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The Policy Response of Agriculture

Hans Binswanger

In assessing the response of agricultural production to government policies, it is necessary to look not just at output prices but at all the factors that affect real farm profits; to disentangle the effects on individual (or export) crops from the effects on aggregate output; and to distinguish the short-run aggregate response from the long-run. Individual crops respond strongly to price factors, but growth in one crop usually takes resources away from others. The price elasticity of agriculture overall is very low in the short run because the main factors of production—land, capital, and labor—are fixed. Aggregate output can grow only if more resources are devoted to agriculture or if technology changes. Output is also affected by investments in roads, markets, irrigation, infrastructure, education, and health. Research and extension increase the demand for fertilizer. As for adjustment policy: domestic food supply may not increase rapidly in response to adjustment programs, so structural adjustment programs should do more than ease the balance of payments; analysis should focus on how to make all of agriculture grow.

The policy response of agriculture has been primarily addressed in the supply response literature. Because much of agricultural price policy is made on a commodity by commodity basis, the supply response literature has concentrated on the short- and long-run supply response of individual crops to changes in (relative) output and input prices. Reviews of this literature can be found in Askari and Cummings (1976, 1977) and Bond (1983). Adjusting relative prices among farm outputs and relative to farm inputs can lead to important efficiency gains.

With the rising importance of structural adjustment, however, changes are often contemplated in the entire agricultural price regime. These changes would eliminate urban bias in the terms of trade by devaluing currency and by dismantling the structure of industrial protection. Recent studies have shown that in many developing countries indirect discrimination against agriculture via overvalued exchange rates and industrial protection is quantitatively more important than commodity-specific direct policy intervention (Krueger, Schiff, and Valdés 1988). In analyzing the response to dismantling indirect discrimination,

Hans Binswanger is chief of the Agriculture Operations Division in the Latin America and Caribbean Country Department 2 of the World Bank. He is indebted to Eileen Hanlon for developing the tables and figures and helping him write the paper. Bruce Ross-Larson edited the conference version.

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it is the response of broad agricultural aggregates to the policy changes that must be examined, rather than that of individual crops. Although there are perhaps thousands of individual commodity studies, the literature on the short- and long-term response of aggregate agricultural output to price changes is small. For recent reviews of this sparse literature, see Mundlak, Cavallo, and Domenech 1988; Chhibber 1988a, 1988b; and Bond 1983. Other aggregates that must be evaluated under structural adjustment are the performance of agricultural exports and of domestic food production; for these the literature is even thinner.

A common mistake in policy analysis is to extrapolate from the short-run effects of policy changes on the production of individual crops (or small groups of crops) to the long-run effects on aggregate output. The tendency surfaces in observations of the impressive possibilities for rice, or for maize, or for tree crops, or for some other agricultural product—and in the accumulation of those observations as evidence of the impressive (and immediate) possibilities for all agriculture. The land isn't so kind. Individual crops do respond strongly to price factors. This responsiveness shows up in crop elasticities that are fairly high—and higher in the long run than the short run. But growth in one crop usually takes resources away from other crops. So the price elasticity of all agriculture is very low in the short run. The problem is that the main factors of agricultural production—land, capital, and labor—are fixed in the short run.

Unlike individual crops, aggregate agricultural output can grow only if more resources are devoted to agriculture or if technology changes. The literature shows convincingly that the long-run response of agriculture is large: higher prices will slow migration out of rural areas and increase investment in agriculture. But these responses take time to develop fully—as much as ten to twenty years. They also depend greatly on public investments in roads, markets, irrigation, infrastructure, education, and health.

In addition to the prices of agricultural inputs and outputs, real farm profits are influenced by numerous factors such as the cost and accessibility of consumer goods, farm subsidies and taxes, research, extension, road infrastructure, and services such as marketing or credit. The response of individual crops to some of these factors—research and extension, for example—has been widely studied (Huffman and Evenson, forthcoming; Birkhaeuser, Evenson, and Feder 1988). Again, however, the literature on the response of aggregate output to these factors is very sparse (exceptions are Antle 1983 and Krishna 1982). Yet adjustment policies often require large cuts in public expenditures, which may affect spending for research, extension, infrastructure, or agricultural credit. The impact of such changes on aggregate output is therefore of major importance.

Although the response of individual crops to price changes remains an important tool of policy analysis, there are few controversies in the literature on that topic; this literature will therefore not be reviewed here. Instead, this paper begins by looking at why agriculture's aggregate response to price changes is small in the short run, and what this means for structural adjustment programs. After positing that the long-run response of agriculture to policy changes can

be substantial, the paper reviews recent studies of aggregate supply response with respect to public investment, research, and extension. The conclusion spells out the implications of these findings for the adjustment programs of World Bank clients.

I. Why the Aggregate Response to Price Changes Is Small in the Short Run

Individual crops respond strongly to price factors—a response that is well known. Reviews by Askari and Cummings (1976, 1977) show that one-year elasticities for individual crops can be high and that they vary depending on the characteristics of the crops or regions. (By contrast, livestock supply elasticities are usually negative in the first year, as farmers respond to high prices by first building up their herds (Reutlinger 1963). But the response of an individual crop to price changes differs fundamentally from the response of all agriculture, for individual crop production can grow by taking resources from other crops. Farmers can shift land, labor, fertilizer, and irrigation water from wheat to rice without raising their total farm output. And what is true for a farm is true for a country or region. Aggregate production can increase only if more resources are devoted to agriculture or if technical change is introduced.

The difference between individual and aggregate elasticities is a standard microeconomic lesson that World Bank staff too often ignore. The lesson is that the aggregate agricultural supply response can be very low even if individual crop responses are fairly high. Bapna, Binswanger, and Quizon (1984) estimated the short-run (one-year) elasticities for individual crops from a poor agroclimatic subregion in India: the results ranged from 0.25 to 0.77 for the main crop, sorghum. But when an elasticity matrix is used to estimate the supply elasticity of all agricultural output (see the matrix and formula in table 1), the result is only 0.05. Bapna and his associates also directly estimated an aggregate supply elasticity for a larger region, which included the subregion for which the elasticity matrix is shown. They found an aggregate elasticity of only 0.09, consistent with the implied elasticity.[1] The figure is also consistent with aggregate short-run price elasticities for various other countries. These fall mostly between 0.05 and 0.25 for the United States, several developing countries, and a cross-country sample of developed and developing countries (table 2). Interestingly, the short-run supply elasticities for Sub-Saharan Africa are no lower than for other areas. Long-run elasticities (using the Nerlove technique) tend to be higher than short-run elasticities, but they are still low.[2]

1. It is often believed that poor agroclimatic regions do not respond to price, but the fact that the elasticities for a poor, semiarid, tropical area in India are not much lower than those of the countries listed in table 2, dispels the idea that poor areas do not respond to price changes.

2. The Nerlove technique includes the lagged dependent variables to estimate the long-run elasticities. As argued in the appendix, these long-run elasticities are probably questionable and should not be used for policy analysis. Other econometric issues pertaining to table 2 are discussed in the appendix.

Table 1. *Semi-Arid India: Price Elasticities and Shares of Income by Crop*

	Price of wheat	*Price of sorghum*	*Price of other coarse cereals*	*Price of chickpeas*	*Price of other crops*	*Price of fertilizer*	*Wages*	*Share of crop in aggregate crop revenue*
Fertilizer	1.48	−1.46	−0.30	−0.46	0.64	0.03	0.08	—
Wheat	☞0.33	−0.35	−0.05	0.03	−0.12	−0.12	0.29	0.19
Sorghum	−0.39	☞0.77	0.06	0.00	−0.26	0.14	−0.32	0.23
Other coarse cereals	−0.14	0.16	☞0.23	−0.48	0.41	0.07	−0.26	0.09
Chickpeas	0.08	0.00	−0.41	☞0.46	−0.14	0.09	−0.08	0.08
Other crops	−0.07	−0.13	0.08	−0.03	☞0.25	−0.03	−0.08	0.41

Implied elasticity of supply of all crops

$$\eta = \sum_i S_i \sum_j \eta_{ij}$$

0.05

η = aggregate supply elasticity with respect to price, S_i = share of crop i in aggregate crop revenue, η_{ij} = elasticity of crop i with respect to price of crop j.

Direct econometric estimate for the elasticity of supply of all crops for a similar region

0.09

— = Not applicable.

Source: Bapna and others (1984).

Table 2. *Some Econometric Estimates of Aggregate Agricultural Price Response*

Country or region	*Short-run estimate*	*Long-run estimate*[a]	*Period*	*Notes*
United States	0.05–0.17	0.07–1.09	1920–57	Griliches (1960) (aggregate farm supply)
United States	0.06–0.17	0.10–0.23	1920–57	Griliches (1960) (aggregate crop supply)
Argentina	0.21–0.35	0.42–0.78	1950–74	Reca (1976)
Argentina	0.07	n.a.	1913–84	Cavallo (1988)
India	0.20–0.30	0.30	1952/53–74/75	Krishna (1982)
India	0.28–0.29	n.a.	1954/55–77/78	Chhibber (1988a)
India	0.24	n.a.	1955/56–76/77	Bapna (1981)
Semiarid tropical India	0.09	n.a.	1955/56–73/74	Bapna and others (1984) (uses panel data of districts and within estimators)
India	0.13	n.a.	1961/62–81/82	Binswanger, Khandker, and Rosenzweig (1989) (eliminates simultaneous equation bias, uses panel data of districts and within estimators)

(Table continues on the following page.)

Table 2 *(continued)*

Country or region	*Short-run estimate*	*Long-run estimate*[a]	*Period*	*Notes*
Ghana	0.20	0.34	1963–81	Bond 1983 for the following African countries and African average
Kenya	0.10	0.16	1963–81	
Côte d'Ivoire	0.13	0.13	1963–81	
Liberia	0.10	0.11	1963–81	
Madagascar	0.10	0.14	1963–81	
Senegal	0.54	0.54	1963–81	
Tanzania	0.15	0.15	1963–81	
Uganda	0.05	0.07	1963–81	
Burkina Faso	0.22	0.24	1963–81	
Average for Sub-Saharan Africa	0.18	0.21	1963–81	
Cross-country	0.06	n.a.	1969–78	Binswanger and others (1987) (crop output supply function, uses panel data of countries and within estimators)

n.a. Not available.

a. See appendix for a methodological discussion of the value of these estimates.

Table 3. *United States: The Response of Agriculture to Price Declines in the Depression*

Year	*Price of agricultural output*	*Relative farm prices*	*Agricultural output*	*Manufactured output*	*Land planted*	*Total labor*	*Wage rates*	*Power and machinery*[a]	*Fertilizer used*
1929	100	100	100	100	100	100	100	100	100
1930	86	105	98	82	101	99	93	101	103
1931	60	72	107	68	103	99	72	100	79
1932	46	61	104	52	104	98	53	97	55
1933	48	66	96	62	103	97	47	89	61
1934	60	72	81	67	93	97	53	84	70

Note: All figures reindexed so that 1929 = 100.

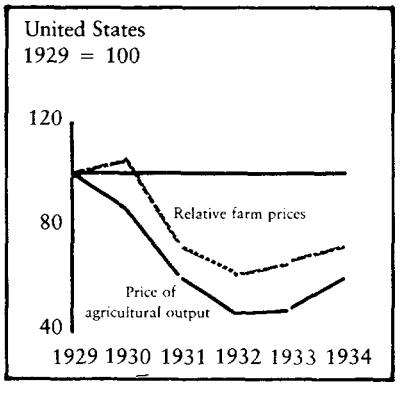
a. Index with volume in terms of 1935–39 average dollars.

Sources: Johnson (1950) and U.S. Bureau of Census (1945).

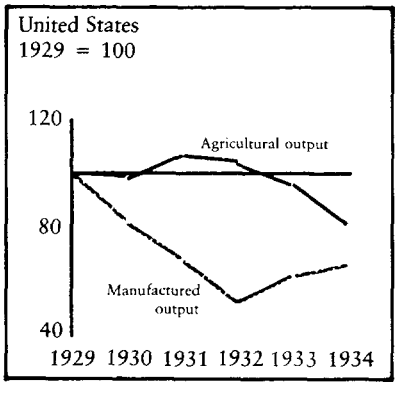
Why are the short-run elasticities for all agriculture so low? The main reason is that most factors of agricultural production are fixed in the short run. The amount of land available cannot change without considerable investment; capital increases only over time; and the labor in agriculture can change only through population growth or migration between sectors or regions. Together, land, labor, and capital account for 70 to 85 percent of the cost of agricultural production. And to get a large response, more of these resources must be devoted to agriculture—something difficult in a short period of time. The only factors that can be changed quickly are variable inputs, such as fertilizers and pesticides, and they account for less than 15 to 30 percent of the cost of production.

The reasons for an inelastic short-run response have long been recognized: D. Gale Johnson explained them clearly in 1950 by using the Great Depression, an episode of price decrease (table 3 and figure 1). During the Depression, all commodity prices fell, but agricultural prices fell more rapidly than nonagri-

Figure 1. *Gale Johnson's Classic Explanation of Inelastic Aggregate Agricultural Response*

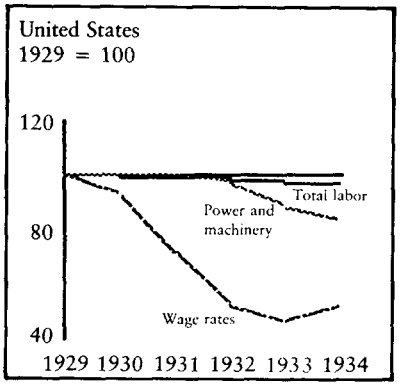


Farm prices declined in both absolute and real terms.

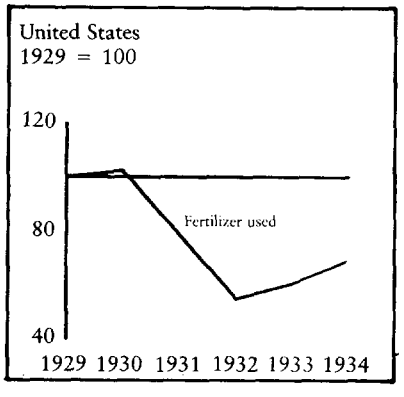


Nevertheless, agricultural output responded more slowly than manufactured output.

Figure 1 *(continued)*



Inputs of labor, capital, and machinery either do not decline because their opportunity costs are zero or decline very sharply (as in the case of wages).



The only resources that can be adjusted in the short run are purchased inputs such as fertilizers.

Because the share of purchased inputs in total cost was quite low, the supply effect of the change was not large.

Source: Johnson (1950).

cultural prices. Despite the sharp price decline, agricultural output did not fall significantly until about 1934. Manufactured output, by contrast, started to decline in 1930 (and was already increasing by 1933). Labor, power, and machinery in agriculture did not decline until 1933. Labor stayed high because the dramatic decline in agricultural wages maintained market equilibrium. The only input whose use declined sharply was fertilizer which, because it made up less than 15 percent of the value of aggregate output, could not lead to large output changes on its own.

II. Agricultural Exports and Food Production during Adjustment

The core of structural adjustment policies is elimination of overvalued exchange rates, reduction in industrial protection, and fiscal austerity. Specific agricultural measures include elimination of export taxation and other trade

restrictions and reduction of subsidies to producers. This package improves the terms of trade for agriculture as a whole and changes relative prices within the sector in favor of tradables. In the long run the improved terms of trade will accelerate agricultural growth, and the elimination of price distortions within the sector will improve efficiency and increase gains from trade. These long-run gains can be very large. But what will be the short-run response of agricultural exports, of aggregate output, and of domestic food supply?

Agricultural exports can react to changes in prices and exchange rates much like individual crops: a favorable price increase can increase production at the expense of nontradables, even if aggregate output does not increase. Balassa (1986) ran a regression of the ratio of exports to output for changes in the real exchange rate and foreign income. He found agricultural export elasticities to be higher than elasticities for exports of all goods and services and almost as high as those for merchandise exports (table 4). The elasticities of net agricultural exports are higher than the elasticities of agricultural exports because as the exchange rate rises, agricultural exports rise and agricultural imports become more expensive and fall. Other reasons are that the base of net exports is considerably smaller than that of gross exports and that devaluations are often associated with fiscal austerity, causing domestic demand to fall.[3]

The short-run response of export crops, and especially net agricultural exports, to exchange rate changes is therefore large. But how does aggregate agricultural supply respond to changes in the real exchange rate? Do changes in the exchange rate result in overall agricultural growth, or do they merely shift production from home goods to tradables?

Table 4. *Elasticity of Ratio of Exports to Output, 1965–82*

	Elasticity of exports with respect to the real exchange rate	
Exports/output	*Developing countries*	*Sub-Saharan Africa*
Goods and services/ total output	0.48	0.88
Merchandise exports/ total output	0.77	1.01
Agricultural exports/ agricultural output	0.68	1.35
Net agricultural exports/ agricultural output	4.96	11.47

Note: All figures are statistically significant at 1 percent or more.
Source: Balassa (1986).

3. Note in table 4 that all export elasticities are higher for Sub-Saharan Africa than for developing countries in general. One possible explanation for this high response is that most African countries are small and heavily dependent on foreign trade. Like the aggregate agricultural response, this high export response dispels another myth about Sub-Saharan Africa.

Table 5. *Recent Agricultural Performance of Countries in Sub-Saharan Africa*

Period	*Countries under adjustment*	*Countries not under adjustment*	*Difference in growth rates*
Agricultural production growth (percent per year)			
1970–80	1.1	0.9	0.2
1980–85	2.7	1.8	0.9
1986	5.8	4.3	1.5
1987	1.5	−1.1	2.6
Index of food production per capita (1979–81 = 100)			
1984–86	97	97	0

Note: Countries under adjustment include: Burundi, Cape Verde, Central African Republic, Chad, Côte d'Ivoire, Gambia, Guinea Bissau, Kenya, Madagascar, Malawi, Mali, Mauritius, Nigeria, Senegal, Togo, and Zaire.

Source: Cleaver (1988).

Cleaver's (1988) study is one of the few that address this issue. He compared the agricultural growth rates of Sub-Saharan African countries under adjustment (with packages of exchange rate adjustments and price and fiscal reforms) with those not under adjustment. Agricultural growth in the two groups was about the same in the 1970s (table 5). A slight difference between the two groups began to emerge in the early 1980s when adjustment programs were initiated. The annual agricultural growth in countries under adjustment was about 1 percentage point higher than that in countries without adjustment programs—and 2.6 percentage points higher in 1987, a bad year for agriculture throughout Africa. The striking difference between the two groups clearly increases over time, showing the responsiveness of Africa's agriculture to policy changes. Cleaver also shows that domestic food supply has not been increasing: through 1984–86, the domestic food self-sufficiency ratio remained at 97 percent for both country groups.[4]

Domestic food supply may not increase rapidly in response to adjustment programs for two reasons. First, a decline in real income often associated with adjustment may reduce the demand for food, shifting resources from the domestic food sector to exports. Second, in countries that are net importers of staple foods, domestic production of these foods is usually well protected even before adjustment. Krueger, Schiff, and Valdés (1988) show that for sixteen developing countries direct protection of imported basic staples averages 20 percent. An agricultural adjustment program usually also calls for a reduction

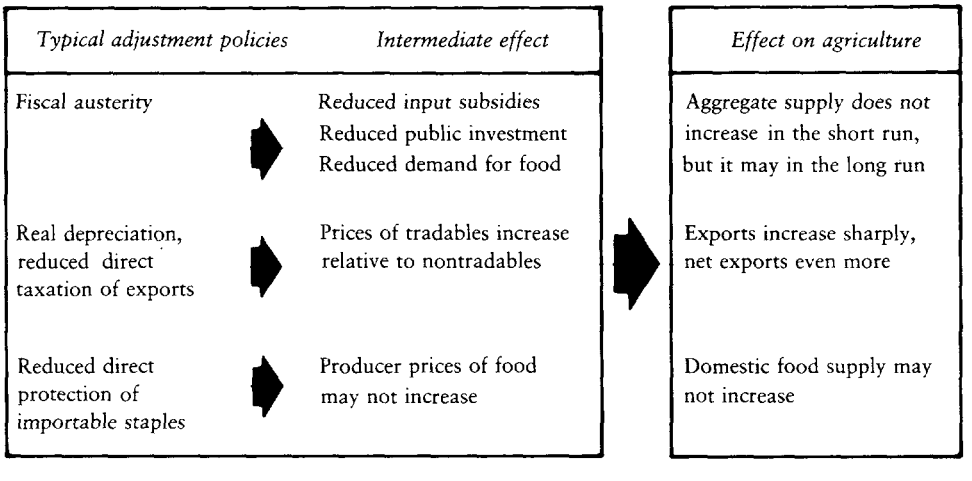
4. Another illustration comes from Mexico's adjustment in the 1984–88 period. Net agricultural exports grew rapidly after the devaluation of 1985, but neither aggregate output nor food consumption have increased.

in this protection. Therefore exchange rate and agricultural price reform may not lead to much higher prices for basic foods. And if the price does not increase, there will be no added incentive to produce food.

The reasoning is summarized in figure 2. Typical adjustment policies call for fiscal austerity, reducing producer subsidies and public investments. The resulting recession curtails the demand for food. In addition a depreciated exchange rate and reduced export taxation raise the prices of tradables in relation to nontradables. The producer prices of importable foods are likely to increase less because direct protection of such foods declines. Given low aggregate supply elasticity and decline in producer subsidies and public investment, the adjustment package will not increase aggregate output in the short run even if average agricultural prices rise. Some crops will respond quickly with sharply higher net exports, contributing much to the foreign exchange objectives of the adjustment effort. But the aggregate supply effects will only come in the long run.

So, with net exports responding quickly to higher prices, with aggregate agriculture responding after a lag, and with food supply responding little if at all, agriculture can support the adjustment program without increasing per capita food consumption. For both exports and domestic consumption to increase, aggregate agricultural output has to increase—and that can happen only in the long run. Structural adjustment programs should do more than ease balance of payments. They should also spur the growth of food production and of all agriculture. And since agriculture is price inelastic in the short run (and policy elastic in the long run), the question should no longer be the size of the price response. Instead analysis should focus on how to make all agriculture grow.

Figure 2. *Effects of Ajustment Policies on Agriculture*



III. What It Takes to Make Aggregate Agricultural Output Grow

Agricultural growth is the outcome of a process in which farmers respond to improved farm profits. Changes in profits, in turn, derive from the interplay of prices, improved infrastructure and better services, and enhanced technology.

The Long-Run Price Response: Labor and Capital

The aggregate long-run response of agriculture to price changes is large, and ultimately comes from private decisions to migrate and invest. As seen above, an expansion of labor and capital is required for agricultural output to respond to higher prices and profits. The most impressive evidence of a substantial response does not come from econometric studies of supply functions (see appendix) but from studies of the intersectoral allocation of labor and capital.

Labor. It is well known that the share of agricultural labor in total labor declines along the growth path, but economic forces affect the speed of this decline. Mundlak, Cavallo, and Domenech (1988) have studied intersectoral labor allocations for Argentina, Chile, Japan, the United States, and a cross-country sample. In all these studies, the intersectoral income differences—a function of aggregate agricultural prices—affect migration rates. Other studies of migration (such as Dhar 1984, for India) relate the migration from rural areas to intersectoral wage differences and find that shrinking wage gaps slow rural-urban migration. Higher agricultural prices do the same—reduce wage gaps and slow migration. Likewise, urban unemployment rates have been shown to lead to a decline in migration in both types of studies.

Capital. An economy's overall rate of investment, and agriculture's share of that investment, govern the growth of the agricultural capital stock. To show the relation between agricultural investment and agricultural rates of return, Mundlak, Cavallo, and Domenech (1988) related the intersectoral allocation of investment or savings to the rates of return for agriculture and nonagriculture. They found a definite positive relation. The rate of return in agriculture is positively related to the relative price of agriculture to nonagriculture. That rate also increases when technical change raises efficiency and farm profits. It is thus perfectly possible for the growth in agricultural capital, the growth in agricultural output, and the decline in agricultural prices to be simultaneous.

Time. It naturally takes time for the reallocation of capital and labor allocation to be translated into growth in output. How much time? Cavallo (1988) has explored this issue in a three-sector (agriculture, nonagriculture, and government) model of the Argentine economy, using data from 1913–84. The model includes econometrically estimated equations that relate intersectoral migration and capital allocation to expected differences in intersectoral earnings and productivity, all in dynamic simulations. The experiment relevant for the discussion here assumes a 10 percent permanent increase in the relative price of agriculture (table 6).

The results confirm the very low short-run elasticities of aggregate agricultural

Table 6. *Argentina: Price Elasticities in Agriculture*

Number of years after price change	*Output*	*Labor*	*Physical capital*	*Land*
1	0.07	0.00	0.05	0.03
3	0.16	0.07	0.18	0.07
5	0.36	0.17	0.38	0.12
10	0.71	0.42	0.90	0.23
15	1.19	0.82	1.39	0.34
20	1.78	1.52	1.80	0.48

Note: The elasticities are computed by assuming a 10 percent permanent increase in the price of agriculture but adjusting the price of government services in order to keep the general price level at historical levels. The price of land is increased in the same proportion as the agricultural price, and government wages are reduced in the same proportion as the price of government services.

Source: Cavallo (1988).

output and inputs to a policy change—they range from 0 for labor to 0.07 for output.[5] The output elasticity three years after the policy change is still only 0.16, but it rises to 0.36 after five years. The full response is very large, with an elasticity of 1.78, but it takes twenty years for that response—and more than half the full response occurs in the second ten years.

The response comes mainly from an almost equal expansion of labor and capital. The supply of land, by contrast, is inelastic, increasing only by a fourth as much as capital.[6]

Public Investments

Public actions and investments have a strong effect on agriculture. In addition, there is a strong interaction with private investment which accelerates with public investment.[7]

Econometrically, it is easier to show the effect of infrastructure, services, and human capital than it is to show price effects. Infrastructure, services, and human capital together affect aggregate agricultural output more than prices alone (table 7). The table is taken from two studies of output, fertilizer demand, and draft power investment, one using cross-country data and the other cross-district data from India. Both studies use the same method, combining cross-section and time-series data, and use only the variations within each country or district over time rather than cross-section variation (see appendix for details).

5. Reca's (1976) direct econometric estimate for Argentina appears to be an overestimate in light of the broader evidence using a full model and longer time series.

6. Cavallo (1988) presents the most realistic way of calculating long-run elasticities. Other econometric studies, such as those in table 2, have not been able to show the remarkably high levels of the long-run elasticities. Peterson (1979) is one author who shows high long-run elasticities, but the method is flawed (see the appendix for details).

7. I know of no studies of the impact of public investment on nonagriculture, so I cannot make comparisons.

Table 7. *Effects of Infrastructure on Agriculture*

	Aggregate crop output		*Fertilizer demand*		*Tractor stock, cross-country*	*Draft animal investment, India*
	Cross-country	*India*	*Cross-country*	*India*		
Prices						
Output price	−0.05*	n.a.	−0.02	n.a.	0.16*	n.a.
International output price[a]	n.a.	0.13*	n.a.	0.06	n.a.	2.90*
Fertilizer price	0.0	−0.12*	−0.16*	−0.57*	−0.05*	−12.25*
Urban wage	−0.05*	0.05	0.16*	0.13	−0.04	5.66*
Interest rate	n.a.	−0.001	n.a.	0.03	n.a.	−0.59*
Infrastructure						
Total irrigation†	1.62*	n.a.	−0.37	n.a.	7.16*	n.a.
Government canal irrigation	n.a.	0.03	n.a.	0.06	n.a.	−0.20
Rural road density	0.12*	0.20*	0.18*	0.22*	0.34*	−2.13*
Paved roads†	0.26*	n.a.	0.23*	n.a.	1.71*	n.a.
Electrification	n.a.	0.03§	n.a.	0.09§	n.a.	0.71*
Services						
Regulated markets	n.a.	0.08*	n.a.	0.41*	n.a.	0.06
Commercial banks	n.a.	0.02*	n.a.	0.25*	n.a.	0.54*
Extension	0.02	n.a.	0.19*	n.a.	−0.03	n.a.

(Table continues on the following page.)

Table 7 *(continued)*

	Aggregate crop output		*Fertilizer demand*		*Tractor stock,*	*Draft animal investment,*
	Cross-country	*India*	*Cross-country*	*India*	*cross-country*	*India*
Human capital						
Rural population density	0.12*	n.a.	0.18*	n.a.	0.34*	n.a.
Adult literacy rate†	0.54*	n.a.	1.27*	n.a.	−0.44	n.a.
Primary school	n.a.	0.33*	n.a.	1.43*	n.a.	3.82*
Life expectancy	1.76*	n.a.	2.64*	n.a.	5.49*	n.a.
Technical						
Research	0.00	n.a.	0.14*	n.a.	−0.05	n.a.
Rainfall	n.a.	0.07*	n.a.	1.27	n.a.	1.50
Miscellaneous						
GDP/capita	0.21*	n.a.	−0.13	n.a.	0.46*	n.a.
No. of observations	580	1,785	580	1,148	580	304

n.a. Not available.

* Statistical significance at 10 percent or more.

§ Statistically significant at 10 percent in a one-tailed test. Only for cases where the hypothesis of a coefficient of opposite sign is unreasonable.

† Coefficients are not in elasticity form: irrigation, paved roads, and adult literacy are ratios expressed as a percentage. The coefficients in the table are given the percentage increase in the dependent variable for a 1 percent increase in the independent percentage. For example, a 1 percent estimate increase in the adult literacy rate in India will lead to a 0.54 percent increase in agricultural output.

a. To circumvent simultaneity problems (see appendix), an index of international prices is used as an instrumental variable for domestic prices.

Sources: Binswanger, Khandker, and Rosenzweig (1989); Binswanger, Mundlak, Yang, and Bowers (1987).

As shown by Antle (1983), the clearest example of infrastructure impact is that of roads. In the two studies reported here, the density of roads has elasticities of 0.12 and 0.20 for aggregate output and strong effect on demand for fertilizer and tractors. In India, the density of roads reduces the demand for draft animals. In the cross-country study, road quality, as proxied by paving, is powerful. In India, electricity has a small positive effect on aggregate output but a substantial effect on fertilizer demand and on reduced investment in draft animals. In the cross-country study, irrigation has a powerful effect on output and on tractor demand. It is not possible to show any effect of the Indian government's investment in canal irrigation over the past twenty years.[8]

Services also affect agriculture. India's regulated markets—featuring a formal auction mechanism to sell individual farmers' output—are a cheap government investment with a powerful impact, even on fertilizer demand. Having branches of commercial banks nearby also sharply increases fertilizer demand. Public extension services increase fertilizer demand; they also increase aggregate output, but the relation is not statistically significant.

Human capital also has an impact on output. Rural population density, a proxy for labor, increases input use and output. In the cross-country study, broader literacy boosts output, shown by a very large elasticity, as well as the demand for fertilizer. In the India study, primary schools have powerful effects on output, fertilizer demand, and investment in draft animals. Life expectancy, a proxy for the people's health, also has a strong impact on output and fertilizer demand (in the cross-country data).

That it is easier to show econometrically that public investments have a strong impact on agricultural growth does not mean that prices are not important. The econometric estimates shown in table 7 are short-run elasticities, which we know

Table 8. *United States: Time Trend of Agricultural Prices Deflated by Wholesale Prices, 1900–83*

Commodity	*Coefficient (percent per year)*	R^2
Sugar	−0.7	0.14
Wheat	−0.7	0.39
Maize	−0.6	0.31
Rice	−0.6	0.27
Cotton	−0.5	0.26
Wool	−0.1	0.49

Source: Binswanger, Mundlak, Yang, and Bowers (1985).

8. All irrigation, which includes private irrigation in wells, has probably been a powerful contributor to aggregate output. But private investment is endogenous, and because the India data (but not the cross-country data) allow separate treatment of public irrigation, only the latter were included.

to be low.[9] If prices are not set right, farmers will not invest, and this would hurt agricultural growth. Low prices also accelerate outmigration and reduce the agricultural labor pool. So, a good price policy is necessary for rapid growth, but it is not sufficient.

Public Research and Extension

Agriculture's long-run growth record is impressive. World production, more than keeping up with demand, has grown so fast that it has led to long-run declining prices (table 8). Since 1900, the prices for the basic staples and cotton (relative to the wholesale price index) have declined by at least 0.5 percent a year. The low coefficients of determination show that there are large variations in prices around these estimates, reflecting commodity booms and busts. And if there is a secular decline in agricultural commodity prices, there is also a secular decline in agricultural production costs—something that can happen primarily with technical change.[10] From this information on declining prices alone, it is clear that technology was a major source of agricultural growth. Technology is developed and diffused by both public and private sector institutions.

What, then, of public research? In the cross-country study (table 7) it has no discernible effect on aggregate output, but it does have a positive effect on fertilizer demand. The relation is similar to that for extension, where the effect of the output is not statistically significant, but that on fertilizer demand is strong. That neither research nor extension has a strong effect is puzzling, because over the long run prices have fallen due to technological change. Perhaps the technological development has been in the private sector, adopted without public help. It is known, however, that public research has helped the supply of individual commodities. Just as in the case of price reforms, it is easier to expand output of an individual crop than aggregate output.

The cross-country data used for the estimates in table 7 may not, however, be the best way to express the impact of extension and research on agricultural production. Birkhaeuser, Evenson, and Feder (1988) reviewed the extension literature on the adoption of technology and the supply of individual crops. They find that extension impact varies, sometimes being powerful, sometimes not. Here, however, the focus is on aggregate output. Just as it is possible to aggregate individual crop price elasticities, one can aggregate research and ex-

9. The cross-country aggregate supply elasticity is negative because it includes livestock products that are close to half the value of output. The stock of tractors and the investments in draft animals (but not fertilizer) respond strongly to increases in output prices. Fertilizer prices nevertheless have a consistently strong effect on fertilizer demand and investment. In the cross-country study, higher urban wages reduce output and lead to the substitution of fertilizer for labor. In the India study, higher urban wages lead to a substitution of draft animals for labor. Only in the India study are higher interest rates shown to reduce draft animal investment.

10. The major decline in transport cost associated with the steamboat and the railroad was already drawing to a close at the beginning of this century.

tension elasticities using weighted shares of individual crops. As one crop's technology changes, its profitability increases. Its production may expand at the expense of other crops whose relative profitability has declined. So, just as the aggregate price response is much smaller than the elasticities for individual crops, aggregate research response should be smaller than individual crop response to research. This is confirmed by the results of Huffman and Evenson shown in table 9.[11]

In North India, research on wheat expanded the production of wheat at the expense of corn and millet. Research also concentrated on industrial crops, such as cotton. The aggregate output elasticity is 0.17, but not as large as the elasticity of 0.31 for wheat alone. Similarly, public extension concentrated on rice, corn, and millet, and on industrial crops rather than wheat. Extension's aggregate supply elasticity is 0.16, as large as the elasticity for research.

In Brazil, the concentration of research on export crops expanded that category at the expense of other crops. The aggregate elasticity is 0.25. It is not possible to show the effect of extension for the Philippines, and the effect of research there is small. The effect of research and extension on production is much easier to show for an individual crop than for all agriculture. In the U.S. study, public research increased the output of cash grain farms—with an elasticity of 0.07. It had the sharpest impact (0.24) on soybeans, which expanded at the expense of wheat and rice. Private research was biased toward feed grains and reduced crop output overall. An aggregate effect of public extension cannot be shown.

Credit

As we have seen, private investment is a major source of growth. But how important is credit for accelerating investment? What is the effect of increased credit on agricultural growth? Binswanger and Khandker (1989) examined the impact of the expansion of India's rural financial system on agriculture by applying the same techniques (supply function analysis) used for deriving most of the results in this paper.

The amount of credit borrowed in each district is determined both by the decisions of the financial institutions to make it available and by the decisions of the farmers to borrow it. This endogeneity means that one cannot estimate the impact of credit by simply regressing the volume of credit on aggregate output or on fertilizer demand, because farmers will borrow more if they plan to produce more and to use more fertilizer. Two methods can circumvent the resulting simultaneity problem. The first estimates the impact of improved financial intermediation by including the number of commercial bank branches as an explanatory variable. The decision to locate a branch in an area is up to the commercial bank and therefore reflects only the supply of credit, making it

11. The results are from systems of output supply and factor demand equations estimated in ways similar to those in table 1. The equations include shifter variables for research, extension, and high-yield varieties, whose coefficients are reported in table 9.

Table 9. *Estimated Impact Elasticities of Public Research, Extension, and High-Yield Varieties*

	North Indian wheat			*Brazil*	*Philippines*		*U.S. cash grain farms*		
Product	*Public research*	*High-yield varieties*	*Public extension*	*Public research*	*Public research*	*Public extension*	*Public research*	*Private research*	*Public extension*
Impact on product supply									
Wheat	0.31	0.21	−0.32	n.a.	n.a	n.a.	−0.06	−1.36	−0.10
Rice	−0.08	0.12	0.33	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Corn and millet	−0.81	−0.12	0.86	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Industrial crops	0.27	−0.09	0.33	0.05	n.a.	n.a.	n.a.	n.a.	n.a.
Export crops	n.a.	n.a.	n.a.	0.74	n.a.	n.a.	n.a.	n.a.	n.a.
Staple crops	n.a.	n.a.	n.a.	0.01	n.a.	n.a.	n.a.	n.a.	n.a.
Beans	n.a.	n.a.	n.a.	0.01	n.a.	n.a.	n.a.	n.a.	n.a.
Animal products	n.a.	n.a.	n.a.	0.07	n.a.	n.a.	0.24	−0.72	0.06
Soybeans	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	−0.03	1.06	0.06
All products[a]	0.17	0.04	0.16	0.25	0.05	−0.05	0.07	−0.23	0.00

n.a. Not available.

Note: Derived from profit function estimates with multiple inputs and outputs. Total land and farm size held constant. For studies with cross-section time series, within estimators have been used.

a. Elasticities for all outputs and inputs are the sum of the individual product or input elasticities weighted by their respective shares. For example, $\eta_R = \Sigma S_i \eta_{iR}$, where η_R is the aggregate output elasticity with respect to research, η_{iR} is the elasticity of crop i output with respect to research, and S_i is the share of crop i in total farm revenue. For the Philippines, only an aggregate supply function with disaggregated input demands was estimated.

Sources: Evenson (1988); Huffman and Evenson (1989).

exogenous to farmers' decisionmaking. But this method cannot capture the lending volumes of the entire financial system, which includes cooperative institutions as well as commercial banks. A second method uses a two-stage least-squares procedure through which the volumes of lending are predicted by the number of branches of commercial banks and cooperative lending institutions. Because the number of institutions affects only supply but not demand, the predicted lending volumes are no longer correlated with the residuals of the output supply and input demand equations.

Table 10 summarizes the effects of financial intermediation variables on aggregate output, fertilizer demand, investments, rural employment, and rural wages. Each result is the financial intermediation coefficient of a separate regression equation such as those in table 7.

- Cooperative credit's output elasticity is 0.014. This elasticity, despite being small, is fairly precise. It is smaller than the output elasticity of overall rural credit, the volume of which is much larger. It is also smaller than the output elasticity of the number of commercial bank branches.
- Fertilizer use responds with an elasticity of 0.06 to cooperative credit, 0.25 to commercial bank branches, and 0.28 to rural credit—all substantially larger than the impact on aggregate crop output and large enough to explain the entire increase in aggregate output.

Table 10. *India: Impact of the Financial System on Agriculture and the Rural Economy*

	Independent variables		
Dependent variable	*Number of commercial bank branches*	*Predicted overall rural credit advanced*	*Predicted agricultural cooperative credit advanced*[a]
Aggregate crop output	0.014*	0.02†	0.01*
Fertilizer demand	0.25*	0.28*	0.06*
Investment			
Tractors	0.14†	n.a.	0.10*
Pumps	0.38*	0.51*	0.31*
Draft animals	0.71*	0.62*	0.38*
Milk animals	0.52*	0.58*	0.19*
Small stock	−0.16	0.67*	0.29*
Agricultural employment	−0.07*	−0.04	−0.01
Nonagricultural employment	0.29*	0.18*	0.00
Rural wage	0.06*	0.04*	0.00

n.a. Not available.

* Statistically significant at 10 percent or better on two-tail test.

† Statistically significant at 10 percent or better on one-tail test.

a. Cooperative credit includes credit by the Land Development Bank system and the primary agricultural credit societies. In 1980–81, credit outstanding to agriculture for the cooperative system was about two-thirds of total credit outstanding to agriculture and about 42 percent of total rural credit.

Source: Binswanger and Khandker (1989).

- Cooperative credit, commercial bank branches, and overall credit expansion sharply increase the rate of investment in tractors, pumps, draft animals, milk animals, and small stock. And all coefficients (except commercial banks and small stock) are statistically significant.
- The growth of commercial banks and overall credit reduces agricultural employment, with respective elasticities of 0.7 and 0.4. Cooperative credit, exclusively for agricultural purposes, also has a negative but not significant coefficient. Clearly, however, agricultural credit does not increase agricultural employment.[12]

It thus appears that the main effect of institutional growth and higher lending volumes has been not a substantial increase in aggregate crop output but more substitution of capital for labor. If increased fertilizer use can account for the entire output effect of additional credit, higher capital investment must have substituted for labor.

The supply approach to agricultural credit pursued over the last three decades in India has spurred the use of fertilizer and investment in agriculture. But it has failed to generate agricultural employment, and it has not reached its agricultural output objectives. The costs of credit programs to governments are high, as losses from poor repayment are ultimately borne by the government or its institutions. The benefits of expanding commercial banks in rural areas—increasing nonfarm growth, nonfarm employment, and rural wages—could have been achieved without imposing costly agricultural credit targets on commercial banks.

The World Bank has a large portfolio of investments in agricultural credit—with US$6.6 billion, or one-quarter of its agricultural lending, to credit schemes during fiscal years 1982–88. Many countries transfer very large resources to their credit systems to cover losses. During the 1980s Mexico's transfer credit system was not less than 12 percent of agricultural value added. Yet agricultural growth in output during the 1980s was less than 1 percent per year, according to World Bank figures. Other Bank-supported studies (including World Bank 1988 and von Pischke 1981) have shown that Bank investments have not led to viable credit institutions in India or many other places. The studies have also shown that it is difficult to direct credit to poorer farmers.

Private and Public Responses to Agroclimatic Potential

It is well known that a poor agroclimate can constrain production regardless of the investment devoted to production. And there appear to be few bounds to agricultural production in good agroclimatic areas. How are public and private

12. Most of the commercial bank credit in rural and semiurban branches in India goes to sectors other than agriculture. Confining the investigation of the effects of rural credit to agriculture would thus be ignoring other effects in the rural sectors. Positive effects on rural nonfarm output and employment could mitigate the negative effects on farm employment.

resources allocated to different agroclimatic environments, given the fact that supply responds to price changes even in poorly endowed agroclimatic zones?

Farmers, governments, and service providers all respond to agroclimatic variables. Their response is very strong. Public infrastructure and services are targeted to better agroclimatic regions. More workers migrate to such regions. Private investment responds to the better area and the better infrastructure. And private providers of services respond to the better business opportunities associated with the good agroclimate, improved infrastructure, and high private investment by increasing services for input supply, marketing, maintenance, and finance.

That's the reasoning. What, then, is the evidence? In India 37 percent of the variation in the density of roads is exclusively the result of measured differences in agroclimatic endowments (table 11). For other investments, a similar proportion of the variation is explained. Across the board, governments and banks invest more where irrigation potential is high. They tend to avoid areas that are at risk of floods. Banks systematically put their branches where rain or irrigation potential promise good water supply and where the risk from droughts or floods is low.

Because the elasticity estimates in tables 7 and 9 are averages for the countries or districts, they do not show differences in the responses to agroclimate. And because governments often make allocations on the basis of agroclimatic potential, the averages of tables 7 and 9 cannot indicate the differences in elasticity for different agroclimatic subregions. Although the estimates show that infrastructure, services, human capital, and technology are crucial to aggregate agricultural growth, this conclusion is not sufficient to make investment decisions. Specific project analysis is still necessary to predict returns to individual projects or programs in particular agroclimatic environments.

Table 11. *India: Effects of Agroclimatic Endowments on Infrastructure and Banking Services*

Explanatory variable	*Rural roads*[a]	*Regulated market*	*Canal irrigation*	*Electricity*	*Commercial bank branches*
Cool months	−0.22	0.004*	0.01	0.39*	0.02
Excess rain	0.23	−0.002	−0.001	0.01*	0.05*
Rainy season	2.44*	−0.004	0.01	0.09	0.05*
Flood potential	−0.08	−0.001*	−0.004	−0.06*	−0.01*
Irrigation potential	0.03*	0.001*	0.002*	0.01*	0.002*
Soil moisture capacity	−0.42*	0.004*	−0.02*	0.23	0.0002
Urban distance	−0.003	0.00004*	0.0001*	−0.001	−0.21
Constant	−4.22*	−0.01	−0.02	0.185	−0.13
Adjusted R^2	0.37	0.36	0.43	0.28	n.a.

n.a. Not available.

* Statistically significant at 10 percent or better.

a. Rural roads corresponds to agricultural year 1974; the remaining variables relate to agricultural year 1981.

Source: Binswanger, Khandker, and Rosenzweig (1989).

In addition, the joint dependence of public and private investment on observed and unobserved agroclimatic conditions increases the difficulties for econometric estimation. Cross-section analysis cannot be used because it cannot take agroclimatic conditions into account (see the appendix for details).

The cost of ignoring agroclimatic conditions can be high. It is known that the rate of return to private investment is sharply lower in marginal areas. Some of the World Bank's project failures in Sub-Saharan Africa can be attributed to expecting too much from such areas. Lele and Meyers (1986) show that the growth of smallholder production in Kenya occurred primarily in high-potential areas, where smallholders produce cash crops that bolster the growth of Kenya's exports. But in Kenya's arid and semiarid areas, agricultural growth has been disappointing despite considerable investment, much of it Bank-assisted.

IV. Implications for the World Bank

The way to look at agricultural growth is to go beyond prices and price elasticities. The first thing to consider is an area's agroclimatic potential. This potential sets the prospects for agriculture and influences the public and private decisions that can, in turn, encourage agricultural growth. If bad agroclimatic conditions constrain agriculture and the investment in it, agricultural growth will be slow. Although the World Bank should assist countries in exploiting the limited potential that usually exists even in marginal areas, it should resist pressure to invest heavily in marginal agriculture on grounds of the alleviation of poverty. If there is no agricultural growth, there can be no alleviation of poverty.

Structural adjustment policies are executed to promote agricultural growth and efficiency, but their effects may take several years to materialize. In the short run agriculture can contribute much to structural adjustment efforts, mainly by increasing net exports. But because adjustment efforts typically take time to increase aggregate agricultural supply, possible stagnation or decline in food production and consumption must be kept at the fore. Where governments protected importable food production before adjustment, domestic food consumption cannot be expected to increase under an adjustment program, so there is a need to design or expand targeted food subsidies and nutrition programs. To ensure that food and nutrition needs are met during the adjustment effort, such targeting should ideally be part of the design of adjustment programs. Of course, designing such programs and obtaining government commitment to them is not easy.

Adjustment packages must also be designed in ways that go beyond reliance on prices alone to spur agricultural growth. Because of the long lags in private responses, the dependence of private investment on public and quasi-public goods, and the long lead times of public investments, the attention to agricultural growth cannot be delayed until the adjustment is complete. Instead, adjustment packages must protect and support investments for agricultural growth—such

investments as those in human capital, infrastructure, markets, research, and extension. How could targeted food subsidies and continued public investment be financed when expenditures have to be cut? Savings can of course come from other sectors. But there are opportunities in agriculture as well, such as the reallocation of fertilizer and credit subsidies to growth-enhancing public investment. Fertilizer subsidies have no effect on agricultural output if fertilizer is at the same time rationed. And many costly credit programs receive very large subsidies but have not created viable institutions or reached poor people. In India and Mexico they have also failed to produce much agricultural growth.

Appendix: Some Econometric Issues

Using Cross-Country Data to Estimate the Long-Run Aggregate Supply

The range of most of the estimated long-run elasticities in table 2 is 0.1 to 0.3. These elasticities are derived using the Nerlove technique, which uses the lagged dependent variable and interprets the coefficient of lagged supply as the intertemporal adjustment coefficient. Few people believe that the low elasticities derived using the Nerlove technique are good estimates of the response of crops to a permanent change in the price regime of agriculture. Little literature exists on aggregate supply using more sophisticated lag structures. Some experiments were performed by Binswanger and others (1985) using cross-section/time-series data for fifty-eight countries. They used free form lags including prices of the three previous years but did not find higher elasticities.

Peterson (1979) convincingly argued that time-series data cannot be used for inferring the long-run elasticity, because few countries have shifted from a regime of low prices to one of high prices. Instead, the time-series data only show the response to short-lived commodity booms (see also the simultaneity problem, below). Peterson also argues that different countries pursue different pricing regimes for long periods of time and their input and output levels have fully adjusted to these regimes. He therefore used country cross-section data to estimate the long-run response and found price elasticities in the range of 1.27 to 1.66. But as Chhibber (1988b) points out, the problem with this cross-country technique is that country output levels differ not only because of differences in prices but also because of differences in agroclimates, public infrastructure, research, extension, and public investment in human capital. When Chhibber included some of these variables in the cross-section estimation, Peterson's estimates declined.

Some of the productivity-enhancing variables are observable, but others are not. Binswanger and others (1987) show that even by including ten measured attributes of agroclimate and public investments, the correlation of the explanatory variable (including price) with unobserved country effects cannot be eliminated. In another experiment using data from eighty-five districts in India, Binswanger, Khandker, and Rosenzweig (1989) show that the correlation be-

tween unobservable district characteristics and government investment cannot be overcome in that data set either. These results are consistent with the idea that governments systematically invest more in regions with high agroclimatic endowments.

Estimates of the effects of prices and government investments on aggregate output using cross-country variation will therefore suffer from unobserved variable biases. Cross-section estimates of aggregate supply, such as those by Peterson and Chhibber, have therefore been ignored in this paper.

The correlation between unobserved endowments of regions or countries with prices and other explanatory variables can be overcome by using cross-section/time-series data and using only the within-country or within-district variability. The cross-district or cross-country variability can be eliminated from the estimation by: (1) including district- or country-specific intercepts, (2) using only differences between successive years, or (3) using differences from district or country means. In table 2, we indicate the studies that use these within estimators.

The Simultaneity Problem

When agricultural price levels rise and supply expands, commodity markets are soon saturated because the demand for aggregate agricultural output is inelastic. Prices then drop again. Although countries or districts trade with the rest of the world and therefore may face more elastic demand, demand is unlikely to be perfectly elastic. The reason is that not all agricultural commodities are tradable; commodities are blocked by natural trade barriers or government trade restrictions. The short-run estimates of demand elasticities reported in table 2 could therefore be biased downward.

Binswanger, Khandker, and Rosenzweig (1989) circumvented this problem in their cross-section/time-series study of Indian districts. Instead of using an aggregate domestic price index, they constructed a price index for districts using international commodity prices. This international commodity price index was then used as an instrumental variable for the domestic prices, thus bypassing the simultaneity problem. Using this technique raises the estimated short-run aggregate crop supply elasticity from 0.045 to 0.13. This confirms that simultaneous equation bias indeed results in underestimation of the aggregate supply elasticities. But the unbiased estimates using instrumental variables are still very low: within the 0.1 to 0.2 range where most estimated short-run elasticities lie.

Can One Estimate Long-Run Supply with Single-Equation Techniques?

The difficulty of estimating truly long-run responses using single-country data or within estimators is likely to persist even if more sophisticated lag structures and simultaneous equation techniques are used. The long-run aggregate supply response is the effect of dynamic capital and labor reallocation among sectors and of government infrastructure, research, and human capital investments. These processes may extend over long periods. Much more elaborate modeling of the underlying migration and investment processes is required, as done in

Cavallo and Mundlak (1982) or Cavallo (1988), using long time series. In addition, the governments' public investment allocation must be modeled. The "long-run" estimates reported in table 2 are probably not usable for policy analysis.

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Comment on "The Policy Response of Agriculture," by Binswanger

Avishay Braverman

This is a clear and well-written paper with two important messages. First, we should not confuse individual elasticities with aggregate, sectoral supply elasticities; aggregate supply elasticities are significantly lower than individual elasticities. Second, input and output price reform should be accompanied by investment in physical and human capital with appropriate, accountable institutional structures. Otherwise, significant long-term effects on agricultural growth cannot be expected.

It should go without saying that serious scholars and careful practitioners ought always to advocate *both* price and institutional reforms and appropriate investment strategies. Nevertheless, we should thank Professor Binswanger for reminding us of this reality: both inside and outside the World Bank, the two strategies are still often debated as if they were mutually exclusive rather than complementary. But the crucial point is how valuable an input this information—that the aggregate supply elasticities are lower than the individual supply elasticities—is to our conduct and assessment of agricultural policy reform.

I would first argue that the accepted point that aggregate supply elasticities are not high is essentially inconsequential to the recent—deserved—emphasis policymakers have been placing on price reform. Second, the paper's focus on sectoral elasticities belittles the importance of individual crop elasticities in agricultural price reform. I would like to make several points about these conclusions.

First, what is the significance of "low" aggregate supply elasticity for policy reform? If the United States is excluded, most of the econometric estimates of short-run aggregate agricultural price elasticity presented in the paper fall in the 0.1–0.2 range (table 2). With structural adjustment, a price change of 100 percent is possible; assuming overall elasticity of 0.2, an aggregate supply response of 20 percent results. This is a very significant change.

Second, it is necessary to assess the effect of policy reform on the budget deficit, foreign exchange, and income distribution, as well as on output and aggregate employment. Aggregate supply elasticities can only help indicate the

Avishay Braverman is chief of the Agricultural Policies Division in the Agriculture and Rural Development Department, World Bank. He would like to thank Jeffrey Hammer for very helpful comments: the views expressed here reflect their joint work on agricultural price reform.

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effect on the last two variables. For the rest, the distinction of supply response for individual crops is essential. And the first three variables are the critical parameters in these days of fiscal and foreign debt crisis in many developing countries, in particular if we are really concerned with the impact of policy reforms on the poor.

Third, as Binswanger points out, high long-run aggregate supply elasticities may be due to price reforms. That is, part of the long-run supply response is an indirect effect of price reform which creates greater incentives and opportunities for investment.

Fourth, the aggregate response to prices may not be nearly as relevant to policy as the intercommodity effects. If the aggregate response is low, then interventions that affect all commodities (such as devaluation) may have small deadweight losses associated with them. But if, as Binswanger points out, the aggregate response is composed of very high own-price and (negative) cross-price effects, then the costs of inappropriate relative prices within agriculture are important. Here, obviously, multimarket approaches (see Braverman and Hammer 1988), which focus on substitution among commodities, are useful. Note that (in the short run) this point is at variance with the Krueger, Schiff, and Valdés (1989) conclusions that the macro exchange rate effects are more important to correct than inefficient direct price interventions in agriculture.

Fifth, because individual crop elasticities are evidently needed for policy analysis, the question of their availability and accuracy becomes important. Given the scarce and limited data in developing countries, and admitting the limitations of the art of econometrics, I agree with the comments of my colleagues Angus Deaton and T. N. Srinivasan at this conference that we should put more effort into collecting data and improving estimation techniques. Given those limitations of our "scientific art," orders of magnitude of elasticities are often the relevant framework for policy debate. World Bank agricultural policy has taken this position for quite some time in generating multimarket models for which estimated and "guesstimated" elasticities are inputs, and which are used to help Bank staff articulate interrelations among commodities and their impact on key policy variables. Incidentally, while liberalization, in moving domestic toward international prices, is often the appropriate policy reform, it is important to note that neither conceptually nor in practice does the Bank advocate "as a holy rule" the immediate equalization of domestic and international prices: rather, a clear analysis of the tradeoffs is required, particularly given the burden of debt and limited availability of tax instruments.

Sixth, one point raised in the paper is that policy reform in agriculture often implies increasing food prices which provide better incentives to producers (correction of the "urban bias"). However, the urban poor, landless farmers, and small farmers with a negative marketed surplus will suffer, at least in the short run. On how to protect these vulnerable groups during adjustment, I agree with Binswanger that well-designed, cost-effective targeted programs would be the solution in an ideal world. But in the real world the track record for administered

programs has not been very good over the last twenty years. We should use targeted programs when the appropriate political will and administrative capacity exist; when they do not, we may sometimes have to resort to subsidization of commodities that, as far as possible, are consumed by the poor significantly more than the rich (that is, subsidies to inferior goods).

Seventh, Binswanger mentioned the failure of the formal credit programs in developing countries. This point should be reiterated until it has been effectively driven home. At the same time, we should continue to explore new institutional possibilities—such as credible voluntary cooperatives to increase the supply of credit to the rural sector—but not without sufficient prior evidence that accountable incentive structures exist to monitor and enforce appropriate behavior both for the borrower and the lending institution (see, for example, Braverman and Guasch 1989; Feder and Huppi 1989).

Eighth, I would like to make a few technical comments on the limitations of the econometric analysis—about which the author is appropriately cautious in the appendix—in terms of data, specification, and estimation techniques.

It is important to read the appendix, perhaps even before the text: more courageous interpretations appear in the latter. These apply not only to the overall flavor of the results but also to specific instances, such as the inference that the availability of credit institutions increases demand for fertilizer but induces higher capital to labor substitution. This could be true, but it is a very precise interpretation that one would be wary of asserting too confidently in view of the admitted flaws in the data base.

Binswanger is right to mistrust the ability of econometrics to estimate accurately the long-run supply response. But simulation approaches should also be handled gingerly. With most conventional function forms, numerically derived production possibility frontiers often tend to be quite "flat"—Harry Johnson's old result—and lead to strong intersectoral movements and high elasticities. The author suggests reasons (for instance, that there are nearly constant returns to scale on good land) why this may be true. But it is worth checking carefully that the results are credible and not an artifact of the technique of estimation.

One kind of simultaneity problem of the econometric studies is mentioned in the appendix; there may be others that affect the estimated impact on growth of some of the nonprice factors, including education. We do not know much about public allocation of investments in human capital, and the impact of prices could be important whether it be through agricultural income or through judgments of relative financial profitability of alternatives. Demand for education is surely income-elastic, and whether educational services are publicly provided or not, they are likely to respond to this demand. The causality may go entirely in the opposite way. Education may be a pure consumption good with high income-elasticity. If output, a proxy for income, were regressed on education, one would get a positive coefficient. A similar story, more or less credible in different markets, might be told for any public investment made with an eye toward recovering costs (higher income or output leading to more confidence in pro-

viding an effective service) and also for private investments such as bank branch location, which is treated as completely exogenous in this paper.

In summary, I would like to thank the author for focusing attention on this long-debated subject and for helping us to further direct the Bank's efforts in the 1990s toward credible hybrid lending which should emphasize both investment lending and required policy reform. We are reminded that we should not create unwarranted expectations—in particular, without appropriate institutional reforms. And here, if it comes to formal credit institutions or targeted food programs, I would emphasize three words: monitoring, enforcement, and accountability.

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Comment on "The Policy Response of Agriculture," by Binswanger

Alberto Valdés

The policy background in Hans Binswanger's very interesting analysis is that current macroeconomic conditions in many developing countries require a reduction in government expenditures (to reduce the deficit) and an expansion in the production of tradables. The success of such a change could depend on agriculture's performance, because agriculture usually has the larger tradable component and a 50 percent or higher share of total export revenues.

In my opinion, the current situation offers an opportunity for revitalizing agriculture, which is often heavily taxed through economywide price interventions. I will discuss Binswanger's analysis against this background.

Although Binswanger does not discuss actual levels of agricultural price distortions, he states that the short-run response of agriculture to price changes is very low and lower than the long-run response. On the expenditure side, Binswanger's concern is that across-the-board cuts in public investment could reduce investment in certain types of infrastructure critical for agricultural growth. What does all this imply for the adjustment programs of World Bank borrowers?

Binswanger refers to the wrongheaded tendency in the development community to overestimate the agricultural aggregate supply response to incentives. As I understand it, this alleged overestimation refers only to the aggregate short-run response, not to the long-run response. Binswanger concludes that price reform alone will not significantly expand aggregate output in the short run because this response takes time. Only subsectors could expand. The clear conclusion is that, though price reform and public investment need to start right now, there is nothing governments can do that will have an effect in the short run—if we accept the short-run supply inelasticity argument and agree that designing and implementing public investment also takes many years.

Furthermore, to avoid loading the burden of adjustment on low-income wage earners, Binswanger recommends that we "design or expand targeted food subsidies and nutrition programs." But this brings us back to programs that take many years to develop. Few developing countries have effective targeted health and nutrition programs with broad coverage of poor households, and even fewer

Alberto Valdés is director of the International Trade and Food Security Program at the International Food Policy Research Institute, Washington, D.C.

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of rural areas. In Latin America I believe only Chile, Costa Rica, and Cuba have such programs.

Let me address the following issues in Binswanger's paper: (1) the short-run aggregate output response; (2) the price versus nonprice issue and the sequencing of policies; and (3) the long-run aggregate output response.

I. The Short-Run Response

Is aggregate output so unresponsive in the short run? This will depend on how depressed prices are; the time frame we have in mind; and the responsiveness to a given price adjustment.

Before addressing these issues, a qualification: Binswanger distinguishes between export and food crops on the premise that exportables are tradable and do react in the short run (on the basis of the evidence in Balassa's work), but food supply is not tradable and responds little, if at all. My understanding is that most food crops are also tradables (import-competing) in most developing countries (certainly in Latin America, somewhat less in parts of Sub-Saharan Africa), and they are expected to be less responsive not because of their tradability but because, at least at the official exchange rate, most agricultural importables are protected and hence trade liberalization would reduce their domestic prices.

Let's now turn to the magnitude of price intervention. In a recent study of eighteen developing countries directed by Krueger, Schiff, and myself (1988), we found that, during 1960–84, the nominal rates of protection (NRP) for agricultural exports at the official exchange rate were negative—on average 12 percent (higher than 25 percent in Côte d'Ivoire, Ghana, and other countries), while for importables they were positive—on average 13 percent (though in some countries, such as Egypt, Pakistan, and Zambia, sectoral policies taxed importables, mostly food). A significant finding of the study is the importance of indirect price interventions, a consequence of industrial protection and unsustainable levels of absorption. In most of the eighteen countries indirect price interventions are huge, which means that a tax is imposed on agriculture close to three times the tax due to sectoral policies. The result is an average total taxation of 34 percent on agricultural exportables, 10 percent on agricultural importables, and 30 percent on all farm products. In Argentina, Côte d'Ivoire, and Ghana taxation of agricultural tradables resulting from the combined effect of price interventions was higher than 40 percent. Thus, the potential effect of a policy reform depends on two critical values: the short-run response parameter and the potential price enhancement. One can quarrel with some of the estimates of the short-run aggregate response and the NRPs, and perhaps not all the potential readjustment in prices of agricultural tradables can be implemented in the short run. However, accepting Binswanger's estimates of the short-run response and reducing the price enhancement by a third, agricultural incentives are so severely depressed by economywide policies that the potential for increasing aggregate output in the short run is still considerable. Thus, even if the

short- and medium-term elasticities are small, the output effects are not, because of the very large price increase which would result from the removal of price interventions. This expansion could come from higher labor productivity per person (more hours of work and more capital), more variable inputs such as fertilizers, and reallocation of land, labor, and capital to more productive uses associated with a change in the output mix.

How "short" is the short run? Binswanger concludes from the study by Mundlak, Cavallo, and Domenech (1988) on Argentina that even after five to eight years the aggregate response would be low. But Coeymans and Mundlak (forthcoming), using a similar general equilibrium framework for Chilean agriculture, find that after three years the resulting increase in aggregate agricultural output implies an elasticity of supply of 0.3 percent, and that at the fourth and fifth years the implied elasticity is about 0.6 percent (over 1.0 percent after ten years).[1] The inference is that the effect on aggregate output is perhaps not so low after four to five years in many countries—particularly in those where agricultural incentives are severely depressed, agriculture is a relatively small sector in employment and capital, or where the physical infrastructure and financial and input delivery institutions are less of a constraint. The three-to-five-year output response could be lower in other developing countries. Ultimately, I would ascribe the lack of output response in the short run more to an inability to put a coherent and credible package of policy reforms in place in two to three years than to physical agronomic constraints.

II. Price Policy versus Nonprice Policy: Implications for Sequencing

Some influential economists argue that "public investments in agriculture are more effective than prices in raising agricultural output" (de Janvry 1986), or that "evidence for Sub-Saharan Africa shows that the responsiveness of total farm output to extra government expenditure is much higher than to prices" (Lipton 1987, quoting Kevin Cleaver), or that the output elasticity with respect to irrigation is larger than with respect to prices (Krishna 1982). I find this a peculiar way of thinking. Why should price elasticities be compared with elasticities for public investments? Why are they perceived as alternatives?

Binswanger does not endorse the "substitutes" view of prices and public investment. My comments here are really a complement to his analysis.

First, the effects of both price reform and public investment take time, and both may be better viewed as complementary than as substitutes; that is, each policy will increase the effectiveness of the other. An increase in publicly provided

1. My casual observation suggests that the lower reponse observed for Argentina arises partly from an econometric problem. Although Chile shifted from a regime of lower farm prices (relative to nonagriculture) to higher prices during the period of analysis, in Argentina we observe price fluctuations, but around a weak trend.

inputs could raise the output effect of higher prices, and vice versa, thus raising the output response.

Second, as mentioned above, the inadequacy of basic infrastructure as a major impediment to output response varies across countries and is likely to constrain low-income more than middle-income developing countries.

Third, conditions may exist that prevent some countries from simultaneously tackling incentive reforms and public investment programs. I do not have hard evidence on this empirical issue, but one can imagine conditions in which budget is a constraint, for example, to reducing export taxes simultaneously with increasing overall public investment. In this connection, Binswanger's econometric finding that cutting fertilizer subsidies and credit programs would not significantly depress aggregate output is important and relevant. It suggests that reallocation of the public sector budget could potentially protect critical investments with little risk of reducing the long-term growth of output.

III. The Long-Term Aggregate Response

In asking how much and how fast aggregate agricultural output responds to prices and government investments, Binswanger is essentially asking what makes agriculture grow and what are the dynamics of the growth process. I fully agree with him that "public investment can have a strong effect on agricultural output," and his analysis of which type of public investment has had a greater effect on output is, in my opinion, the principal contribution of his paper.

In areas where land is under strong population pressure, technological advance is crucial for accelerating agricultural growth. For technological advance, building infrastructure, providing irrigation facilities, and upgrading human capability, as well as offering economic incentives, are essential. But where population pressure is lower, aggregate agricultural output could increase quite rapidly in response to incentives concentrated on expanding the area under cultivation and on increasing labor input (as happened in Southeast Asia until the 1960s and, until recently, in South America). A shift to high-value crops might also boost the aggregate response.

Perhaps the hardest problem to be solved in enhancing technological progress is how to set up institutions that will provide incentives for innovation among farmers as well as among the public and private agencies that serve them, and how long this might take. For this process, the overall economic climate for investment is important, and this climate is influenced by the economic incentives.

Remember too that agricultural growth does not spring exclusively from accumulation of capital and labor and technical progress. Reallocation of resources from activities with low to high (marginal) productivity may also be important, particularly in developing countries, where productivity varies widely among sectors within agriculture, and between agriculture and the rest of the economy, because of a certain inertia in the reallocation of capital and labor arising from

erratic domestic policies, high variability in terms of trade, and the consequent difficulty in determining whether a price change is permanent—all sometimes compounded by institutional instability. Often, limits between the private and public sectors are undefined, creating considerable uncertainty about the legal framework for the private sector (such as the input delivery system), property rights, and hence about returns to private investments. Have the econometric estimates available on aggregate output response been able to capture these factors? In my opinion, they have not.

I agree with Binswanger that most of the empirical studies on the aggregate supply response in developing countries turn up a weak response to price changes, and the widespread pessimism about this response has probably affected the design of economic policies in many developing countries. If the aggregate supply response to incentives is low, then the social cost of taxing agriculture is also low. Structuralism in the 1950s in Latin America is a case in point, and it is a view that has become quite popular in Sub-Saharan Africa.

But the empirical foundations of the analysis on the aggregate supply response are still quite fragile. The available response estimates are, I believe, biased downward (relative to the potential response) owing to the prevailing uncertainty about the domestic terms of trade and the lack of policy changes that can be counted on to last. Output may reasonably be expected to respond less to price changes that reflect annual price variation around a given mean than to price changes that reflect a change in the mean that is expected to last. How the elasticity would have changed with less price variability and more credibility of policies is not incorporated in most studies. Assessment of the potential response to reform of incentives needs to take account of these two aspects.

Furthermore, most of the literature is dominated by studies using a single-equation time-series approach, which—I agree with Binswanger—fails to capture the underlying migration and investment processes (Bond 1983; Herdt 1970; Peterson 1979; Reca 1980). The long-run aggregate supply response should be viewed in an intersectoral and macroeconomic context: in most countries, the economywide policies overwhelm the effect of sectoral policies on incentives (Krueger, Schiff, and Valdés 1988).

The econometric studies of Mundlak and his associates for Argentina and Chile explicitly include intersectoral resource reallocation over time through migration and investment responding to relative prices. These studies obtain a larger supply response than those obtained with single-equation time-series data.

But there are still unsolved questions. One could argue that the studies do not fully control for exogenous changes in public goods affecting infrastructure, and that this may introduce a bias in the estimates, depending on whether changes in infrastructure are (positively or negatively) related to changes in the agricultural terms of trade. Second, their approach is not entirely immune from the Lucas criticisms (change in some parameters in response to policy changes). The agricultural terms of trade are highly variable in both countries. In Argentina there is a fluctuation around a weak trend; in Chile, 1965–73 was a period of

a drastic agrarian reform that inhibited private investment in activities with longer gestation periods such as livestock, fruit trees, and land improvements. Furthermore, while in Chile the actual agricultural terms of trade did increase (in the 1970s and 1980s relative to the 1950s and 1960s), this was attributable not so much to explicit farm price policies as to changes in the real exchange rate (RER) and lower industrial protection. Before about 1983, the RER was highly unstable, probably inhibiting the output response. These factors have, I believe, lowered the estimated aggregate supply response.

In sum, I believe there is a range of values for the short- or the long-run aggregate agricultural supply "elasticity" that applies across countries and through time. The time path in the potential aggregate output response could be greatly influenced by the coherence and credibility of the policy reform, by the relative size of the agricultural sector in the economy, and by how depressed agriculture's incentives are before the reform begins. In many developing countries, the potential for increasing agricultural incentives appears to be substantial, especially taking into account the exchange rate misalignment.

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Floor Discussion of Binswanger Paper

Both panel discussants seemed to think that the paper gave the wrong message about prices—communicating an impression that Binswanger probably did not intend to convey. Denying that he had implied prices were unimportant, Binswanger reemphasized the importance of price reform. He did not mean that price reform produced few benefits; in the long run, supply responses to permanent changes in the price regime are strong. At the same time, it is important to understand the short-run consequences of adjustment programs and how best to deal with them.

A participant felt that it was time economists looked at asymmetrical responses to changes in real price levels. In discussing different responses to pricing, Binswanger had described a situation in which land and alternative activities for the farming community are typically severely constrained. Where land is available and the rural community has alternatives to agricultural activity, as is often true in Africa, even the short-run response could be significant. A number of studies on Africa show significantly higher elasticities than Binswanger mentioned, and the response was not symmetrical. Agricultural performance and output are more likely to decline rapidly after inappropriate price reductions than after inappropriate price increases. Binswanger responded that he did not mean to suggest that responses in Africa were lower than elsewhere. Aggregate supply elasticities were in the same range in Africa as elsewhere—if anything higher—and Cleaver's estimates show that structural adjustment programs have led to some agricultural growth in Africa.

Binswanger felt that there was no getting away from low short-run elasticities using econometric arguments, for example, by claiming simultaneity. First, theory predicts that short-run elasticities are low because purchased and variable inputs represent a low share of agricultural output. Second, if you adjust for simultaneity of prices and quantities, as he had done in a study of India, you do end up with a simultaneity bias, but the elasticity rises from 0.05 to 0.1, so elasticity is still not high in the short run. Third, in many countries for which short-run elasticities have been estimated—India, for example—elasticities remain low despite stable policy regimes.

A participant was surprised that Binswanger was placing so much emphasis on low elasticity numbers. This participant doubted that calling an elasticity of 0.05 large—how large is large? how small is small?—would tell you whether a

This session was chaired by Csabi Csaki, professor of agricultural economics, Karl Marx University of Economics.

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particular policy change would produce a larger return to investment than another activity.

Another participant observed that whether nominal domestic prices are higher or lower than world prices is very time-specific, and they can flip-flop with the tendency to maintain stable real domestic prices. Speaking from his experience with Latin America, real exchange shifts can also be large—in the case of Argentina, the real exchange rate movements have been very large. This flip-flopping of the incentive structure, both from the macro and the nominal side, makes it difficult to focus on a price response. He felt that price response was further complicated by the change in output mix that results from reform.

Valdés (discussant) agreed that elasticity estimates do flip-flop—partly because world prices change so much—but had found them to be fairly stable on the whole, despite a lot of noise around trends. He entirely agreed about the difficulty of capturing the change in the output mix, which is an important part of the aggregate supply response in some countries. If there had been no reform, the structure of agriculture would be very different, but how do you measure that?

One participant cited Nigerian farmers as saying (in a review of a World Bank-funded agricultural development project) that what really encouraged them to produce more was construction of a road from their village to the market. In many areas, he found public investment to be more of an incentive to increase agricultural output than prices.

A participant felt that rural institutions were as important to productivity as technology and inputs. In 1959 China changed from household to collective farming. As a result, total productivity dropped 30 percent. In 1979 the winds changed again. The collective system was replaced by the household system, and the resulting productivity increase has been estimated at 15 percent. Farmers were more responsive to new technology and inputs in the household than in the collective setting. Binswanger, who had not analyzed the situation in China, said that so fast a response was atypical but was understandable because China had both price reform and complete institutional reform right after ten to fifteen years of heavy investment in agricultural infrastructure. So all sources of growth were either already present or quickly put in place.

Criticizing the thrust of Binswanger's argument in his paper, a participant noted that concern for the poor was no substitute for hard-headed analysis as to what brought about the need for adjustment in the first place. Attention must be focused on the distortions and the anti-poor policies that lead to the unsustainable situation wherein adjustment is the only recourse. Pointing out then that adjustment will affect the poor adversely seemed to him to be putting the cart before the horse. The participant also criticized Binswanger for recommending targeted interventions in the context of adjustment. The record of reaching the very poor using targeted policies in health and nutrition has been very bad, and the linkages and distributional impacts have often gone in the wrong directions.

A participant asked how—if significant output response from the most important sector occurs only in the long term—most policymakers in Sub-Saharan

Africa could be expected to maintain difficult adjustment programs when they have a very short-term perspective. She felt Binswanger's treatment of rural credit was cavalier: how could the Bank, with a large portfolio of rural credit loans, suddenly announce that credit programs have had little effect? What does the Bank tell governments about substantial credit programs the Bank has supported?

Braverman (discussant) responded that the art of reform is how to combine honesty about the track record with a sense of optimism. He felt that it is the Bank's responsibility to admit that it is only one of many players and occasionally makes mistakes. Changing the incentive structure in Africa requires developing not only (physical and financial) capital and (skilled and unskilled) labor but also social capital. Social capital—the political and institutional setting for development—which provides the values and incentives for agents to perform, often makes the difference between success and failure, between a Japan and an Argentina. But he agreed that the Bank should be careful about raising unjustified expectations.

A participant who is studying the impact of structural adjustment on Nigerian agriculture said that Nigeria's food supply is not increasing and in some areas is declining. Most Nigerian farmers are not expanding the food supply because effective demand is limited by fixed wages and salaries and the food farmers prefer to produce crops that earn foreign exchange.

Quoting Binswanger's paper that "the Bank should resist pressure to invest in marginal agriculture on the grounds of poverty alleviation," a participant asked what the governments of developing countries are supposed to do with poor agricultural producers when formal employment (particularly in Latin America) has grown little and more than half of employment is in the informal sector, in tiny enterprises with low productivity and income. Binswanger replied that even in marginal areas there are pockets of agricultural potential that can and should be exploited—not just to alleviate poverty but for efficiency. About the only thing you can do in the short run for poor populations in marginal areas is help them with education and health interventions.

The point of the paper, Binswanger concluded, is that all too often we forget about simple issues. We tell countries to go into price reform (which is necessary), suggest that things will improve rapidly, and do not specify that some things, which are important to these policymakers, may actually get worse—namely, food consumption and domestic absorption. And so we get the kinds of disappointment with price reform mentioned during the discussion. We should expect and predict these costs so countries do not have any false expectations, and if we really want to do something about consumption, we have to do it in a targeted way.

Responding to the earlier criticism of his advocacy of targeted programs, Binswanger admitted the difficulty of targeting, but he noted that there were few other options in the short run. Rather than wait for the bad news to roll in, he felt it was far more prudent to plan for the short-run costs of adjustment programs and provide specific relief in areas such as nutrition.