Public Policy and the Competitive Position of U.S. Agriculture in World Markets

by

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The purpose of this paper is to estimate the static and dynamic comparative and competitive advantage of U.S. farm products in world markets. A related objective is to analyze the contribution of public policy to that advantage. A principal conclusion is that American agriculture is losing competitiveness. Public policy, although a cause for loss of advantage, must be part of the cure.

We shall observe that:

(1) The United States is losing competitiveness in major agricultural commodities such as soybeans because technological gains lag the rest of the world and because American farm policies have encouraged our farmers to sacrifice their soybean market to Argentina and Brazil.

(2) If the absence of worldwide market interventions by governments, the United States would have a competitive advantage in livestock production and export.

(3) If 1950-90 trends continue, real food prices will begin to increase by the year 2000. The trend could be reversed by new biotechnologies but those technologies would be held up by environmental concerns.

(4) For the U.S. to be competitive, public support needs to shift from protectionism which hurts competitiveness by raising costs to research on technology which increases competitiveness by lowering costs.

Measuring Competitiveness

Because comparative and competitive advantage are elusive concepts not easily measured, analysts have resorted to a number of methods to quantify the competitiveness of agricultural products. These measures include static indicators such as production costs or related landed costs, and domestic resource cost coefficients or related competitiveness indices. Dynamic measures of competitiveness include rates of increase in domestic productivity, agricultural versus nonagricultural productivity, and U.S. commodity yields versus foreign commodity yields over time. Various measures are presented herein before turning to the public policy connection.

Production and Landed Costs

Perhaps the single most widely used measure of competitiveness is production cost or landed cost, the latter being production cost plus transportation cost from various major supply surplus areas to major demand deficit areas of the world (see Ortmann *et al.*). The approach is popular because laypersons perceive that they understand the numbers. A frequent finding of these studies is that Argentina and Australia can produce wheat more cheaply than can the U.S.; Argentina and Thailand can produce corn more cheaply than can the U.S.; and Argentina and Brazil can produce soybeans more cheaply than can the U.S. (see Barkema *et al.*).

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Economists are critical of using cost of production to measure comparative advantage. Major reasons are discussed below.

1. Cost of production measures absolute competitive advantage rather than the conceptually preferred comparative advantage. That statement is valid, but for many purposes it is useful to know absolute competitive advantage. Comparative advantage is a measure of the long-term ability of commodities of a nation to compete in foreign markets given its natural resources and its human and material resource endowments and technology. But sometimes decision makers want to know if they can export at a profit today.

   Comparative advantage as measured by the competitiveness index (the inverse of the domestic resource cost coefficient) is in fact closely related to cost of production. In a one-price world, cost of production and net return (price less production cost) are highly (negatively) correlated. Net return per hectare is essentially the return to the fixed (nontraded) factors of land and operator labor and management, the same as is the competitiveness index. The difference in ranking of enterprises for comparative advantage is often minimal because border price, the major "connection" in the competitiveness index, is not a part of the cost of production. Of course, costs of production per kilo or per hectare are more difficult to compare within a country among a large number of livestock, crop, and nonagricultural commodities than are competitiveness indices which have nontraded input flow costs (rather than physical quantity) as the common denominator.
2. A second major criticism of production cost or landed cost is failure to consider exchange rate adjustments. However, comprehensive studies of production costs do consider alternative exchange rates (see Ortmann *et al.*). Exchange rate adjustments are not as helpful as might be expected, however, because real exchange rates of major competitors to U.S. agricultural exports tend to move in harmony with those in the U.S. To be sure, major markets (Japan and Europe) experience large real exchange rate adjustments relative to exporters, but that does not affect relative advantage of major agricultural exporters.
3. Cost of production has been faulted for failure to consider the diversity in production costs within a country. Costs differ widely among regions and among farms within a region. Whose costs are to be used?

   Figure 1, showing soybean landed costs by region, is revealing. It indicates that Argentina is indeed a low cost producer but its "low-input" agriculture has limited supply response potential. It could increase supply considerably only with major application of chemical fertilizers and pesticides but at higher cash costs per unit of output. Brazil is a high cash cost producer (variable costs only) because soils require commercial application of nutrients. Figure 1, which is a type of supply curve for soybeans, indicates that if world demand and price were very low Argentina would supply much of the world's exports. In an intermediate range of demand and price the United States would supply most of the world's soybean exports. And at high demand and price Brazil would be a major supplier.

The importance is clear to the U.S. of avoiding policies that artificially create high world prices for soybeans. In fact, the U.S. has not avoided such policies as noted later.

Comparative Advantage Measured by Competitiveness Index

A nation is said to have a *comparative advantage* in those products it can produce and export at highest return per unit of fixed (nontraded) resources in a well-functioning market. A nation is said to have a *competitive advantage* in those products it can produce and export at highest return per unit of fixed resources in the world of markets as they exist with all their imperfections. Because actual border prices are opportunity costs facing the United States, it follows that there are two important comparative advantage measures for the U.S.:

1. U.S. products or commodities produced and exported at highest returns per unit of fixed resources in a well-functioning U.S. market but given border prices offered by distorted rest-of-world (ROW) markets.
2. The same as (1) except assuming undistorted ROW markets and prices. Comparative advantage will not necessarily be the same for the U.S. under these two assumptions. Comparative advantage is measured alternatively under (1) nd (2) herein.

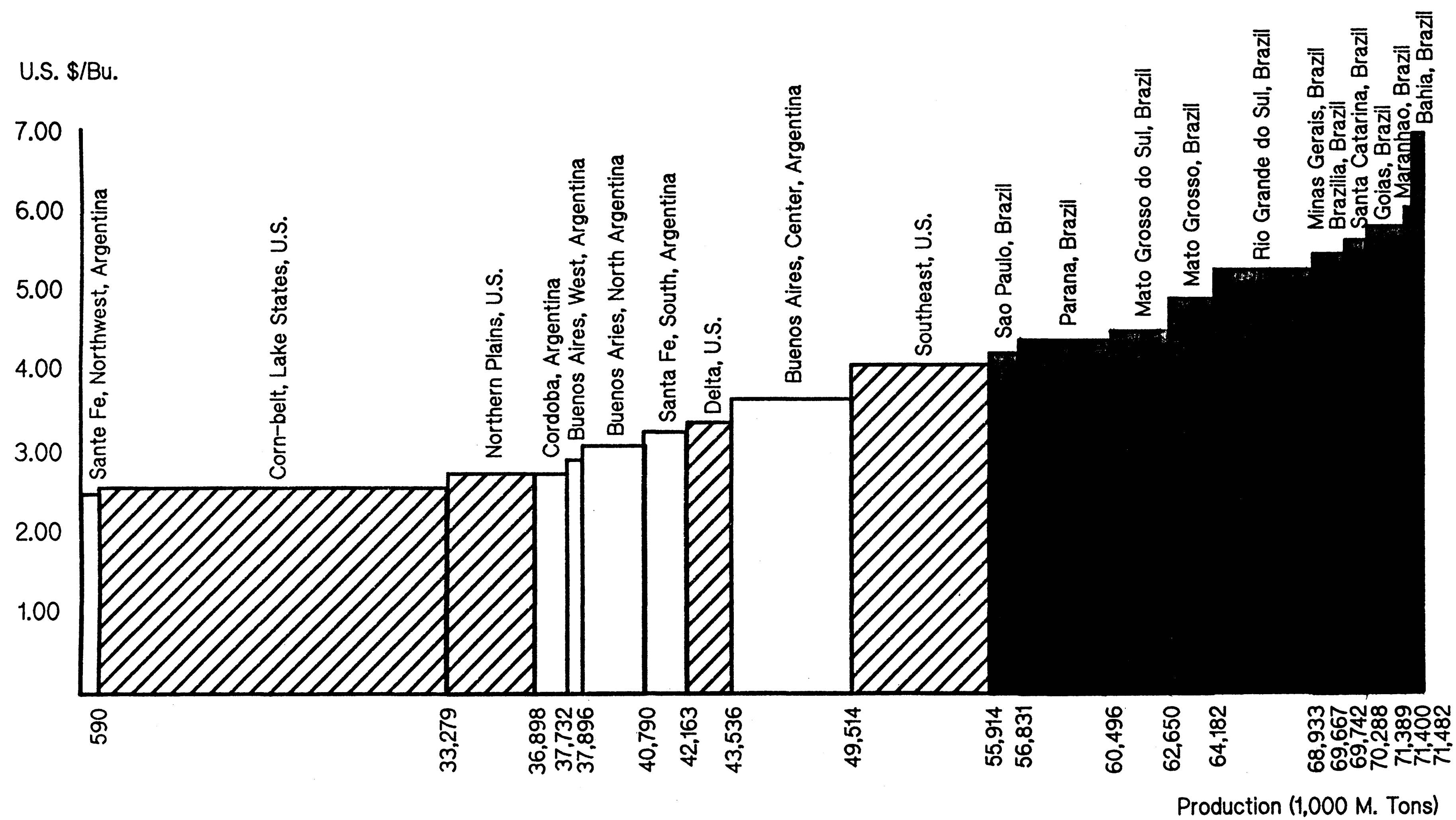

Figure 1. Marginal Landed Costs (operating plus transport to Rotterdam) of Soybean Production by Region of Argentina (white), Brazil (dark), and U.S. (crosshatched), 1986/87.
Source: Tweeten (1989).

A widely used measure of comparative advantage is the domestic resource cost coefficient D_i for commodity i

$$D_i = \frac{\sum_{j=m+1}^{n} a_{ij} P_j}{P_i - \sum_{j=1}^{m} a_{ij} P_j} \qquad (1)$$

where a_{ij} is the quantity of resource j used to produce a unit of commodity i, P_i is the price of commodity i, P_j is the price of input j for traded inputs j = 1 to m and nontraded inputs j = m+1 to n.[1] D_i is the domestic resource cost (numerator in (1)) required to earn foreign exchange (denominator in (1)) by exporting a unit of i or, alternatively, domestic resource cost saved through import substitution by importing a unit of commodity or product i. As commodities are ranked from lowest to highest comparative advantage, D_i begins with small negative values for highly unprofitable commodities and approaches negative infinity as i approaches profitability -- returns above variable (traded) costs. As a commodity moves to profitability, D_i approaches positive infinity, then moves toward a positive but ever smaller value of D_i.

The discontinuous function D_i makes reading of comparative advantage confusing at best. We prefer to use the inverse of D_i, the competitiveness index C_i, to measure comparative advantage. One desirable characteristic is that it is monotonic. It steadily increases in algebraic value with commodities of ever higher comparative advantage. It also has intuitive appeal. It is logical that a country maximizing returns to fixed (nontraded) factors of production is also maximizing national net income. The numerator of C_i is the return to fixed factors of production. The denominator of C_i, or the annualized accounting cost of fixed inputs, is a convenience to aggregate disparate nontraded inputs of land and operator labor and management. C_i is the return per dollar of fixed inputs -- that which a country wishes to increase for efficiency.

Competitiveness indices are shown for U.S. agricultural commodities under various assumptions in Table 1. All estimates are adjusted for the overvalued dollar in the 1983-87 period to an estimated equilibrium exchange rate 5 percent below the actual 1983-87 average -- a number derived in the Annex.[2]

Comparative Advantage Based on Producer Price Changes with Liberalization

U.S. producer prices for some commodities differed considerably from world prices in the 1983-87 period but were adjusted to border prices. However, removing U.S. market distortions alone does not necessarily improve producers' ability to compete in world markets. Given adjustments in U.S. producer prices from actual 1983-87 levels to levels with U.S. liberalization only, comparative advantage remained strong in soybeans and fluid milk for liquid consumption. However, the U.S. has a comparative advantage for local use only because it is "protected" by transport costs from foreign competition. Neither U.S. fluid milk nor milk products are competitive in world markets.

With only U.S. trade liberalization, comparative advantage among farm products is mainly in crops -- with soybeans, corn, and wheat ranking from high to low among commodities in Table 1. With full world trade liberalization, comparative advantage is highest in livestock products (in contrast to current net imports of pork and beef from Canada and elsewhere), followed in order by soybeans, corn, and wheat.

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[1] Linear programming of representative farms is attractive to measure comparative advantage because the technique recognizes the changing scarcity value of operator and other labor by season and scarcity value of irrigation water even where no charge is made for the water (see Epplin and Musah).

[2] The Competitiveness Index was computed from cost of production estimates for the U.S. for years 1983 to 1987 (U.S. Department of Agriculture). These years were chosen to average low and high rainfall years, and years of government programs holding market prices above normal market levels (e.g., 1983) with years of government payments-in-kind holding prices below world levels (e.g., 1986 and 1987). Government payments were excluded and rental rates adjusted to normal market accounting prices to value land. All labor was valued at the hired farm labor wage rate. All farm inputs except land and operator and family labor and management were treated as traded inputs.

Table 1. Competitiveness Index (Inverse of Domestic Resource Cost Coefficient), 1983-1987 Average with Exchange Rate Adjustment.

	Based on World Price Change			Based on U.S. Producer Price Change	
Commodity	With Existing Policy	With U.S. Liberalization[a]	With World Liberalization[b]	With U.S. Liberalization[c]	With World Liberalization[d]
Corn	0.98	0.68	1.17	0.44	0.69
Barley	0.50				
Wheat	0.66	0.48	0.85	0.23	0.38
Rice	0.56				
Soybeans	1.36	1.39	1.40	1.25	1.25
Cotton	1.03				
Cattle	0.44	1.29	8.19	- 1.47	2.06
Pigs	1.03	0.89	5.01	- 0.15	3.67
Sheep	1.33				
Milk	2.40	3.58	8.38	1.64	1.88

[a]U.S. liberalization based on world price changes are as follows: Corn, -7.56%; Wheat, -6.83%; Soybeans, 0.94%; Beef, 2.46%; Pork, -0.54%; and Milk Powder, 16.69%.
[b]World liberalization based on world price changes are as follows: Corn, 4.81%; Wheat 7.35%; Soybeans, 1.16%; Beef, 22.36%; Pork, 14.60%; and Milk Powder, 85.05%.
[c]U.S. liberalization based on producer price changes are as follows: Corn, -13.87%; Wheat, -16.45%; Soybeans, -3.91%; Beef, -5.52%; Pork, -4.53%; and Milk Powder, 10.83%.
[d]World liberalization based on producer price changes are as follows: Corn, -7.38%; Wheat, -10.72%; Soybeans, -3.73%; Beef, 4.68%; Pork, 9.69%; and Milk Powder, -7.52%.
Price changes calculated from Ohio State version of the SWOPSIM general equilibrium world trade model; 1986 conditions.

Comparative Advantage with Adjustment from World Prices

Since 1983-87, U.S. producer prices have moved closer to world prices. Thus Competitiveness Indices calculated from *world price changes* may more nearly represent comparative advantage based on 1990 conditions. (In contrast, Competitiveness Indices calculated from U.S. *producer price changes* more nearly represent comparative advantage for the historic 1983-87 period.)

With opening of world markets under multilateral liberalization, assuming U.S. farm prices change fully in response to world prices, American producers of livestock and livestock producers display strong comparative advantage. Cheaper local grains and concentrate supplies undoubtedly play a role as does the cutback in subsidized production elsewhere in the world.

In conclusion, Competitiveness Indices in Table 1 indicate that the U.S. especially has a comparative advantage in livestock and livestock products in a world without market distortions. Overall comparative advantage is generally improved with removal of distortions but the big gains are in livestock. Grains fare worse than with past subsidies. However, competitiveness of grains is higher than of tobacco, sugar, manufactured dairy products, fruits, and vegetables -- some of which are not shown in Table 1.

Measuring Static Competitiveness with CGE Models

An alternative means to measure comparative advantage is to observe changes in U.S. exports following removal of trade barriers. The computerized general equilibrium model (SWOPSIM) of the Economic Research Service of the U.S. Department of Agriculture predicted changes in the U.S. competitive position under multilateral removal of market distortions in 1984 (Table 2). Interpretations must be cautious because changes depend on relinquishing past protectionist or trade expansion policies as well as on true comparative advantage.

Major export *value* gains are in meat and eggs and to a lesser extent in oilseeds and products with multilateral trade liberalization. Food and feed crops and dairy products fare less well because they were subsidized.

Table 2. Changes in the Value of Net Exports from Multilateral Removal of Agricultural Commodity Supports, 1984.

Commodity	U.S.	Canada	E.C.	A.N.Z.	Japan	C.Plan	Rest World	Total
				(Million US$)				
Meat & Eggs	7929	238	-11357	1463	- 3006	617	3832	- 284
Dairy Products	- 1323	- 129	- 6	1307	- 865	152	1326	462
Food Crops	- 285	- 55	122	160	- 3188	166	3435	355
Feed Crops	- 565	343	- 284	186	115	15	488	258
Oilseeds & Products	182	- 50	- 115	18	55	4	- 93	1
Other Crops	- 1899	- 102	- 1123	10	- 396	67	2638	- 805
All Commodities	4039	245	-12763	558	- 7285	1021	11586	- 14

Source: Roningen *et al.*, p. 13.

Table 3 shows changes in export *volume* with unilateral U.S. and multilateral world trade liberalization based on predictions for 1986 from the Ohio State version of the SWOPSIM model. Dairy milk powder exports drop sharply with unilateral and to a lesser extent with multilateral liberalization, suggesting lack of comparative advantage in manufactured milk products. Relatively large export gains in grains are made with U.S. liberalization only whereas large gains in meat exports require world trade liberalization. U.S. feed grain production expands especially with multilateral trade liberalization because domestic feed use for livestock expands along with exports. Changes in soybean exports are modest under any of the scenarios. Argentina and Brazil offer formidable competition, in part because Brazilian soybean land prices fall for lack of alternative cropping opportunities while U.S. farmers have feed grain cropping alternatives.

Table 3. The Changes in U.S. Export Volume with Trade Liberalization, 1986.

	With U.S. Liberalization		With World Liberalization	
Commodity	Trade Change	Change as % of Production	Trade Change	Change as % of Production
	(1,000 MT)		(1,000 MT)	
Beef	- 268	- 2.42	807	6.91
Pork	13	0.20	1112	15.58
Milk Powder	- 193	- 42.27	- 129	- 25.51
Wheat	9502	14.20	10102	14.98
Corn	6077	2.82	8227	3.71
Soybeans	- 138	- 0.26	- 287	- 0.55

Source: Ohio State computerized general equilibrium model.

In summary, the above analysis indicates that the United States would make major gains in export value of meat and eggs and to a much smaller extent oilseeds and products with worldwide free trade. It would be a net gainer from trade despite modest predicted losses in "other crops" (e.g., fruits and vegetables) and sizable losses in dairy products, sugar, and tobacco. With free trade, agriculture in Japan and the European Community would be major losers while the rest of the world (Argentina, Brazil, Australia, Thailand, etc.) would be major gainers. While agriculture in Europe and Japan would lose, national economies of these areas would gain. Welfare analysis shows that the major losers from market distortions are the nations that impose them. Full national income gain (in reduced deadweight losses) in the European Community and Japan would be several times as much as the estimated net gain of $5 billion in the United States.

Dynamic Competitive Advantage

The foregoing measures of comparative and competitive advantage indicate competitiveness of U.S. agricultural commodities at a given point in time. Of interest also is how ability to compete is changing. Competitiveness of American agriculture is influenced internally over time by rates of productivity change in agriculture versus other domestic industries. It also is influenced by relative rates of productivity or yield change in U.S. agriculture versus in foreign agriculture. Relative yield trends are important: An improvement in soybean productivity in Brazil relative to the U.S. increases world soybean supply and reduces world price. This reduces the Competitiveness Coefficient in the U.S. for soybeans relative to other U.S. exports. It reduces the ability of the U.S. to compete with Brazil.

U.S. Yield Trends

U.S. yield trends for crops, livestock, and livestock products have been depicted graphically over time (see CAST). The most striking conclusion from those graphs is that yield trends are nearly linear at least since 1950 for individual commodities and for an aggregate such as total crop and livestock output per unit of all production inputs. This Malthusian specter of food output increasing at an arithmetic rate while demand is increasing at geometric rate may give rise to alarm. That alarm needs to be tempered by noting that agriculture has been characterized by a series of technological revolutions (see Tweeten, November 1987). Any one technology such as the current chemical fertilizer-pesticide-tractor revolution which began in the 1930s settles to linear or even diminishing yield increments over time. However, the former revolution is replaced by the new revolution of biotechnologies sharply increasing growth rates. The envelope curve of productivity growth under successive technological revolutions increases at an increasing rate.

The slowing growth rate of crop yields under the current technology for the 1950 to 1986(8) period is apparent in Table 4 from best-fit equations. A number of functional forms were allowed. The ones chosen based on adjusted R^2 were slightly curvilinear but were not a significant improvement over a straight line. For most U.S. commodities, growth rates will be nearly halved comparing 1950 to year 2000 if past trends continue.

Demand for U.S. output is expected to grow nearly 1.5 percent annually to year 2000. Total output per unit of input, the last measure in Table 4, shows that the 1986 trend rate of expansion in the agricultural supply curve kept up. But if past productivity trends continue so total annual increase by year 2000 is only 1.3 percent, real food prices will rise as demand growth outstrips supply growth. Of course, many futurists contend that bioengineering will accelerate productivity by year 2000 and result in excess production capacity rather than shortage. Consequences could be severe of over-confidence in cornucopia, however.

Dynamic Measures:
Long-term Competitiveness Trends

Comparative Yields and Productivity

U.S. agricultural productivity is increasing although at a decreasing rate as just noted. U.S. farm comparative advantage could improve if American agricultural productivity gains slow less than in other American industries and less than in foreign agriculture.

Farm labor productivity has risen steeply relative to nonfarm labor productivity. Figure 2 compares *multifactor* productivity, a more comprehensive indicator than labor productivity of trends in domestic comparative advantage, between the farm and nonfarm sectors in the United States from 1950 to 1986. Multifactor productivity, which shows the ratio of all output of a sector per unit of all production inputs, has risen in the U.S. farm sector compared to the nonfarm sector. This indicates favorable trends toward comparative advantage for farming within the domestic economy. It does not necessarily indicate competitive advantage internationally if other countries are increasing agricultural productivity at a more rapid rate than the United States.

Table 4. Crop Productivity and Total Output per Production Input (Multifactor Productivity) Trends.

Item	Trend 1950	1970	1986	Projected 2000[b]
	(percent increase per year)			
All crop production per hour (1950-89)[a]	11.00	7.85	6.39	5.50
All crop production per acre (1950-86)	2.60	1.86	1.51	1.30
Wheat production per acre (1950-88)	2.97	2.12	1.73	1.49
Corn production per acre (1950-88)	3.98	2.84	2.31	1.99
Soybean production per acre (1950-88)	1.57	1.12	0.91	0.79
Cotton production per acre (1950-88)	1.58	1.13	0.92	0.79
Total output of crops and livestock per all production inputs (1950-86)	2.59	1.85	1.51	1.29

Source: Tweeten, 1989.
[a]Period of estimation from annual data; predictions from best-fit equations.
[b]Predicted outside range of data assuming continuation of 1950-86(88) trend.

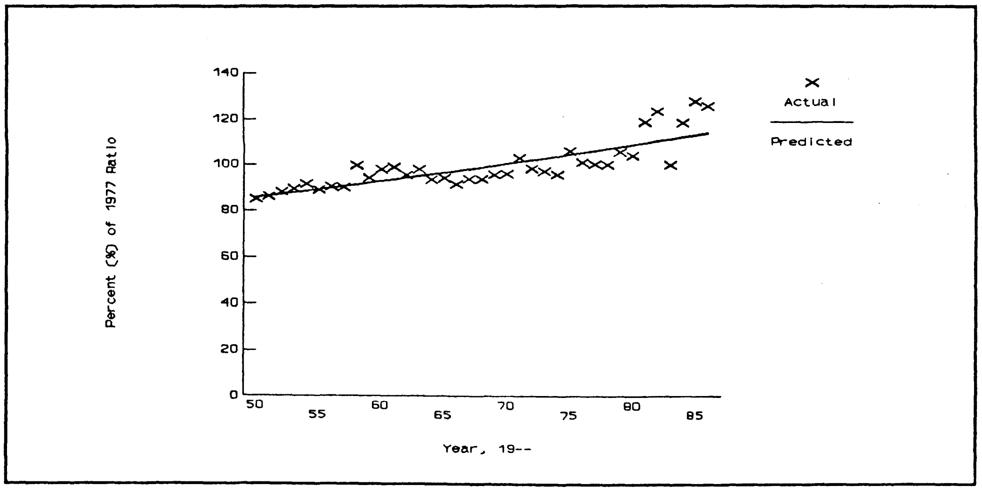

Figure 2. Multifactor Productivity: U.S. Farm as Proportion of Nonfarm.
Source: See Tweeten (1989) for sources of data for Figures 2-7.

Rapidly rising productivity (as measured by yield proxies) of foreign agricultures tend to reduce world farm prices relative to nonfarm product prices in the U.S. and abroad. The result is lower profitability for farm output relative to other output in the U.S. if, unlike in other countries, U.S. productivity gains do not compensate for lower prices to maintain profitability.

Figures 3 through 7 show yields of major crops in the United States as a percentage of foreign yields of the respective crops. The U.S. wheat trend yield was 150 percent of foreign trend yield in 1961, the first year for which reliable foreign data became available (Figure 3). The green revolution and other technologies in foreign countries caused foreign yields to increase more rapidly than those in the United States. Continuation of the converging yield trend in Figure 3 will bring foreign yields up to those of the United States in the 1990s. Yield trend evidence is only circumstantial, but it suggests declining competitive advantage for the United States. The U.S. share of world wheat exports has varied widely from year to year since 1970 but has declined generally (see Tweeten, 1989). Despite some large shares in the early 1980s, the average share was 4.4 percentage points lower overall in the 1980s than in the 1970s.

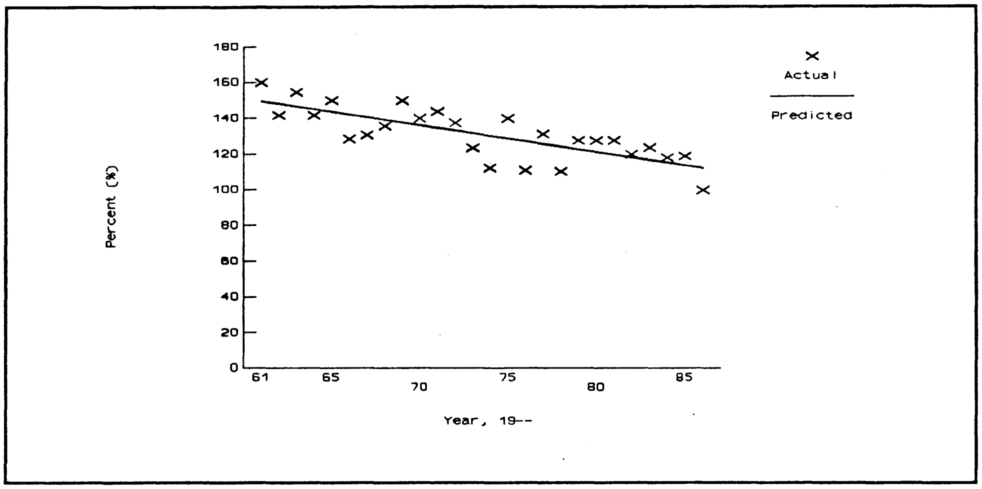

Figure 3. Wheat Yield Trends: U.S. as Proportion of Foreign Yield.

Coarse grain yields for the United States as a percent of those in other countries display an uneven but generally rising pattern from 1961 to 1986 (Figure 4). U.S. trend yield, 2.6 times that in other countries in 1961, increased to a ratio of nearly 3.0 by 1986. The high and rising ratio of U.S. to foreign coarse grain yields indicates historically strong and slightly increasing competitive advantage. That is manifest in the generally higher share of world corn exports accounted for by the U.S. in the late 1980s than in earlier years.

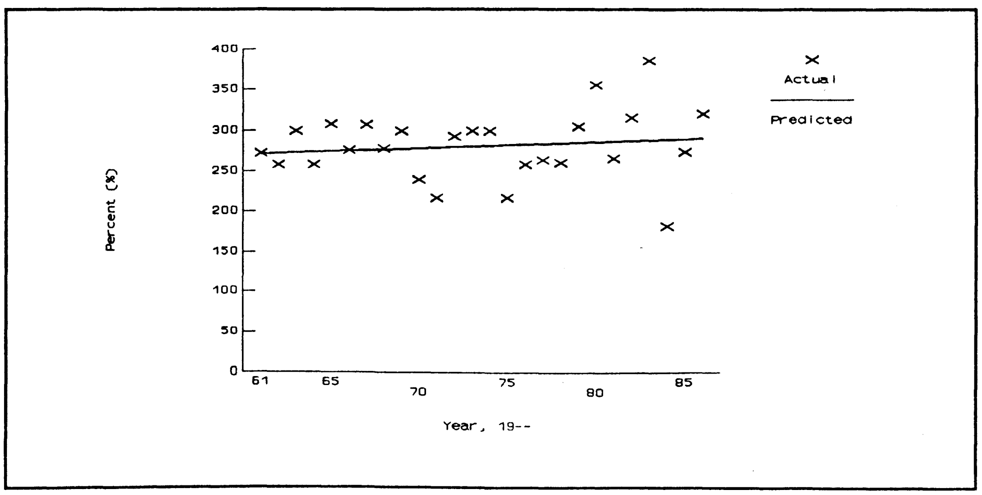

Figure 4. Coarse Grain Yield Trends: U.S. as Proportion of Foreign Yield.

In the case of soybeans, the U.S. displayed a trend yield 15 percent above foreign yields in 1961 (Figure 5). Foreign yields reached American yields by the early 1970s, and surpassed them in the 1980s. By 1986 trend yield in the United States was approximately 90 percent that of foreign countries. The declining U.S. share of the world soybean market corroborates the trend apparent in Figure 5 (Tweeten, 1989). Nevertheless, other factors, such as government payment inducements to produce grains rather than soybeans, contributed to the trend.

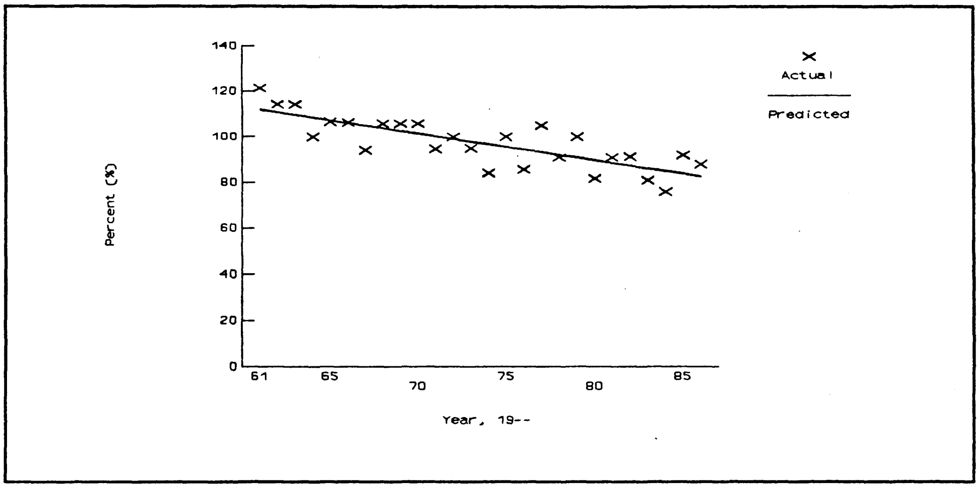

Figure 5. Soybean Yield Trends: U.S. as Proportion of Foreign Yield.

The vast Cerrado region of central Brazil is rapidly expanding soybean production. The region has adequate average rainfall but is low in soil nutrients. Operating costs for fertilizers are high but labor and land costs are low. Changes in U.S. policies to reduce discrimination against soybeans in commodity programs will be essential for the U.S. to remain competitive and avoid extensive expansion of soybean acreage in the Cerrado and like circumstances elsewhere.

Cotton trend yields for the U.S. versus foreign countries display an even sharper decline than soybean trends although the U.S. continues to enjoy a 40 percent cotton yield advantage (Figure 6). The linear equation used in all yield ratios does not properly fit the cotton yield trend. The decline in U.S. relative to foreign yields bottomed in the 1970s. Thereafter, the yield relationship has been rather flat and the United States continues to enjoy an approximately 40 percent yield advantage over other countries. The U.S. share of world cotton exports has varied widely since 1970 (Tweeten, 1989).

Tobacco yields have been declining in the United States versus foreign countries (Figure 7). U.S. trend yield averaged 240 percent that of other countries in 1961 but the ratio declined to 180 percent by 1986. Figure 7 suggests loss of competitive advantage. Because tobacco production is relatively labor intensive, rising labor costs in the United States reduce comparative advantage. The problem is exacerbated by mandatory controls maintaining tobacco prices well above free market levels. As with soybeans, policy changes could improve the competitive position of U.S. tobacco in world markets. The U.S. generally has lost export share since 1970.

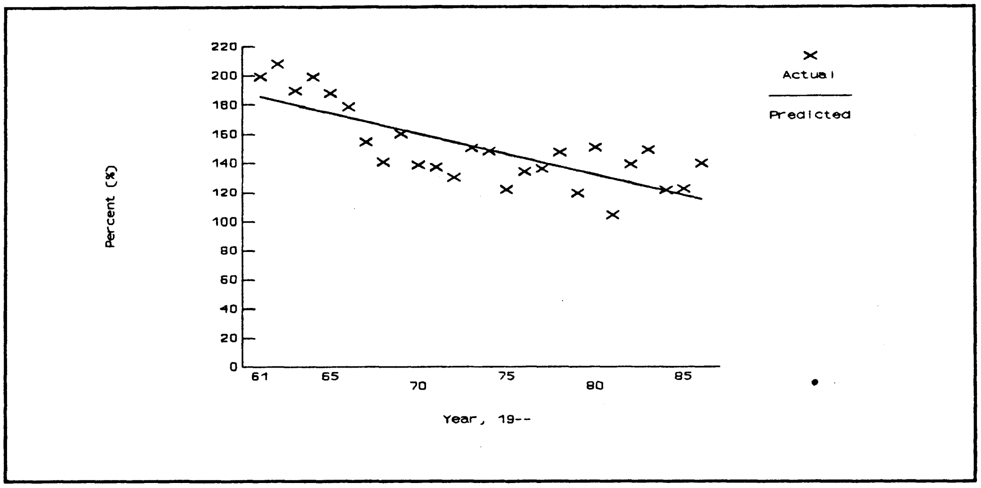

Figure 6. Cotton Yield Trends: U.S. as Proportion of Foreign Yield.

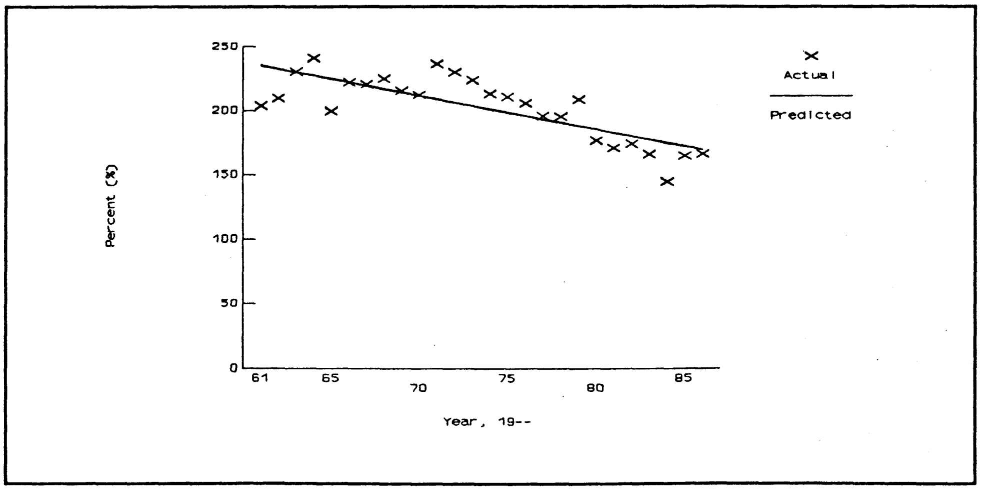

Figure 7. Tobacco Yield Trends: U.S. as Proportion of Foreign Yield.

Impact of Policies on Ability of American Farmers to Compete Internationally

The foregoing static and dynamic indicators reveal that technological predominance of American agriculture cannot be taken for granted. Competitiveness is determined by natural resource endowments and by policy and other decisions made by people that influence technology and economic incentives. Selected public policies are addressed in this section.

U.S. Farm Policy

Government commodity programs reduce competitiveness when they idle resources, control production, force an inefficient input mix, and raise costs and prices. Commodity programs remove resources, mainly land, from production which could be used to supply exports at prices covering variable costs of production. Commodity programs that subsidize output and exports raise competitiveness but violate the spirit if not the letter of international trade codes.

The impact of commodity programs on exports from year to year is mixed, however. High support prices mandated by the 1981 farm bill priced some American farm products out of international markets and encouraged foreign competition. On the other hand, lower loan rates coupled with release of government stocks on domestic and foreign markets (export subsidies) under the 1985 farm bill lowered U.S. farm export prices and raised quantities above those that would have prevailed with a free market.

Commodity programs as currently structured are not a positive force for U.S. international competitiveness, because commodity program features that reduce production and raise prices reduce competitiveness while program features that subsidize production or exports often violate the General Agreement on Tariffs and Trade principles. In fact, commodity programs in the U.S. have weakened GATT principles applied to agricultural products. The result has been not only major U.S. trade barriers such as for dairy and sugar, but retaliatory trade restrictions abroad on imports of commodities in which the U.S. enjoys a comparative advantage.

Science Policies

A major impact of policies influencing agriculture's ability to compete comes through input markets, especially for science and technology. All world regions have increased outlays and employment in agricultural research in recent decades. Most agricultural research worldwide is funded and operated by the public sector. However, the private sector role is growing and in the United States outlays exceed those of the public sector. Total scientist-years devoted to agricultural research increased 2.3 percent annually in North America and 5.2 percent annually in the world from 1959 to 1980. The share of North American manpower in total world agricultural research manpower fell from 14 percent in 1959 to 7 percent in 1980. Japan, France, and several other countries devote a greater proportion of non-military research spending to agriculture than does the United States. The United States spends about $1 on public research per $100 of farm output. By the same measure, Japan and Australia spend three times as much and New Zealand and Canada twice as much (Bonnen). The relatively slower gains in agricultural outlays and the diminishing world share of resources devoted to agricultural research in the United States help explain converging world yield trends apparent in earlier graphs.

Environmental concerns will delay introduction of major productivity-enhancing technologies such as genetically engineered growth hormones. Sustainable agricultural systems, however beneficial to the environment in the long run, are not expected to enhance productivity and comparative advantage of U.S. agriculture in the foreseeable future. Reduced rates of use and more efficient use of phosphate, nitrogen, and other fertilizers are desired. Alternatives such as nitrogen-fixing capability of legumes genetically engineered into grasses (including grains) could enhance options and diminish problems of commercial fertilizer depletion.

In short, U.S. agricultural competitiveness should not be taken for granted. Just as technology is one source of today's environmental problems in agriculture, so too it is an unavoidable part of the solution. Technology for a sustainable and productive agriculture will not happen by chance; it will be the product of large and structured public and private initiatives in scientific research and education.

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Appendix

Asset Market Approach to Exchange Rate Determination

In the full-employment economy of the 1983-87 period used for comparative advantage calculations, the U.S. ran substantial budget deficits which reduced the supply of net savings relative to investment requirements of the private and public sectors. The result was to drive up real interest rates in the U.S. relative to other countries, to raise demand for dollars abroad relative to supply, and to increase the value of the dollar in foreign exchange markets. The higher dollar restrains U.S. exports, expands imports, and creates a U.S. trade deficit that gives foreign countries the dollars demanded to invest in U.S. financial markets to fund the federal budget deficit and other needs. Because the trade and budget deficits are not sustainable, the overvalued dollar was transitory and hence needs to be adjusted for in comparative advantage calculations.

Following Driskill (1989), we use the asset-market approach to exchange rate determination. The asset-market theory of exchange rate determination emphasizes the demand and supply for stocks, rather than flows, of internationally traded financial assets and recognizes that the net additions to the stock of foreign bonds available to domestic residents can only be generated by trade balance surplus. The theoretical model includes (1) the demand for foreign assets, (2) the foreign bond market equilibrium condition, and (3) the trade balance equation.

For simplicity, the net demand for foreign assets is specified as a linear function of the relative rate of return:

(1) $$F_t^d = \eta\{E_t e_{t+1} - e_t - r_t\}$$

where
η = a positive constant,
F_t^d = stock demand for net foreign assets,
e_t = the log of the exchange rate, defined as the domestic currency value of foreign exchange,
E_t = the mathematical expectation of any variable conditional on information available at time t,
r_t = the difference between the domestic and foreign nominal interest rate.

Equilibrium in the foreign bond market means that demand equals supply. Denoting net foreign bond supply as F_t^s, we have

(2) $$F_t^d = F_t^s$$

Substituting (2) into (1), we obtain

(3) $$e_t = E_{t+1} e_t - r_t - F_t^s/\eta.$$

Because net additions to the stock of foreign bonds can only be generated by the trade balance surplus, we have

(4) $$T_t = \alpha\,\{e\text{-}p\} + \mu_t = F_t^s - F_{t-1}^s$$

where
T_t = the trade balance at time t,
α = a parameter reflecting the responsiveness of the trade balance to relative prices,
p = the log of relative price levels between domestic and foreign countries,
μ = a zero-mean serially uncorrelated random variable to capture shocks to the underlying fundamental determinants of the trade balance, e.g., taste and technology.

Assuming F_t^d follows a first-order autoregressive process through time, we have

(5) $$F^d_t = \pi_1 F^d_{t-1} + \pi_2 \mu_t + \pi_3 r_t$$

Then, differencing the fundamental equation (3) and substituting the trade balance for $(F_t - F_{t-1})$, we get the following ARIMA(1,1) process:

(6) $$e_t = \pi_1 e_{t-1} - \pi_1 r_t + \pi_1 r_{t-1} + \{(1-\pi_1)/\alpha\} \mu_t$$

Following equation (6), the $/SDR rate is specified as

(7) $$e^{us}_t = \pi_1 e^{us}_{t-1} - \pi_1(r^{us} - r^{row})_t + \pi_1(r^{us} - r^{row})_{t-1} + \{(1-\pi_1)/\alpha\} \mu_t$$

where
e^{us} = log of $/SDR,
r^{us} = nominal U.S. treasure bill rate,
r^{row} = London interbank offer rate on U.S. dollar deposits, 3-month.

We estimate equation (7) for the flexible exchange rate period, 1972-1987 by using the restricted coefficient method. The results indicated that during the 1983-1987 period the U.S. dollar was overvalued by 4.20% at average. We arbitrarily round that to 5 percent in the competitiveness calculations.