Implications of the North American Free Trade Agreement for Long-term Adjustments in U.S.-Mexican Beef Production and Trade

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Dale Jorgenson provided data on the U.S. leather industry.

Abstract

Mexico and the United States have a long history of substantial trade in cattle and beef. The enactment of a NAFTA, and the subsequent elimination of tariffs and non-tariff trade barriers, will alter that trade balance. In the short run, this will result in increased imports of feeder cattle from Mexico to the United States and increased exports of beef. In the longer run, technology transfers that reduce Mexico's cost of beef production may result. Mexico could become a net beef exporter to the United States with accompanying shifts in beef cow herd size.

Implications of North American Free Trade Agreement for Long-term Adjustments in U.S.-Mexican Beef Production and Trade

North America is in the midst of forming one of the world's largest free trade areas. The Canada-U.S. Free Trade Agreement was signed in 1988, and signing of the North American Free Trade Agreement (NAFTA) between the United States and Mexico completes the major agreements for the trading area.

The agreements for a free trading area are small compared to those being undertaken by the European Community as it attempts a complete integration (free trade, free labor mobility, common currency, and common monetary and fiscal policies). The general provisions of NAFTA are (1) to replace nontariff trade barriers with tariffs (which are more favorable to trade under a range of economic conditions) and (2) then gradually reduce and eliminate all tariffs between the United States, Canada, and Mexico. Nontariff barriers, which are implemented largely through health and sanitary standards and general grades and standards for products, are to be removed immediately, except for special provisions to be worked out over the phase-in period. All tariffs on agricultural products are, in principle, subject to elimination under a time schedule. Thus, some will be reduced immediately and others will face slow reductions.

Before NAFTA, Mexico's principal agricultural exports to the United States included live cattle (primarily feeder cattle) and the U.S.'s principal agricultural exports to Mexico included feed grains, oilseeds, live cattle (breeding stock), and meats and hides. Thus, predictions of immediate effects of NAFTA suggest larger quantities of these commodities being traded (see USDA 1993; CAST 1993; Hamilton 1991; Rosson et al. 1993). The long-term impacts of NAFTA for the U.S. cattle industry might, however, be considerably different (e.g., see Hueth, O'Mara, and Just 1993) and are of considerable interest to U.S. cattle and feed grain producers (e.g., see Sobba 1993).

Earlier studies of NAFTA effects on the U.S. beef industry have primarily focused on growth in Mexico's demand for beef but ignored changes in the supply function of Mexican beef (e.g., Rosson et al., Hamilton 1991; USDA 1993). To explore this facet, we believe that it is useful to organize the beef industry of both countries into three sectors: cow-calf or reproduction, post-weaning or stocker and feeder production, and meat packing. Earlier studies of NAFTA effects on the beef industry have ignored the meat packing sector and technical change in Mexican beef production. However, the importance of technology transfer in U.S. agriculture has been demonstrated by Huffman and Evenson (1993). We believe that over the long term, international technology transfers in each of these sectors will play a key role in deciding how the benefits of NAFTA are distributed among the U.S. and Mexican beef industries.

Mexico currently has fewer than a dozen modern meat packing plants, accounting for roughly 20 percent of the animals slaughtered (by weight). As Mexico's economy grows following NAFTA, one reasonable possibility is that modern U.S.-style meat packing plants will be built in Mexico, potentially through foreign capital investments. Furthermore, beef production technology, including cattle genetics, will change in Mexico to accommodate the new meat packing technology. Key factors driving these potential technology transfers are the large labor cost share for meat packing, use of low-skilled labor, a substantial Mexican wage advantage over the United States, and relatively low transport costs.

This paper examines the potential impacts of NAFTA on the U.S. and Mexican beef industries, where each country's industry is divided into three interlinked sectors. Equations have been fitted to U.S. data to obtain new estimates of demand functions for meat and hides and supply functions for the cow-calf, post-weaning, and meat packing sectors. We have scaled our U.S. beef industry model so that it is reasonable to assume that the same functions can be applied to the Mexican beef industry. Nation-specific information is used for exogenous variables, and the model is used to simulate likely effects of NAFTA-associated changes in slaughter weights and productivity, number of modern meat packing plants, and Mexican wage rates. The output from our analysis is a comparison of pre- and post-NAFTA prices and quantities for inputs and outputs of the U.S. and Mexican beef industries. As such, this analysis ignores a much larger set of regional effects that may arise within the two countries following NAFTA.

National Beef Industry Model

The model of the beef industry is composed of aggregate demand and supply functions. The supply component has three sectors as summarized in Figure 1. The complete model is described by a set of stock and flow equations for quantities and a set of price and cost equations.

Beef Demand

The beef industry is assumed to have two final products—beef(meat) and hides. The national aggregate demand functions for these products are:

(1) $$Q_t^B = D_B(P_t^B, P_t^P, P_t^C, P_t^{VP}, P_t^A, I_t)$$

(2) $$Q_t^H = D_H(P_t^L, P_t^K, P_t^E, Q_t^L)$$

where Q_t^B = annual quantity of beef (on a carcass weight basis) per capita

Q_t^H = annual quantity of beef hides per capita

P_t^B = price of beef

P_t^P = price of pork

P_t^C = price of chicken

P_t^{VP} = price of plant products for food[1]

P_t^A = price of other animal products dominated by dairy products

I_t = gross domestic product per capita

P_t^L = wage rate for labor

P_t^K = price of capital services

P_t^E = price of energy

Q_t^L = annual quantity of leather (per capita)

Thus, equation (1) is the demand function by final consumers for meat (on a carcass weight basis), and equation (2) is the demand function for hides derived from the production of leather.

Beef Supply

Beef supply is composed of three sectors: cow-calf (reproduction), post-weaning (stocker and feeder), and meat packing.

<u>Cow-calf</u>. We have equations for the size of the breeding herd, cow replacement, calf slaughter, and calves weaned and for prices of cull cows and calves:

(3) $COWH_t = g_{11}[F_{t-1}, P^{cf}_{t-1}, E(P^{cc}_{t+7}), E(P^{g}_{t-1}), t, COWH_{t-1}]$

(4) $COWREP_t = g_{12}(F_{t-1}, P^{cf}_{t-1}, COWREP_{t-1})$

(5) $COWSLT_t = g_{13}(DCOWH_{t-1}, BCOWH_{t-1})$

(6) $1\text{-}(CALFSLT/CALFWEN)_t = g_{13}[P^{cf}_t, (DCOWH/BCOWH)_{t-1},$
$(COWREP/CATTLE)_{t-1}, (COWREP/CATTLE)_t, t]$

(7) $CALFWEN_t = g_{14}[P^{cf}_t, (DCOWH/CATTLE)_{t-1}, (COWREP/CATTLE)_{t-1},$
$(COWREP/CATTLE)_t, t]$

(8) $P^{cc}_t = g_{15}(P^{st}_t, t)$

(9) $P^{cf}_t = g_{16}(P^{st}_t, ACF_t, t)$

where

$COWH_t$ = the number of beef cows and heifers for breeding per acre

$COWSLT_t$ = number beef and dairy cows slaughtered (culled) per acre

t = year or trend

$COWREP_t$ = the number of cow replacements per acre

$CALFSLT_t$ = number of calves slaughtered (as calves) per acre

$CALFWEN_E$ = number of calves weaned

$DCOWH_t$ = number of dairy cows per acre

$BCOWH_t$ = number of beef cows per acre

$CATTLE_t$ = total head of cattle per acre

F_t = index of available forage per acre

P_t^{cf} = price of calves

$E(P_{t+j}^{cc})$ = expected price of cull cows, discounted

$E(P_{t+j}^{g})$ = expected price of grain (on a corn basis), discounted

P_t^{st} = Fed steer price

ACF_t = average feeding cost from weaning to slaughter for calves

Stocker and Feeder. This sector transforms weaned calves into slaughter weight fed cattle:

(10) $FEDCATSLT_t = g_{21}[CALFWEN_{t-1}, CALFWEN_{t-2}, E(P_{t+1}^{st}), P_t^{g}, t]$

(11) $ACF_t = g_{22}(FEDCATSLT_t, GAIN_t, W_t^{L}, r_t, P_t^{g}, P_t^{F}, t)$

(12) $P_t^{st} = g_{23}(P_t^{B}, P_t^{H}, ACF_t)$

where

$FEDCATSLT_t$ = number of cattle flowing through the post-weaning production process

$GAIN_t$ = net animal weight gain per head in this sector or phase

W_t^{L} = wage rate for labor

P_t^{g} = price of grain

P_t^{F} = price of forage

r_t = interest rate for commercial loan borrowing

Beef Packing. This sector transforms live animals into meat and hides.

(13) $Q_t^B = g_{31}(CALFSLT_t, COWSLT_t, FEDCATSLT_t, t)$

(14) $Q_t^H = g_{32}(CALFSLT, COWSLT_t, FEDCATSLT_t, t)$

(15) $ACP_t = g_{32}(HEAD_t, WT_t, W_t^{LP}, r_t, W_t^{pk}, W_t^{ot}, U_t, t)$

where

ACP = average cost of packing

$HEAD_t$ = total number of head of cattle slaughtered

WT_t = average slaughter weight for cattle

W_t^{pk} = price for beef packaging material

W_t^{ot} = price of other inputs in meat packing

U_t = unionization rate for workers in meat packing[2]

W^{LP} = packing labor wage rate

These equations summarize the most important behavioral relationships in our beef industry model.[3]

Estimates of Key Parameters

Virtually all of the model's coefficients were estimated from U.S. annual aggregate data. Demand elasticities obtained from a complete set of household expenditures, a leather sector cost function, a beef packing cost function, and beef post-weaning (growing and finishing) cost function are reported in Tables 1 through 4. The reported elasticities were computed at the sample mean values of relevant variables in order to provide the reader with a point estimate of the price responsiveness built into our model. Our simulation model, however, uses elasticities computed from the data for each year, and therefore they vary over time.

We would like to draw your attention to results in Tables 1 and 2 that pertain directly to beef. First, consider the results obtained from fitting a household demand system. We distinguish one nonfood commodity and five food commodities. The food commodities consist of four animal product groups: beef, pork, chicken, and other animal products (primarily dairy products, fish, and eggs), and one commodity for plant products. Total expenditures on all commodities add up to gross domestic product. The AIDS demand system is imposed on annual U.S. data, 1963-87, to obtain the coefficients used in computing the elasticities.

Focusing on beef, the Hicksian own-price elasticity is -0.31; pork, chicken, and other animal products are substitutes for beef; beef and plant products are complements; and beef and the nonfood commodity group are substitutes. The real income (per capita) elasticity of demand for beef is -0.101 (even with each share equation including a trend). Few negative income elasticities for beef appear in the literature, but we believe that the elasticity estimate is sensitive to the time period over which a demand system is fitted. When we compute the beef income elasticity for each year of our sample, it is generally small and positive in the early years but increasingly negative after 1976.

Second, the price elasticity of demand for beef hides is obtained from fitting a translog cost function for the U.S. leather sector, 1967-85, where labor, capital, energy, and hides make up the input groups. The own-price elasticity of demand for hides, holding leather output constant, is -0.41. Labor, capital, and energy are substitutes for hides in leather production. On a net value added output basis, 83 percent of leather production cost is labor cost. Hence, leather production is very labor intensive.

Our cost function for U.S. beef packing distinguishes four input groups: labor, capital, packaging, and other (largely energy) inputs (see Table 3 and Melton and Huffman 1993). Labor's cost share is about 50 percent on a net value added output basis. The demand for labor in beef packing is quite inelastic, -0.14; other inputs are weak substitutes for labor, and unionization has a positive impact on meat packing cost by raising the wage and by changing optimal factor proportions separate from the wage effect. Also, meat packing uses relatively low-skilled labor, and the size of the capital investment per slaughter capacity in modern plants is relatively low. These are some key parameters that seem important to the long-run adjustments of the beef industry under NAFTA.

Our cost function for post-weaning beef growing and finishing distinguishes four inputs: feed, capital, labor, and pasture/forage (see Table 4). This sector has very low labor intensity (a mean labor cost share of 3 percent) but it is relatively intensive in livestock feed (50 percent) and pasture/forage (25 percent). The own-price elasticity of demand for feed is -0.36 and for pasture/forage is -0.52. The own-price elasticities of demand for capital and labor are -0.59 and -1.18, respectively. Feed and pasture and all the other input pairs, except one, are substitutes. Pasture and capital are compliments. When the interest rate rises, other things equal, beef producers speed up the beef growing and finishing process, which means reducing the demand for pasture and increasing the demand for feed grain.

Results and Discussion

To evaluate the model, static (annual) general equilibrium solutions (using actual values of lagged endogenous variables) were obtained for each country over the period 1965-85. Over this period the predicted values of the endogenous variables were generally within 10 percent of their actual values and the model was judged to adequately represent the beef sector in each country. Next, a base solution reflecting pre-NAFTA conditions was obtained for the average 1980-82 levels of exogenous variables in each country (see Table 5 for means 1980-82 values of key exogenous variables).

The model for the two countries consists of approximately 80 simultaneous equations. The variables listed in Table 5, including the U.S. price of feed grains, plus the population of both countries, are fixed in the simulations. The simulation results are general equilibrium solutions within the context of our beef industry model. They are partial equilibrium solutions to economy-wide models of both countries.

To assess the potential impacts of NAFTA and technology transfers on bilateral beef trade between Mexico and the United States, three additional solution scenarios were defined:

1. Short-run effects reflecting the elimination of all beef tariffs and trade restrictions between the two countries, but not allowing sufficient time for structural or technological change to occur in Mexico's beef industry;

2. Long-run effects allowing adequate time for the investment, structural, and technical changes required for Mexico's beef industry to reach a cost and productivity level comparable to that of the U.S.; and

3. Long-run effects (of scenario 2) plus a real increase (from average 1980-82 levels) in the prevailing national wage rate and per capita income levels in Mexico.

The effects in the United States and Mexico of each scenario potentially arising from post-NAFTA adjustments are represented for comparison to the base solution (i.e., in real 1980-82 terms).

In the first post-NAFTA scenario, domestic beef price and production controls in Mexico and tariffs and trade barriers between Mexico and the United States are all assumed to be eliminated at the time of the NAFTA implementation. These include the immediate elimination of recently enacted Mexican tariffs of 15 percent on live cattle and 20 percent and 25 percent on fresh and frozen beef imports, respectively, as well as U.S. tariffs of about $.02 and $.01 per pound for beef and live animals.

Furthermore, under NAFTA Mexico will eliminate its coarse grain tariffs and licensing policy. These changes will occur at various times over the course of NAFTA's implementation, beginning with sorghum (15 percent) and ending with corn (215 percent phased out over 15 years). Thus, the first post-NAFTA scenario reflects beef, live cattle, and grain trade conditions between Mexico and the United States that seem likely to exist immediately following NAFTA (where U.S. grain exports are predominantly sorghum, which is freely traded immediately). Due to the short-run nature of this scenario, no technical or structural change in the Mexican or U.S. beef industries is anticipated. Instead, the industry and its productivity are held fixed at pre-NAFTA levels, including only small adjustments in the beef cow herd (per acre) in each country (within 5 percent of their pre-NAFTA levels).

The second post-NAFTA scenario represents what we judge to be more realistic long-term adjustments in the U.S. and Mexican beef industries. Mexico has already taken dramatic steps to reform its domestic and foreign investment policies.[4] These changes, coupled with the enactment of NAFTA and the relatively low wage rates in Mexico, create a strong incentive for growth and development – especially in low-skilled, labor-intensive industries such as food processing (CAST 1993). Based on the empirical evidence of highly inelastic labor demand in meat packing and leather goods manufacturing, these industries appear to be prime candidates for post-NAFTA expansion in Mexico. We anticipate that this development will take the form of capital investments that expand and modernize beef packing facilities in Mexico. In the process, technology comparable to that of U.S. beef packing and processing will be transferred to Mexico, bringing improvements in productivity.

Beef packing is, however, highly dependent upon adequate local supplies of slaughter cattle. For example, a modern U.S. packing plant can typically slaughter approximately 2,500 head per day, or more than .5 million head per year. Thus, although labor accounts for about 50 percent of U.S. net value added packing costs, it accounts for only 10 percent of gross packing costs while slaughter animals account for more than 80 percent. Hence, we anticipate that the development of a modern beef packing industry in Mexico will require the concurrent development of modern live-animal production sectors. This means genetic improvement of Mexico's beef herds and capital investments in both pre- and post-weaning production will be necessary to insure an adequate and stable supply of slaughter animals. Thus, we anticipate that the modernization of Mexico's beef industry will be integrated in nature, extending from enhanced genetics and cow-calf management through improved post-weaning production and management (including cattle feeding) to modern slaughter and processing.[5] Hence, the second post-NAFTA scenario is intended to consider long-run effects of modern technology transfers for all phases of the Mexican beef industry.

Finally, many industry groups, both in and out of agriculture, have argued that long-term post-NAFTA growth will increase income levels in Mexico. If the income elasticity of demand for beef is positive at prevailing Mexican income levels, this may increase Mexican beef imports. Assessing the aggregate income effects of post-NAFTA adjustments is beyond the scope of this study. However, it is reasonable to assume that NAFTA will increase Mexican real income (but have little effect on U.S. real income).[6] The growth in Mexican real income seems likely to be wage based. Thus, the third post-NAFTA scenario considers the effects on a long-run equilibrium (scenario 2) of increased Mexican real wage rates, leading to increased real income levels. If the Mexican earnings account for about 50 percent of GDP, a 10 percent income increase (as considered by Rossen et al. 1993) will result from a 20 percent increase in wage rates. Thus, for scenario 3 we assume a 20 percent increase in real wage rates in Mexican manufacturing in addition to the long-term post-NAFTA adjustments of scenario 2.

The general equilibrium solution to the bilateral (U.S.-Mexico) beef trade model for each of these post-NAFTA scenarios is driven by the equalization (within the transportation cost difference) of prices for traded commodities (beef, feeder animals, and grain) between the United States and Mexico.[7] When exogenous variables, including population, are held fixed at 1980-82 levels (Table 5), the solutions provide an adequate representation of the post-NAFTA adjustments required for each narrowly defined scenario. These solutions are summarized along with the solution for pre-NAFTA (base 1980-82) conditions in Table 6.

Short-run Effects of NAFTA

The short-run post-NAFTA adjustments in bilateral beef trade between Mexico and the United States are dominated by the absence of supporting infrastructure and production technology in Mexico. At present, the overwhelming majority of Mexico's beef production is forage based. As a result, calves are maintained on forage from birth to slaughter at an age of up to four years and an average weight of about 900 pounds or exported (largely to the United States) for feeding and slaughter. In 1980-82, Mexico exported about 750,000 head of feeder cattle and imported about 22 million pounds of beef. Currently these numbers have increased to more than one million head of feeder cattle and about 200 million pounds of beef annually. In the short run, post-NAFTA adjustments are only expected to exaggerate this trade cycle, as more Mexican producers are able to freely access U.S. feeder cattle markets and consumers gain freer access to imported beef. In the process U.S. and Mexico retail beef prices are equalized (within the transportation cost).

For the short run, our projections are that following NAFTA Mexico will increase its exports of feeder cattle to the United States about 3.2 million head (relative to 1980-82 levels), which is an increase of about 400 percent (225 percent larger than current levels). As a result, the U.S. feeder calf supply is expected to increase by about 10 percent, causing U.S. feeder calf prices to cow-calf producers to decline by 32 percent. While this reduction in feeder calf prices is significant, it is moderated by our imposition of static technology in the United States. Specifically, by imposing this condition we assume that U.S. producers in post-weaning segments of the industry do not respond to the increased beef supplies represented by these calves. As a result, average costs for feeding and packing rise. These cost increases, combined with the increased beef demand in Mexico accompanying removal of current tariffs and trade barriers, result in higher U.S. beef prices that largely sustain (slaughter steer) or slightly increase (carcass) prices in the post-weaning sectors of the U.S. beef industry.

Assuming the development of an adequate beef marketing and distribution system, Mexico is also expected to increase its short-run post-NAFTA beef imports from the United States by about 2.4 billion pounds (tenfold from current levels) and its feed grain imports by 155 million bushels (more than double on a corn grain equivalent basis).[8] As a result the U.S. could be supplying as much as approximately one-half of Mexico's total beef demand (more than 30 pounds per capita) and essentially all of its feed grain requirements.

Long-run Effects of NAFTA with Full Beef Technology Transfer

In the second post-NAFTA scenario, full modern beef industry technology transfer to Mexico and long-term adjustments in the U.S. and Mexican beef industries occur. With modernization of Mexican meat packing and post-NAFTA standardization of U.S. and Mexican food safety and health inspections, Mexico is in a position to potentially export large quantities of retail beef to the United States.

With full modern technology transfer, major restructuring of the U.S. and Mexican beef industries occurs relative to the short-term post-NAFTA and pre-NAFTA outcomes. The size of the Mexican beef cow herd doubles (from 8.4 to 16.6 mil. head), and the U.S. beef cow herd decreases by about 13 percent (see Table 6). Mexican exports of feeder cattle to the United States are 1.4 million head larger than the pre-NAFTA base and 1.8 million head smaller than for the short-term post-NAFTA outcome. The reason for this change is that Mexico goes from being a high cost post-weaning and beef packing location to a low-cost location after modern technology transfer and new capital investments in the beef industry occur.

Mexico now exports an additional 2.5 billion pounds of retail beef to the United States relative to the pre-NAFTA base, and this is a 4.9 billion pound net change relative to the short-run post-NAFTA outcome. The increment to U.S. feed grain exports to Mexico is about 170 million bushels relative to the pre-NAFTA base outcome but slightly less than the short-run post-NAFTA outcome. With technology transfer and associated adjustments, Mexican consumers obtain retail beef at 30 to 35 cents per pound less relative to the pre-NAFTA base and short-run post-NAFTA outcomes. U.S. consumers benefit from a slightly lower retail beef price relative to the pre-NAFTA base and a 30 cents per bushel reduction relative to the short-run post-NAFTA outcome.

Beef Technology Transfer and Rise in Wage

For some readers, our third post-NAFTA scenario will be of greatest interest because it combines plausible changes in the Mexican beef supply function with increases in real wages and income. The 10 percent rise in real income per capita causes a small increase in Mexican beef demand, which results in slightly larger U.S. and Mexican beef cow herds, relative to the full technology transfer outcome with constant wages and income. The 20 percent higher Mexican wage rates reduce Mexico's comparative advantage in post-weaning and beef packing. The result is Mexico exports a larger number of feeder cattle to the United States (1.8 versus 1.4 million head) and less retail beef (1.9 billion versus 2.5 billion pounds). U.S. feed grain exports are, however, approximately unchanged relative to the full technology transfer outcome. Also, the retail price of beef in the United States and Mexico rises slightly (1 cent per pound).

Conclusion

The major force for change in the beef industries of the two countries following NAFTA is the dramatic narrowing of intercountry price differences. Without tariff and nontariff trade barriers, prices of traded commodities equalize except for transport costs. The primary cause for all of the short-term post-NAFTA adjustments is intercountry price equalization of feed grain, feeder cattle, and retail beef. In the long run, when Mexican beef industry technology transfer, wage rates, and income change, the dominant force in the new equilibrium is the beef industry technology transfer. In particular, the 20 percent rise in Mexican real wage rates, and its resultant 10 percent rise in real income, causes relatively small changes in equilibrium trade and beef prices. It does, however, reduce slightly Mexico's comparative advantage in meat packing. Technology transfers and the associated shifts in beef industry cost functions have potentially much larger effects on intercountry beef trade than the likely post-NAFTA wage and income effects.

We must, however, caution the reader that direct technology transfer is never easy, and we may overestimate the cost advantage that Mexico can attain with full technology transfer. Furthermore, the number of variables that must be held fixed (exogenous) in an analysis of this type is large. Changes in these variables can potentially alter the solutions and the impliclations of post-NAFTA adjustments in beef trade. This analysis is not intended to provide an all-encompassing answer to issues of post-NAFTA adjustments in beef trade. More work, including the inclusion of positively sloped U.S. grain supply functions and assessment of interregional impacts, needs to be done. These modifications, and more extensive consideration of the effects of exogenous variable level, are anticipated for future study.

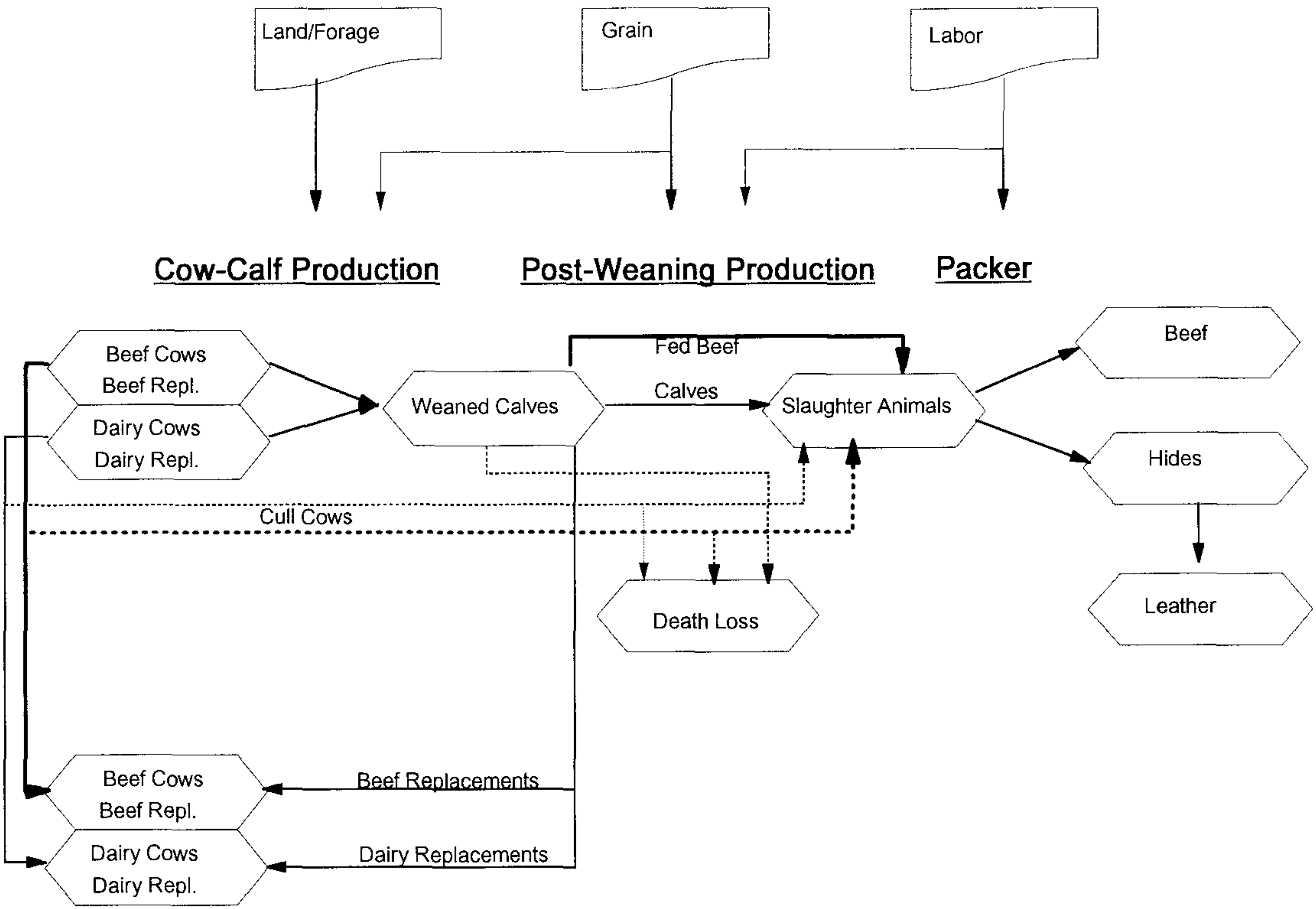

Figure 1. Beef supply system model.

Table 1. Estimates of (Hicksian) Price and Income Elasticities of Per Capita Demand for Food and Nonfood Goods by U.S. Households (from AIDS model fitted 1963-87)[a]

Quantity	Food Prices: Beef	Pork	Chicken	Other Animal Products	Plants and Plant Products	Nonfood Price	Real Income (per capita)	Trend[b]	Expenditure Share (mean)
Food									
Beef	-0.309	0.163	0.019	0.286	-0.275	0.233	-0.101	0.00004	0.015
Pork	0.294	-0.762	0.010	0.508	-0.075	0.894	0.288	0.00001	0.008
Chicken	0.100	0.008	-0.213	-0.071	-0.150	0.305	0.801	0.00005	0.003
Other Animal Products	0.098	0.163	-0.008	-0.397	-0.562	0.706	1.349	-0.0002	0.026
Plant and Plant Products	-0.069	-0.010	-0.007	-0.244	-0.637	0.967	-0.190	0.0009	0.061
Nonfood	0.004	0.000	0.001	0.021	0.066	-0.092	1.097	-0.0008	0.887

[a] All elasticities were evaluated at the sample mean.
[b] The estimated average change in expenditure share per year.

Table 2. Elasticities of Input Demand for U.S. Leather Sector (translog cost function and cost share equations fitted 1963-85)

Quantities	Prices[a]				Technology[b]	Cpst Share (mean)
	Labor	Capital	Energy	Hides		
Labor	-0.611	-0.010	0.003	0.618	-0.0023	0.345
Capital	-0.056	-0.314	-0.001	0.371	0.0020	0.062
Energy	0.105	-0.007	-0.605	0.508	0.0004	0.010
Hides	0.365	0.039	0.008	-0.413	-0.0001	0.584

[a] All price elasticities were evaluated at the sample mean.
[b] The estimated average change in factor cost share per year.

Table 3. Elasticities of Input Demand for U.S. Beef Packing Sector (from translog cost function and cost share equations fitted 1963-84)[a]

	Prices				Unionization[b]			Cost
Quantities	Labor	Capital	Packaging	Other	Non-Wage	Wage	Technology[c]	Share (mean)
Labor	-0.137	0.097	0.030	0.011	-0.412	0.068	-0.005	0.502
Capital	0.676	-1.061	0.255	0.131	0.229	0.005	0.005	0.072
Packaging	0.112	0.139	-0.349	0.097	-0.081	-0.019	0.003	0.132
Other	0.018	0.032	0.044	-0.093	0.272	-0.053	-0.002	0.294

[a] All elasticities evaluated at the sample mean.
[b] An estimate of the percentage change in cost shares due to a one percent change in unionization.
[c] An estimate of the average change in factor cost share per year.

Table 4. Elasticities of Input Demand for U.S. Beef Post-Weaning Sector (from translog cost function fitted 1963-85)

	Prices[a]					
Quantities	Feed	Capital	Labor	Pasture	Technology[b]	Cost Share (mean)
Feed	-0.363	0.1392	0.022	0.202	.0047	0.596
Capital	0.639	-0.589	0.017	-0.067	.0028	0.129
Labor	0.463	0.079	-1.184	0.643	.0014	0.028
Pasture	0.481	-0.035	0.072	-0.518	-.0089	0.247

[a] All elasticities were evaluated at the sample mean.
[b] The estimated average change in factor cost share per year.

Table 5. Values of Key Exogenous Variables: United States and Mexico, Base 1980-82

Variable		United States	Mexico
Wage rate (mfg)	$/hr	7.92	2.09
Gross domestic product per capita	$1000	13.067	3.100
Pork price	$/lb	1.56	0.92
Chicken price	$/lb	1.06	1.20
Other animal products (food)	$/lb	1.05	1.00
Corn for grain	$/bu	2.34	5.39
Labor unionization	Index (1980=100)	0.97	0.10
Dairy cows	1,000	10,978	3,943
Dairy replacement heifers	1,000	4,472	1,605

Table 6. Effects of Alternative NAFTA Scenarios on Bilateral Trade

Endogenous Variables	Units	Pre-NAFTA Base		Post-NAFTA Short Run		Post-NAFTA Full Beef Tech Trf		Post-NAFTA Incr Mex Wage[a]	
		U.S.	Mexico	U.S.	Mexico	U.S.	Mexico	U.S.	Mexico
Beef cow herd	mil hd	44.56	8.18	42.29	8.40	37.28	16.55	37.62	16.72
Retail beef price	$/lb	2.21	2.42	2.40	2.45	2.14	2.10	2.15	2.11
Carcass beef price	$/cwt	94.04	103.21	102.44	104.71	90.93	88.80	91.37	89.22
Slaughter steer price	$/lb	59.00	73.04	61.03	64.68	59.26	57.97	59.05	57.86
Feeder calf price	$/lb	67.73	40.07	46.13	41.13	68.34	63.34	68.78	63.78
Avg. feed cost	$/lb gain	0.43	[b]	0.82	1.10	0.43	0.46	0.42	0.45
Avg. packing cost	$/lb slaughter wt	0.13	0.02	0.12	0.25	0.14	0.04	0.13	0.05
Δ Animal trade[c]	mil hd			+3.23	-3.23	+1.39	-1.39	+1.80	-1.80
Δ Beef trade	bil lb			-2.41	+2.41	+2.45	-2.45	+1.95	-1.95
Δ Grain trade	mil bu			-155.36	+155.36	-167.61	+167.61	-167.29	+167.29

[a] This increase in the Mexican wage comes after full beef technology transfer to Mexico.
[b] Current Mexican beef production is dominated by "grass-fed" beef making estimates of current post-weaning cost difficult to assess.
[c] The convention of plus (+) for imports and minus (-) for exports is adopted in reporting the trade change.

ENDNOTES

1. The plant food price index was constructed by regressing the per capita nutrient intake of 6 nutrients (fat, protein, etc.) in each of 9 plant food catagories (citrus fruit, noncitrus fruit, etc.) on the price index of each plant food catagory included for each year from 1963 to 1987. The estimated regression coefficients were then multiplied by aggregate plant dietary nutrient shares to obtain the aggregate plant price index used.

2. The rate of unionization in meat packing is defined as an index of union coverage (proportion of eligible workers covered by union agreement where a plant is assumed to be fully covered if 75% of the eligible employees are covered) in the aggregate meat products industry.

3. Of course the model consists of other equations, including accounting identities.

4. Following the Mexican Land Reform, ownership limitations were placed on private landowners as a means of developing rural areas. As a result, many agricultural enterprises have remained small and failed to capture potential economies of scale. Mexico is currently in the process of removing these limitations.

5. The transfer of modern beef technology to Mexico is expected to be aided by U.S. companies. In particular, IBP already has a modern beef packing facility in Mexico. Monfort has a dvision specializing in "turn-key" construction of beef packing plants for itself and others. Thus, Monfort has the potential for constructing modern U.S. beef packing plants in Mexico. Japanese firms also have the potential for building these plants. Furthermore, two of the three largest U.S. meat packers have cattle feeding subsidiaries (Monfort and Excel) and are experienced at establishing and operating large scale cattle feedlots.

6. A minimal income effect in the U.S. economy can be supported by results reported in Brown (1992) and the fact that the Mexican economy is about 20% the size of the U.S. economy.

7. In the scenario solutions beef herd sizes are assumed to be fixed at the equilibrium levels. Hence, lagged values are equal to current values.

8. In the short run, the increased feed grain exports to Mexico are expected to come from diversions of current U.S. exports to other countries and depletion of U.S. feed grain reserves. In future refinements we intend to incorporate a positively sloped feed grain supply function to replace the assumed perfectly elastic suppy used in this solution.

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