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ESSAY 6

LINEAR PROGRAMMING AND AGRICULTURAL POLICY: SUMMARY AND SUGGESTIONS FOR FURTHER WORK

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The research presented in the foregoing essays represents several iterations of data collection and analysis. Each author has benefited tangibly and directly from his predecessors; each, in turn, has contributed to a broader data base and a better analytical understanding of Punjab agriculture. It is therefore fitting, and in keeping with the spirit of the volume, to be as much concerned in this brief summary with the future as with the past. Accordingly, the following comments combine three objectives. First, some of the more important general observations and conclusions that run through all models are reviewed. Given the similarity of approach, every author, regardless of his particular perspective, has had something to say about prices, the nature of scarce resources in the Punjab, and the effects of simulating different kinds of technological change.

These results are then examined for their relevance to the current set of policy issues with which Pakistan's agricultural planners are faced. True, the parameter values for a number of the most important variables have changed significantly in recent years. However, familiarity with the basic trade-offs provides insights into the likely direction of the system's changes, even if precise quantitative estimates cannot be made. Finally, the juxtaposition of past and present provides the basis for suggestions regarding new field studies needed to update the parameters of the most recent analysis or to explain discrepancies that have arisen between model results and empirical surveys.

AGRICULTURAL PRICE AND INCOME POLICIES

A substantial portion of the sensitivity analysis that was done on the models in this volume involved the parametric variation of input and output prices. With respect to the latter, the exercises showed that in an agriculture with a large number of crop alternatives, relative prices are important in determining optimal enterprise combinations. Less readily evident at the start was that development of additional flexible supplies of supplementary irrigation water significantly increased the sensitivity of price responses as well. This was due to the decrease in the number of water constraints to which large penalties were attached and the emergence of competition for land in one or two time periods as the principal limiting resource.

It was to be expected that a price-sensitive system would show considerable "misallocation" of resources if domestic prices diverged significantly from world market values. A comparison of optimal solutions when domestic and world prices, respectively, were used to weight the quantities of inputs and outputs supports this conjecture. It was found that the foreign exchange earned or saved was nearly 25 percent higher for the optimal cropping pattern when relative prices in world markets were used as weights than when domestic prices were used.

Reconciliation of domestic and world agricultural prices continues to be a problem for Pakistan's planners. The devaluation in May of 1971 removed a number of the distortions from world prices that were a part of the agricultural policies of the 1960s. However, the rapid changes in international commodity prices that followed the currency reform produced new pressures for domestic intervention and, by mid-1973, there were substantial export duties on cotton and rice, sugarcane was being highly subsidized, and wheat was being procured and sold in ration shops at well below world prices. The latter policy, aimed basically at subsidizing urban consumers, proved to be untenable. The prices set in 1972 and 1973 were responsible, at least in part, for a stagnation in wheat output. Bad weather and fertilizer shortages were also to blame but parametric variation of wheat prices, assuming the prices prevailing for other commodities in 1970/71, leaves no doubt that the comparative advantage of even the improved wheat varieties had slipped badly. Price levels set by the government were maintained only with the help of over a million tons of imports annually.

Wheat prices for the 1975 crop have been increased by more than 50 percent. Judging from the programming exercises indicated above, however, it is problematical whether this is enough to reorient the agricultural sector in the direction of the government's food self-sufficiency goal. Unfortunately, the question cannot be pursued at the margin with the models as they currently exist. Several things have occurred which make substantial revisions necessary before any confidence can be placed in refined quantitative estimates. First, price relatives of both outputs and inputs have changed substantially in the past two years. On the input side, all costs have risen, but the impact of increased oil and fertilizer prices has varied considerably by crop. These changes in relative net revenues need to be incorporated if suggestions about the appropriate relative price structure on the output side are to be more precise.

A revision of virtually all of the price parameters is also required for attempts to address perhaps the most controversial policy issue of all, namely, the income terms of trade between agriculture and nonagriculture. To date, the debate between the farming community and the government has focused on changes in single commodity prices (e.g., fertilizer, water, wheat, etc.); the real issue, however, is whether the "package" of price policies—plus the gains in productivity that have occurred—has seriously affected farm incomes. Failure to see the problem at the farm level in general equilibrium terms has produced a number of piecemeal responses that are recognized in retrospect by government officials as inappropriate pricing decisions.

Revisions of a structural sort are also required. The behavior of the model with respect to price responses was heavily dependent on assumptions about the competition of winter food crops and summer cash crops for land and draft power. To the extent that farmers are able to avoid these "bottlenecks" to double-cropping by changing planting and harvesting dates and by mechanizing their farms, the supply response curves of the affected crops will be radically altered. Field work on the extent and character of crop rotations that are now producing substantially higher cropping intensities in certain areas therefore has a high priority.

THE GREAT TRACTOR DEBATE

Under the impetus of requests for foreign assistance, arguments surrounding the tractorization of Pakistan agriculture continue. Both of the programming exercises dealing with mechanization suggested that in areas where groundwater supplies existed and tubewells could be installed, tractors purchased by farmers at prices prevailing in the late 1960s were extremely profitable investments. These results were only modified somewhat when *all* prices were changed to reflect world market values; although tractor and implement prices were artificially low because farmers used an overvalued currency in payment, this was offset by the undervaluation of currency that was obtained from the sale of their export crops. The result was a rate of return in irrigated areas that was only slightly less than the rate of return at domestic prices. (In the mixed integer model, the tractor was dropped entirely from the optimal equipment package when only its price was increased.)

Both programming exercises predict substantial increases in cropping intensity (often double-cropping) in areas where supplementary water is available. Employment opportunities are also predicted to increase to the point where the total man-hours used after the introduction of the tractor exceed those used prior to its purchase. Field surveys have not borne out the model predictions on cropping intensities and employment, although the divergences have varied with different studies. For example, Bashir Ahmed found that for a 50-acre tubewell farm the cropping intensity of the model was approximately 20 percent higher (160 vs. 190) than has been observed. J. P. McInerny and Graham Donaldson reported an even greater discrepancy, one that increased with farm size (*3*).

Several explanations are possible. It may be that there are constraints to increasing intensities, i.e., moving in the direction of double-cropping, that have not been captured in the model. These may have to do with the amount of time that is actually available for various cultural operations, or, more likely, the lack of management skills that the emphasis on greater timeliness of operations requires. There is also another possibility. It may be that the low cropping intensity, particularly on the larger farms, reflects a failure on the part of the large farmers to replace with tractor power, the power of the displaced tenants and their bullocks. Model intensities much closer to the International Bank for Reconstruction and Development (IBRD) survey data would result if the power-land ratios shown to obtain in the field were introduced as constraints in the mechanization model. For example, in the mixed integer model, the optimal equipment package on a 75-acre farm, one that produces a cropping intensity of 197 percent, consists of two tractors, one pair of bullocks and one stationary engine. In the

McInerny-Donaldson study, roughly the same size farm had only one tractor and two pairs of bullocks. This suggests that by concentrating on tractorization as a means of bringing their holdings under direct management, large farmers may not have paid enough attention to the total amount of power that would be required to achieve high cropping intensities. Alternatively, the long list of unfilled orders that existed in the late 1960s implies that probably many of the larger farmers were simply unable to get the machines they wanted. Such a finding from further field work would lead to the novel conclusion that, because of the inability to raise cropping intensities, adverse employment effects were the result of too little rather than too much mechanization.

INTERMEDIATE TECHNOLOGY—SOME MISSING INGREDIENTS

The results of the models concerned with mechanization pointed to the distributive effects inherent in the indivisibilities that characterize most types of mechanical technology. They also indicated, however, that several of the technologies studied yielded very high rates of return to farmers who could utilize them fully. Indeed, pumps, engines, threshers, and the like appear to be absolutely essential to sustained increases in agricultural output in the Punjab.

It is obvious that, up to a point, both productivity and equity objectives could be served by redesigning the existing technology to suit small farm sizes. Mechanical principles rule out complete divisibility, but examples of the successful diffusion of small threshers, tubewells whose discharge is measured in fractions of a cusec, and high-speed, water-cooled diesel engines in the 10 h.p. range can readily be found in the neighboring Indian Punjab. The average operated holding is considerably smaller than it is in Pakistan. However, some 60 percent of the land in the irrigated areas of the Pakistan Punjab is cultivated by farmers operating less than 25 acres. It is hard to see why a group this size has not created an effective market for small-capacity machines.

It may be that the economics of introduction are much less favorable in Pakistan than in India. Until very recently, the real costs to Indian farmers of purchasing and owning mechanical technology of the type described was approximately half that of the Pakistani cultivator (*2*). Given that the efficiency of machines tends to decline as they are reduced in size, it may be that their rate of return is insufficient to produce a strong demand for the smaller-capacity units.

It may also be that the equipment manufacturers in Pakistan do not have the engineering skills or the prototypes of small threshers and engines that could be readily copied. Particularly in the case of the high-speed diesel, some know-how is required beyond that needed to make the large, cumbersome, slow-speed engines that are standard in Pakistan.

Lastly, there may be subtle differences in the agro-climatic environment that are not apparent to the casual observer. For example, one farmer in the south-central Punjab of Pakistan, when asked to explain the reason that so little of the grain in the Pakistan side was threshed as compared to virtually complete mechanization of threshing operations in India, suggested that the likelihood of pre-monsoon showers was much greater there and this put a premium on timely threshing. This may be true. However, it does not explain the lack of mechanical threshing capacity in the northern parts of the Punjab where the rainfall patterns are similar to those obtaining in India.

Whatever the reason, the differences in the experience of India and Pakistan in the area of mechanization deserves further analysis. One way of approaching the problem would be to include, in the Pakistan mixed integer model, activities that represented smaller sized mechanical units. These would undoubtedly be characterized by lower fixed charges and high operating expenses. By varying the farm size within this framework, a better understanding could be obtained of how far down the capacity scale policies aimed at diffusing intermediate technology should go.

Within the same model, it would also be possible, by varying prices, to ascertain to what extent explanations regarding the absence of "fractional" technology should focus on government price and income policies and to what extent they must be sought elsewhere. The provision of mechanical technology suitable for small farms is one of the few distributive policies that cannot be easily captured by the larger operators. More explicit knowledge about the role of economic incentives might therefore lead to a program of subsidies that would have the classic rationale of accelerating technological change and yet at the same time work to improve the distribution of income in the rural areas.

WATER USE AND WATER MANAGEMENT

The role of water has been central to the behavior of all of the programming models. Historically, agriculture in the Punjab has been dominated by water constraints that limited cropping intensities to approximately 100 percent. Although these constraints have been broken to a considerable extent in most areas by groundwater development, it is anticipated that in the long run water will continue to be the ultimate constraint on agriculture. Reputable consulting firms report, for example, that the target cropping intensity for the area as a whole should not go above 150 percent if the water needed for leaching requirements is also to be provided and the area's long-term salt balance is to be maintained (2).

Two types of issues relating to the optimal use of scarce water resources were investigated in the modeling exercises. First, investigations were conducted on the value of the water to the individual farmer and its optimal allocation to and among particular crops. The inclusion of several activities for each crop, each representing a different yield-water relationship, made it possible to take into account the well-documented fact that water-response curves exhibit significant diminishing returns to total availability. Because the shape and position of the response curve differ from crop to crop, selection of the optimal activity set provided information not only on the cropping pattern but on the optimal depth of irrigation.

Considered also was the problem of managing the groundwater reservoir. If groundwater is a scarce resource, and if its exploitation is left in private hands, there is, of course, no guarantee that potentially serious ecological and economic side effects will be held in check by the individual recognition of common need to regulate withdrawals. For example, where there are saline groundwater–sweet groundwater interfaces, overpumping of sweet water would produce a hydraulic gradient that could lead to a contamination of sweet water areas. Unregulated withdrawals would also, over time, produce serious distributive consequences. Presently, tubewells are a relatively low-cost means of producing water because they utilize locally made low-lift centrifugal pumps, motors, and engines. Should the water table decline significantly, larger, more expensive turbine pumps and motors would be required. These are within the financial capacity of the larger farmers, and hence they could continue to farm at cropping intensities beyond those possible for the Punjab as a whole. Turbine pumps, however, would place difficult financial hurdles in the way of the continued intensification of agriculture by the small and medium farmer.

Debates concerning the management of the irrigation system will continue in Pakistan during the foreseeable future. At the micro-level, the argument continues to revolve around the fees that the Government should charge for the water that is provided in the canal system. The programming exercises reported above have played a role in convincing the authorities that additional revenues and increased efficiency of water use could be achieved if water charges were increased to reflect more closely the value of water to the farmer. However, as in the case of output prices, some revisions are required in the model parameters if more precise quantitative estimates are to be provided. Both prices and input-output coefficients have changed in recent years, in each case increasing the scarcity value of irrigation water supplies. Charges are still well short of the cost of groundwater, however, and hence considerable leeway exists, even under conventional water management practices, to improve allocative efficiency.

It would also be exceedingly interesting to use the models to evaluate the current experiments to improve water management at the farm level. Under the auspices of the United States Agency for International Development technical assistance program, efforts are being made to increase yields while using less water by carefully leveling the land and introducing furrow irrigation. This practice allegedly improves germination, eliminates the over- and underwatering produced by uneven fields, improves the leaching action of the water that is applied and decreases the total amount of water required. There is increasing evidence to support these claims, although no economic analysis of the rate of return on investments of this type exists. The programming models provide a useful point of departure for such an investigation.

At the more aggregate level, disillusionment with the ability of the public authorities to manage large-scale projects involving public tubewells continues to grow. As the programming exercises suggested, this may in part be the result of faulty design in that insufficient capacity was provided, or a failure to construct a water distribution system that would permit the installed capacity to be used effectively. (Whatever the cause, at one stage the situation deteriorated to the point where rumors were circulated that the Government intended to sell the tubewells to the farmers.)

On the other hand, whatever the virtues of rapid private investments in tubewells may be in terms of growth, the proponents of private development have not faced up to the long-term management problem. On some areas, where water tables were already low, the small drawdowns that have thus far occurred have been sufficient to dry up the shallower wells. Unlike the SCARP I project, where the drawdown has provided welcome relief from waterlogged soils, the southern portion of the Punjab, where a large portion of the private tubewells are located, already has a water table that can only be reached by placing centrifugal pumps in holes 15 to 20 feet deep. Because these areas do not exhibit the severe waterlogging problems that characterized the areas to the north, the southern districts will be the last to be placed under a public authority. Consequently, the need for an indirect solution to the management problem is more pressing. Additional quantitative information relevant to groundwater policy could be provided by some rather extensive sensitivity analysis of pumping costs in models that have been revised to take current economic parameters into account.

CONCLUSIONS

The preceding observations have sought to identify some of the more general conclusions reached in the programming exercises. These in turn were used to make comments about a number of policy issues currently being debated in Pakistan and to make suggestions about how the existing models might be revised and improved. It is to be hoped that some of the incoming generation of researchers may find points of departure in the investigations that have been presented here.

CITATIONS

1 C. H. Gotsch, "Agricultural Mechanization in the Punjab: Some Comparative Observations from India and Pakistan." Paper presented at the Ford Foundation Conference on Employment and Rural Development, Ibadan, Nigeria, April 1973 (mimeo.).

2 Harza Engineering Company International, *Program for Water and Power Development in West Pakistan, 1963–75: Supporting Studies. An Appraisal of Resources and Potential Development* (Lahore, Sept. 1963), and *ibid., Through 1975 (Master Plan–Initial Phase)* (Lahore, Jan. 1964).

3 J. P. McInerny and Graham Donaldson, "The Consequences of Farm Tractors in Pakistan" (Intl. Bank for Reconstr. and Dev. [IBRD], Washington, 1973), mimeo.