

Altering the Variables of the Food Supply-Demand Situation

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I

It is with genuine pleasure that I meet with you to engage in a common inquiry into one of the problems of greatest moment confronting not only this country but the free world today. I accepted this invitation with, I fear, more enthusiasm than wisdom, because I had not at that time examined the assignment. Its title -- "Altering the Variables of the Food Supply-Demand Situation" -- is frightening enough in itself. The elaboration of what is supposed to be covered under that title is even worse; I quote as follows: "A discussion of the variables in food supply, population growth, and food demand; existing economic, cultural and political restraints on agricultural improvement, synthetic food production and population control; which variables can and should be varied; what is the potential outlook and return from varying different

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variables of the set; what are the time lags and what potential contributions can each make in the short run and in the long run." I summarize this assignment as being that of covering everything else discussed at the conference, or "solving the world food problem in one easy lesson."

The correspondence from the conference sponsors uses such words as "formidable," "immense," and if I am not wrong in my recollection, "impossible." This is of course the basic point. It is clear that the people who put the program together, having first broken the subject of the conference up into discrete, manageable pieces and assigned them to persons competent to handle these topics, felt it necessary to devote a little time to looking at the problem in its entirety, to insure that it be reflected upon in its full complexity. My job is to provide a little time-break to permit such mutual reflection. I am happy that my instructions are that my comments should be subjective; rather than any attempt at a formula for putting these many pieces together. In all seriousness, I believe it is perhaps useful to catch our breath for a while, to reflect upon some of the interrelations among the elements of the world food supply-demand situation, and especially to try to get as much perspective as possible. I shall make no attempt at systematic exposition of the interrelations among these variables; I will attempt by anecdote and commentary to stimulate somewhat our mutual thought processes as we look at this problem in its full complexity.

First of all, I wish to make very clear that none of my statements should be misinterpreted to mean that I do not share fully the concern that the world is indeed in a tight situation with respect to

food production, one which is likely to become much worse before it is better, and one which should occupy our full concern and effort. I can say this with clear conscience because for a substantial time I did as much as perhaps anyone in my Agency to try to draw attention to the lagging agricultural development in the less developed countries and the food production problem which was enveloping us. I also participated in some of the efforts at the prognoses to which I shall be referring. I wish to emphasize, therefore, that I am in no way retreating from or contradicting the basic premises underlying this conference: that we must give agricultural development in the less developed countries the highest possible priority consistent with other objectives. It is against this backdrop that all my following remarks are to be interpreted.

II

I should like first to comment a bit upon the prognosis itself. Projections of future world food supply-demand prospects are necessary; planning cannot proceed without them. Although the many sets of projections have been made by honest and competent people, the crystal ball they have had to look into is by no means clear. Though competently done with best knowledge available, these projections are extremely fraught with potentialities for wide margins of error for three very fundamental reasons.

First: The data base in most of the countries, by common consent, is really quite fragile. If we exclude a relatively small handful of countries, data are far from adequate to describe even past trends with

any degree of accuracy, especially when the significance of long and short cycles in weather and the effects of various aberrations, both in real conditions and in the processes by which they are reported, are considered.

Second: Predictions of future deficits depend upon margins between estimated growth rates of demand and of supply; rather small errors of estimate of either enormously affect the margin which describes the deficit. Nor are the factors which may determine these growth rates well understood nor factually documented.

In historical terms, about all we can say is that the most complete purification yet made of the data for those less developed countries for which the data merit analysis, indicates that, during the 1948-63 period, in 21 of the 26 countries food production increased substantially faster than their populations. From 1955 to 1963, population increases exceeded food production growth in only two of the 26 countries.¹ It is important, however, that in many countries the margins were narrowing and the lines may have crossed by now. Furthermore, population growth is only one of the two major components of the demand, the other being the effects of increased income. On this latter, we can only make assumptions regarding future growth rates in total income, and we have very little reliable evidence on the income elasticities of demand for food in the less developed countries. In many, perhaps most of them, inadequate dietary levels may well be more a result of the general lack of effective demand than of supply -- i.e., the agriculture sector may well provide about what present income levels and consumer preferences demand of it.

A third major difficulty in estimating world food supply-demand prospects is the problem of how to treat population growth in the analysis. Virtually all the analyses I have seen or engaged in treat population growth simply as an exogenous variable working only on the demand side. This treatment is probably analytically adequate for such countries as India and Pakistan. But in an analytical context adequate to deal with the entire less developed world, population growth relates to the food supply-demand equation in a more complex way. As you know, there has been a very stimulating book written recently which advances the case that population pressure is a necessary condition for stimulating growth in food supply.² Although this case is over-stated by the author, it has its points of relevance and might, if properly introduced into our analyses, substantially alter our long-range prognosis for certain countries.

Population growth may indeed, for a variety of reasons, be positively related to food supply in the long run in several countries. There are countries with undeveloped frontiers awaiting sufficient population pressure to force their development, and which may, when developed, be more efficient in use of resources than the lands presently settled. This was, of course, the character of our country's growth in the early stages. A somewhat more subtle but essentially similar situation exists in those countries where the tenure systems result in extremely inefficient use of land resources. These are countries in which most of the land is owned by a relatively few families whose economic and social motivations are such as to result in very non-intensive land use.

Though there are undoubtedly more effective and direct means of intensifying land use, sheer population pressure will probably be a primary motive factor in forcing such adjustments. Then there is also the basic problem of scale in terms of national identity and competence, which is very difficult to analyze or even to describe, but which is nonetheless significant to the future of several of the sparsely settled land areas of the world.

I would like to dwell a moment on this general point. It is an impressive fact to me that the Congo -- that is, the old Belgian Congo -- is about three-fourths the size of India, and has natural resources probably not greatly different in the aggregate from India, though they are certainly not as fully exploited nor developed. It maintains a population of around 15 million as against the nearly 500 million of India. The same lack of population concentration characterizes other areas of Africa and Latin America. One can look at this as a description of the enormous population pressure on resources in India; but one can also look at the reverse side of the relationship. India and Pakistan populations, which together exceed the combined populations of Africa and Latin America, are almost adequately fed by an area not much bigger than the Congo and one other medium size country of Africa or Latin America. The significance of this is that, depending upon our perspective, we may look upon the less developed world as extremely over-populated or as largely empty. Also, I believe that a case could be made that (1) a very substantial part of the increased food production in the less developed countries during the last decade has come from cultivation of new lands³, and that (2) increases in average

yields per acre, where they have occurred, have been largely in heavily populated, small-farm countries. If so, this poses some interesting questions about our population-food supply analysis! In summation, though the basic "race between population and food supply" analysis in which all of us have engaged is genuinely relevant and significant, there may well be areas in which the ancient farm proverb still has relevance -- that "every new mouth brings two hands with it."

III

So much for prognostication. I would like now to comment on the interrelations among some of the many variables in the world food supply-demand equation. I would introduce this by relating Max Millikin's comments to the Executive Staff of A.I.D. when he was discussing his experience in leading the six weeks 1964 MIT seminar on increasing world food supplies.⁴ Max indicated that each of the very distinguished people from different professional subdivisions of agriculture tended to think of his own particular field as holding within it the essential answer to the world food supply problem. Fertilizer specialists felt that the answer would be found primarily in increased fertilizer production. Plant breeders represented that the problem would be solved by improved plant varieties. The economists felt that the answer lay in improving economic policies and more efficient allocation of resources. Water specialists would rely on a fuller and better utilization of the world's water resources; etc., etc. Max said that what he came to realize was that they were all right. I took this to mean not only that each of these variables has an important contribution to make, but that in certain

specific cases any one might be the essential variable. Furthermore, the interrelations among these variables in the set is so ill understood that a good case can be made by any subject specialist for the primacy of that variable for which he has an enthusiasm. Each of us is likely to be a devotee of one or more variable. I, personally, have a strong pre-disposition toward the principle which I borrow from Howard Beers -- that "the circumstance determines the case."

There are also advocates for the premise that a given set of variables is tied together in some immutable fashion and in very rigid relationships -- much as are hydrogen and oxygen in the making of water. Underlying this argument is, of course, a lot of truth. Economists will recognize it as, essentially, a variant of the single factor thesis. A refinement of this argument is that the returns to what the agronomists have come to call the "interactions" among the variables are in all cases so much higher than to the individual variables themselves that programs must work simultaneously on the system as a whole. I should like to appeal for a great deal of intensive investigations, in given situations, of the actual substitution and complementarity relationships among these various variables, to use old fashioned terms. I believe there are undoubtedly many situations within which it is easy to overlook the enormous potentialities of working on one or two variables and the equally enormous handicaps and complexities introduced by trying to move them all forward in lock step. Particularly is this true in short-run development activities as distinct from long-range institution-building programs. Equally, omission of a key variable in a given situation can render

investments of energy or resources on the other variables ineffective or, at best, inefficient.

There is a systems relationship among the many variables in agriculture. In one sense, almost all elements of the universe, both human and physical, are tied together in this development process. This is not the same thing by any means, however, as the proposition that all of these variables are, everywhere, of equal importance, or that they must or can all be changed to effect development.

I was impressed, for example, at the conclusions of a simple analysis I made in India of yield responses to fertilizer. Indian experiment station fertilization research is drawn up after the pattern of similar experiments in our own country, and shows the same general pattern of diminishing marginal response functions. But an analysis of the response to fertilizer from trials on cultivators' fields, indicates an increasing marginal rate of return to fertilizer well beyond the fertilization rates recommended by the States -- which are in turn far beyond the rates of normal farmer practice. I would like to dwell on this just a moment for clarification. The amount of fertilizer now used in India would provide something like four lbs. of plant nutrient per cultivated acre in the country, although obviously those farmers who use fertilizer apply it at substantially heavier rates. Tests were carried out in eight states on many thousands of individual farms at three levels of fertilization -- a zero level, the level recommended by the particular state for the crop in question, and 150 percent of that recommended level. At every single test area (for irrigated wheat, unirrigated wheat, and for rice) the returns per pound of fertilizer was much heavier for the

50 percent above the recommended level than for the recommended level when measured against the zero point. On the average, returns were 50 percent greater for the second than for the first segment of "the curve" -- nearly 90 percent higher for rice. The significance of this increasing marginal returns, if this evidence can be trusted, can be appreciated when one realizes that these "recommended" levels of fertilization are about ten times the present average level of fertilizer availabilities per crop acre in India. This suggests the truly enormous potentiality of increasing yields in India from the application of fertilizer at rates reaching far beyond those in sight from existing or proposed fertilizer production and import levels.⁵

The experience of the University of Tennessee Team in recent years in encouraging the farmers of Mysore State to fertilize the millet which is its staple food crop indicates a similar responsiveness to the application of fertilizer. It is quite clear that production rates per acre can be increased three- or four-fold with fertilizer alone in average years and that the proportionate differential is even higher in drought years.

To look at a different input, research that I personally started in South India indicates that a truly efficient reallocation of the water resource alone could effect aggregate increases in the magnitude of 400 or 500 percent in total food production in that state, if the institutional, legal and other obstacles could be solved. Capital requirements, in this case, would be modest. Analysis of the actual farmer experiences indicates that the amount of water wasted⁶ on a typical acre of rice could provide necessary supplemental irrigation

for enough other crop lands to increase their production by at least four or five times the amount produced on the acre of rice itself -- with no loss in rice production.

There are other countries in which hostile economic policies appear to be the primary obstacle to economic growth of the agriculture sector. In some cases, the removal of a few specific inhibiting policies might cause agriculture to spurt forward. In others, thoroughgoing policy overhaul and specific price support programs may be necessary to create the kind of economic environment conducive to rapid increases in agricultural production. In others, political stability is the key variable in the set.

In still other countries, phenomenal increases in total yields could be achieved by the development, through continuous research of high-yielding varieties properly protected from the hazards peculiar to the country and adapted to the climate, soils and other local conditions. Dr. Moseman has spoken fully on this point already, so I shall not emphasize it further.

I mention the possibilities of concentrating on single factors not to prove the point that single factor approaches are proper for most circumstances, but rather to keep perspective on the fundamental underlying reality. Every country and every situation has its own unique character. Each investment has its opportunity cost, that which must be foregone because of its cost. Different factors are significant in different degrees -- in a range from zero up -- in different situations. A rigid systems approach applied in the same way in each country would inevitably result in an inefficient use of the resources of that country,

and of our assistance as well, in exactly the same way that over-investment in a single factor predestines inefficiency.

The margins we are working with are so high in terms of potential response to the right combination of inputs, and the magnitude of the inputs that can be brought to bear on the problem is so small in relation to the total need, that the correct combination of inputs is all-important. If I am fearful of anything in our "war on hunger," it is that because of the dearth of physical research data and economic analysis the sense of crisis we are feeling may lead us and the less developed countries to make investments with insufficient analytical attention to the payoff potentials from alternative patterns of programs and investments. For example, I have indicated under Indian conditions what I feel to be the tremendous short-range potentialities from increased fertilizer use alone. This gives some sense of the opportunities that lie ahead rapidly to increase Indian food production if adequate resources are applied. However, it would be both foolhardy and dangerous to build the food production program of India entirely on fertilization without adequate attention to other variables. Dr. Moseman has mentioned the physical and biological hazards of proceeding without an adequate, continuous research program to provide the necessary science and technology. I would like to emphasize the economic aspect. I should imagine that if we had the evidence around which to make such an analysis, we would find that the proper combination of fertilizer and new technology would result in much greater returns per unit investment even than those I have indicated might be possible from fertilizer alone. At low or zero levels of fertilization,

indigenous varieties might compete well with, the new, higher yielding varieties. At what level of fertilization and cultural practice do these higher yielding varieties utilize fertilizer more effectively? These basic physical relationships are not nearly well enough documented at this time to provide a basis for even crude calculations of optimum economic input ratios, partially because, for most less developed countries, the adapted varieties and other embodiments of new technology do not exist to be measured. Furthermore, countries never move forward by moving the averages. Individual farmers lead the way, and many of those farmers are already applying fertilizer at a level where present varieties are not efficient.

Finally, the problem of getting these production increasing inputs actually introduced into farming practice must be introduced into our calculus. I have become much impressed of late with the fact that farm people in the less developed countries, and probably in our own, do not adopt new practices primarily because they are told by some expert that they should do so. Neither are they influenced primarily by a demonstration plot or trial on their own field, or some other such thing which shows them merely how much larger yields they can get per acre. Really powerful communication takes place only when a cultivator who has been persuaded through some device or another to invest his own money in improving his farming practice makes a really impressive profit from doing so. If this experiment pays off, and his 100 dollars, rupees, or whatever investment gives him 400 in return, his neighbor will get the point and be a very willing candidate for innovation the next time around.

The significance of this is that the communication process by which new technology and new methods of farming are communicated throughout a society probably works much faster and more effectively from a few farmers who make a killing by putting together the complete set of necessary inputs and practices than from a large number who make a little profit from small or from single-factor investments. Stated more simply, one farmer who doubles his income is probably a much more effective agent of change than are ten farmers who increase their incomes by ten percent, or 100 who increase theirs by one percent. Such de facto experiences are much more effective for communication than exhortation of the villagers by extension workers on the presumed benefits to be achieved from one or two changed practices or modest investments. Thus it is very important that we exploit fully the possibilities of dramatic increases in income from a cluster of investments.

IV

Another point of perspective might be called for on the problem of institutional adaptation. Dr. Moseman's paper emphasizes the need for adaptive research to bring our science and technology to the point of genuine relevance and usefulness in the less developed countries. As he makes clear, it is best that we start from the assumption that our knowledge, and the embodiment of that knowledge in specific plant materials and machinery, etc., is only indirectly, not directly, relevant and useful in the climatic and economic situations characterizing a given less developed country. The same thing is true of their institutional requirements. I do not have time here to develop this thesis.⁷ But it is my strong,

personal conviction that by and large the less developed countries do require very substantial institutional transformation if they are to achieve agricultural development. Their existing institutions were simply evolved for different purposes and will not, by and large, accomplish this new objective. However, it is equally true that our institutions will not fit their needs. Something much more profound is needed than either of the two extremes of a minor tinkering with and slight modification of their existing institutions, or a direct transplantation of our institutions into their foreign soil. What is needed is an adaptation to the conditions of the given country of precisely the same kind required for our hybrid corn or high-yielding wheat varieties.

This institutional development has to be built up through adaptive research in exactly the same way that plant varieties or animal strains and breeds must be evolved, in situs. There are doubtless underlying principles with respect to institutional organizations which are relevant, just as there are in the sciences. I would assume that certain principles about the proper interrelationships among knowledge-developing and knowledge-disseminating processes, such as illustrated best by our land-grant college system experience, are of this type. At this level of principle and theory we have a good deal to work with -- but very little to apply directly. Our credit institutions, for example, have been tailored through a long history to serve our peculiar needs, and have been modified in substance and approach as our problems and needs have changed from decade to decade. Carelessly transplanted and substituted for existing arrangements, these may do more harm than good in specific cases, just as a transplanted wheat variety may fall prey to an indigenous

disease; but the basic principles having to do with development of effective instruments for capital formation and disbursement to increase productivity and enhance individual farmer effectiveness have genuine relevance to virtually all less developed countries if they can be properly tooled into their physical, political and institutional realities.

The entire U. S. aid effort to this point has necessarily been built largely upon the premise that the transference of capital resources on the one hand and knowledge on the other, if properly linked together, could bring forth agricultural development abroad. The amount of capital resources available for this is obviously limited. More seriously limiting, however, is the fact that the knowledge we have to transfer is not ready-made, ready to go, and useful in most less developed countries. This process of transference must be transformed into a process of developing new knowledge through joint endeavors with host country scientists and institutions. This is true whether it be scientific knowledge, economic knowledge, or institutional knowledge. Since I am an economist, by training and by bias, and the subject of my assignment centers in economics, I make my plea largely that economists actually get with, in every way they can, the hard analytical requirements of developing, step by step, the building blocks of knowledge necessary to speed the agricultural development process on its way. These building blocks will not be fabricated from afar, but built in the countries themselves. I have little confidence in analysis by remote control. I must say in all seriousness that I feel that there is relatively little really good scholarship in the area we are addressing; we have invested

very little in such scholarship. It is difficult to do. People are scarce. And we, as a country, have allocated only a minute portion of our financial, human and scientific resources to this effort. Some thumbnail calculations I have made would indicate that perhaps not more than one or two percent of American professional manpower in agriculture has been allocated to strengthening the agriculture sectors of the less developed countries. This is far too modest an allocation in our own best long-range and short-range national interests.

Through our assistance programs we have been helping the less developed countries build their institutional foundations. I mean the foundations literally -- the hard, slow-moving work beneath the ground. Have you ever noticed a building project, how it seems to take forever to complete the part below the ground, to get the hole dug, the forms laid, the concrete poured? This is what we have been engaged in in most countries up to this time. Then, when the foundation is completed, the building seems to shoot up overnight. It doesn't have all the glossy finishes, but it takes its form and its substance, and declares to the world what it intends to be. This always seems dramatic when it happens. It is my belief that the agricultural development of many countries may well be standing at the edge of this stage by virtue of the foundation-building work which we and they have been doing together these last ten to fifteen years. Then, of course, after the building has taken its basic form, there seems to be an interminable process of putting on the finishing touches. This last step will not be importantly our concern. We will watch it as an interested neighbor, and here and there perhaps lend a helpful hand, but we will not have to assume a major responsibility. Several countries with which we have worked are, happily, in this non-dependent stage now.

If we put adequate resources into the effort in the years immediately ahead, we may be astounded at how fast the agricultural development structure rises from the foundations we have been working on so hard these years. But it is important that we put in the right kinds of resources. Food assistance serves a different kind of need. Technical assistance of the extension type in the literal sense, which takes our knowledge and spreads it around, is not of this type either -- because the job that must be done is to develop within the individual countries an engine by which knowledge of science and knowledge of practice is continuously produced and made functional. This requires our scientific brains; not the practitioners of agriculture but the practitioners of the science of agriculture. It is hoped that we as a people have the wisdom, the courage and the personal commitment to put an adequate amount of the right kinds of resources into the effort, to the end that the many unhappy prognoses will be proved wrong by the very dynamics which those prognoses have set in motion. This is the challenge, the intellectual burden and the moral responsibility of this generation of agriculturists in our society.

The Agricultural Economist's task in this effort is not a simple one. Not only must he develop understanding and analytical techniques by which to reveal the physical relations among all the variables necessary to provide a basis for sound investment decisions; he must develop also the ability to analyze the causal relationships of these investments to the process of changing those very variables themselves. The meaningful economic allocation problem is not, in the context of economic development, a simple better allocation under conditions of given resources,

given technology, and given state of the arts, but that of using allocative decisions as the instrument for optimizing their development -- individually and in relation to each other. Stated differently, it is not primarily a better orchestration of present production functions, but determining that pattern of investments of energy and resources which, through time, will provide optimum changes of the production functions themselves. In fact, in the very long-run definition relevant for economic development theory, resources, technology, and the state of the arts turn out to be the same thing. Far from being the givens which the economist must accept as independent, exogenous factors, they are the very dependent variables which his analysis must be designed to change in accordance with growth maximizing criteria. Neither existing theory nor physical data are well equipped to provide him the answers.

In making this same general point in a paper which I gave some 14 years ago, I stated that the only definition of resources relevant for the long-run is the ability of the human mind to manipulate mankind's environment to its own ends.⁸ The problem which this conference is addressing truly challenges all that the human mind in its total institutionalized character can deliver.

1. "Changes in Agriculture in 27 Developing Nations." Foreign Agricultural Economic Report No. 27, Economic Research Service, USDA. (Report is the result of an AID-financed USDA research project.)
2. Esther Boserup: The Conditions of Agricultural Growth: The Economics of Agrarian Change Under Population Pressure; London; George Allen and Unwin, 1965
3. The referenced USDA study would suggest that agricultural output increases resulted more from expanded crop acreage than from output per acre in half the less developed countries studied -- including, interestingly enough, both India and Pakistan.
4. Conference on Productivity and Innovation in Agriculture in the Underdeveloped Countries. Dedham, Mass., 1964. Policies for Promoting Agricultural Development. Report of a Conference ...held at the Massachusetts Institute of Technology...International Studies, M.I.T., 1965. 361 p. Comments reproduced here with his concurrence.
5. Analysis reported in unpublished ms. "Some economic hypotheses from Indian fertilizer demonstrations," data from Report of Results of Fertilizer Demonstrations in India, Indian Council of Agricultural Research, Government of India.
6. "Wasted" defined as that in excess of needs for maximum yields per acre.
7. I have tried to do so in my paper, "Institutional Factors Limiting Progress in the Less Developed Countries," in Agricultural Sciences for the Developing Nations, Publication No. 76 of the American Association for the Advancement of Science, Washington, D. C., 1964.
8. "Some Theoretical Issues in Economic Development," December 1952, Journal of Farm Economics, pp. 723-733.