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Policy and programmatic decisions dealing with beef exports require good information as to the impact of exports on the domestic beef industry. This paper utilizes a partial equilibrium model of the world beef market to assess the impacts on the U.S. beef sector of increases in real income in major beef importing countries, the impacts of changes in the prices of pork and poultry products, and the impacts of changes in the price of feedgrains. A one percent increase in real GDP in Canada, Japan, Mexico, and South Korea yielded a 1.6 percent increase in U.S. exports of high-quality beef. This increase in exports leads to approximately a 29.2 million pound increase U.S. beef production on a retail weight basis. The increase in export demand also yields an increase in beef prices of approximately $0.275 per cwt. on a $120 box of beef and $0.18 per cwt on a $70 fed steer. One percent increases in the prices of pork and poultry products yield a smaller 0.8 percent increase in U.S. beef exports, but also lead to a 1.5 percent increase in U.S. imports of low-quality beef. This is due to U.S. consumers viewing low-quality beef as a substitute for pork and poultry. Finally, a one percent increase in the price of feedgrains reduces U.S. beef exports by 0.4 percent. This is due to a reduction in U.S. beef production from the increased feeding costs.

Background

Exports of U.S. beef have grown rapidly, especially in the decade of the 1990s. Figure 1 shows the quantity of beef and veal exported has increased nearly tenfold since 1980. The 1999 level of exports, 2.328 billion pounds, was equal to 9 percent of commercial beef production in the U.S. As the export quantities approach 10 percent of domestic U. S. production levels, the importance of export activity to the economic viability and future of the U.S. beef industry increases accordingly. Decisions that influence the level of checkoff funds spent on efforts to enhance beef exports and policy, and programmatic decisions in the various federal agencies that monitor and report export activity also become more important. Research on the economic impact of export activity is needed to guide policy and programmatic decisions.

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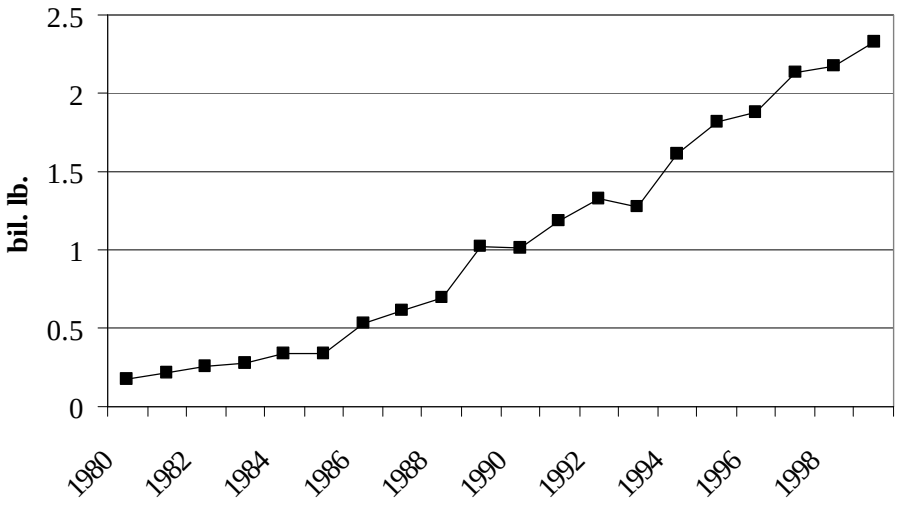

Figure 1. Quantity of U.S. Beef and Veal Exports, 1980-1999 (Carcass Weights)
Source: Livestock and Poultry Situation and Outlook, ERS, USDA, various issues.

Research dealing with the impact of U. S. beef and veal exports is limited by the available data. Typical econometric analyses require, at a minimum, accurate and complete information on quantities and prices. Varying types of beef are involved in U.S. beef exports, but the price/quantity data collected by the Foreign Agricultural Service in the U.S. Department of Agriculture offer little detail on quantity or price by category of product. Exporters complete a form that shows weight and total value of the shipment, with no detail on the exact product mix in the shipment. Most shipments are simply identified as frozen or chilled boneless beef with little added detail.

The objective of the project was to analyze the impact of beef and veal exports on the U.S. beef industry with impacts measured in terms of trade, prices, and production. To accomplish this overall objective, it is important that the analysis take appropriate account of the impact of export activities not only on demand but on supplies as well.

The Economic Setting

An increase in export activity, at a constant price, leads to an increase in aggregate demand for U.S. beef production. Figure 2 shows an increase in demand from D_dD_d, which represents domestic market demand, to D_aD_a or aggregate demand when export demand is included. The shape and position of D_aD_a is intended to suggest that the advent of export demand not only increases demand for U.S. beef but could also change the nature of the aggregate demand in terms of elasticity. If export buyers are more responsive to price changes than are domestic buyers, then the aggregate curve will "flatten out" and become more elastic (or less inelastic), especially at lower prices. Analysis of such possibilities is important to the domestic industry and to trade groups attempting to influence export movement.

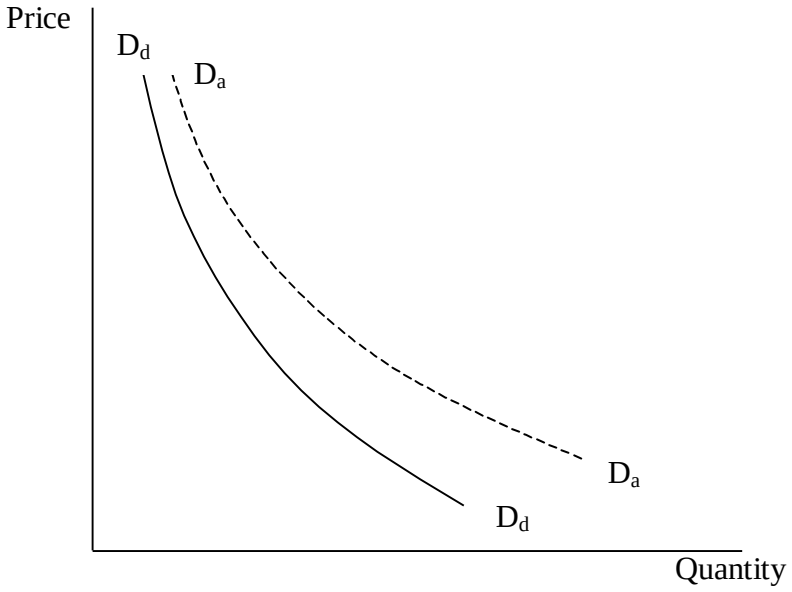

Figure 2. Demand Increasing Impact of an Expanding Beef Export Market

When domestic pipelines are jammed with a seasonal or cyclical surge in production, the presence of a more elastic export demand will be important to the market's efforts to discover a market-clearing price. If own-price demand elasticity for beef in the domestic market is –0.67, a 1.0 percent decrease in price will be associated with a 0.67 percent increase in quantity taken. If there is a significant surge in production levels, a substantial decrease in price will be required to move that increase into domestic consumption and to clear the market pipelines.

If elasticity in the export market is more elastic at, for example, -1.5 then a 1.0- percent reduction in price could prompt a 1.5 percent increase in quantity taken. This would help to clear added production through pipelines and reduce the time required for the marketplace to discover and register a new and lower market-clearing price. The net result, other things equal, could be a benefit to the domestic industry and to domestic cattle producers in terms of reduced duration and magnitude of supply driven price declines in periods of heavy supply.

Figure 3 suggests that export volume is, as would be expected, negatively related to nominal U.S. boxed beef prices (Choice grade). A single equation model fitted to the data indicates that changes in nominal quarterly prices of beef and veal exports explain nearly 80 percent of the variation in quarterly export quantity. This strong relationship provides anecdotal evidence that quantity is highly responsive to price.

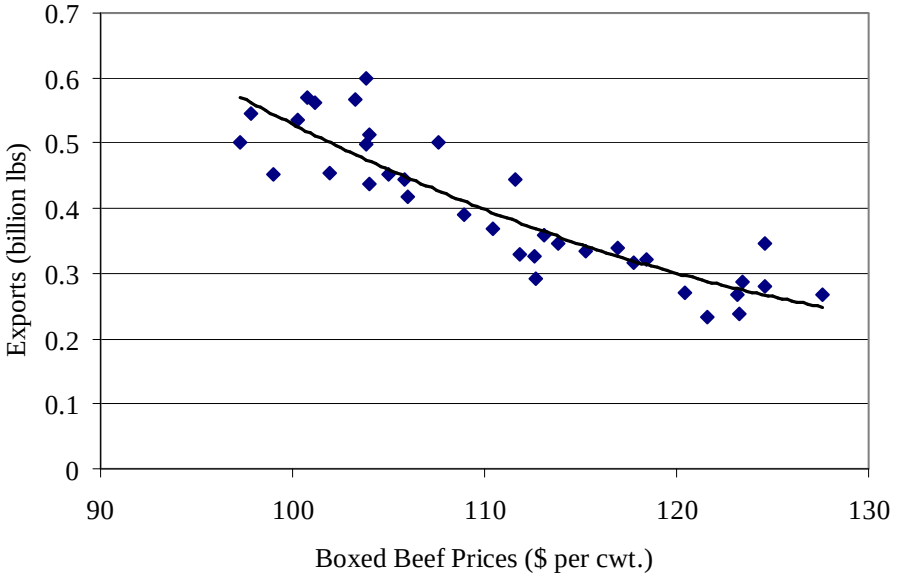

Figure 3. The Relationship Between Beef and Veal Exports and Nominal Boxed Beef Prices, by Quarters, 1990-1998
Source: Livestock and Poultry Situation and Outlook, ERS, USDA, various issues.

The possibility of a turn in the downward trend in beef demand in the domestic market has been widely discussed and documented with the demand index and research now being completed for the Cattlemen's Beef Board by researchers at Kansas State University. In 1999, increased quantities moved into the domestic market at higher nominal and inflation-adjusted prices. Export buyers had to compete in the same higher-priced beef market. The nominal quarterly prices were much higher during 1999 than they were during 1998 on export volumes that matched or exceeded levels of earlier years. The 1999 coordinates would lie well above the tight relationship shown in Figure 3, adding to the anecdotal evidence that demand for beef did, in fact, increase in 1999.

Any new source of buying strengthens demand. Most observers of the growth in beef exports across the past decade would agree that aggregate demand has been increased and that, for a given supply, beef prices in the domestic market would be higher. Choose any quantity and superimpose it on the earlier Figure 2 and the price will be where that supply and demand, as represented by D_aD_a, intersect. Price will be higher than would have been the case if demand were still as represented by D_dD_d in the domestic market alone for any fixed supply. But in the face of higher prices for beef as export demand comes into the marketplace, supply will not be "given." Supply is the schedule of quantities that will be offered by producers at alternative prices. When price is pushed up by the advent of export demand, a profit window opens as price is pushed above the average total cost (ATC) of production. Price above ATC of production generates economic rents. In the beef business, with low barriers to entry, such profit opportunities can lead to new investment in expanded production capacity and the industry supply curve shifts out and to the right. Figure 4 shows the possibilities with S_nS_n signifying a new and higher supply that pulls the price back below the initial and higher price, P_{exp}, that

export buying prompted when SS was the supply. But the important point is that supply will not be "given." The industry will respond to price incentives by moving to a larger output and a larger industry.

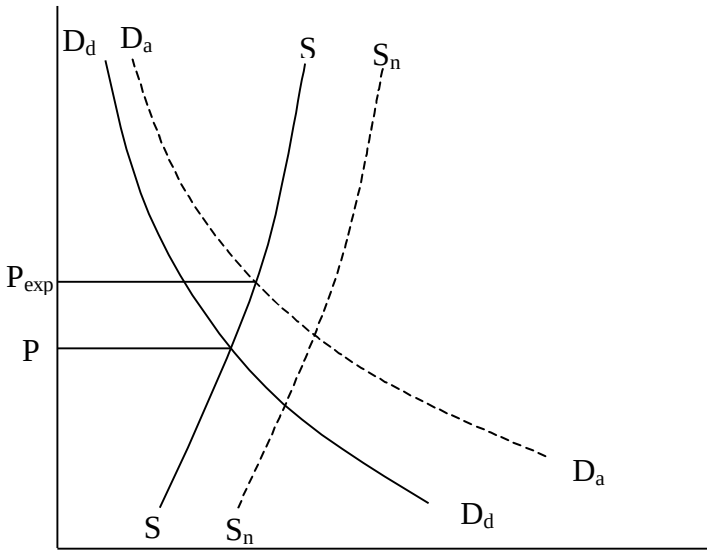

Figure 4. Price Decreasing Impact of Supply Increases Prompted by Exports that Generate a Price Increase

The Methodology Employed

Due to the absence of detailed data on price, quantity, quality and the composition of export shipments, a comparative static partial equilibrium model of world beef production, consumption, and trade is utilized rather than an econometric approach. The partial equilibrium model specifies the relevant demand and supply components of the beef sector and is designed to simulate the impacts on the U. S. beef industry of "shocks" from outside the beef sector. Examples of such shocks would be demand-shifting forces such as changes in incomes in important buying countries or changes in relative prices of substitutes, or supply shifting forces such as changes in the prices of feedgrains.

Partial Equilibrium Model of the U. S. Beef Industry

The model is comprised of eight regions: the U.S., Japan, Mexico, South Korea, Canada, Australia, New Zealand, and the rest of the world (ROW). These regions were chosen because the U.S. primarily exports beef and hides to Japan, Mexico, South Korea, and Canada and primarily imports beef from Australia, New Zealand, and Canada. The beef exported by the U.S.

is generally higher quality cuts while the beef imported by the U.S. is generally lower quality meat used in processing.

The U.S. portion of the model is comprised of three vertically linked sectors: calf production, cattle finishing, and packing. The cow-calf or calf sector produces weaned calves for input to the finishing sector using two inputs, feedgrains and a calf sector specific factor (this represents breeding stock, facilities, land, operator labor and management, etc.). The finishing sector produces slaughter cattle for input to the packing sector and uses three inputs: calves, feedgrains, and a finishing sector specific factor (facilities, labor, management, etc.). The packing sector is assumed to produce three final products: high-quality beef, low-quality beef, and hides and uses two inputs: fed cattle and a packing sector specific input (facilities, labor, management, etc.). The product mix of the packing sector is somewhat of a simplification but the value of variety meats and tallow exports is relatively small.[1] The markets for all goods are assumed to be perfectly competitive.

The non-U.S. beef industries are specified in less detail. Only an aggregate beef sector, that incorporates all growing and slaughter activities, is specified in other countries, such as New Zealand, that competes directly with the U.S. for world beef markets. This simplification is appropriate because we are interested primarily in analyzing the impact of U.S. beef exports on the U.S. beef prices and production and due to a lack of detailed production information in the non-U.S. regions. The demand equations for processed beef products in the non-U.S. regions are modeled identically to the U.S. demand equations. The supply of beef and veal and hides is specified as a monotonically increasing function of output prices (high-quality and low-quality beef prices, and hide prices).[2]

The partial equilibrium model is a system of linear differential equations describing each sector and is divided into four components: a system of demand conditions, a system of supply conditions, a system of zero profit conditions, and a system of market clearing conditions. In addition, a system of retail demand equations is specified for processed beef products. The complete model consists of 67 equations in 67 endogenous variables. There are also 12 exogenous variables defined in the model. These variables and the model equations are described in detail in Appendices A and B. Detailed descriptions of the development of the model, by sectors and in algebraic form, are available from the authors.[3]

The system of linear differential equations can be expressed in matrix notation by

$$\mathbf{A}\hat{\mathbf{x}} = \hat{\mathbf{b}}$$

[1] The relatively small value is a justification for not including variety meats and tallow, but including them would also require additional model parameters, such as income and cross-price elasticity parameters. No research that estimated such parameters could be located.

[2] The distinction between high and low quality is not Choice (high quality) and Select (low quality). Some 40 percent of U.S. fed cattle are now Select, and Select is an important part of the fresh beef market. The distinction used was "thin" meats as low quality, and U.S. production was divided into 74 percent and 26 percent for high quality and low quality, respectively, using guidelines provided by the American Meat Institute.

[3] Contact Wayne Purcell at (540) 231-7725 or purcell@vt.edu.

where **A** is a matrix of endogenous variable coefficients, $\hat{\mathbf{x}}$ is a vector of percentage changes in the endogenous variables, and $\hat{\mathbf{b}}$ is a vector containing the sum percentage changes in the exogenous variables scaled by the appropriate parameters (i.e. the right hand side of the equations listed in Appendix B). For a specified change in one or more exogenous variables, the corresponding changes in the endogenous variables are given by

$$\hat{\mathbf{x}} = \mathbf{A}^{-1}\hat{\mathbf{b}},$$

which can be solved with any standard spreadsheet software.

Data Requirements

Data on own-price and cross-price elasticities of demand, supply elasticities, income elasticities, elasticities of substitution between production inputs, cost and revenue shares, and consumption and production shares are required. To employ the model, an initial shock to one or more of the exogenous variables must also be provided.

Demand, supply, and income elasticities were taken from the Tvedt *et al*. publication, *Elasticities in World Meat Markets*. Own-price and cross-price elasticities of demand were reported for fed beef, nonfed beef, pork, and poultry in each country. Fed beef was, after examination of literature on other countries, considered to be equivalent to U.S. high-quality meat and nonfed beef to be equivalent to U.S. and other producing countries low-quality beef. Demand elasticities were not reported for fed beef in Australia and New Zealand. The U.S. fed beef elasticities were imputed to Australia and New Zealand. Own-price elasticities of demand were not always reported for hides. Coefficients assigned ranged from -0.6 in New Zealand to –1.16 in Mexico.[4] (See Appendix C for a complete list of model parameters.)

Supply elasticities were not generally reported separately for high-quality beef, low-quality beef, and hides. However, supply elasticities were reported for a generic beef product in each region. Since the production of the three beef products is inextricably linked, the same supply elasticity was used for each product.

Income elasticities were reported for fed beef, nonfed beef, pork, and poultry in each region. There was no acceptable income elasticity for Mexican high-quality beef, so the same income elasticity was used for ROW and Mexico. No income elasticities were reported for hides, and this parameter was set at 0.1 for all regions. This relatively low elasticity value reflects that the demand for hides is really a derived demand by leather manufacturers. As incomes increase, consumers will purchase more leather products, thereby increasing the demand for hides. If the per-unit input usage of hides in leather products is constant, then the income elasticity for hides is the income elasticity for leather products times the per-unit hide requirement. In the U.S., hides comprised approximately ten percent of the total cost for the

[4] These parameter estimates constitute one of the weaknesses of the study. There are very few published reports that estimate, for example, the cross elasticity between beef and pork in a country like Mexico or demand elasticities for high-quality beef in producing countries like New Zealand. Parameter estimates were sometimes adapted from available research on similar countries, and special attention was paid in the overall analysis to the sensitivity of model results to the levels of elasticity parameters employed.

leather manufacturers (1992 U.S. Input/Output table). Thus, an income elasticity of 0.1 for hides would imply an income elasticity of 1.0 for leather products.

The production and consumption shares of the three products in each country were derived via original calculations from reported data on production and consumption. The cost and revenue shares were calculated or estimated based on published data from a number of sources.

The elasticity of substitution between inputs of production was set at low levels based on knowledge of the industry and levels used in partial equilibrium research on other economic sectors. The input supply elasticities were chosen to equal 0.67 for all sectors of the beef industry in order to obtain own-price supply elasticities of approximately 1.0 for the fed cattle and 0.9 for meat products. We believe that this represents a reasonable short to intermediate run supply own-price supply response for the U.S. beef sector.

Results

Increase in Income in Importing Countries

The first simulation of the impact of exports involves a one percent increase in the real Gross Domestic Products of the major importers of beef--Japan, Mexico, Canada, and South Korea. Table 3 gives the point estimates, standard deviations, and the minimum and maximum values of the point estimates for U.S. beef exports, U.S. beef imports, beef production, and beef prices. In addition, Table 3 provides an estimate of the probability of the point estimates taking on a negative value (based on a sensitivity analysis that is formally discussed later).

Table 3. Effects of a One Percent Increase in the Gross Domestic Products of the Major Importers of U.S. Beef and Veal (Japan, Mexico, Canada, and South Korea)

Variable	Point Estimate	Standard Deviation	Minimum	Maximum	Probability Less Than Zero[a]
			Percentage Change		
U.S. Trade					
High-Quality Beef (Exports)	1.63	1.18	-26.28	3.72	0.03
Low-Quality Beef (Imports)	-0.36	0.56	-1.19	8.01	0.81
U.S. Beef Production	0.16	0.17	0.04	3.39	0.00
Prices					
High-quality Beef	0.23	0.29	0.07	7.04	0.00
Low-quality Beef	0.17	0.36	0.05	7.27	0.00
U.S. Fed Cattle	0.16	0.26	0.04	6.56	0.00
U.S. Calves	0.22	0.36	0.05	8.68	0.00

[a] This represents the probability of the point estimate taking on a negative value based on a sensitivity analysis of the model parameters.

The increase in real GDP in Canada, Japan, Mexico, and South Korea initially increases these countries demand for high quality beef, low quality beef, and hides, based on the specified

income elasticities (see Appendix C). Because the demand for high quality beef is more responsive to changes in income than low quality beef and hides, there is a disproportionate increase in the demand for high-quality beef compared to low-quality beef and hides. Japan, Mexico, and South Korea are the largest importers of high-quality beef. Because their domestic beef industries are either very small, as is the case for Japan and South Korea, or does not respond significantly to price changes, as is the case for Mexico, the increase in demand for high and low quality beef is satisfied through increased imports by these countries. The U.S. provides almost all of the increase in imports of high-quality beef by these countries because the beef supply in the U.S. is much more responsive to price changes than in other major exporting countries.

Because exports comprise approximately ten percent of U.S. beef production, the overall increase in U.S. beef production is approximately one-tenth the increase in exports. On a 25 billion lb. U.S. production base (carcass weight) or about 18.25 billion lbs. retail weight, this would mean an increment of 29.2 million lbs. retail weight or about 53,284 fed steers or heifers weighing some 1200 lbs. and producing 548 lbs. of boneless retail beef cuts per animal. An added 53,284 slaughter animals would require 65,000 to 70,000 more beef cows in the cow herd, depending on calving percentage and whether heifers are being held for herd replacement. If 70,000 more cows *are* needed, this would mean an increase of 0.002 percent increase in a 35 million head beef cow herd.

In addition, the increase in U.S. beef production provides more trimmings and low-quality cuts from an expanded cattle slaughter in the domestic market. Therefore, less low-quality processing beef needs to be imported into the U.S. market.

The increase in export demand for U.S. high-quality beef leads to a 0.23 percent increase in the price of high-quality beef, or about $.275 per cwt. on a $120 per cwt. boxed beef market. The price of low-quality beef also increases, but by a slightly smaller amount than high-quality beef. This is because the income elasticities for low-quality beef are much lower than for high quality beef, implying a smaller increase in the demand for low-quality beef as incomes increase. The price of fed cattle increases by 0.16 percent, around $.11 to $.12 per cwt. on a $70 fed steer market. The reason why fed cattle prices have a slightly smaller increase, compared to high-quality and low-quality beef, is because the price of hides decreased. Thus, the packer cannot afford to pay the same percent increase for fed cattle as they received for high-quality and low-quality beef.

The reliability of estimates from any partial equilibrium model depends on the reliability of the model's parameter values.[5] Because of the great deal of uncertainty about the value for many of the parameters in this model, a sensitivity analysis is conducted. Each elasticity in Appendix C is assumed to be a random variable with a uniform distribution. The end points for each distribution are plus and minus 75 percent of the base elasticity value. The sensitivity analysis is conducted by randomly drawing a value for each elasticity from a uniform distribution and then resolving the model. This procedure is replicated 1,000 times using 1,000 different sets of elasticity values. The minimum and maximum values given in Table 3 were

[5] Of course, the reliability of the model also depends on the model structure, such as assumptions concerning producer behavior, being correct.

determined using this procedure. In the case of a one percent increase in income in the major beef importing countries, the prices of high-quality and low-quality beef always increase, regardless of the model parameters chosen. In addition, U.S. beef production always increased. While an occasional extreme result is generated, the vast majority of the estimates were in a very close range around the point estimate reported. Figure 5 presents the frequency histogram for the percentage change in U.S. high-quality beef exports from a one percent increase in the real GDP in Japan, Mexico, Canada, and South Korea.[6] As shown in Figure 5, it is possible for the U.S. exports of high-quality beef trade to decrease when real income increases in the major beef importing countries. This scenario occurs when U.S. consumption of high-quality beef increases instead of decreasing, where decreasing consumption is the general case. The increase in U.S. high-quality beef consumption occurs when the own-price demand elasticity for high-quality beef is relatively low and the cross-price elasticity between high-quality beef and low-quality beef is relatively high. Because the prices of high-quality and low-quality beef increase, the cross-price effect dominates the own-price effect, causing consumption of high-quality beef to increase.

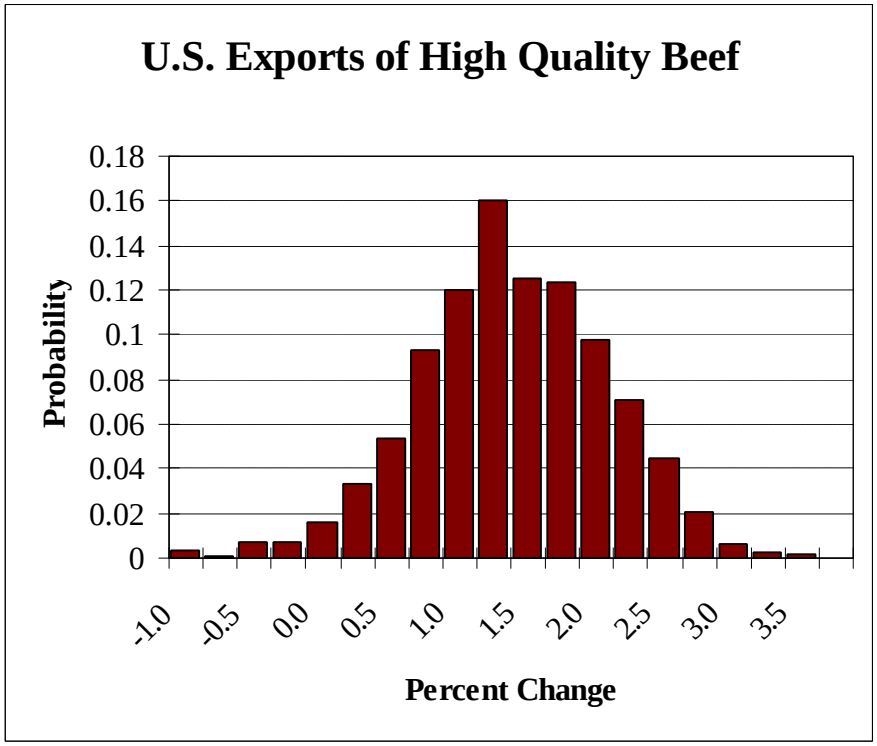

Figure 5. Frequency Histogram for Percentage Change in U.S. High-Quality Beef Exports from a One Percent Increase in GDP in Japan, Mexico, Canada, and South Korea

[6] Sensitivity tests on all the results are available from the authors. Contact Wayne Purcell at (540) 231-7725 or purcell@vt.edu.

Increase in the Prices of Beef Substitutes

Table 4 shows the results of a one percent increase in the price of pork and chicken in the world market. The effect of increased prices for substitutes on the world beef sector is determined by the relative differences in the cross-price demand elasticities for high-quality and low-quality beef in all regions. In the U.S., low-quality beef is a much stronger substitute for pork and poultry than is high-quality beef, with high-quality beef being a complement with poultry. Thus, in the U.S., consumers increase their consumption of low-quality beef while decreasing their consumption of high-quality beef. The cross-price elasticities for Australian and New Zealand are relatively small so consumers in those countries respond very little to pork and poultry price changes. In Canada, pork is a strong substitute for high-quality beef, so high-quality beef consumption increases by approximately one percent. In Mexico and ROW, high-quality beef is a weak substitute for pork and poultry, while low-quality beef is a complement with pork and poultry. Thus, the consumption of high-quality beef increases while the consumption of low-quality beef decreases in those regions. Finally, in Japan and South Korea, high-quality beef is a complement with pork and poultry while low-quality beef is a complement with pork but a substitute for poultry. In both of these countries, the consumption of high-quality beef decreases while the consumption of low-quality beef increases (the substitute relationship with poultry offsets the complementary relationship with pork).

Table 4. Effects of a One Percent Increase in the Prices of Beef and Veal Substitutes (Pork and Poultry)

Variable	Point Estimate	Standard Deviation	Minimum	Maximum	Probability Less Than Zero[a]
			Percentage Change		
U.S. Trade					
High-Quality Beef (Exports)	0.78	0.62	-15.18	1.56	0.03
Low-Quality Beef (Imports)	1.54	0.46	0.36	6.09	0.00
U.S. Beef Production	0.05	0.09	-0.21	1.79	0.13
Prices					
High-quality Beef	0.05	0.15	-0.21	3.85	0.10
Low-quality Beef	0.06	0.20	-0.38	4.18	0.23
U.S. Fed Cattle	0.05	0.14	-0.21	3.63	0.13
U.S. Calves	0.06	0.19	-0.27	4.81	0.13

[a] This represents the probability that the point estimate takes on a negative value based on a sensitivity analysis of the model parameters.

The 0.78 percent increase in U.S. exports of high-quality beef may be attributed to three causes. First, because of the strong substitution between high-quality beef and pork in Canada, which is the second largest exporter of high-quality beef, Canadian consumption of high-quality beef increases dramatically. Thus, less high-quality beef is available for export from Canada. Second, the ROW is a large consumer and importer of high-quality beef. Because of the relative size of this region, even a small increase in high-quality beef consumption leads to a relatively large increase in high-quality beef imports. Finally, the U.S. beef supply elasticity is much

larger than the other exporting countries, implying that the U.S. will have a larger supply response. Thus, the U.S. captures a large portion of the increase in high-quality beef exports.

To meet the increase in U.S. high-quality beef exports and the increase in U.S. low-quality beef consumption, U.S. beef production also increases. However, because high-quality beef and poultry are complements in the U.S., high-quality beef consumption declines. This decrease in U.S. consumption offsets a portion of the increased export demand, yielding a smaller increase in total U.S. beef production. Finally, because of the increase in U.S. consumption of low-quality beef, and the relatively small increase in U.S. beef production, U.S. imports of low-quality beef increase by 1.54 percent.

In contrast to the first experiment, the direction of the changes in prices and quantities are much more sensitive to the set of parameters chosen. Thus, there is a higher level of uncertainty of how changes in world pork and poultry prices will affect the U.S. beef sector. For example, depending on the values of the cross-price demand elasticities in each region, U.S. beef production could actually decrease. (Figure 6 shows the frequency histogram for U.S. beef production for this experiment). If high-quality beef is a strong enough complement with chicken in the U.S., then domestic beef consumption could decrease. Similarly, strong complementary relationships between high-quality beef and pork and poultry in Japan and South Korea could reduce their demand for high-quality beef exports, which would reduce the demand for U.S. beef. Out of the 1,000 replications of the model using different sets of parameter values, U.S. beef production decreased 132 times.

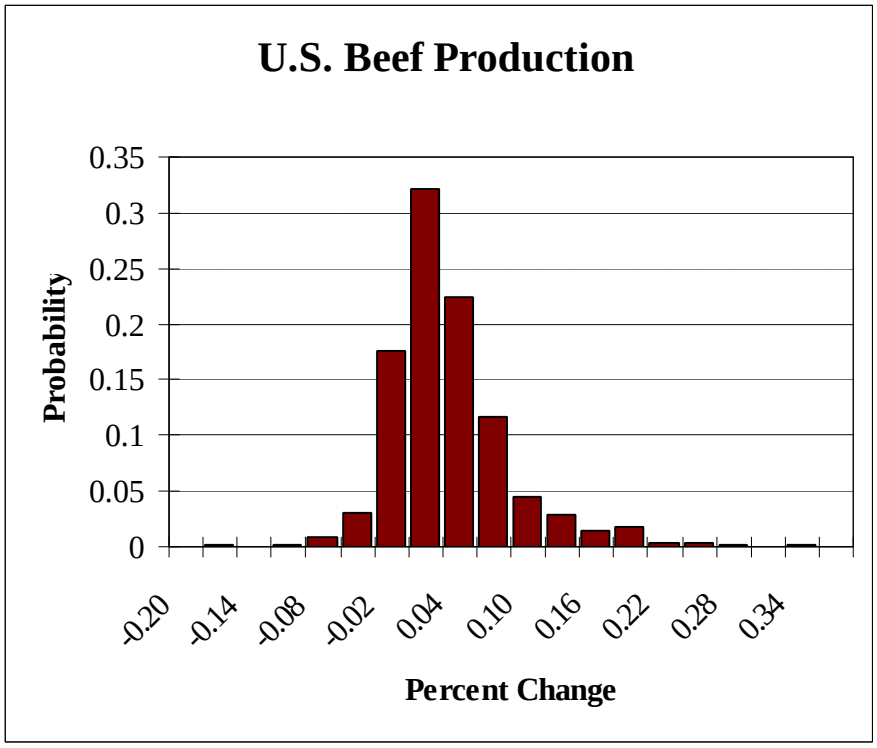

Figure 6. Frequency Histogram for Percentage Change in U.S. Beef Production from a One Percent Increase in the Price of Pork and Poultry

Increase in the Price of Feedgrains

Table 5 shows the results from a supply side shock associated with a one percent increase in price of feedgrains. The increase in the price of feedgrains increase the costs for the cow-calf and cattle finishing sector in the U.S., which, at constant output price, will lead to a reduction in U.S. beef production. Similarly, the cross-price supply elasticities for feedgrains are negative for all other regions in the model (see Appendix C). This initial decrease in world beef supply leads to an excess demand for beef at initial beef prices. Thus, the prices of high-quality and low-quality beef rise. However, this rise in beef prices will also illicit a supply response by producers in all regions. If the own-price supply elasticity is relatively large compared to the feedgrain cross-price supply elasticity in a given region, beef production can actually increase. This is the case for all regions except the U.S., Canada, and Mexico, although the increases in production are relatively small, approximately 0.05 percent. Overall, world production of high-quality beef and low-quality beef decrease by 5 million and 1.7 metric tons respectively (or 0.02 percent and 0.008 percent). In the U.S., the ratio between the own-price and cross-price supply elasticities is approximately four to one; however, the increase in high-quality and low-quality beef prices is only one-fifth the size of the price increase in feedgrains. Thus, the increase in supply from the price increase is not enough to offset the decrease in supply from in the increase in the price of feedgrains, so U.S. beef production declines by 0.06 percent, or about 11 million lbs. of retail weight.

Table 5. Effects of a One Percent Increase in the Price of Feedgrains

Variable	Point Estimate	Standard Deviation	Minimum	Maximum	Probability Less Than Zero[a]
			Percentage Change		
U.S. Trade					
High-Quality Beef (Exports)	-0.40	0.82	-20.19	1.04	0.84
Low-Quality Beef (Imports)	-0.17	0.51	-1.12	6.80	0.66
U.S. Beef Production	-0.06	0.14	-0.20	2.84	0.81
Prices					
High-quality Beef	0.21	0.22	0.07	4.96	0.00
Low-quality Beef	0.21	0.30	0.05	6.22	0.00
U.S. Fed Cattle	0.26	0.19	0.13	4.69	0.00
U.S. Calves	0.02	0.26	-0.16	5.88	0.32

[a] This represents the probability that the point estimate takes on a negative value based on a sensitivity analysis of the model parameters.

Due to the decrease in world production of beef, the prices of high-quality and low-quality beef both increase by 0.21 percent, or approximately $0.25 per cwt. on a $120 per cwt. box of beef. Because of the increase in feed costs, U.S. fed cattle prices increase by 0.26 percent, or $0.18 per cwt on a $70 per cwt fed steer. However, the price of calves in the U.S. remains virtually constant. This is because the cow-calf industry in the U.S. uses relatively little feedgrains, implying a much smaller increase in production costs than is the case for the finishing industry. It is interesting to note that in almost one-third of the model replications, the price of calves in the U.S. decreased (compared with fed cattle prices that never decreased). This

happens because as U.S. beef production decreases, the demand for calves also decreases, which leads to a reduction in the demand for the specific factor in the calf sector. If the supply of this factor is relatively inelastic, then its price could decrease enough to offset the increase in cost from the increase in the feedgrain price.

U.S. exports of high-quality beef and imports of low-quality beef both decline in this experiment. Imports of low-quality beef decline because the increase in the price of low-quality beef decreases U.S. low-quality beef consumption by 0.1 percent, more than the decrease in U.S. beef production. U.S. exports of high-quality beef decline because the increase in the price of high-quality beef leads to a 5 million metric ton decrease in the world consumption of high-quality beef. However, as shown in Table 5, it is possible for U.S. imports of low-quality beef and exports of high-quality beef to increase. If U.S. beef production decreases by more than the decrease in U.S. low-quality beef consumption, the imports of low-quality beef must increase. This occurred in approximately one-third of model replications. U.S. exports of high-quality beef could increase if the substitution effect between high-quality and low-quality beef is strong enough in other regions to dominate the own-price effect. Not surprising, this happens much more infrequently, in approximately 16 percent of the model replications.

Rankings of Relative Impacts on U.S. Beef Sector

Tables 6 through 8 presents the relative rankings of the impacts on the U.S. beef sector from changes in real GDP, the price of substitutes, and feedgrain prices. Table 6 gives the relative impacts on U.S. beef trade of a one percent exogenous increase in real GDP in Japan, Mexico, Canada, and South Korea; a one percent increase in the price of pork and poultry; and a one percent increase in the price of feedgrains. Considering the absolute values of the percentage changes in U.S. high-quality beef exports, an increase in real GDP in Japan and Mexico have the largest impacts on U.S. exports because they are the largest importers of high-quality beef. An increase in the price of poultry or pork has the largest impact on U.S. low-quality beef imports because of the strong substitution effects in U.S. consumption between those products and low-quality beef.

Table 6. Relative Impacts on U.S. Beef Trade of Various Exogenous Shocks

	U.S. High-Quality Beef Exports		U.S. Low-Quality Beef Imports	
One Percent Increase In:	Percent Change	Rank	Percent Change	Rank
Japanese GDP	0.78	1	-0.04	6
Mexican GDP	0.57	2	-0.24	3
Poultry Price	0.51	3	0.79	1
Feedgrain Prices	-0.40	4	-0.17	4
Pork Price	0.28	5	0.74	2
Canadian GDP	0.15	6	-0.02	7
South Korean GDP	0.12	7	-0.05	5

A change in the price of feedgrains has the largest impact on the price of high-quality beef and low-quality beef (see Table 7). This reflects the relative importance of feedgrains in the cost of producing beef in the U.S. and Canada. The next three largest impacts are from increases

in Japanese and Mexican GDP and from an increase in the price of pork. Again, this is due to Japan and Mexico being relatively large importers of high-quality beef and beause pork is a relatively strong substitute for beef in some regions.

Table 7. Relative Impacts on High-Quality and Low-Quality Beef Prices of Various Exogenous Shocks

	U.S. High-Quality Beef Exports		U.S. Low-Quality Beef Imports	
One Percent Increase In:	Percent Change	Rank	Percent Change	Rank
Feedgrain Prices	0.21	1	0.21	1
Japanese GDP	0.11	2	0.06	4
Mexican GDP	0.08	3	0.08	3
Pork Price	0.08	4	0.10	2
Poultry Price	-0.03	5	-0.03	5
South Korean GDP	0.02	6	0.02	6
Canadian GDP	0.02	7	0.01	7

Finally, Table 8 shows the rankings of the relative impacts on U.S. beef production, fed cattle price, and calf price. As with the previous rankings, a change in feedgrain prices, the pork price, Japanese GDP, and Mexican GDP have the largest impact. With the exception of the impact of an increase in feedgrain prices on the fed cattle price, there are only very small differences in the absolute values of the percentage changes for all of the experiments.

Table 8. Relative Impacts on U.S. Beef Production and the Prices of Fed Cattle and Calves

	U.S. Beef Production		U.S. Fed Cattle Price		U.S. Calf Price	
One Percent Increase In:	Percent Change	Rank	Percent Change	Rank	Percent Change	Rank
Pork Price	0.07	1	0.07	2	0.09	1
Mexican GDP	0.07	1	0.06	4	0.09	1
Japanese GDP	0.06	3	0.07	2	0.09	1
Feedgrain Prices	-0.06	3	0.26	1	0.02	5
Poultry Prices	-0.03	5	-0.03	5	-0.03	4
South Korean GDP	0.01	6	0.01	7	0.02	5
Canadian GDP	0.01	7	0.02	6	0.02	5

Summary and Conclusion

Export activity exerts a significant influence on the U.S. beef industry. Influence takes the form of changes in production and prices in the domestic industry and on imports of low-quality beef.

The largest impact on U.S. exports of high-quality beef is associated with an increase in real income in major beef importing countries. An increased in real GDP of one percent in these countries lead to a 1.63 percent increase in exports of high-quality beef. This increase represents approximately a 29.2 million-pound increase in retail weight of beef, requiring some 53,284

additional 1200-lb steers or heifers and 65,000 to 70,000 more cows in the beef herd. This increase in exports of high-quality beef would also prompt up to a 0.23 percent increase in box-level price of high-quality beef. This is about $0.275 per cwt. on a $120 boxed beef market, and it would be $0.16 to $0.17 per cwt. on a $70 fed steer market.

The simulation results reported are intended to represent short-run to intermediate-run changes in the world beef market. This is a reflection of the partial equilibrium nature of the model. Thus, the length of run for the model is long enough for the beef markets to adjust to a new equilibrium but not long enough for substantial changes to occur in other markets/sectors in the global economy. Based on this shorter time frame, we have chosen demand and supply elasticities that are in general fairly inelastic. Particularly on the supply side, this reflects the limited ability for producers to be able to respond to price changes due to biological and time constraints. In addition, because the model is a system of first-order differential equations (i.e., a linear approximation), the model results are only valid for "small" changes in the exogenous variables. Using relative large changes in the exogenous variables increases the potential for substantial approximation error in the results.

Better measurement of price of export items is needed to allow more refined analysis. The elasticities (demand, supply, cross, input substitution) used in the partial equilibrium analysis were gleaned from a very limited research literature. This type of analysis would be more effective if measurement of impacts if the elasticity estimates were of more recent tenure and more consistent, in terms of how they were estimated, across countries. Concern about the efficacy of these important elasticity parameters prompted an extensive effort to test the sensitivity of the results. The tests indicate the estimates are generally reliable and useful. But there is little doubt the industry would be well served in the future from better and more complete collection and reporting of quantity, grade or quality, and price data associated with export activity.

Relevant Literture

International Financial Statistics Yearbook. International Monetary Fund, various issues.

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Appendix A: Description of Variables

As outlined above, the model consists of 67 equations in 67 endogenous variables and 12 exogenous variables. Following is a list of the endogenous and exogenous variables used in the model.

Endogenous Variables:

- x_{hq}^{i} *(8)* quantity of high-quality beef and veal consumed in region *i*
- x_{lq}^{i} *(8)* quantity of low-quality beef and veal consumed in region *i*
- x_{h}^{i} *(8)* quantity of hides consumed in region *i*
- x_f *(1)* input demand for fed cattle in the U.S.
- x_c *(1)* input demand for weaned calves in the U.S.
- x_{zc} *(1)* input demand for non-grain inputs by the cow-calf sector in the U.S.
- x_{zf} *(1)* input demand for non-calf inputs by the feeder cattle sector in the U.S.
- x_{zp} *(1)* input demand for non-cattle inputs by the processing sector in the U.S.
- y_{hq}^{i} *(8)* production of high-quality beef and veal in region *i*
- y_{lq}^{i} *(8)* production of low-quality beef and veal in region *i*
- y_{h}^{i} *(8)* production of hides in region *i*
- y_{p}^{i} *(1)* production of processed beef products in region *i*
- y_f *(1)* production of fed cattle in the U.S.
- y_c *(1)* production of calves in the U.S.
- y_{zc} *(1)* supply of non-grain inputs to the cow-calf sector in the U.S.
- y_{zf} *(1)* supply of non-calf inputs to the feeder cattle sector in the U.S.
- y_{zp} *(1)* supply of non-cattle inputs to the processing sector in the U.S.
- p_{hq} *(1)* price of high-quality beef and veal in the U.S.
- p_{lq} *(1)* price of low-quality beef and veal in the U.S.
- p_h *(1)* price of hides in the U.S.
- p_f *(1)* price of fed cattle in the U.S.
- p_c *(1)* price of weaned calves in the U.S.
- P_{zc} *(1)* price of non-grain inputs to the cow-calf sector in the U.S.
- P_{zf} *(1)* price of non-calf inputs to the feeder cattle sector in the U.S.
- P_{zp} *(1)* price of non-cattle inputs to the processing sector in the U.S.

Exogenous Variables:

- p_{pk} *(1)* price of pork in the U.S.
- p_{ch} *(1)* price of poultry in the U.S.
- p_g *(1)* price of feedgrains in the U.S.
- p_{ls} *(1)* price of leather substitutes in the U.S.
- I^{i} *(8)* gross domestic product in region *i*

Appendix B: Reduced System of Equations

In this appendix the system of equations is expressed in simplified form with all endogenous variables listed on the left hand side and all exogenous variables listed on the right hand side. In addition, a definition is given of each parameter.

Equations 1 – 8: $$\hat{x}^i_{hq} - h^i_{hqhq}\hat{p}_{hq} - h^i_{hqlq}\hat{p}_{lq} = h^i_{hqpk}\hat{p}_{pk} + h^i_{hqch}\hat{p}_{ch} + e^i_{hq}\hat{I}^i$$

Equations 9 – 16: $$\hat{x}^i_{lq} - h^i_{lqlq}\hat{p}_{lq} - h^i_{lqhq}\hat{p}_{hq} = h^i_{lqpk}\hat{p}_{pk} + h^i_{lqch}\hat{p}_{ch} + e^i_{lq}\hat{I}^i$$

Equations 17 – 24: $$\hat{x}^i_{h} - h^i_{hh}\hat{p}_{h} = h^i_{hls}\hat{P}_{ls} + e^i_{h}\hat{I}^i$$

Equation 25: $$\left(n_{zf} + c_{gf}\, s_{gzf}\right)\hat{P}_{zf} - n_{zp}\hat{P}_{zp} = c_{gf}\, s_{gzf}\,\hat{p}_g$$

Equation 26: $$\left(n_{zc} + c_{gc}\, s_{gzc}\right)\hat{P}_{zc} - n_{zp}\hat{P}_{zp} = c_{gc}\, s_{gzc}\,\hat{p}_g$$

Equation 27: $$r_{hq}\hat{P}_{hq} + r_{lq}\hat{P}_{lq} + r_h\hat{P}_h - c_{zp}\hat{P}_{zp} - c_{fp}c_{zf}\hat{P}_{zf} - c_{fp}c_{cf}c_{zc}\hat{P}_{zc} = \left(c_{fp}c_{cf}c_{gc} + c_{fp}c_{gf}\right)\hat{p}_g$$

Equations 28 – 34: $$\hat{y}^{i*}_{hq} - n^{i*}_{hq}\hat{P}_{hq} = 0$$

Equations 35 – 41: $$\hat{y}^{i*}_{lq} - n^{i*}_{lq}\hat{P}_{lq} = 0$$

Equations 42 – 48: $$\hat{y}^{i*}_{h} - n^{i*}_{h}\hat{P}_{h} = 0$$

Equation 49: $$\sum_i j^{\,i}_{hq}\hat{x}^i_{hq} - \sum_{i*} f^{i*}_{hq}\hat{y}^{i*}_{hq} - f^{us}_{hq}n_{zp}\hat{P}_{zp} = 0$$

Equation 50: $$\sum_i j^{\,i}_{lq}\hat{x}^i_{lq} - \sum_{i*} f^{i*}_{lq}\hat{y}^{i*}_{lq} - f^{us}_{lq}n_{zp}\hat{P}_{zp} = 0$$

Equation 51: $$\sum_i j^{\,i}_{h}\hat{x}^i_{h} - \sum_{i*} f_{h}\hat{y}^{i*}_{h} - f^{us}_{h}n_{zp}\hat{P}_{zp} = 0$$

Parameter Definitions:

h_{jk}^{i} : Price elasticity of demand between commodities *j* and *k* in region *i*

e_{j}^{i} : Income elasticity of demand with respect to the price of commodity *j* in region *i*

n_{j}^{i*} : Supply elasticity of commodity *j* in country *i**

n_{zp} : Supply elasticity of non-cattle inputs to the U.S. packing sector

s_{gzc} : Elasticity of substitution between feedgrains and other inputs in the U.S. calf sector

s_{gzf} : Elasticity of substitution between feedgrains and other inputs in the U.S. finishing sector

r_j : Revenue share of commodity *j* in the U.S. packing sector

c_{fp} : Cost share of cattle in the U.S. packing sector

c_{cf} : Cost share of calves in the U.S. finishing sector

c_{gc} : Cost share of feedgrains in the U.S. calf sector

c_{gf} : Cost share of feedgrains in the U.S. finishing sector

c_{zp} : Cost share of other inputs in the U.S. packing sector

c_{zf} : Cost share of other inputs in the U.S. finishing sector

c_{zc} : Cost share of other inputs in the U.S. calf sector

f_{j}^{i} : Share of world production of good *j* in region *i*

j_{j}^{i} : Share of world consumption of good *j* in region *i*

Appendix C. Elasticities, Production and Consumption Shares, and Cost and Revenue Shares Used in the Partial Equilibrium Analysis

Elasticities

	U.S.	Japan	Mexico	Korea	Canada	Aus.	N.Z.	ROW
Price Elasticities of Demand								
hqhq	-0.774	-0.036	-0.111	-0.036	-1.840	-0.774	-0.774	-0.111
hqlq	0.728	0.026	0.046	0.026	0.757	0.728	0.728	0.046
hqpk	0.034	-0.184	0.022	-0.184	1.038	0.034	0.034	0.022
hqch	-0.104	-0.031	0.027	-0.031	0.046	-0.104	-0.104	0.027
lqhq	1.292	1.279	0.013	1.279	0.005	1.292	1.292	0.013
lqlq	-1.816	-0.785	0.005	-0.785	-0.075	-0.027	-0.027	0.005
lqpk	0.364	-0.709	-0.014	-0.709	0.039	-0.010	-0.010	-0.014
lqch	0.224	0.843	-0.114	0.843	0.016	0.004	0.004	-0.114
hh	-0.700	-1.000	-1.160	-0.800	-0.800	-0.780	-0.600	-0.700
Own-Price Supply Elasticities								
hq	0.91	0.977	0.007	0.977	0.609	0.421	0.421	0.244
lq	0.91	0.977	0.007	0.977	0.609	0.421	0.421	0.244
H	0.91	0.977	0.007	0.977	0.609	0.421	0.421	0.244
Feedgrain Cross-Price Supply Elasticities								
hq	0.24	-0.15	-0.05	-0.15	-0.15	-0.05	-0.05	-0.05
lq	0.24	-0.15	-0.05	-0.15	-0.15	-0.05	-0.05	-0.05
H	0.24	-0.15	-0.05	-0.15	-0.15	-0.05	-0.05	-0.05
Income Elasticities								
hq	0.5	1.5	1.5	1.5	0.5	0.5	0.5	1.0
lq	0.2	0.5	0.5	0.5	0.2	0.2	0.2	0.35
H	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Consumption and Production Shares and Initial Trade Levels

	U.S.	Japan	Mexico	Korea	Canada	Aus.	N.Z.	ROW
Consumption Shares								
hq	0.304	0.043	0.031	0.007	0.026	0.011	0.003	0.576
lq	0.200	0.018	0.057	0.012	0.017	0.020	0.003	0.674
h	0.147	0.033	0.065	0.065	0.009	0.016	0.004	0.662
Production Shares								
hq	0.339	0.016	0.024	0.005	0.034	0.030	0.014	0.538
lq	0.131	0.005	0.054	0.010	0.013	0.055	0.011	0.720
h	0.241	0.008	0.039	0.008	0.020	0.042	0.011	0.631
Initial Trade Levels (1,000 Metric Tons)								
hq	1138	-691	-169	-49	247	511	288	-600
lq	-1385	-266	-29	-30	-69	766	192	1373
h	384	-102	-105	-233	48	106	29	-127

Elasticities of Supply, Elasticities of Substitution, Cost Shares, and Revenue Shares for the U.S. Beef Industry

	Cow-Calf	Cattle Feeder	Processing
Elasticity of Supply for Other Inputs			
	0.67	0.67	0.67
Elasticity of Substitution Between Other Inputs and Feedgrains			
	0.05	0.1	-
Cost Shares			
Calves	-	0.7	-
Cattle	-	-	.8
Feedgrain	0.1	0.25	-
Other Inputs	0.9	0.05	.2
Revenue Shares			
High-quality Beef	-	-	0.64
Low-quality Beef	-	-	0.23
Hides	-	-	0.13