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The Future Productive Capacity of U.S. Agriculture:
Economic, Technological, Resource, and Institutional Determinants

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During the late 70s it appeared that U.S. agriculture might not develop the capacity to meet the domestic and foreign demands then in prospect. Domestic demands rose at a steady pace during the decade while exports burgeoned at 8 percent per year. Projections of those trends led onlookers to conclude that the pace was unsustainable and that food prices could increase dramatically. Then export demand slackened. The value of exports fell 21 percent during 1981-82; about half was the result of reduced shipments and the remainder the result of lower prices received. The concern about agricultural capacity turned from how to deal with prospective shortages to how to deal with the accumulating surpluses. During such turbulent times, it is difficult to focus on longrun trends.

Agriculture - Economic Aspects

Is U.S. agriculture likely to have the capacity to meet the demands to be placed on it during the next 2 or 3 decades? The question is ambiguous. First of all, capacity for what? Certainly we can meet the growth in domestic food demand. We can do so with fewer and fewer agricultural resources each year. One can imagine domestic biomass demands (for gasohol, for example) that could strain capacity, but such demands do not appear very likely to materialize. It is growth in export markets that raises issues about capacity. If exports resume the rate of growth of the 70s for an extended period capacity could become strained, but if export markets stagnate U.S. agriculture will experience excess capacity. Second, capacity at what price? It is conventional to assume that U.S. agriculture could produce at almost any level

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if the prices received were high enough. At historical prices, U.S. agriculture has usually found itself in the position of having some idle resources; output could have been increased at then-present prices. Third, there is ambiguity about capacity with respect to viewpoint. The greater the capacity the more food there can be for hungry people to eat. But the smaller the capacity the easier it is to maintain prices and farmer income.

U.S. agriculture is likely, according to our research, to have ample capacity to meet not only the export demands most likely to be placed on it but more, should it materialize. Projected demands can be met at present or even decreasing real prices received by farmers. Agriculture has the resilience to adjust efficiently to a wide range of market demands; however, prospective shifts in demand can have important implications for the redistribution of income among not only consumers and farmers but also marketing firms, input suppliers, and U.S. trading partners.

U.S. Agricultural Supply Response to Export Growth

Imagine 2 or 3 decades of growth in food production and consumption such that there is little change in real food prices. Consumers would spend smaller shares of their increasing real incomes for increasing quantities of food per capita and farmers would maintain or improve their earnings. On which side of this hypothetical trend line is food production and consumption likely to fall: toward higher real food prices of benefit to farmers, or toward lower real food prices of benefit to consumers?

To assess this question, we first looked at world trends. We found that neither extreme abundance nor extreme scarcity is very likely. The past few decades have been close to the middle, but show a tendency toward the scenario of plenty. Real food prices have been trending downward over the decades, and percapita production has been rising. We found no reason for calling for a change in these trends. And we found that food prices have returned to their

earlier level of volatility after an interlude of relative stability during the 50s and 60s. We concluded that U.S. agriculture will be exporting into markets characterized by prices that show shortrun volatility around a longrun, moderate downtrend.

To help assess the U.S. supply response to changes in world food markets, we simulated growth from 1982 to 2000, for alternative levels of exports, based on the structure of U.S. commodity markets for major crop and livestock products over the last decade or so. If exports of the seven crops were to grow at 3 percent per year over the next 2 decades, we estimate that production would expand to satisfy both domestic and foreign demands with little change in consumers' real food prices. There would be little or no need for price and income support if present farm programs are continued. This scenario implies less than a 10 percent increase in cropland use over the next 2 decades, with most of the added acreage used for soybeans. Export markets grow faster than domestic markets and the proportion of cropland harvested for export would rise from 40 percent in 1982 to 50 percent in 2000. Expectations are for export growth close to this 3-percent scenario. This suggests that domestic agriculture will become increasingly dependent on foreign markets. And it implies that real food prices could be little changed or moderately lower -- not only because of prospective growth in domestic capacity relative to demands, but also because of the need to keep prices of export products competitive in world markets.

If exports were to grow only about 2 percent per year for the next 2 decades, the forthcoming U.S. food supply would be large relative to domestic plus export demand. This would result in lower real food prices than under the 3-percent scenario. Domestic consumers would spend a smaller share of disposable income for slightly more food and the marketing sector would expand to handle the increased volume. Farmers would produce less wheat, corn,

soybeans, and cotton and nearly the same amount of livestock products compared to the faster growth scenario. Real prices received by farmers would decrease for all commodities. If advanced technology continues to be adopted then many resources now available to agriculture would not be required. For example, less cropland would be used in 2000 than in 1982. Export growth of 2 percent or less per year is unlikely for the long term. Were it to occur, it implies plentiful food supplies for domestic consumers, but in the absence of farm income and price programs, there would be depressed farm incomes, capital losses, and a reallocation of resources out of agriculture in search of better economic opportunities in the nonfarm sector of the economy.

If, instead, exports rise at an annual rate of 4 percent or 5 percent per year, the domestic plus foreign demand would be large relative to supply. Real food prices would increase. Domestic consumers would pay a larger share of disposable personal income for a smaller quantity of food than under the 3-percent scenario. Consumption of most livestock products would decrease but more wheat products would be consumed. More resources would be required and higher prices would be paid for them. Acreage planted would increase about 22 percent above the 1982 level under the 5-percent scenario, and land values would increase. The proportion of acreage harvested for export would rise to around two-thirds of harvested acreage by 2000. Export growth of 5 percent or more per year is not expected for the long term. Were it to occur, it implies higher real food costs to domestic consumers and reduced consumption of livestock products relative to crop products. Livestock growers would sell fewer products at higher prices; crop growers more at higher prices. Farm income would be high enough to eliminate most payments and supports if present farm programs are continued. However, the gains in farm income are mostly for crop enterprises. Livestock enterprises face higher feed costs which induce a reduction in livestock production and, despite higher prices received, may

result in a reduction in livestock income.

Resource availabilities, prospective advances in technology, and the institutions reflected in the structure of these simulations appear to be adequate to support domestic markets which grow in line with past trends plus export markets which grow at between 2 and 5 percent per year. If export growth is below that range, the agricultural sector could again become a severely disadvantaged and depressed industry. If export growth is above that range, various structural and distributional problems could beset agriculture long before natural resource availability becomes limiting. Rapid growth presses against institutional arrangements before it presses against physical capacity. Export growth within that range implies continued internationalization of U.S. agriculture. Fluctuations within the range are considered likely. This raises considerations of how to maintain balance between consumer and farmer interests, between livestock and crop growers, and/or between land owners and land users as relative prices change for individual commodities and resources.

U.S. Agricultural Supply Response to Price Volatility

Price volatility has characterized U.S. agriculture throughout this century -- the major exception was during the 50s and 60s when massive government intervention stabilized domestic farm prices above world prices and therefore above prices that would have existed in the absence of commodity programs. The price volatility of the 70s was of the same relative magnitude as the volatility of the first half of this century. Forty years ago when T.W. Schultz spoke of agriculture in an unstable economy, he identified unbalanced economic expansion and business fluctuations in the domestic nonfarm sector as the major sources of agricultural instability. The price volatility experienced by farmers during the 70s appears to be mostly of foreign rather than domestic origin. World production did not appear to be less stable than

formerly, but prices became more volatile. Insular trade policies during the 70s of both grain importing and exporting countries were major contributors to the recent price volatility as were floating exchange rates and other nonagricultural policies of various governments.

Farmers who are risk averse treat increasing price uncertainty similarly to an increase in the cost of production or to a decrease in the price received. They cope with uncertainty by physical and financial diversification, flexibility, reluctance to borrow and invest, off-farm employment, and similar actions that may reduce farm production efficiency. Price uncertainty and income variability affect the physical organization and financial structure of individual farm businesses. An increase in the variation in world food prices reduces the U.S. supply of cash crops by risk averse farmers. The accompanying higher prices lead to a reduction in the quantity of crop products used in food, feed, and export markets. Income to crop enterprises improves, but the reduced demands for farm resources decreases the income to resource suppliers. Higher feed costs reduce income to the livestock enterprise. An increase in world price volatility decreases production and thereby results in what appears in descriptive statistics to be a reduction in agricultural capacity. However, the decrease is not large and the prospect of high risk is not expected to limit the ability of U.S. agriculture to meet prospective domestic and export demands.

The Implications for Resource Use in U.S. Agriculture

The analysis of supply response in the commodity markets indicates that we will have the capacity to meet the market demands likely to be placed on U.S. agriculture in coming decades. The commodity supply response -- and the capacity of U.S. agriculture -- depends on the changes in technology, resource availability, regional location, and institutional arrangements. Let us look at some of these. Cross sectional simulations using linear programming

constraints helped us assess the allocation of resources among alternative uses. The framework incorporated additional livestock and crop enterprises relative to the time-series simulations and recognized regional location. The analysis was comparative statics; that is, the time path between 2 periods was not examined. The time-series simulations focussed on commodity markets; however, they included estimates of cropland requirements.

Technology. Total resource use in U.S. agriculture is about the same now as it was in the 30s, but production has doubled. An increase in productivity through adoption of new technology tends to increase the level of farm output and reduce the demand for traditional farm inputs. The increased availability of food products at lower prices benefits consumers, trading partners, and the domestic marketing sector. It also benefits agriculture despite its tendency to reduce net income because it keeps agriculture competitive with other sources of food, such as imports. If technology were the same now as it was in the 30s, the cost of production would be higher and U.S. agriculture would be priced out of domestic and well as world markets.

During the 70s, the growth in productivity appeared to slow. This slowdown occurred during a decade in which total output was expanding to fill export markets. The slowdown raised questions whether technological advance in agriculture was approaching a limit at the same time that cropland harvested was approaching its historical high. However, the slowdown was not substantiated for various disaggregations of the aggregate measure. For example, trends for corn yields did not change in either the Cornbelt or the South, but an increase in corn acreage in the lower-yielding South resulted in a reduction in the weighted-average national corn yield. And trends in livestock and crop productivity were little changed, but an increase in purchased inputs for the rapidly expanding crop enterprise changed the weighted average ratio of crop plus livestock outputs to all inputs. Therefore, what

appeared to be a change in productivity may, instead, have been regional and commodity shifts in production.

Prospects for further technical change in U.S. agriculture include genetic engineering and a new generation of more specialized and computerized machinery. Other prospects include: remote machinery monitors, controls, and robotics; reduced-tillage and no-till practices; varieties which are more pest resistant, higher yielding, and capable of being grown in new geographic locations; varieties with shorter growing seasons; fertilizer and pesticide encapsulation; crop hormone changes; drouth resistant and salt tolerant crops; nitrogen fixation by grass crops; biological pest controls and vaccines; control of animal reproduction; more efficient animal feed conversions; and alternative ways to satisfy human nutrition requirements. Improvements in information flows and decision-making by farmers will also increase efficiency.

If the growth in productivity were to continue for the next thirty years at the 1.9 percent per year pace shown in the past thirty, total farm output can increase by 70 percent from the present level. With domestic markets likely to increase by well under 1 percent per year, a 1.9 percent per year increase in productivity from existing resources would support a 3 percent per year increase in exports. Current projections are for average annual increases of less than 3 percent for the coming decade. In addition, rate of adoption of technology may increase. Therefore, as long as markets grow close to the projected trends or slower, technology is not likely to become limiting. The question is what happens if exports grow faster, say at 4 or 5 percent per year, or at the 8 percent rate observed during the 70s? Then, of course, technology could become limiting unless other changes are made. However, when this happened during the 70s, the commodity and regional mix changed and resources were reallocated in response to changing resource price ratios. These resilient adaptations by agriculture enabled it to meet the expanding

market demands despite the apparent decrease in the growth rate of the ratio of output to input. Technological advance is not likely to be a limiting factor in the ability of a flexible, resilient agriculture -- which has opportunities for substitutions among resources, commodities, and regions -- to meet the domestic and foreign demands likely to be placed on it during the next 2 or 3 decades.

Land. An unused potential to convert other lands into cropland has always been available to U.S. agriculture. During the past half century there was not sufficient economic incentive to use this potential. Quite the contrary, more often the problem was how much land to idle under supply management programs to limit price-depressing surplus production. The 1982 Natural Resources Inventories (NRI) estimate that there was 421.4 million acres of cropland in the U.S. compared to 413.3 in 1977. An additional 35.3 million acres (8.3 percent of the total) is considered to have a high potential of conversion to cropland. Yet an additional 117 million acres (27.9 percent of the total) is considered to have a medium potential. Allowing for various institutional, economic, and physical constraints on conversion, cropland might be increased by 17 percent before conversion difficulties and accompanying high conversion costs are encountered. That is, some 70 million acres of cropland might be added on a cost-effective basis if it is needed.

If U.S. exports were to increase around 3 percent per year until 2000 (to a level 70 percent above the 1982 level), and if yields continue to increase in line with the past trend, the time series analysis suggests that about 10 percent more crop acres will be required. Export growth of only 2 percent per year (to a level 40 percent above the 1982 level) can be met with about the same amount of crop acres used in 1982. Present expectations are for export growth within these ranges. If, instead, exports were to grow at an annual rate of 5 percent per year to 2000 (to a level of 140 percent above the 1982

level) 22 percent additional cropland will be required. This would stretch land use to a level only moderately above the readily convertible level of 17 percent and well below the high plus medium conversion potential. Using the cross sectional simulation, it was estimated that if exports were to increase 90 percent from the present level, using present technology, about 40 million more acres would be required after all resource and regional adjustments to the change were completed, well under the 70 million considered to be readily convertible. When adoption of technology was allowed for, it was found that exports could double during the next few decades and domestic plus export needs could be met using less cropland than is being used now.

Water. The number of acres irrigated doubled during the past 3 decades, mostly during the later years. This growth supported considerable expansion in agricultural production. While there could be increases in output from additional supplemental irrigation in humid areas, there is little prospect for further expansion in the arid regions. It is more likely that we can find additional irrigable land beyond the 50.8 million acres now in use to put water on than it is that we can increase the quantity of water to a major extent from the 93.1 million acre-feet now in use.

When crop exports are increased, most of the added production is on dryland; therefore, a limit to the possibilities for irrigation need not limit the capacity of U.S agriculture to meet growing export market demands for major crops. A 90-percent increase in exports, assuming yields constant, would require 25 percent more dryland and 7 percent more irrigated land after all adjustments were completed, according to our cross sectional simulations. Additional soybeans and cotton would be irrigated for small increases in exports. But only for the high export scenarios, under which resources were relatively scarce and agriculture was approaching its capacity, would inducements be sufficient to irrigate substantial amounts of additional corn

and wheat.

The output of irrigated crops from present water supplies can be increased in various ways. More efficient application systems are being developed and present systems can be used more effectively. Adoption of improved management facilities and practices can increase the effective supply of water sufficiently to meet the additional water requirements associated with a 90-percent increase in exports. Tight world food supplies and consequently higher prices received by farmers would increase the prices that farmers are willing to pay to irrigate, but would not greatly increase the quantity used. The availability of irrigation water is not likely to limit the ability of U.S. agriculture to meet export demands during the next 2 or 3 decades.

Purchased Farm Inputs. Farmers are using more purchased inputs and less labor on the same amount of land than they used to. Nearly three-fourths of cash receipts are used for the purchase of farm inputs now compared with around one-third 3 decades ago. The productivity increases of recent decades are highly correlated with the increases in expenditures by farmers for purchased farm inputs. The availability of inputs and service from the nonfarm sector of the economy during the next 2 or 3 decades will be more important in determining the capacity of agriculture relative to market demands for food than the availability of natural resources and labor. Backward linkages from farmers to the nonfarm sector are primarily for machinery, materials, chemicals, energy, and various services such as transportation, real estate, and financial services. These linkages are a little stronger for crops than for livestock and therefore are responsive to changes in the export markets for crops.

The U.S. food system, from production to consumption, uses approximately 13 percent of the nation's energy. Until the early 70s it was customary to assume that energy would continue to be plentiful and cheap. Since the energy

crunch of 1973, this is no longer a safe assumption. The real price of world oil likely will increase over the next 2 or 3 decades. As petroleum prices increase 2 adjustments can be expected. First, users of oil will shift some of their demand for energy to other sources, such as electricity (increasingly from coal) and natural gas. Second, over the longer run, users will continue to invest in energy conserving devices and practices, thereby substituting relatively less expensive capital and labor for the more expensive fuels. Energy supply disruptions can cause temporary changes in food production but are not expected to limit U.S. agriculture's ability to meet the domestic and foreign demands likely to be placed on it during the next 2 or 3 decades.

Prices that sellers of farm inputs are willing to accept are affected by opportunities to sell the same or related goods and services to the nonfarm sector. Manufacturers, for example, set prices of farm machinery with recognition of opportunities for sales of other equipment they manufacture to construction firms. Prices in the farm input markets, therefore, are influenced not only by the demand for farm products, but also by the prices of nonfarm producer goods and services. The nonfarm sector is expected to have the capacity to supply farms with the quantities of inputs needed to meet growing domestic and foreign demands for food; the real prices farmers pay for purchased farm inputs may increase, particularly for energy intensive inputs.

Conclusion

Farm policies likely will cope, over the next 2 or 3 decades, with a continuation in the longrun trend of a declining ratio of prices received by farmers to prices paid, and with continued price variability of foreign origin. U.S. agriculture has shown a resiliency for adapting to these trends by making appropriate commodity, resource, and regional substitutions, adopting new technology, and changing its structure and its institutional relationships. The basis for domestic farm income support and price stabilization policies is

changing, primarily because of increased reliance of U.S. farmers on export markets which are volatile and which are expected to continue to grow more slowly than the domestic potential to fill them.

There are 3 reasons for anticipating a probable longrun decline in real prices received by U.S. farmers. First, the trend since 1860 has been in that direction, and nothing in the present situation points to a new and compelling reason for concluding that a change has or is about to take place. Second, U.S. agricultural capacity is growing faster than the markets are expected to grow. This implies a domestic propensity to produce more than will clear the market at current real prices. This force for decreasing real prices need not be strong, but is in the direction of reinforcing the other 2 forces. Third, world agricultural capacity is growing faster than world markets are growing. If U.S. farmers are to expand their markets by means of exports, then their real prices received for exported commodities will have to gradually decrease to remain competitive.

Price volatility returned during the 70s to the level of the first half of the century. The relative stability of the 50s and 60s was attributable to U.S. price support policies which maintained domestic prices above world levels and permitted accumulation of burdensome carryover stocks. Except for the war years, volatility earlier in this century was attributed to domestic sources including weather and instabilities in urban markets. The important source of volatility now appears to have shifted to foreign origin, particularly to policy changes of major governments. This includes decisions to import to stabilize domestic supplies instead of "tightening the belt" regardless of the destabilizing impact on others, and embargos for political or diplomatic purposes. Prices seem unlikely to return to the unusual, relative stability of the 50s and 60s.

The estimated domestic agricultural supply response to a range of

alternative world food conditions suggests that there will not be a physical capacity problem in meeting food demands in coming decades. It appears that U.S. agriculture can produce enough to meet domestic and export demands for food, even at moderately decreasing real prices. This requires that current efforts continue which conserve and develop natural resources, discover new technologies, promote efficient regional relocations of enterprises, and maintain an increasing supply of purchased farm inputs. Temporary strains are anticipated again, perhaps even as severe as those of the 70s.

While physical limits on capacity are not anticipated, there may be institutional ones. Another doubling of exports within the short period of one decade, such as was experienced during the 70s, will again put the agricultural structure and its related markets under strain. Other events, which are not considered agricultural, can limit the demand for farm products and agriculture's supply response. These include high interest rates, credit rationing, and a substantial strengthening of the dollar against the currencies of countries which import U.S. farm products.

Changes in relative prices induce shifts in the distribution of income. Therefore, in view of the prospective continuance of price volatility, programs are likely to be considered which share the risk while at the same time maintaining agriculture's flexibility and resiliency in adjusting to change. How farm programs are financed and operated when world food markets are scarce or volatile compared to when they are plentiful or stable affects the distribution of food and income among domestic consumers, the marketing sector, farmers, input suppliers, and U.S. trading partners. The equity of such redistributions of income during times of shortrun stress could prove to be of more concern for policy makers than will the longrun limits to U.S. agricultural capacity.