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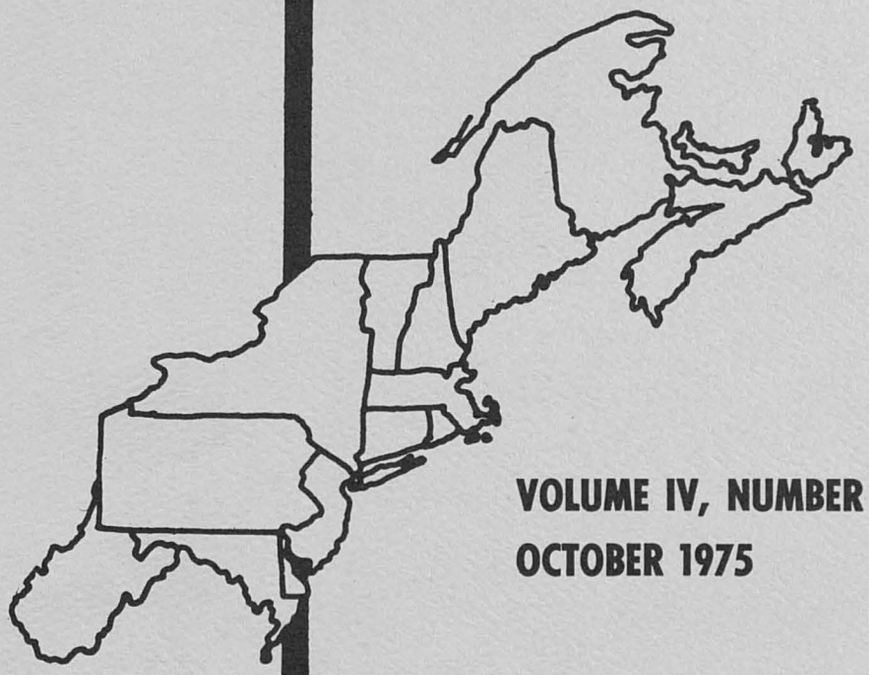

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WORLD FOOD PROBLEMS

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Responsible and informed individuals and groups now view the prospective balance between the world's demand and supply for food for the next decade quite differently. There are those who view the recent short-falls in production relative to desired consumption as relatively temporary in nature and that the most likely course of events is stocks of grain will be rebuilt and grain prices will decline to more usual levels over the next year or two. Those who argue this position consider the present situation as primarily a temporary aberration, of which there have been several others in recent history.[1] At the turn of the present century the British were concerned that the demand for wheat was going to outpace the supply; after World War II there was deep concern about the problems of rebuilding agriculture in Europe and, somewhat later, meeting the increased demand for food due to the sharp increase in birth rates that occurred in both industrial and developing countries, and in the mid-1960's, following unfavorable crops in the Soviet Union, China and South Asia it was feared that the world faced famine on a large scale. Yet, following each, the course of events was feared that the world faced famine on a large scale. Yet, following each, the course of events was quite the opposite and grain and food prices fell and the concern of governments was to protect their farmers from the consequences of supply growing more rapidly than demand.

There are others who see the recent and current relative stringency in food supplies as a more permanent situation with rising real costs of farm products as a definite possibility and a real threat to the health and welfare of poor people. This is the view that one finds expressed frequently in newspapers and national magazines and, I suppose, is now the more popular view.

My purpose in this paper is to discuss a number of world food problems. There is not a single world food problem but several potential problems or difficulties that clearly warrant careful consideration. I have stated each in the form of a question. Six major questions relevant to world food problems are:

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[1]An effort was made to present differing viewpoints by the Panel on Nutrition and the International Situation to the Select Committee on Nutrition and Human Needs, U.S. Senate, National Nutrition Policy Study: Report and Recommendations-VI, 93rd Congress, 2nd Session, June, 1974.

1. Is the world faced with substantially higher food prices over the next decade than during the decade prior to 1973?

2. Does the virtual disappearance of grain reserves mean that the world will be faced with substantially greater variability in food supplies and prices than during the two decades prior to 1973?

3. Does affluence--the high level of food in the industrial countries--represent a threat to the poor?

4. Can there be a significant improvement in the per capita food supplies of the developing countries unless there is a decline in population growth rates?

5. Are there adequate resources to increase food production in the developing countries to at least keep pace with population growth?

6. Does the political will exist in the United States, in the other industrial countries or in the developing countries to undertake the measures required to significantly increase world food output?

Rising Real Cost of Food

Those who say that the world is faced by food prices substantially higher than during the past decade have not, so far as I know, quantified such a prediction.[2] Are real food prices to be higher by 10 percent or 25 percent or 50 percent?

There are grounds for believing that real grain prices in international markets will be somewhat higher in the future than during the four of five years prior to 1972. The primary reason is that international grain prices were depressed during that period by the over-

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[2]"The international scarcity of major agricultural commodities which emerged in 1973 reflects important long term trends as well as the more temporary phenomenon of lack of rainfall in the Soviet Union and parts of Asia and Africa. We appear to be entering an extended period in which global grain reserves which provide a crucial measure of safety when crop failures occur, will generally reamin on the low side, and in which little if any excess cropland will be held idle in the United States. Food prices are likely to remain considerably higher than they were during the last decade." Lester R. Brown and Erik P. Eckholm, U.S. and the Developing World, Overseas Development Council, 1974, p. 66.

valuation of the American dollar and, to a lesser extent, the Canadian dollar.[3] For the countries whose currencies are closely related to the dollar, the increased imports of agricultural products by countries whose currencies have appreciated in terms of the dollar will result in higher grain prices. To some considerable degree the impact of the overvaluation of the dollar was offset for the American farmer by annual direct payments of $3 billion to $4 billion from 1968 through 1972.

But this source of increase in the international prices of grain--perhaps of the order of 10 to 15 percent in the long run--is not what the pessimists have had in mind. As I understand their position, it is that the expansion of supply required to keep pace with the growth in demand will result in significantly higher unit costs of production of food products. Such a development is possible, but is it likely? If so, it would represent a reversal of the trend toward lower real prices of grain for the past six decades. Between 1910-14 and the 1971 crop year the real farm price of feed grains and hay declined by 40 percent; the real price of food grains declined by 37 percent. In both calculations prices received have been adjusted for direct government payments as though the total of such payments represented a net addition to prices and incomes.[4] The declines in real farm prices in the United States, as measured here, have been somewhat less than the declines in real export prices from the major grain exporting areas.[5]

Why is it expected that the real cost of producing grains will increase? The reasons appear to be the following: First, there is relatively little uncultivated land remaining and all of the diverted acreage in the United States has been returned to production; second, increasing yields will increase costs in part because of diminishing returns to fertilizer, and, third, the price of farm inputs--especially those based on petroleum products--will be substantially higher in the future than in the past.

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[3] G. Edward Schuh, "The Exchange Rate and U.S. Agriculture," American Journal of Agricultural Economics, Vol. 56, No. 1 (February, 1974), pp. 1-13.

[4] I have elsewhere argued that the direct payments did not increase net farm incomes by more than a third to a half of the gross payments received. See D. Gale Johnson, Farm Commodity Programs: An Opportunity for Change, American Enterprise Institute, Washington, 1973, p. 48.

[5] Farm prices in the United States in 1971 included farm program payments and an export subsidy was paid on wheat. No such distortions existed in 1910-14.

The first two reasons for rising real costs of grain can be said to be either incorrect or irrelevant or both. There are substantial possibilities for expanding the cultivated land area in Africa, South America, South East Asia, North America and Australia.[6] It is true that the potential for expanding cultivated land in parts of Asia is relatively small, but this does not mean that the real costs of producing grains must increase. It is not at all certain that cultivating additional land is generally a significantly lower cost means of expanding output than increasing yield per acre. The answer for the past several decades in the United States appears to be that it has generally been cheaper to expand output through higher yields than by adding new land; some new land has been brought into cultivation but far more has been retired.[7] It is clearly possible to increase yields in the developing countries and yields have increased in the developing countries in the past three decades. But yields are still much lower in the developing countries than in the industrial countries.[8]

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[6]"While in some developing countries the practical ceiling on land development may have been reached, in a large part of the developing world there remains land resources which are either unutilized or are utilized in production processes with very low returns. The largest 'land-reserves' in the developing countries are in South America, Africa and in parts of South East Asia. All of these regions suffer from specific limitations . . . but modern technology is increasingly able to cope with the problems and one may expect some very major development programes for cultivated land in these regions." Preparatory Committee of the World Food Conference, Preliminary Assessment of the World Food Situation Present and Future, United Nations, 1974, p. 65.

[7]Total cropland (excluding cropland used only for pasture) in the United States in 1950 was 409 million acres; in 1969 total cropland was 384 million acres. (H. Thomas Frey, Major Uses of Land in the United States: Summary for 1969, ERS, USDA, Agr. Econ. Rpt. No. 247, 1973, p. 4.) Cropland harvested declined from 352 million acres in 1949 to 286 million acres in 1969, ibid., p. 9.

[8]Theodore W. Schultz has given strong emphasis to the limited role of land in agricultural production: ". . . only about one-tenth of the land area of the earth is cropland. If it were still in raw land in its natural state, it would be vastly less productive than it is today (underlining in the original). With incentives to improve this land, the capacity of the land would be increased in most parts of the world much more than it has been to date. In this important sense cropland is not the critical limiting factor in expanding food production.

"The original soils of western Europe, except for the Po valley and some parts of France, were, in general, very poor in quality. They

The second reason for higher costs--increasing yields will result in higher costs because of diminishing returns to fertilizer--is not a valid one. While higher yields may require more fertilizer per unit of output, it does not follow that real costs per unit of output will increase due to the higher yields because fertilizer is only one of many inputs used in grain production. As yields increase per unit of land, the productivity of other inputs increase and thus contribute to lower costs if the returns to these resources remain constant. In addition, farmers do not continue to operate on a single fertilizer-yield function, but the function changes over time. As farmers use fertilizer for longer periods of time, they learn how to use fertilizer more effectively through a multitude of adjustments such as better adapted seed varieties, greater plant density, timing of application, location of fertilizer in the soil and more effective types of fertilizer.[9]

There is a possibility that the prices of farm inputs having significant energy component will be substantially higher in the future than in the past. The cost of energy is an important element in fertilizer production cost. The Tennessee Valley Authority estimates

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are now highly productive. The original soils of Finland were less productive than most of the nearby parts of the Soviet Union, yet today the croplands of Finland are far superior. The original croplands of Japan were vastly inferior to those of Northern India. Presently, the difference between them is greatly in favor of Japan. There are estimates that the Gangetic Plains of India could, with appropriate investments, produce enough food for a billion people. . .

"Harsh, raw land is what farmers since time immemorial have started with; what matters most over time, however, are the investments that are made to enhance the productivity of cropland." "The Food Alternatives Before Us: An Economic Perspective," Agricultural Economics, University of Chicago, Paper No. 74:6, May 25, 1974.

[9]In a study of adjustments in the use of nitrogen fertilizer in the Corn Belt, Wallace Huffman found that there was a major change in the fertilizer corn yield function between 1959 and 1964. The function became much flatter and even though nitrogen use per acre of corn increased 150 percent between 1959 and 1964 the marginal productivity of nitrogen declined very little. See Wallace Huffman, "The Contribution of Education and Extension to Differential Rates of Change," unpublished Ph.D. dissertation, University of Chicago, 1972, pp. 27-34.

indicate that a four-fold increase in the price of natural gas--from $0.20 per thousand cubic feet to $1.00 per thousand cubic feet--would increase the plant gate price of a ton of urea by $22 or approximately 24 percent.[10] But there are many other factors that affect the cost of nitrogen fertilizer, including technology, size of plants, and percentage of capacity utilized. In fact, with a natural gas price of $1.00 per thousand cubic feet, the cost of producing nitrogen fertilizer with the 1974 technology would be less than the cost with free natural gas and the 1960 technology.[11] The TVA estimates indicate that the gate price of urea with natural gas at $1.00 per thousand cubic feet for a plant with a capacity of 1,000 tons per day would be less than for a plant with a capacity of 600 tons per day with natural gas at $0.40 per thousand cubic feet.[12]

Another factor affecting the cost of fertilizers in the developing countries is the low ratio of output to capacity. In such countries most of the nitrogen plants operate at 60-70 percent of capacity,[13] if capacity utilization were increased to the level achieved in the industrial countries of approximately 90 percent, fertilizer costs would decline significantly.[14] Many developing countries protect

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[10] Tennessee Valley Authority, "World Fertilizer Market Review and Outlook," in U.S. Senate Committee on Agriculture and Forestry, U.S. and World Fertilizer Outlook, 93d Congress, 2d Session, March 21, 1974, p. 106. Natural gas at $0.20/MCF is equivalent to petroleum at $1.54 per barrel; at $1.00/MCF for natural gas the equivalent petroleum price is $6.53 per barrel.

[11] Ibid. For a 200 ton per day plant using the older technology the gate price of a ton of urea if natural gas were free would be about $164. With natural gas at $1.00/MCF the gate price would be $116 for a plant producing 1,000 tons of ammonia per day. Interpolations made by the writer indicate that with a natural gas price of $1.80/MCF (equivalent to $11.50 per barrel of oil), the gate price of urea would be approsimately $140 per ton.

[12] Ibid.

[13] Ibid., p. 81.

[14] According to TVA estimates, the gate price for urea per ton in a plant with 1,667 metric tons per day capacity operating at 60 percent of capacity is approximately $155 per ton; at 90 percent of capacity, approximately $120 per ton. The calculations assume natural gas at $1.00 per thousand cubic feet. Ibid., p. 172.

their fertilizer industries, thus imposing unnecessarily high costs on their farmers. And as will be noted later, if a durable peace is achieved in the Middle East enormous quantities of nitrogen fertilizer could be available at costs comparable to those of recent years.

I do not believe that a strong case for significant increases in the real costs of producing grains in the years ahead has been made. It has only been asserted. The improvements in methods of production that we have seen over the past four decades will continue into the future. There is a major potential for relatively low cost increases in output in the developing countries if the appropriate conditions are established and if we consider a dynamic rather than a static framework.

The agriculture of the industrial countries is often accused of being highly energy intensive and increasingly so over time. In many respects the technology associated with the high yielding varieties in the developing countries have similar characteristics. Yet, surprisingly, it is not obvious that the agricultural technology associated with the major U.S. grain was more energy intensive in 1970 than it was a quarter century before. Pimentel and associates have estimated that in 1945 the average output of corn in terms of energy units was 3.7 per unit of energy used while by 1970 the ratio had declined to 2.82.[15]

Such a calculation ignores the fact that in 1970 U.S. corn output was 70 percent greater than in 1945. If 1970 corn output had been the same as in 1945 and had been produced on the highest yielding land there would have been energy savings, especially for machinery and gasoline. I do not know if these savings would have offset the actual decline in the ratio of energy output to energy input, but it is inappropriate to compare output to input ratios for such disparate levels of output and conclude that the change in technology had resulted in a loss of energy productivity. It might also be noted that there was no significant change in energy productivity between 1954 and 1970 while corn yields nearly doubled. All of the decreases in energy output to energy input occurred between 1945 and 1954, when relatively little fertilizer was applied to corn.

To have produced the 1970 corn output, with the 1945 energy inputs and methods of production, would have required almost 140 million acres of corn harvested for grain. In 1970 approximately 60 million acres were sufficient. In effect a 32 percent increase in energy requirements per bushel of corn "saved" 80 million acres of land. Or put another way, assume land had been available to produce the 1970 corn output

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[15] David Pimentel, et al., "Food Production and the Energy Crisis," Science, Vol. 172, 2 November 1973, p. 445.

with the 1945 yield, and that all the energy requirements were converted into gallons of gasoline, the use of 1.2 billion gallons of gasoline saved 80 million acres of cropland. Even at today's high prices, 1.2 billion gallons of gasoline has a value at the refinery of about $325,000,000. Is this an exchange that we would want to make, assuming it were possible? I think not.

Depletion of Grain Reserves and Instability[16]

From the end of the Korean War until 1972 the grain reserves of North America served as the granary for the world. These reserves were

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[16] Brown and Eckholm (op. cit., p. 74) have constructed an index of world food security, which is based on the total stocks of wheat and feed grains held in Australia, Argentina, Canada and the United States plus an estimated grain equivalent of the idled U.S. cropland. Using this index it is shown that grain reserves equaled 26 percent of world grain consumption in 1961, 15 percent in 1967 and projected to be only 7 percent in 1974. A significant part of the decline in the index of world food security resulted from a significant overestimation of the amount of grain that would be produced on the diverted or set-aside land. While the estimating procedure was not revealed, a check of the estimates indicates that it was assumed that each idled acre would yield 90 percent as much as the acreages actually harvested. For example, in 1972 the acreage diverted was 61.7 million and the grain equivalent was estimated to be 78 million metric tons. The average yield for the diverted land was 1.26 metric tons per acre compared to 1.40 metric tons per acre of grain actually harvested. By the calculations made total reserves declined from 209 million metric tons in 1972 to 89 million tons in 1974; over half of the decline was due to the reduction in the grain equivalent from idled cropland from 78 million tons to zero.

Brown and Eckholm greatly exaggerated the amount of grain that would have been produced on the idled cropland by assuming an unrealistically high yield and that all of the idled land would return to cultivation. Planting intentions for 1974 (unaffected by the adverse spring weather) for wheat and the feed grains exceed actual planted acreage in 1972, when 61.7 million acres were idled, by only 26 million acres. If the increase in planned soybean acreage is added, the increase in planted area of wheat, feed grains and soybeans was 35 million acres. And part of the increase in acreage between 1972 and 1974 was a response to higher real grain prices and not to the release of the "land reserve." Planting intentions for 1975 for wheat, feed grains and soybeans exceed 1972 actual by 35 million. Cotton acreage, however, is planned for 1975 at 3.5 million acres below 1972. The 1972 actual acreage of grains and soybeans was 2.2 million below intentions in March.

large enough to provide a remarkable stability of grain prices, around a declining trend, and were adequate to meet the shortfalls in world production that occurred during the two decades. The reserves were not the consequence of a deliberate policy decision on the parts of the American and Canadian government but were the results of price and other agricultural policies. The existence of the reserves made it possible for most of the rest of the world to avoid the cost and bother of holding reserves.

There was some level of grain reserves as of mid-1972 that would have prevented most of the grain price increases that have occurred during the past three years. At the beginning of the 1961 crop year the four major grain exporters--Argentina, Australia, Canada and the United States--had 139 million metric tons of wheat and feed grain stocks. This was approximately 15 percent of the trend level of world grain production. From 1961-62 through 1965-66 the net shortfall in world grain production calculated as the algebraic sum of departures above and below trend production was 72 million tons. From 1970-71 through 1974-75 the net shortfall was 62 million tons. The stocks held in mid-1961 were adequate to meet the production shortfalls and with only moderate increases in world grain prices. The reduction in grain stocks held by the major grain exporters from 1961 through 1966 was approximately 70 million tons.[17]

If the same ratio of stocks to production had been held in 1970 or 1972 as were held in 1961, grain stocks would have been approximately 170 million tons instead of the 112 million tons at the beginning of the 1970-71 crop year or 93 million tons at the beginning of the 1972-73 crop year. But stock levels approaching 170 million tons were not politically tenable in the exporting countries. The major exporters were unwilling to carry such levels of stocks by themselves. In fact, when wheat and feed grain stocks rose from 70 million tons in 1967 to 105 million tons in 1969, major efforts were made by Australia, Canada and the United States to reduce the production of wheat. In large part as a result of deliberate governmental action, the wheat area was reduced from 45.1 million hectares in 1968 to 29.4 million hectares in 1970 and production declined from 75.4 million tons to 54.2 million tons.[18] It was certainly obvious to the rest of the world that the major grain exporters were unwilling to hold grain stocks as large relative to world production as they had held only a decade earlier. Yet there is no evidence that grain stocks were increased in

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[17] D. Gale Johnson, World Food Problems and Prospects, American Enterprise Institute, Washington, 1975, Chap. 6.

[18] U.S. Department of Agriculture, Agricultural Statistics, 1970, pp. 5-6 and 1972, pp. 5-6.

the rest of the world to offset the planned and actual declines in stocks held by the major exporters.

There are numerous forums in which grain reserve policies are being actively discussed. But in most of these forums the rationale given for the holding of substantial grain reserves is an erroneous one. The commonly asserted reason for stocks is to offset year-to-year fluctuations in grain production. Year-to-year fluctuations in world grain production are relatively small and would not, if there were free trade in grains, make the holding of any grain reserves in excess of working stocks an economic investment more than one year out of five. At least that is the result that Yagil Danin, Daniel Summer and I found in an analysis of optimal grain reserves for the world. It was assumed that reserves were optimal when the expected gain or increase in price equalled the expected cost of holding an additional ton of grain. In only one year out of 20 would world reserves (in excess of working stocks) be expected to exceed 10 million tons.[19]

The basic reason why world grain or good reserves are required is that governmental policies prevent ready access to the available supplies of grain. Potential purchasers are prevented access by export controls, such as exist in almost all countries. In addition, governments may enter the world market to purchase grain at one price and then resell it into the domestic market at a lower price, as has been the practice in recent years in the European Community, the Soviet Union and China. In other words, the price system has not been permitted to allocate grain and this is the primary reason for the need to hold reserves.

The reason why the world needs to hold food reserves is not nature, but the policies adopted by man. This means that it is almost certainly unrealistic to expect the private market to hold sufficient stocks to prevent relatively wide swings in grain prices unless there is a substantial change in the agricultural and trade policies followed by most of the governments of the world. It is unlikely that such changes will occur in the near future. Thus if substantial reserves are to be held they will have to be held by or with the encouragement of governments. I have elsewhere discussed the merits of three different types of reserves--emergency reserves for the developing countries, reserves held by the major exporters as a means of encouraging freer trade and reserves to meet the erratic import pattern of the Soviet Union and, potentially, China.[20]

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[19] Yagil Danin, Daniel Summer and D. Gale Johnson, "Determination of Optimal Grain Carryovers," Office of Agricultural Economic Research, University of Chicago, Revised March 23, 1975, p. 27.

[20] Johnson, World Food Problems and Prospects, Chap. 6.

I expect that if there is normal weather in 1975 in the major grain producing areas of the world that there will be an opportunity to rebuild grain reserves. In fact, I fear that unless such reserves are rebuilt that the short run declines in grain prices in the United States and in world markets will be very drastic. The demand for grain appears to have rather fully adjusted to the 1974 level of supplies. One of the adjustments that has occurred has been the remarkable 30 million ton reduction in the feed use of grain in the United States in 1974-75 compared to 1973-74.[21] Given the peak cattle numbers not only in the United States but in all of the industrial nations and the current and prespective high rates of slaughter, the demand for feed grains during the next six to twelve months can hardly be described as robust. It is quite probable, though obviously not certain, that there will be an opportunity--perhaps it might be more accurate to say a political necessity--to rebuild stocks of feed grains and wheat in the next few months.

Increasing Affluence as a Threat to the Poor

There are those who argue that the high income countries should reduce their food consumption, especially of meat, in order to either build up grain reserves or to increase food aid shipments. With respect to our longer run responsibilities relative to food, it is stated that in the United States we consume approximately 2,000 pounds of grain per person per year compared to about 400 in many developing countries. Thus one American makes as large a demand upon the world's grain supplies as five Indians or Chinese or Pakistanis.

Before the high income countries are urged to significantly reduce their consumption of grain by reducing livestock product consumption, we need to consider what the longer run effects would have been if such reductions had occurred in the past. Suppose that the United States and the other industrial countries had held their per capita direct and indirect use of grain to half of the actual levels for the past several decades. Would this have made more food available to India or Bangladesh in 1973, 1974 and 1975? The answer is clearly in the negative. The United States, as well as other industrial countries, would have produced much less grain than has been produced. Reserve stocks would have been much less than they have been. If U.S. grain production had been 125 million metric tons instead of 200 million metric tons or more, it would not have been politically possible to have had 70 million metric tons of grain reserves in 1972.

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[21] U.S. Department of Agriculture, Agricultural Supply Demand Estimates, #26, April 25, 1975. Data in the source are in short tons and not in metric tons used in this paper.

Nor would Canada, with much lower export demand from the other industrial countries, have held such large stocks of grain in recent years. It might also be noted that if total grain consumption in the industrial countries had been much lower in the past, the institutions involved in the exports of grain would have been incapable of handling the grain exports to the developing countries in the mid-1960's or during the past three years. International trade in grains under the circumstances assumed would have virtually disappeared. Western Europe would not have required grain imports even with a much smaller reduction in grain consumption than postulated here.

Even with the actual, and claimed excessive, grain consumption in the industrial countries in recent years, grain production was below potential output level in the late 1960's and early 1970's. There is a fundamental and necessary relationship between demand and supply for a given product or group of products. Policy suggestions or recommendations that ignore this relationship have the potential for great damage to human welfare.

It might be argued that the potential for expanding grain production in 1974 and 1975 would have been much greater with the lower output level than with the output level that has prevailed. But this does not follow, either. How much would have been spent on corn research over the past two decades if our annual production had been 3 billion bushels or less? And with little prospect for increased demand? Would the major breakthroughs that cut the cost of nitrogen fertilizer almost in half in the early 1960's have occurred if grain production in the industrial countries had been half of the then existing level? It is simply not possible to change a single major variable, such as per capita grain utilization, by a large fraction and then assume that everything else would have been the same.

Nor does it follow that if per capita grain utilization in the industrial countries had been substantially smaller that grain prices would have been lower in recent years than they were. In other words, it cannot be assumed that the developing countries could have bought grain in international markets at prices below those that actually existed. As noted earlier real grain prices and costs have fallen for the past six decades. This has occurred at the same time that output has increased substantially. Incentives have existed for the development of production techniques that both reduced costs and made possible greater output. If demand for grain had nearly stagnated in the industrial countries as population growth rates declined, there would have been limited incentives for investment in research and development.

The total utilization of grain per capita in the United States is about five times the per capita consumption in many developing countries. The high per capita consumption of grain, both directly and indirectly through livestock products, is generally attributed to our

high and increasing per capita income. Between 1909 and 1971 the per capita gross national product in the United States increased by 180 percent. Would you believe that per capita grain utilization in the United States actually declined between 1909 and 1971? You should, because it did.[22]

The primary reason for the decline in per capita grain use was the substitution of mechanical for animal power. More recently the per capita use of grain or concentrates has increased in the United States with an increase of 14 percent between 1950 and 1971 or an annual rate of increase of 0.6 percent. However, the longer run comparison does indicate that not all of the effects of increasing affluence leads to increasing per capita use of grain.[23]

There is no doubt that Americans could achieve satisfactory nutrition with a substantially smaller per capita consumption of grain and other concentrates. But it may be noted that the high per capita utilization of concentrates in the industrial countries constitutes an important reserve that could be drawn upon if there were an extended period of adverse grain crops in the world, and in fact was drawn upon in the United States in 1974-75.

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[22] In 1909 direct grain consumption per capita was 136 kilograms; in 1971, 64 kilograms. Livestock consumption of grain, converted to a per capita basis, was 798 kilograms in 1909 and 706 kilograms in 1971. Thus the totals were 934 kilograms in 1909 and 770 kilograms in 1971. If all concentrates fed to livestock are used rather than grain, since many of the non-grain concentrates are a substitute for grain in production, the same result emerges. Per capita direct grain consumption plus per capita concentrates fed to livestock decreased from 1,092 kilograms in 1909 to 920 kilograms in 1971. Data on grain and concentrate use by livestock from Ralph D. Jennings, Consumption of Feed by Livestock, 1909-56, Agric. Res. Service, USDA, Prod. Res. Rpt. No. 21, November, 1958, pp. 82 and 92; George C. Allen and Earl F. Hodges, Livestock-Feed Relationships--National and State, ERS, USDA, Stat. Bul. No. 530, June, 1974, p. 175. Direct per capita grain consumption from USDA, Agricultural Statistics, various issues.

[23] There is a high positive correlation between the tractor use and per capita gross national product-affluence, that is. If one excludes grain and other concentrates fed to horses and mules, in 1909 per capita direct and indirect use was 824 kilograms; in 1971, 915 kilograms.

Reducing the Birth Rate

The concern over the current rather precarious food situation in the developing countries should not overshadow the food production gains of the past two decades. In spite of population growth rates in the developing market countries of 2.4 percent per annum for 1952-62 and 2.5 percent during 1962-72, food production has increased slightly more than population.[24] The population growth rates of the developing countries have exceeded any achieved in the United States in this century, even during the baby boom after World War II.

But significant improvements in per capita food supply can only be achieved as birth rates decline and the population growth rate is reduced. Unfortunately the United States and the other developed countries can have a very limited role in either inducing or aiding in efforts to reduce birth rates. As our own experience shows, there is strong opposition to a government taking an active role in reducing birth rates. And the opposition becomes solidified if a case can be made that outsiders--cultural imperialists--are making an effort to induce a country to engage in a positive program.

Our greatest contributions are likely to be in maintaining our present policy, namely to undertake research, both basic and applied, to improve contraceptive techniques, and to provide technical assistance when requested for establishing family planning programs. We should emphasize research on contraceptive techniques that are both simple and cheap, that require a minimum input by the medical profession, and that can be made available in the most remote village in the world. Obviously much more than improved family planning programs is required to reduce birth rates.

It is important that we use all available means that can be used quietly and in a noncoercive manner to induce the developing countries to face up to their population problems. The subject is a delicate one and requires enormous tact and patience.

While a reduction in birth rates would contribute toward minimizing the danger of famine or near famine conditions in the developing countries, the most important contribution is that it would permit a significant improvement in the quantity and quality of food intake. If food production were to increase at 3 percent annually, food output would double in 23 years. But if population continues to increase at 2.5 percent annually, during that 23 year period per capita production would increase by not quite 12 percent. But if the population growth rate could be reduced to 2 percent, the increase in per capita food

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[24] United Nations World Food Conference, Assessment of the World Food Situation: Present and Future, E/Conf. 65/3, 1974, p. 30.

production would be 25 percent. The difference between the two outcomes is important, especially for the poorer people in the developing countries.

Increasing Food Production in the Developing Countries

The developing countries have two main alternatives for increasing food supplies--increased imports and increased production. For most of the developing countries significant further expansion of food imports does not appear to be a viable alternative--at least not in the amounts required to meet the increased demands over the rest of this century. If there is to be an improvement in per capita food supplies in the developing countries, the primary source of the improvement must be increased food production in the developing countries. Projections made for the World Food Conference indicate that in the developing market economies the growth in demand for grain between 1970 and 1985 could exceed 240 million tons.[25]

The same projections indicate that if past trends in consumption and production continue until 1985 that the imports of grain in the developing market economies would increase from 16 million tons in 1969-71 to 85 million tons in 1985.[26] It is most improbable that grain imports of this magnitude could be sustained. If there is to be a significant improvement in per capita food supplies in the developing countries, there must be a larger annual growth in food production than has been achieved over the past two decades. While in the longer run a decline in population growth rates may help to improve per capita food supplies, there is little likelihood of achieving a significant reduction in population growth during the next decade even if birth rates start to decline in the near future.

There appears to be rather general agreement that there is large potential for expanding food production in the developing countries.[27]

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[25] United Nations World Food Conference, Assessment of the World Food Situation: Present and Future, pp. 84 and 91.

[26] Ibid., p. 84. In the Asian Centrally Planned Economics the projected demand growth is 96 million tons.

[27] The unanimity on this point seems so great that perhaps one should be suspicious! Among recent studies the following may be noted: United Nations World Food Conference, Assessment of the World Food Situation: Present and Future, EC/Conf. 65/3, 1974; Economic Research Service, U.S. Department of Agriculture, The World Food Situation and Prospects to 1985, For. Agric. Econ. Rpt. No. 98, December 1974; L. L. Blakeslee, Earl O. Heady, and C. F. Framingham, World Food Production, Demand and Trade, Ames, Iowa State University Press, 1973, and University of California Food Task Force, A Hungry World: The Challenge to Agriculture, Berkeley: University of California Division of Agricultural Sciences, July 1974.

In some countries there can be substantial increases in the cultivated area; in all countries there can be large increases in yields. The much higher grain yields in the industrial countries than in the developing countries does not appear to be due to more favorable weather or soil. In fact, with the potential for double and triple cropping that exists to a far greater degree in the developing countries than in the temperate zone industrial countries, the potential annual production from a hectare of land is almost certainly the greater in the developing than in the industrial countries.

It is instructive to compare the development of yields in the industrial and developing countries over the past four decades. During 1934-38 grain yields per hectare were the same at approximately 1.15 tons. Grain yields were static in the developing countries between 1934-38 and 1952-56 while yields in the industrial countries increased to 1.37 metric tons per hectare. During 1969-70 grain yields in the industrial countries averaged 2.14 tons and 1.41 tons in the developing countries. It is worth noting that grain yields in the developing countries in 1969-70 were slightly higher than the industrial countries in 1952-56.[28]

The necessary conditions for significant increases in food production in the developing countries are well known. The main conditions are a major expansion of agricultural research in the developing countries, adequate supply of modern inputs required to increase yields, incentives sufficient to encourage farmers to make the required adjustments and expansion and improvement of transportation, marketing and processing institutions. In addition, increased investment in human capital and improved communications are desirable not only because of the contributions to increased agricultural output but also through assisting farm people in the long run adjustments that they must make to economic growth.[29]

Agricultural Research

In 1970 it has been estimated that only 15 percent of the world's publicly supported agricultural research was undertaken in Latin

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[28] Grain yields estimated from FAO data.

[29] Space limitations prevent more than noting the importance of the expansion and improvement of marketing, transportation and processing institutions and increased investment in human capital and improved communications. For the role and importance of investment in human capital, see Theodore W. Schultz, Transforming Traditional Agriculture, New Haven: Yale University Press, 1964, Chap. 12.

America, Africa and Asia.[30] Agricultural research has had a major role in the more than doubling of grain yields in the industrial countries over the past four decades. Obviously many other factors have had their role--the reduction in fertilizer costs, improved pest and disease controls, and more effective control of weeds. But for all of these changes the research results can be said to have been a necessary condition. Without hybrid corn, for example, lower cost fertilizer would have had only a modest impact on yields.

If we and the other industrial nations are sincere about increasing the food supply in the developing countries we will support a major expansion in agricultural research, both basic and applied, in the developing areas. The expenditures required are not large. It has been estimated that total expenditures on publicly supported agricultural research in 1965 was less than a billion dollars for the world; private research relevant to agriculture was almost certainly less than that. What is required is a long term commitment by the United States and other industrial countries to provide support for agricultural research throughout Africa, Latin America and Asia. At the present time the United States does not seem to have the capacity to provide foreign aid on an annual basis, let alone make a commitment for a decade. We want quick results and as a consequence we are always disappointed.

There are a number of multilateral and bilateral ways that the industrial countries could assist agricultural research. One is through regional centers and in fact it appears that much of the international funding, both private and public, of agricultural research is now going to such centers. While regional centers are important and can make significant contributions, it is necessary that national research capabilities be developed. Such capabilities are required to adapt varieties to local conditions, to continue the fight against the predators of nature--insects and disease; to provide the capacity for independent discovery and to create centers for developing the scientists and researchers for the future.

There are a number of particular research programs that deserve the highest priority. Root crops, which serve as the main food for upwards of a tenth of the world's population, have received little emphasis. A major research effort is required to eliminate the tse-tse fly which according to the Preparatory Committee of the World Food Conference would add "7-million square kilometers to agricultural

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[30] Estimates made by Robert Evenson and Yoav Kislev in Agricultural Research and Productivity, New Haven: Yale University Press, 1975, Chap. 2.

lands, an area larger than the agricultural area of the United States."[31] The challenges are many; the opportunities are enormous.

There are substantial risks involved when new grain varieties are introduced into agricultural regions that lack viable agricultural research institutions. Such institutions are required to modify the varieties as they become susceptible to disease or insects, as will inevitably occur. Such institutions are also required to adapt varieties to meet local tastes, just as it has been necessary to modify the high yielding varieties of rice to meet the taste patterns of South Asia. When one grain is the major food, it is important that it be a grain that is liked. Even very poor people have their likes and dislikes.

If the industrial nations among them were to commit themselves to provide $1 billion annually for a decade and half that amount for the subsequent decade, great strides could be made to bring the benefits of agricultural research to all the major climatic zones of the developing world. Additional scientists need to be trained, but one who is familiar with academic life in the United States knows that the facilities for such training are readily available.

Adequate Supply of Modern Inputs

Man, land and seed are not enough to achieve grain yields of 2.5 to 3 tons per hectare, which will be necessary in the developing countries by the end of this century. Plant nutrients adequate for such a yield must be added to the land; plant populations dense enough for high yields require protection from diseases and insects; water supplies, where irrigation is required or desirable, need to be reliable and controllable.

Some of the modern inputs, such as pumps and pipes for irrigation, can be produced economically in the developing countries. Developing countries, in their efforts to industrialize, should not make the mistake of maintaining and encouraging farm input industries where the costs are substantially greater than import costs. High cost fertilizer or high cost insecticides only add to the costs of food and inhibit the growth of output.

There are two possible developments, both largely outside the control of the developing countries, that could contribute substantially to the availability of modern farm inputs. I shall comment briefly

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[31] Preliminary Assessment of the World Food Situation: Present and Future, p. 66.

about each of them--international trade liberalization and peace in the Middle East.

International Trade Liberalization

It is infrequent when a link is made between the liberalization of international trade and per capita food supplies in the developing countries. It is unfortunate that there is so little understanding of the role of trade in increasing incomes and food supplies in the developing countries. The industrial countries have been willing to go a considerable distance in removing barriers to trade in industrial products produced by other industrial countries, but have been most reluctant to lower the barriers to their imports of agricultural products and labor intensive manufactured products from the developing countries. It seems rather odd that it is accepted that there are gains from trade among industrial countries in industrial products, yet little progress has been made in extending the same advantages to the developing countries where their products are competitive with either the industrial or agricultural products of the industrial countries.

The present round of GATT negotiations provides an opportunity for reducing the barriers to trade on labor intensive industrial products, such as textiles, and on farm products that cannot be competitively produced in temperate zones, such as sugar and numerous fruits and vegetables. The additional foreign exchange earnings made possible by reduced trade barriers would permit the developing countries to obtain modern farm inputs at the lowest possible cost. There would be less need to engage in high cost production of such inputs if the low cost products of the developing countries had ready access to international markets.

Peace in the Middle East

A stable and durable peace in the Middle East could make a significant contribution to the food supplies of the developing countries. Higher yields will require substantially larger amounts of fertilizer, especially nitrogen. The lowest cost area in the world for producing nitrogen fertilizer is in the Middle East. The Middle East has enormous reserves of natural gas that could serve as the base for a large fraction of the world's output of nitrogen fertilizer. More natural gas is flared (wasted) in the Middle East than is consumed by the entire petrochemical industry in the United States. The transportation costs of the fertilizer to the rest of Asia would be less than the other major low cost producing areas.

There has been a significant increase in nitrogen fertilizer production in the Middle East following the major developments in the technology of production in the mid-1960's. However, the unstable political situation has seriously inhibited the very large capital

investments that are required. But if there were a durable peace, there is no reason why such investments will not be made and a very large supply of relatively low cost nitrogen fertilizer made available.

I believe that the nitrogen fertilizer would be produced at relatively low cost even if the price of crude oil remains substantially above the 1972 levels. While some of the natural gas supplies of the Middle East will find their way into European markets, it appears that the gas will return most to its owners by being transformed into a finished product in the region. The production of nitrogen fertilizer is one of the profitable activities that peace would make possible.

There are those who point out that it would be dangerous to concentrate the production of nitrogen fertilizer in the Middle East. To do so, it is claimed, would only add an economic weapon in addition to crude oil that could be used in the future. Perhaps so; no one could say that such would not be the case. But we live in a world in which many risks must be taken. In my opinion, the benefits to the developing world of a substantial increase in the supply of nitrogen at relatively low cost is worth the risk. Increasing grain yields in the developing countries to at least the current yields in the industrial countries will require enormous amounts of nitrogen fertilizer. A durable peace in the Middle East is of great importance to the poor people of the world.

Adequate Incentives

The growth of food production will be disappointing unless farmers are provided with adequate incentives. The ready availability of the products of agricultural research and modern farm inputs is not enough. The utilization of these products must be profitable. These seem like self evident statements and they are. Yet we still find many governments, especially among the developing countries, that follow short run and short sighted policies of holding down the prices of major farm products. India, for example, has generally held the price of rice below world prices. It is not surprising that the new high yielding varieties of rice have failed to be adopted as rapidly or as extensively as the new wheats since the price of wheat has been kept much above world prices.

The Short Run

The measures that can increase the rate of growth of food output in the developing countries admittedly require time. Expanding fertilizer output in the Middle East would require a minimum of three years while significant results from expanded research activities would

almost certainly take much longer. The factors that will affect food supplies in the developing countries for the rest of this decade, except for changes in incentives, are already under way. Whether the developing countries can escape food shortages over the next two or three years will largely depend upon climatic conditions and the capacity of the industrial countries to respond if adversity should strike.

Performance versus Promise

A strong case can be made that the major barriers to significant improvements in the per capita food supply of the developing countries are political in nature. The barriers are not primarily economic, except as economic matters affect both domestic and international political decisions. Neither are the barriers scientific in nature; the productivity of agricultural research institutions has been well documented. Nor are the barriers due to the intractability, ignorance or laziness of hundreds of millions of farmers around the world. If any of us found ourselves on a three acre farm in India and we had to feed ourselves and our family from the output of that farm, the probability of our starving would be substantial. Most of the poor farmers of the world make very efficient use of their limited resources.[32] They have shown both their willingness and capacity to adopt new seed varieties and complex production technologies and to do so very promptly where the profitability is evident.

I am cautiously optimistic that the food supply situation of the developing countries will continue to improve over the coming decades. If I had as much confidence in the political process in the industrial and developing countries as I do in the farmers of the world, I would drop cautiously from the "cautiously optimistic."

It is not at all clear that the industrial countries, either directly or through the international aid agencies, will move promptly enough and with sufficient resources in expanding the world's agricultural research. Foreign economic assistance does not appear too high on the list of priorities of any of the industrial countries. What we are witnessing in our own Congress in its unwillingness to provide resources and to provide them on terms suitable for the solution of the pressing problems is duplicated in many other countries. Only Canada, through the International Development Research Centre, appears to have achieved the proper institutional arrangements. Unless there is an important change in our own approaches to the assistance of agriculture in the developing countries we may well look back in 1985 and discover that Canada has contributed far more than we have.

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[32] Schultz, Transforming Traditional Agriculture, Chap. 3.

Nor is it at all obvious that the developing countries have either the political will or the administrative capacity to undertake the measures required to realize the potentials for expansion of food production. Only the developing countries themselves can do anything to reduce the rate of population growth. So far one can have little optimism about their performance over the next decade.

All too many developing countries attempt to use governmental authority and administration to carry out functions that would be much better left to the market. Rigid import controls, price ceilings, governmental ownership or control of farm input industries do not contribute to increased farm production and often have negative influences. Most developing countries do not have the required administrative capacities to operate a rigidly controlled economy--at least not and maintain a modicum of freedom.

But before we become too pessimistic about the performance of governmental institutions in the developing countries we should remember that at least some of these countries responded very positively to the food stringencies of the mid-1960's. It is quite probable that the next few years will see similar responses by many governments. The problem may well not be how governments will react over the next few years but whether once food supplies are more ample again, as I am confident they will be, there will be another relaxation of efforts, just as there was in 1970 and 1971. And then, not too many years later, unfavorable climate in some major area of the world will result in another crisis or near crisis.

World food problems are continuing ones, at least until the per capita incomes of the developing countries increase substantially from their present levels. Somehow it must be recognized that the efforts must be long run in nature. It should be recognized that the measures or programs started now will need to continue until at least the end of this century.

Norman Borlaug told us a few years ago that the new high yielding varieties of grain would not solve the food problems of the developing countries but the new varieties could buy time for those problems to be solved if the time were used effectively. It cannot be said that the world has used the time since 1967 at all effectively. The same mistake should not be made again. The stakes are too high.

In concluding, it should be noted that the most important factor that will lead to improvement in per capita food supplies is an increase in per capita real income. Food insufficiency is primarily the fate of poor people. The context of this paper has been to suggest how per capita food supplies can be increased somewhat more rapidly as economic growth occurs in the developing countries. But in the longer run, say beyond the next two decades, higher per capita incomes will be primarily responsible both for decreasing the rate of population growth and increasing the rate at which food production increases.