Policy Implications for U.S. Agriculture of Changes in Demand for Food

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Foreign Trade Implications for U.S. Demand for Beef

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Recent U.S. administrations have pursued the liberalization of international trade, especially in agriculture. Negotiations on trade reforms have proceeded on several fronts. In 1986, in the Uruguay Round of General Agreement on Tariffs and Trade (GATT) negotiations, the participating nations agreed that agricultural policies have distorted world trade, and they formed a negotiating group to tackle the difficult problem of agricultural policy reform. The U.S. proposal calls for the elimination of all trade-distorting policies. The United States has negotiated free trade agreements with Canada and Israel. Also, the United States and Canada have entered into negotiations with Mexico on creating a North American free trade area. Agricultural trade policies will be an important part of these negotiations. The Chilean government has expressed interest in reducing trade barriers between Chile and the United States, and there is talk of expanding a free trade area throughout the Western Hemisphere.

Agricultural policy reform could have profound effects on U.S. agriculture and on the producers and consumers of agricultural products. U.S. policy makers want to know how proposed reforms will affect the U.S. economy. In order to support economists' policy analysis, we have estimated the impact of changes in the availability of beef on its price and the economic welfare of U.S. beef consumers. In our analysis, we divided beef into two products: grain-fed (high-quality) and grass-fed (manufacturing-grade) beef. These two beef products are clearly differentiated by the industry in the United States and other countries. The United States exports grain-fed beef and imports manufacturing-grade beef. Trade policy reforms would have different impacts on these sectors.

In this paper, the U.S. beef trade and trade policy are discussed first, and then the structure of U.S. meat demands is estimated. Finally, the impact of foreign trade on beef price and consumer welfare is analyzed. Many studies have used consumer surplus as a measure of consumer welfare. Consumer surplus, however, is not an appropriate welfare measure when more than one price changes. Given the interactions between the demands for beef and other meats, and the fact that changes in grain prices arising from policy reforms will affect all meat producers and the prices of all meats, it is unrealistic to assume that beef prices will change and the prices of other meats will not. Because of the weaknesses of consumer surplus as a welfare measure, we use compensating variation. Compensating variation can be calculated from Hicksian or compensated demand functions.

The United States Beef Trade and Trade Policy

The United States is the world's largest importer of beef, accounting for approximately one third of the world's total beef imports. The most important suppliers of beef to the U.S. market, as shown in Table 1, are Australia and New Zealand. Between them, Australia and New Zealand supply approximately 60 percent of the U.S. beef imports. The bulk

Table 1. U.S. trade in beef and veal (carcass weight)

Year	1987	1988	1989	1990
	Million Pounds			
Imports from:				
Australia	997	1,081	818	1,084
New Zealand	613	641	578	578
Canada	191	172	239	222
Argentina	198	209	189	209
All other	295	303	354	263
Total	2,294	2,406	2,178	2,356
Exports to:				
Japan	397	503	716	574
Canada	37	53	98	191
All other	117	53	208	241
Total	651	609	1,022	1,006

of U.S. imports from Australia and New Zealand are frozen beef trimmings for use in hamburger and sausage products. These lean beef trimmings are mixed with fattier trimmings from U.S. beef. Imported beef competes directly with domestically produced cow beef. Imported beef is used together with fattier domestic trimmings in the production of hamburger and other ground beef items.

Canada is the third largest supplier of beef to the United States. Canada ships slightly more beef to the United States than the United States ships to Canada. Beef flows from Western Canada to the Western United States, and from the Eastern United States to Eastern Canada. Argentina is the fourth most important supplier of beef to the U.S. market. Because foot and mouth disease is endemic to Argentina, it may ship only products that have been cooked to an internal temperature that kills the foot and mouth virus; then, the product must be sealed in airtight, sterile containers. Argentina's beef exports to the U.S. are mostly canned corned beef.

Overall imports represent about 10 percent of U.S. beef consumption. The U.S. Meat Import Law places an upper limit on the amount of beef allowed into the country. The U.S. government negotiates voluntary restraint agreements with its major suppliers of beef when it appears that imports will exceed the "trigger" level. In six of the ten years from 1981 to 1990, however, imports into the United States were low enough that no restrictions were negotiated. Trade reform proposals might modify or eliminate the Meat Import Law, and this could lead to higher beef imports in some years. When the United States and Canada negotiated their free trade pact, the United States reduced its trigger levels but allowed free importation of beef from Canada. Canadian beef no longer counts toward the U.S. meat import limitations. In addition to limits under the Meat Import Law, the United States also charges a 2 cent per pound tariff on most imported beef items.

The United States is also a growing exporter of beef. Beef exports more than doubled between 1985 and 1990 and now represent 4 to 5 percent of production. Japan is the most important beef customer, taking more than one half of all U.S. beef exports. U.S. shipments to Japan are higher quality beef. The Japanese prefer grain-fed beef to grass-fed beef, and with its low grain prices, the United States appears to have an advantage in the production of grain-fed animals. The United States' second most important customer is Canada.

While beef trade between the United States and Canada is relatively unrestricted, U.S. exports face substantial barriers in the Japanese market. The Japanese market, however, is more open now than it has been in the past. At the urging of the United States, the Japanese government has been expanding its beef import quotas and will eliminate them at the end of Japan's 1991 fiscal year. The Japanese beef import quota will then be replaced with a substantial tariff. The tariff will start at 70 percent and drop to 50 percent in two years. Eliminating or substantially reducing the Japanese tariff on imported beef could lead to higher exports of U.S. beef.

To show the role of U.S. beef trade in domestic consumption, Table 2 illustrates the trade and consumption of beef from 1971 to 1990. Also, the ratios of imports and exports to consumption are computed in the table. The share of imports in consumption increases from 7.48 percent in 1971-75 to 9.08 percent in 1986-90. The share of exports in consumption increased from 0.5 percent in 1971-75 to 3.07 percent in 1986-90. As trade reform progresses, we anticipate that the importance of foreign trade in beef production and consumption will increase.

Measuring the Effects of Trade Reform on Consumer Welfare

Measuring the effects of trade reform on U.S. beef prices is a daunting task. These effects depend on a large number of factors, including the nature of the reform of U.S. and foreign policies and the economic structure of beef markets in the rest of the world. At this time, no agreement has been reached in the GATT talks, and the talks with Mexico have yet to begin. Consequently, we cannot even begin to predict the effects of trade reform on U.S. beef prices. For the purposes of this report, we have analyzed a range of possible effects. We caution our readers that the ranges we have selected are illustrative and do not represent any projection or opinion of the possible ranges of the effects of trade reform.

Estimating Demand Systems

To determine the economic benefits or costs of trade reform to U.S. beef consumers, we need to know (1) the effects of trade reform on U.S. beef prices, and (2) the structure of U.S. beef demand. Using the elasticity form demand system as in Huang (1985), we estimated the structure of U.S. demand for meats. We imposed the theoretical restrictions of homogeneity, symmetry, and Engel aggregation upon the parameters of this system. We assumed that the demand for meats is separable from the demands for all other commodities, and estimated the meat demand functions conditional on meat expenditures. Our use of separable preferences is consistent with much of the previous applied work on the demand for meats. Also, Alston and Chalfant's (1990) nonparametric tests suggest that U.S. meat consumption is separable from the consumption of other goods.

We used four meats in our demand system: high-quality beef, manufacturing-grade beef, pork, and broilers. Per capita pork and broiler consumption and retail pork and broiler prices were taken from USDA sources. We used the USDA retail choice beef price as the price of high-quality beef, and the hamburger price for the retail price of manufacturing-grade beef. USDA data on the slaughter of cattle by classes were used to split beef production into high-quality and

Table 2. U.S. beef trade and consumption, yearly average

Period	1971-75	1976-80	1981-85	1986-90
	Million Pounds			
Imports	1,811	2,156	1,910	2,262
Exports	120	137	276	765
Consumption	24,230	25,686	24,690	24,914
Imports/consumption (percent)	7.48	8.39	7.74	9.08
Exports/consumption (percent)	0.50	0.53	1.12	3.07

SOURCE: Compiled from Putnam and Allshouse (1991).

manufacturing- grade beef. Grain-fed animal slaughter determined high-quality beef production. Grass-fed, cow, and bull slaughter determined the production of manufacturing-grade beef. We also assumed that all U.S. imports were manufacturing-grade beef and that all exports were high-quality beef.

The price and meat expenditure elasticities implied by our empirical model are reported in Table 3. Special caution is required to interpret these results as the consumer response to allocate a given meat expenditure (not total consumption expenditure, as in more general demand systems). On average, one half of meat expenditure is spent for high-quality beef, 29 percent for pork, and about 10 percent each for broilers and manufacturing-grade beef. In general, most estimated demand elasticities are statistically significant. The goodness of fit of this demand system is reasonably good with root-mean-square errors less than 7 percent in all cases.

The conditional demand for high-quality beef is relatively elastic, with an own-price elasticity of –0.78, while the own-price elasticity for manufacturing-grade beef is only –0.48. Similarly, the estimated meat-expenditure elasticity for high-quality beef is rather high at 1.27, while that for manufacturing-grade beef is 0.17. To provide information for the interdependent relationships of these meat commodities, the compensated elasticities are computed and compiled in Table 4. The results imply that two kinds of beef are complementary with each other. As we noted before, manufacturing-grade beef and grain-fed beef are both inputs in the production of hamburger. High-quality beef is substitutable for pork and broilers, a result consistent with our prior expectations. Manufacturing-grade beef is shown to be substitutable for pork.

For the purposes of this paper, we decided to investigate how changes in the availability of high-quality

Table 3. Ordinary demand system for quarterly meat consumption (constrained estimated uncompensated elasticities, 1970-90)

	Price				
Quantity	Beefh	Beefm	Pork	Broiler	Meat-exp
Beefh	–0.7794 (0.0986)	–0.1708 (0.0490)	–0.2677 (0.0765)	–0.0478 (0.0302)	1.2657 (0.1173)
Beefm	–0.3453 (0.2793)	–0.4814 (0.2000)	0.7090 (0.1926)	–0.0528 (0.1014)	0.1705 (0.3063)
Pork	–0.4290 (0.1521)	0.1320 (0.0583)	–0.6719 (0.1397)	–0.2364 (0.0486)	1.2052 (0.2128)
Broiler	0.4598 (0.1700)	–0.0224 (0.0951)	–0.2822 (0.1453)	–0.0522 (0.0910)	–0.1030 (0.2134)
Weight	0.5054	0.0961	0.2943	0.1043	NA

Note: Figures in parentheses are the standard errors of estimated elasticities. The abbreviated notations are Beefh (high-quality beef), Beefm (manufacturing-grade beef), Meat-exp (Meat expenditure), weight (expenditure weight), and NA (not applicable).

Table 4. Ordinary demand system for quarterly meat consumption (computed compensated elasticities)

	Price			
Quantity	Beefh	Beefm	Pork	Broiler
Beefh	–0.1398	–0.0493	0.1049	0.0841
Beefm	–0.2591	–0.4650	0.7592	–0.0350
Pork	0.1801	0.2478	–0.3171	–0.1107
Broiler	0.4078	–0.0323	–0.3126	–0.0630

Note: The abbreviated notations are Beefh (high-quality beef) and Beefm (manufacturing-grade beef).

Table 5. Inverse demand system for quarterly meat consumption (computed uncompensated flexibilities)

	Quantity			
Price	Beefh	Beefm	Pork	Broiler
Beefh	–0.6225	–0.1309	–0.1600	–0.0005
Beefm	–0.6834	–0.2497	0.0403	–0.0104
Pork	–0.3294	0.0017	–0.4847	–0.2099
Broiler	–0.2703	–0.0615	–0.7164	–0.3954

Note: The abbreviated notations are Beefh (high-quality beef) and Beefm (manufacturing-grade beef).

and manufacturing-grade beef would affect consumers in the United States. To calculate compensating variation, however, we needed price, not quantity changes. Therefore, we estimated a compatible, compensated inverse demand system in which prices are functions of quantities demanded and income by following Huang's (1988) approach. Our estimated inverse demand system also incorporated the implications of economic theory. To save space, only the computed, uncompensated inverse demand system obtained from the directly estimated compensated system is presented in Table 5. The estimates in the table are price flexibilities showing the effects of meat quantities on prices.

Calculating Welfare Effects

As noted before, we use compensating variation to measure the welfare effects of changes in U.S. beef consumption. The derivation of compensating variation can be shown using the indirect utility function and a cost function. These two functions can be derived from the economic theory of consumer demand. Let Q denote an n-coordinate column vector of quantities demanded by a consumer, P an n-coordinate vector of the corresponding prices, M the consumer's expenditure, and U(Q) the consumer's utility function. Marshallian demands can be derived by maximizing consumer utility, subject to the budget constraint. The solutions to the utility maximization problem can be summarized in the indirect utility function, denoted by V(P,M). The indirect utility function gives the maximum level of utility the consumer can achieve, given the budget constraint implied by prices P and expenditure M. The cost function, C(P,U), shows the minimum cost of achieving utility level U, given prices P. The properties of cost and indirect utility functions are well documented in Deaton and Muellbauer (1980).

Suppose that M_0 denotes a specific level of expenditure, and that P_0 is some initial level of prices. If consumer's expenditure is fixed at M_0 and prices change from P_0 to P_1, then the consumer's demands and utility level may change. The consumer's maximum utilities, given expenditure M_0 and the two alternative price vectors, can be determined from the following two indirect utility expressions:

$$U_0 = V(P_0, M_0)$$
$$U_1 = V(P_1, M_0)$$

Compensating variation can be calculated by determining how much expenditure must change so that the consumer is as well off after the price change as was the case when prices were P_0. In terms of the indirect utility functions, compensating variation (CV) is the number that solves the following equality:

$$V(P_0, M_0) = V(P_1, M_0 + CV)$$

The minimum expenditure necessary to reach the level of utility U_0, given prices P_1, can be determined by the cost function. Consequently, the compensating variation can be calculated as the following equation:

$$CV = C(P_1, U_0) - M_0$$

This welfare measure reflects the additional expenditure required to achieve the same level of utility as before the change in price. One may regard P_0 as the initial price level and P_1 as the price level after trade reform, and then evaluate the change in expenditures to represent the level of gain or loss in consumer's welfare. If the compensating variation is positive, the consumer's welfare is decreasing; if negative, the consumer's welfare is increasing.

Since the cost function $C(P_1, U_0)$ is the minimum expenditure necessary to maintain the level of utility U_0 given prices P_1, we can express the cost function as the product of P_1 and the compensated quantities demanded $Q^*(P_1, U_0)$. Thus, the measurement of CV can be represented as

$$CV = P_1' Q^*(P_1, U_0) - M_0$$

To measure the compensated quantities demanded, we need to know the compensated quantity changes from the initial quantities $Q_0(P_0, U_0)$. We approximate the change rate by summing up the product terms of compensated elasticity and multiplying by the change rate of price for each meat commodity.

We evaluated changes in consumer welfare under 25 different scenarios. In these scenarios, pork and broiler quantities remained the same, while the availability of both types of beef ranged from 10 percent lower to 10 percent higher in 5-percent increments. The effects of these changes are summarized in Table 6, which shows how changes in beef supply affect beef prices and consumer welfare.

In Table 6, we have used savings in meat expenditure as a measure of welfare; these savings are the opposite of the CV. As is to be expected, as beef availability expands and beef prices drop, the economic well-being of consumers rises. Also, consumer welfare is much more sensitive to the price of high-quality beef. This is also reasonable as our data set shows that consumers spend approximately five times as much on high-quality beef as they do on manufacturing-grade beef. Note further that the estimated savings are small. In the baseline we used for this simulation, per capita quarterly meat expenditures were just over $100. Our estimates imply that a 10-percent increase in the availability of all types of beef will save consumers approximately 5 percent of their meat budget.

While the estimated welfare effects of beef availability on individual consumers are small, given the number of consumers in the United States, the aggregate effects are large. For instance, savings from a 10-percent increase in the availability of both types of beef exceed $1 billion for the United States as a whole. Smaller shifts in beef availability will have smaller effects on aggregate consumer welfare, but it appears that even the smallest of shifts will change consumer welfare by hundreds of millions of dollars.

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Table 6. Changes in beef prices and consumer's welfare

Percent change in amount of manufacturing-grade beef	Percent change in amount of high-quality beef				
	–10	–5	0	5	10
	Percent change in the price of high-quality beef				
–10	7.53	4.42	1.31	–1.80	–4.90
–5	6.88	3.77	0.65	–2.46	–5.57
0	6.22	3.11	0	–3.11	–6.22
5	5.57	2.46	–0.65	–3.77	–6.88
10	4.92	1.80	–1.31	–4.42	–7.53
	Percent change in the price of manufacturing-grade beef				
–10	9.33	5.91	2.50	–0.92	–4.34
–5	8.08	4.67	1.25	–2.17	–5.59
0	6.83	3.42	0	–3.42	–6.83
5	5.59	2.17	–1.25	–4.67	–8.08
10	4.34	0.92	–2.50	–5.91	–9.33
	Per capita savings (negative CV), in dollars per quarter				
–10	–6.05	–3.44	–0.85	1.74	4.31
–5	–5.61	–3.01	–0.42	2.16	4.73
0	–5.17	–2.58	0	2.57	5.13
5	–4.75	–2.16	0.41	2.98	5.53
10	–4.33	–1.75	0.82	3.37	5.92