credit, and marketing services were not available to the native smallholder. In Zimbabwe, for example, these services were reserved for large-scale (white) farmers. Independence swept away most of these constraints, opening up the opportunities to all farmers. But the constraints on participation of smallholders in commercial crops are reemerging in the form of new regulations passed by indigenous elites. Such a case is the reservation of tobacco production for the estate sector in Malawi, with small farmers allowed to participate in the lucrative tobacco economy only by contractual arrangements with estate owners (Lele, van de Walle, and Gbetibouo 1989).

Targeting Technological Change and Commercialization

An extension of the optimistic view of technology and commercialization—that, through growth, they bring benefits to the poor and that most adverse effects are caused by bad policy and can be rectified by appropriate policy—is the idea that these forces can be instruments specifically directed toward alleviating poverty. Before we review the pros and cons of specific possibilities

for targeting, two problems of this form of "social engineering" need to be emphasized.

First, the research necessary for developing poverty-targeted technology may have opportunity costs. Introducing the extra element of targeting into research and development originally oriented exclusively to growth introduces constraints that may result in forgone growth. The hypothetical tradeoff then is whether untargeted, but possibly higher, agricultural growth has more potential to alleviate poverty than development and dissemination of poverty-targeted technology.

Second, poverty-targeted technology and market development cannot be assessed in isolation. They need to be ranked against alternative instruments for the alleviation of poverty that may be available, such as targeted health and nutrition interventions or rural employment programs. Comparing these instruments is not, of course, easy.

Below we discuss six targeting possibilities. Demonstrating feasibility of any one of them must not be taken as synonymous with proving effectiveness—especially in view of the important role, stressed earlier in this article, played by rural growth in the alleviation of poverty.

Targeting by Agroclimatic Potential

Green revolution technology reduced poverty in the favorably endowed regions where it could be adopted (Hossain 1988), and commercialization did the same in areas with known or hidden potential. It is therefore tempting to accelerate technological change and commercialization in agroclimatically "poor" regions in the hopes of reaching out to the poor. The developing countries and the donor community have undertaken research and launched projects to replicate green revolution success in such low-potential areas as the Sahel, the semiarid zones in India, and the humid tropics of Africa. So far the investment has not had very powerful effects—complex environmental constraints in these zones cannot be easily overcome—but there have been some successes with sorghum, ragi, and perhaps millet breeding in India, and with hybrid maize in East Africa. In the high-potential areas, research for wheat and rice could build on a long history of (re)search for technological change; furthermore, costs of adaptive research are lower in those areas which enjoy a high degree of water control. But research at the regional level has perhaps been going on for too short a time and at a scale insufficient to tap the hidden possibilities for low-potential areas.

Targeting Foods Consumed by the Poor

The poor consume substantial amounts of certain staple foods that are considered inferior. Directing research toward roots, tubers, and coarse grains is one possible means of exploiting the treadmill effect in favor of poor consum-

ers. In comparison with research on wheat and rice, the research history for these crops is rather short, and the jury is still out for assessing the effectiveness of this approach. Moreover, such targeting, even if successful, may in some cases become less powerful. Recent evidence suggests that low-income households are shifting into more time-saving staple foods. Cases in point are the increasing consumption of rice by the urban and rural poor in West Africa (Delgado 1989) and of wheat by low-income households in Sri Lanka (Senauer, Sahn, and Alderman 1986). The cost of women's time appears to be an important factor in these changes.

Many of the poor, however, still consume a lot of what they produce. When technical change occurs in crops produced and consumed by the same households, the treadmill effect is irrelevant, as is the potential conflict between net buyers and sellers. Increased levels and stability of yields of subsistence crops promise to mitigate the chronic as well as transitory food insecurity of the subsistence household. The pressure from increasing population rapidly raises demand for yield-increasing technology in subsistence crops where food and labor markets are risky. For instance, in Rwanda, the production of sweet potatoes rises rapidly when ratios of people to land increase (von Braun, de Haen, and Blanken forthcoming). And in many parts of the Sahel, the drought sequence of the 1980s (a transitory problem) led to a rapid shift from sorghum into early millet, with lower mean yields but higher drought resistance. Efforts by the Consultative Group on International Agricultural Research and national research systems to increase productivity in sweet potatoes and improve drought resistance in coarse grains remain important avenues for research.

Targeting Nutrients and Dietary Components

Attempts to improve the nutrition of the poor through technical advance or commercial development have focused on plant breeding and on nutritional targeting in rural development.

From the conventional wisdom about the nature of the malnutrition problem in the 1960s and 1970s many efforts sprang to increase the protein content and the content of certain amino acids, such as lysine, in cereals. The International Agricultural Research Centres (IARCs) and many national programs participated. By the early 1980s most breeding activities whose goals were to increase certain nutrients had been abandoned. The nutritional traits had low heritabilities and competed with the achievement of other attributes, such as yield and resistance to disease and pests (for a review of the experience, see Pinstrup-Andersen, Berg, and Foreman 1984; for other proposals, see Lipton and Longhurst 1989). Nutritionists shifted emphasis from the protein gap to energy deficiency. It has become apparent that the diversity of diet of the poor has frequently been underestimated in the past: nutritional characteristics of commodities need to be seen in the context of the total diet of the poor.

In their plant breeding, IARCs nowadays generally consider minimum standards of nutrient content in addition to other characteristics of consumption and processing (palatability, preparation requirements, storage characteristics, and so on). Concern for meeting the poor's specific constraints on resources (for instance, time, cooking energy, absorbability by young children) may be more relevant than the nutrient content of a specific commodity, and these may offer some scope for targeting.

An example of nutritional targeting in rural development is dairy development schemes. The rationale is that these schemes directly contribute to improving the nutrition of dairy producers by making more milk available for home consumption. In most instances, however, the effects on consumption and nutrition are more indirect. Poor dairy smallholders sell expensive calories (milk) and increase net purchases of cheap calories, thereby improving food consumption (Alderman, Mergos, and Slade 1987). Thus the favorable effects on nutrition arise from the link between commercialization and income rather than directly from the effect of technology on production. Facilitating the poor's access to the technology and to marketing outlets makes the nutritional benefits possible.

Speeding Up Adoption of Technology

We noted before that late adoption of new technology and market opportunities is a problem with particular repercussions for the poor. Treadmill effects tend to push prices down, and late adopters forgo the early rents brought by technology and commercialization, as well as find procurement and processing opportunities blocked or closed by the time they enter the arena. (Note, however, that encouraging early adoption carries with it greater risks—the risks that the innovators' rents reward.)

Extension and credit are the instruments usually advocated for speeding adoption by the poor. Another promising instrument is the marketing cooperative. Policies to institute early cooperative marketing arrangements can be powerful and sustainable tools for targeting marketing opportunities to the poor. The Guatemalan example of the export vegetable cooperative and the Indian dairy cooperative system are both cases in point.

Targeting Poor Producers

Targeting the poor frequently means targeting farm households with high labor-land ratios or low capital-labor ratios, or both. The poor are also more subject to credit constraints than large farmers. It follows that poor farmers would more readily adopt technologies that do not require high capital-input ratios—for example, disease-resistant varieties would be easier to adopt than pesticides to combat the diseases. Emphasis in plant breeding on resistance and

tolerance to pests, diseases, and moisture stress would therefore be especially beneficial to poor farmers without lessening their advantage to large farmers.

The much discussed question of whether green revolution varieties are superior to traditional varieties only with high doses of fertilizers has clear implications for the poor. Poor farmers would be deterred if large doses of fertilizer were needed. Most results from experiment stations where the environment is held constant suggest that high-yielding varieties outyield traditional varieties at both high and low fertilizer doses.

Rental markets, credit markets, and tied contracts allow the poor to rent out labor and obtain capital, so that even if endowment ratios differ strongly among farmers' groups, factor-use ratios are often much closer (Ryan and Rathore 1980). If a small tenant farmer can get the landlord to pay for fertilizer, he or she may still adopt the optimum dose. Resources will be efficiently allocated, although the landlord is likely to extract the benefit of the fertilizer from the tenant by writing the rental contract accordingly. Better targeting technology to the purchasing power of the poor would therefore still improve equity. However, the efficiency gains that could be achieved by better-targeted technologies would be small.

Even in cases in which the poor specialize in some enterprise, targeting that enterprise for technology development may not benefit them, if richer farmers respond to the enhanced profitability of the enterprise. Jodha's (1985) intensive surveys of Rajasthan villages illustrate the problem. Raising sheep and goats was a traditional occupation of the local and seminomadic tribal group in Rajasthan; one would therefore have thought that benefits from research on sheep and goats would accrue primarily to these poor groups. Following the land reform in Rajasthan in 1952, the profitability of raising sheep and goats increased sharply because households no longer had to pay land revenue to feudal landowners and were not charged for the use of common property resources. Prices rose too. Jodha found that, as a result, by 1963–64 many high-caste households in his study villages were engaged in sheep and goat production, whereas in 1955 no higher-caste households had invested in these enterprises. Any researchers who thought that benefits from sheep and goat research in 1950 would have benefited only the poorer households in the community would have been disappointed.

Targeting by Gender

In view of the disadvantaged situation of women in many rural environments of the developing world, development organizations and research institutes have been giving increasing attention to the potential for directing the benefits of technology and commercialization to women.

Experience with a program for irrigated rice development in the Gambia specifically targeted toward women underlines the difficulties. In the Gambia, women are the traditional rice growers, and it was thought that technology for

Table 3. *Rice-growing Technology and Women Farmers in the Gambia, Wet Season, 1985*

Variable	*Irrigation by pump*	*Improved rain-fed system*	*Traditional technology*
Fields under women's control (percent)	10.0	77.0	91.0
Yield (tons per hectare)	5.9	2.5	1.3
Cost of inputs (U.S. dollars per hectare)[a]	294	154	20
Women's labor (as a percentage of unpaid family labor)	29.0	60.0	77.0

a. Variable cost of inputs (seed, fertilizer, irrigation, hired labor, transportation, mechanized land preparation). Dollar converted at parallel exchange rate (US$1 = dalasi 6).

Source: Survey by the International Food Policy Research Institute, Washington, D.C., and Programming, Planning, and Monitoring Unit, the Gambia, 1985/86.

this crop would therefore directly benefit poor women. But men responded to the increased profits available from growing rice, with the result that a strong inverse relation developed between the level of technology and the control of women over the newly improved crop (table 3). The reason was that the technology changed the very nature of the cropping arrangements and induced a large shift of male labor from communal agriculture into the newly developed rice perimeters to overcome labor bottlenecks. Constraints on women's access to credit and to hired labor exacerbated the problem (von Braun, Puetz, and Webb 1989). The outcome suggests that the full range of constraints under which women operate needs to be understood when targeting by gender is attempted.

In this connection, it is worthwhile to consider ex ante implications of untargeted new technology for poor women in rural areas. In semiarid India almost all hand weeding is done by hired women, and earnings from hand weeding make up a significant share of women's wage income. Thus the primary effect of any reduction in this task by herbicides would be to reduce the work and income opportunities of the most disfavored labor group, female agricultural laborers. Technological development, which would make herbicide use more cost-effective, would certainly have adverse effects on female laborers (Binswanger and Shetty 1977).

Conclusion

How then do the optimistic and the pessimistic viewpoints fare? Even with well-functioning markets for factors and products, it is easy to construct scenarios in which poor producers lose from technical change. All these scenarios depend on highly inelastic demand. The resulting agricultural treadmill is a reality with important regional and international dimensions. Its potentially

serious damage is often diluted by inbuilt compensating effects. In particular, its favorable effects for consumers—especially given that the majority of the poor are net purchasers of food—should be taken into account when weighing its disadvantages for small nonadopters. Once the consumption effects and other general equilibrium effects are included in the assessment, the treadmill effects are usually seen to be diffused (although commodities such as coffee, principally consumed by developed countries, do not produce these benefits for poor consumers).

Commercialization and specialization, in contrast, are usually introduced for commodities for which demand is elastic—often as a means of bypassing the problem of inelastic demand faced by traditional commodities. It is therefore hard to construct scenarios in which commercialization by itself—unaided by failures of institutions, policies, or markets—brings adverse consequences.

The relative seriousness for the poor of the various scenarios differs; the worst outcomes arise when several scenarios or effects coincide. Late adoption of new technology is a case in point. The risks associated with the new technology discourage the poor farmer from adopting it early; in conjunction with treadmill effects, late adoption is likely to injure the profits of poor farmers or close doors for them, or both.

Many of the adverse scenarios arise not because of the inherent nature of the technology or the commercialization opportunity but because of bad policy. Constraints on trade, coercion in production, and ill-advised tenancy laws are government actions that may turn a promising opportunity into a disaster for the poor. The answer to many of these issues is policy reform rather than the reversal or deceleration of technological advance and commercialization (Nerlove 1988).

Possibly adverse effects such as late adoption can also be mitigated by government action. Credit policies and extension services are often needlessly biased against the poor. Government policies can facilitate market or capacity expansion where doors have been closed and help the poor to seize the opportunities and derive the benefits.

The conclusion that policy changes can either avert or mitigate adverse effects is based on the assumption that the policy and institutional response can be exogenous and independent of the technology or the expanded commercialization. In some cases, however, institutional changes and policy responses are not exogenous but reflect existing conflict among social groups. The perverse responses then are a logical outcome of these conflicts and cannot be altered by a benevolent policy. Some of the cases of tenant eviction fall in this category. Where institutional and policy responses are endogenous in this way, more pessimistic conclusions are warranted about the benefits of technology and commercialization for politically weak poor groups. An important issue for further empirical research, therefore, is the extent to which these responses are endogenous (de Janvry and Sadoulet 1988).

The case studies discussed afford little support for the view that technological progress and commercialization in and of themselves are harmful to the poor. Nor, at the other extreme, does the evidence encourage the idea that it is easy to engineer them successfully into instruments of targeted poverty alleviation. We are thus back to the view that technological change and commercialization do expand opportunities, bringing large general benefits whose complex distributional implications are hard to predict. Targeting is difficult because of unpredictable distributional implications, and its scope is often limited by technological tradeoffs or agroclimatic constraints.

However, opportunities for cost-effective targeting do exist and should be seized whenever possible. Equally important, if not more so, is the elimination of policies and intervention that alone, or in interaction with technical change and commercialization, harm the poor, and that may needlessly bias the availability of productive support services against them.

Note

Hans Binswanger is chief of the Agricultural Operations Division in the Country Department II (Central America) of the World Bank. Joachim von Braun is director of the Food Consumption and Nutrition Policy Program of the International Food Policy Research Institute in Washington, D.C.

1. Certain forms of mechanization, especially when heavily subsidized, are bad for the labor income of the poor. The effects of mechanical technology are not considered in this article. For a review, see World Bank (1987).

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