IMPORT DEMAND FOR U.S. BEEF BY-PRODUCTS AND AFFECTS ON DOMESTIC BY-PRODUCT AND LIVE CATTLE PRICES

by

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ABSTRACT

The objectives of this study were to econometrically estimate the impacts of economic factors such as income and exchange rates in the Asian and North American countries on import demand for U.S. by-products, and translate these changes to U.S. by-product value and inverse slaughter demand. Four countries (Japan, Korea, Mexico and Canada) and four beef by-products (variety meats, edible tallow, inedible tallow and hides) were considered in the econometric study.

Given the maintained hypothesis, the empirical model consisted of three stages. First, structural import demand equations were estimated by country and according to by-product class using a systems (SUR) approach. In the second stage, a behavioral equation for U.S. beef by-product value was estimated (by OLS) in order to statistically link foreign sector affects on U.S. beef by-products and domestic slaughter cattle price. The third stage was to estimate U.S. slaughter steer inverse demand, the function that finalized relating impacts of foreign income and currency valuation on prices received by U.S. beef producers.

The majority of the model coefficients were statistically significant. The marginal impacts indicate, for example, that a one percent depreciation in the Japanese yen, Korean won, Canadian dollar and Mexican peso decreases U.S. slaughter steer price by 0.160 percent, 0.148 percent, 0.074 percent and 0.068 percent, respectively, as a result of decreasing by-product import demands. A one percent decreases in real GDP in Japan, Korea, Canada and Mexico decreases U.S. slaughter steer price by 0.058 percent, 0.089 percent, 0.036 percent and 0.015 percent, respectively.

In post-sample analysis, the period from 1997 to 1998 indicated that real Japanese GDP decreased by 1.93 percent and the yen depreciated by 8.2 percent; real Korean GDP declined by 5.8 percent and the won depreciated by 9.5 percent. The impact from deteriation in Asian income and currency values therefore was to reduce nominal slaughter steer price by \$2.18/cwt and real steer price by \$1.35/cwt. Model implications are that producer returns can be enhanced by further trade liberalization in the area of by-products.

CHAPTER 1

INTRODUCTION

Background

Beef by-products are an important source of income to the U.S. meat packing industry. Competition often forces meat packers to sell carcasses and boxed beef for less than the value of live cattle inputs, creating a revenue deficit. Consequently, by-products are necessary to cover packer slaughter costs and normal profits. As joint products in production, they also influence prices bid by packers for slaughter cattle (Ward). By-product sales are made in both domestic and international markets, with over 45% of total sales (all by-products) destined for export (Blake and Clevenger).

Over the years, beef by-products have accounted for an increasing share of trade in U.S. beef related products (i.e., by-products and bone-in and boneless beef cuts). Beef by-products include hides and skins, edible and inedible offal, and edible and inedible tallow. Variety meats are important products of edible offal. Because by-products are important sources of revenues for U.S. packers, volatility in foreign demand for by-products impact export values, economic returns to meat packers, and prices received by U.S. cattle producers. [1]

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[1] U.S. beef and beef by-products exports as a percentage of total export value in 1997 are as follows: hides and skins, 20.2%; red meat, 49.5%; variety meats, 10.2%; tallow 11.01%; other products, 9.09% (USDA, Dairy, Livestock, and Poultry: U.S. Trade and Prospects, 1999).

In 1996, exports of U.S. hides totaled $1,125 million, compare to $2,429 million earned from beef exports. Exports of edible and inedible tallow totaled $463.6 million. Exports of variety meats (ie, balogna and cured meats), which include edible products from the inner organs, heart, tongue, liver and head meat etc, are also important sources of revenue to the meat packing industry. In 1996, the export sales of variety meats amounted to $616.9 million. (Appendix: Table 27).

In 1997, however, hide exports dropped from 20,289,294 pieces to 18,990,623 pieces, a 6.4% decrease. This decline was generally attributed to the Asian financial turmoil that started in 1997. Both South Korea and Japan are major importers of U.S. cattle hides. In 1996, the exports to the two countries accounted for 54% of U.S. cattle hide exports (USDA). However, because both countries were affected by the Asian financial crisis, Korean imports declined by 6.1% and Japanese imports declined by 24.1% (Appendix: Table 29). Mexico and Canada are also important cattle hide importers. Mexican cattle hide imports increased by 137% from 1995 to 1996, and 16.5% from 1996 to 1997.[2] Canadian cattle hide imports increased by 20.8% from 1995 to 1996, and only 8.6% from 1996 to 1997.[3] Thus, these countries also experienced declines in import demand for hides.

Japan, South Korea, Mexico and Canada are also major purchasers of U.S. variety meats. The combined imports of those countries accounted for 64.5% of total U.S. exports of variety meats in 1996 (USDA), with Japan accounting for 50% of U.S. exports

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[2] Mexico imported 893,019 pieces of cattle hides in 1995, which amounted to $50 million.

[3] Canada imported 951,071 pieces of cattle hides in 1995, which amounted to $47.8 million.

of variety meats. However, in 1997, Japanese variety meat imports decreased by 50.1% from 177,862 metric tons to 88,826 metric tons (Appendix: Table 30). Japanese import values declined by 39.6% (Appendix: Table 30). South Korea's imports also declined sharply (47.3%) from 10,589 metric tons to 5,576 metric tons, and import values declined by 19.4% (Appendix: Table 30). While variety meat imports by Mexico and Canada increased 29.4% and 8.86%, respectively (Appendix: Table 30), total U.S. variety meat exports declined by 20.1% from 1996 to 1997 in terms of quantities, and by 24.1% in terms of value (Appendix: Table 28 and 25, respectively).

Japan, South Korea, Mexico, and Canada are also major importers of U.S. edible and inedible tallow (animal fat). In 1996, those four countries accounted for 87.6% of total U.S. exports of edible tallow, which is used for margarines and cooking oil, and 30% of total U.S. exports of inedible tallow, which is used for soaps, candles, etc (UDSA). However, in 1997, South Korea's import quantities of edible tallow declined by 35.8%, and by 27.8% in terms of value (Appendix: Table 31). South Korea's import quantities of inedible tallow declined by 81.5%, and 80% in terms of value (Appendix: Table 32). Japan's import of inedible tallow declined by 5.7% in volume and 9.9% in value (Appendix: Table 32). From 1996 to 1997, total exports of edible tallow declined by 13.7% in value and 19.4% in volume, and inedible tallow declined by 10% in value and 15.2% in volume.

Objectives

The objectives of this thesis are two-fold. The first is to develop a model of U.S. beef by-product markets and econometrically estimate derived import demands for U.S.

beef by-products (hides, variety meats, and edible and inedible tallow) in the Pacific Rim and North America countries (Japan, South Korea, Mexico and Canada). The second objective is to analyze the impacts of changes in foreign demand for by-products, particularly due to income and exchange rate shocks, on U.S. farm level (slaughter) cattle prices.

Procedures

Based upon economic theory, knowledge of the industry and previous research, a structural model of separate import demands by the above foreign countries for the classes of U.S. beef by-products is specified. Foreign import demands are then linked to U.S. inverse demand for slaughter cattle to measure the effects of foreign shocks in by-product markets on U.S. slaughter cattle prices. Annual time series data from 1980 to 1997 is used for econometric estimation and simulations.

A modified version of Hooper and Kohlhagen's trade model is used to specify import demands. The model assumes risk-averse importers maximize expected utility of profits. Utility is assumed to be an increasing function of profits, and a decreasing function of the standard deviation of profits (i.e., risk). Export by-product supplies and elasticities are based upon previously estimated fed cattle supply functions (Marsh 1994). Fixed proportions between cattle slaughter and by-product quantities are assumed. Linking foreign by-product sectors to U.S. cattle prices is accomplished using import demand and export supply of by-products, quantity share weights of U.S. farm by-product components, and a partial equilibrium (demand-supply) price model of the U.S. fed cattle sector. Import demands are econometrically estimated. Shared weights are obtained by regressing U.S. farm by-product value on domestic factors and export /import prices of hides, variety meats, and edible and inedible tallow. Marsh's 1999 partial equilibrium price model of the U.S. fed cattle sector provides the basis for estimating domestic price flexibility coefficients used to transfer shocks in foreign by-product markets to U.S. cattle prices.

Various statistical tests will be used to evaluate the robustness of the estimation procedures. Unit root tests (Augmented Dickey-Fuller, or ADF) on individual variables and on equation residuals will determine variable stationarity and equation cointegration. The results will determine whether the model can be estimated in first-difference or data-level form (Johnston and DiNardo, pp259-69). Hausman specification tests will determine the presence of joint dependency, and correlation coefficients of cross-equation equation residuals will determine if efficiency gains can be obtained by Seemingly Unrelated Regressions (SUR). Ordinary Least Squares (OLS) will be used if all assumptions of the classical normal linear regression are met. Instrumental Variables (IV) will be used if joint dependency exists, and Generalized Least Squares (GLS) will be used to jointly estimate the equations if errors are contemporaneously correlated. If both joint dependency and contemporaneous correlation occur, Iterative Three Stage Least Squares (I3SLS) will be employed.

CHAPTER 2

LITERATURE REVIEW

This literature review consists of two parts: (1) theoretical models widely used in international trade analysis, and (2) previous beef by-product research. The former focuses on three types of models (excess demand/excess supply; Armington; Hooper-Kohlhagen trade model). Little research has been conducted on either domestic or foreign beef by-product markets.

Excess Demand/Excess Supply Model

Excess Demand/Excess Supply (ED/ES) models provide a convenient analytical framework that can be used to determine the economic effects of changes in production and transportation costs on the volume and direction of trade. In addition, such an analytical model may be used to ascertain the price effects of relaxing or increasing trade barriers between countries or regions (Tomek and Robinson pp.147).

ED/ES models suggest that price differences between regions are determined largely by transfer costs, assuming competitive market structure with homogeneous commodities. These transfer costs may include loading or handling charges as well as direct transportation costs. The underlying principle for regional price differences is, given regional supply and demand conditions, price differences between any two regions (or markets) that trade with each other will just equal transfer costs.[4]

This economic concept enables one to determine optimum or least-cost trading patterns between regions as shown in Figure 1.

Figure 1. Two-Region Spatial Equilibrium Model.

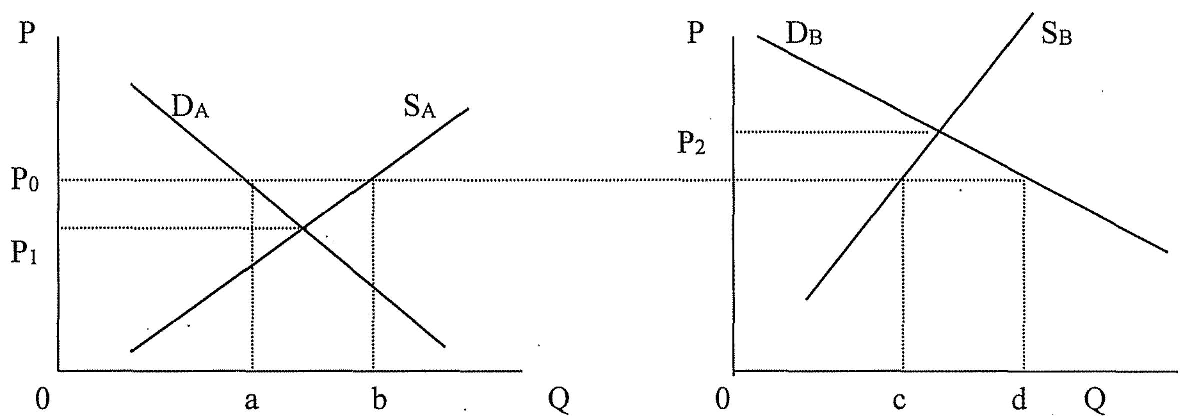


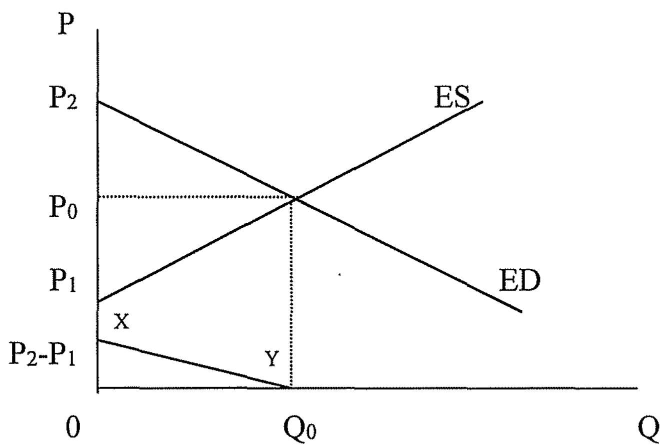
Figure 1 shows a potential surplus region A and a potential deficit region B for a homogeneous commodity. In the absence of trade, demand and supply in region A would be equated at P_1 and demand and supply in region B are in equilibrium at P_2. At a price above P_1 in region A, a disequilibrium (excess supply) occurs and some product would become available for export. In region B if price were below P_2, a disequilibrium

[4] While the general structure of prices in the absence of trade barriers, such as tariffs, conforms to this theory, there are important exceptions. Differences may exceed transfer costs, even for extended periods, because of incomplete or inaccurate information, preferences on the part of buyers for produce grown in a particular area, and institutional or legal barriers to the movement of commodities between regions. Temporary factors, such as a shortage of railroad cars, elevator space, or barge transportation also can lead to price differences between regions that at times exceed normal transfer costs (Tomek and Robinson).

(excess demand) occurs and imports are required to satisfy local demand. Price P_0 represents the equilibriating price between the regions and serves as the basis for trade.

The information obtained from these diagrams can be used to construct excess supply and demand curves as shown in Figure 2.

Figure 2. Excess Supply, Excess Demand, and Volume Trade Model.



The excess supply curve is based on the horizontal distance between the supply and demand curves in region A at prices above equilibrium (e.g., point b minus point a). The excess supply curve is positively sloped since the gap between supply and demand widens as the price increases. Excess supply is zero at the equilibrium price of P_1 and intersects the vertical axis at that point in Figure 2. The horizontal distance between the demand and supply curves at prices below equilibrium in region B (e.g., point d minus point c) provides information needed to construct an excess demand curve. The ED schedule is negatively sloped since the difference between the demand and supply curves widens as the price declines. The ED schedule intersects the vertical axis at P_2, the point where excess demand is zero.

The ED and ES schedules intersect at P_0. If transfer costs between these two regions were zero, Q_0 units of the commodity would be shipped from A to B (ab = cd = Q_0). Volume traded between these two regions, however, declines with the introduction of transfer costs. The effect of changes in transfer costs on the amount shipped between regions can be illustrated by constructing a "volume trade" line, which is shown as the diagonal line XY in Figure 2. The vertical intercept for this line is (P_2 –P_1), since no trade would occur if it costs more than $P_2 - P_1$ to transfer a unit of product from region A to region B. In that case, demand and supply would be equated within each region and the price difference would be less than transfer costs. The horizontal intercept of the volume of trade line, which shows the maximum trade that can occur when transfer costs are zero, is at Q_0. The point Q_0 also represents equilibrium between the excess demand and supply schedules. Excess demand price exceeds excess supply price by transfer costs. As transfer costs increase, volume traded declines.

Several quantitative studies have used ED/ES models. Brester (1996) used an excess demand model to derive the U.S. import demand elasticity for beef. It was assumed that U.S. demand for beef imports is an excess demand characterized by:

(2.1) $\quad I(P) = D(P) - S(P)$

Imports (I), which is a function of domestic price (P), represents excess domestic demand. Excess domestic demand is the difference between domestic demand, D(P), and domestic supply, S(P). Beef was disaggregated into two categories: ground beef and table-cut beef. Long-run and short-run import demand elasticities were estimated for each category and for aggregate beef products. Brester concluded that the import demand elasticities for ground beef and table-cut beef were both very elastic.

Brester, Marsh and Smith (1999) used an excess supply model to evaluate potential economic impacts of an *ad valorem* tariff (5.57 percent) on U.S. imports of live Canadian cattle. Impacts of the proposed tariff on import quantities of Canadian live cattle, U.S. and Canadian slaughter and feeder cattle prices, and Montana and Washington feeder cattle prices were simulated. In the models, Canadian live cattle exports were assumed to form an excess supply function:

(2.2) $E(P) = S(P) - D(P)$.

Exports (E) were assumed to be a function of cattle price (P). The difference between domestic supply S(P), and domestic demand D(P), represents the excess supply of Canadian cattle.

The article concluded that the ultimate impacts of the proposed tariff on U.S. live cattle imports from Canada depend on the actions of the beef processing sector which would face increased costs if the tariff was imposed. In all likelihood, reduction in cattle imports resulting from the tariff would be partly offset by increased carcass and boxed beef imports. If carcass or boxed beef imports do not increase in response to the proposed tariff, and increased packer costs are not passed to cattle producers, the tariff would have generated very small positive impacts on U.S. slaughter and feeder cattle prices.

Armington Trade Model

The Armington model is a popular specification for estimating import demands. The Armington approach permits the calculation of direct elasticities and cross-price elasticities between imports from all sources (Alston, Carter, Green and Pick). It is a disaggregated model which distinguishes commodities by country of origin, with import demand determined by a separable two-step procedure. In the first stage, an importer is assumed to decide import quantity levels. The first stage maximizes a representative consumer's weakly separable utility function subject to a fixed total expenditure. Total consumer expenditure is allocated over broad groups of goods within a system of Marshallian demand equations, such as $Q_i = Q_i(E, P_i)$ $i=1,\ldots,n$, where Q_i is an aggregate quantity index for group i; n is the number of groups of goods; E is the total expenditure of the importing country; and P_i is an aggregate price index for group i. P_i and Q_i must either be linearly homogeneous or homothetic to satisfy consistency requirements of two-stage budgeting procedures.

In the second-stage, expenditures are minimized subject to a utility index.

$$\text{(2.3)} \quad \min \; E_i = \sum p_{ij}\, q_{ij}$$

$$\text{s.t.} \quad Q_i = \left(\sum b_{ij}\, q_{ij}^{-\rho i} \right)^{-1/\rho i} \quad i = 1,\ldots n,$$

where q_{ij} and p_{ij} are the quantity and price, respectively, of good i from commodity source j; E_i is total expenditure on group i; and $b_{ij} \in [0,1]\ \forall\, j$, $\sum b_{ij} = 1$.

A CES function is often used for Q_i to satisfy linear homogeneity requirements of the utility index.[5] Solving this problem yields conditional Hicksian demand equations:

$$\text{(2.4)} \quad q_{ij} = b_{ij}^{\sigma i}\, Q_i\, (p_{ij}/P_i)^{-\sigma i} \quad j = 1,\ldots,m,$$

[5] Although imposing CES functional form on Q_i is a typical approach followed by those who have estimated Armington models (e.g., Sarris; Grennes, Johnson, and Thursby), others (e.g., Goddard) have modified the Armington model by using a different functional form. Goddard used a generalized Box-Cox functional form.

where $\sigma_i = (1+\rho_i)^{-1}$ is the elasticity of substitution; and Q_i and P_i are the CES quantity and price indices, respectively. Equation (2.4) is often referred to as the " Armington equation", and is a function of two parameters b_{ij} and σ_i, and three variables q_{ij}, p_{ij}, and E_i. Such models are often estimated in double log form using Ordinary Least Squares (OLS). Armington models have often been applied to international agricultural trade markets because of ease of application and flexibility of the functional form. The Armington model often provides plausible parameter estimates and statistical significance.

However, in recent years, the Armington model has been criticized for several reasons. Alston, et al. tested the Armington assumptions of homotheticity and separability using international cotton and wheat market data. Parametric and nonparametric tests rejected the Armington assumptions. Davis and Kruse showed that the Armington trade model results in inconsistent parameter estimates from both a theoretical and statistical prospective. They proposed a method to eliminate the inconsistencies by changing the second stage from a minimization problem to a maximization problem such that:

$$(2.5) \quad \max \; Q_i = (\Sigma b_{ij}\, q_{ij}^{-\rho i})^{-1/\rho i}$$

$$\text{s.t. } E_i = \Sigma p_{ij} q_{ij} \quad i = 1,\ldots,n.$$

The resulting conditional Marshallian demand equations are:

$$(2.6) \quad q_{ij} = E_i\,(p_{ij}/b_{ij})^{-\sigma i}\,(\Sigma b_{ik}^{\sigma i} p_{ik}^{1-\sigma i})^{-1} \quad i, k = 1,\ldots, m.$$

Equation (2.6) is nonlinear in parameters which requires a nonlinear regression estimation. The method corrects for bias and inconsistency in the traditional Armington model and yields consistent parameter estimates.

Hooper-Kohlhagen Trade Model

Hooper and Kohlhagen (1978) examined the effects of exchange-rate volatility on trade flows and export prices using a supply and demand model. The model assumes that import demand is a derived demand in which imports are used in the domestic production of final goods. Importers face a domestic demand for output (Q) which is a function of domestic income (Y), prices of substitutes and complements (PD), own price (P) and nonprice rationing (CU) of output:[6]

(2.7) $Q = aP + bPD + cY + dCU,$

where a, b, c, and d are parameters. Importing firms maximize a linear utility function, which varies directly with the expected value of nominal profits and inversely with standard deviation of profits:

(2.8) $\max_{Q} \; U = E(\pi) - \gamma\,(V(\pi))^{1/2},$

where γ is the relative measure of risk preference.[7] Assuming a constant input-output ratio, input requirements are presented by:

(2.9) $q = iQ,$

where Q is the domestic demand for output, q is the quantity of input needed, and i is the input-output ratio. Thus, an importer's profit is given by:

(2.10) $\pi = QP(Q) - UC{\cdot}Q - HP^{*}\, iQ,$

[6] CU behaves as a price variable: as demand pressure and capacity utilization increase during cyclical upswings, available supply is rationed through such techniques as longer order-delivery lags and tighter customer credit conditions, thereby depressing quantity demanded (Gregory (1971)).

[7] $\gamma>0$ implies risk aversion, $\gamma=0$ risk neutrality, and $\gamma<0$ is risk seeking.

where UC is the unit cost of production; H is the foreign exchange variable, and P* is import price in the foreign currency.[8] The variance in the importing firm's profit is:

$$(2.11) \quad V(\pi) = [\, P^* \, iQ\beta(1-\alpha)]^2 \, \sigma^2_{R1}.$$

Substituting equations (2.10) and (2.11) into equation (2.8) and differentiating equation (2.8) with respect to Q yields the first-order condition:

$$(2.12) \quad [Q/a + P - UC - P^* \, i(E(H) + \gamma\delta\sigma_{R1})\,] = 0 \,^{9},$$

where $\delta = \beta(1-\alpha)$. Substituting for P from the domestic demand schedule and q/i for Q into equation (2.12), and solving for q yields the import demand function for an individual firm:

$$(2.13) \quad q = i/2 \,(\, aUC + bPD + cY + dCU\,) + ai^2/2 \; P^*(E(H)+\gamma\delta\sigma_{R1}).$$

Exporter behavior is modeled in a similar fashion:

$$(2.14) \quad \max_{q^*} \; U^* = E(\pi^*) - \gamma^*(V(\pi^*))^{1/2},$$

and

$$(2.15) \quad q^* = nq,$$

where q* is quantity of exports and n is the number of competing importers. Thus, exporter profits are given as:

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[8] $H = \beta\,(\alpha F + (1-\alpha)\,R_1) + (1-\beta)F$,
where β is the share of imports denominated in the exporter's currency, $(1-\beta)$ is the share of imports denominated in the importer's currency, α is the proportion of foreign currency costs hedged in the forward market, F is the forward cost of the exporter's currency in terms of the importer's currency, and R_1 is the spot exchange rate realized in the second period. (Pick (1990))

[9] The calculation is as follows:
$U = QP(Q) - UCQ - E(H)P^*iQ - \gamma P^*iQ\beta(1-\alpha)\sigma_{R1}$,
$dU/dQ = P + Q\, dP/dQ - UC - E(H)P^*i - \gamma P^*i\beta(1-\alpha)\sigma_{R1} = 0$;
$\Rightarrow \; P + Q/a - UC - P^*ii\,(E(H) + \gamma\delta\sigma_{R1}) = 0$ ($dP/dQ = 1/a$ from equation (2.7)).

(2.16) $\pi^* = q^*P^*H^* - q^*UC^*$,

where UC^* is the exporter's domestic unit cost of production and H^* is the cost of foreign exchange for the exporter. It is assumed that exporters do not use imported inputs in production.

Import demand (equation 2.8) and export supply (equation 2.16) above can be solved to obtain the following reduced form equations for equilibrium quantity and price, respectively:

(2.17) $q^* = f\,(Y, CU, UC, UC^*, PD, E(H), E(H^*), \sigma_{R1})$

(2.18) $P^* = g\,(Y, CU, UC, UC^*, PD, E(H), E(H^*), \sigma_{R1})$

where: q^* = quantity of exports,

P^* = nominal export price given in exporter's currency,

Y = money income in importing country,

CU = importer's nonprice rationing, behaving like a price variable,

UC, UC^* = importer's and exporter's unit cost, respectively,

PD = the prices of complements and substitutes,

$E(H)$, $E(H^*)$ = expected cost of foreign exchange for the importer and exporter respectively,

σ_{R1} = standard deviation of the future spot rate.

Hooper and Kohlhagen employed this model to estimate reduced-form price and quantity equations for sixteen U.S. and German traded goods and found that exchange rate risk had a significantly negative impact on market prices in cases where importers assumed the bulk of exchange risk. However, they found no significant effect of exchange risk on trade volumes.

Cushman (1983) modified the Hooper and Kohlhagen model by assuming real profit maximization and uncertain foreign and domestic price levels in addition to uncertain nominal exchange rates. Thus, firm's decisions are affected by real variables rather than by nominal variables. This model was applied to 14 bilateral trade flows for 1965-77. Results indicated that exchange rate volatility had significant negative effects on six trade flows (U.S. exports to Canada, France, and Japan, U.S. imports from Canada and Japan, and German exports to the United Kindom).

Cushman (1988) and Kenen and Rodrik further modified the Hooper-Kohlhagen model to examing a variety of exchange rate risk measures. In both cases, the following reduced-form equation was used:

$$(2.19) \qquad Q^* = \alpha + \eta Y + \rho UC_{im} + \phi UC_{ex} + \xi R + \kappa M + \nu S,$$

where Q^* is the real export value (as a measure of quantity); Y is the importer's real income (GNP); UC_{im} is the importer's real unit production cost; UC_{ex} is the exporter's real unit production cost; R is the foreign currency per U.S. dollar exchange rate; M is a four-quarter moving-average of recent percentage change in R (proxy for expectations of uncertain growth rate of the real exchange rate), and S is a risk measure representing uncertain growth rate of the real exchange rate.[10]

[10] Cushman (1983) formulated the uncertain component of the exchange rate as $R_1 = R_0\theta$, where R_0 is the known current real exchange rate and θ is the uncertain growth rate of R.

Cushman (1988) used (2.19) to test for the effects of real exchange rate risk on U.S. bilateral trade flows. Increased exchange rate risk negatively affected five of six U.S. import flows, but risk effects on U.S. exports were less conclusive.

Pick (1990) analyzed the effect of exchange rate risk on U.S. agricultural trade flows using the Hooper and Kohlhagen model. The model's assumption that the demand for imports is a derived demand is particularly relevant for agricultural trade since most goods are intermediate in nature. Pick applied the model to U.S. agricultural exports to ten countries and found that while exchange rate risk was not significant in seven developed markets, exchange rate risk adversely affected U.S. agricultural exports to three developing countries. He concluded that exchange rate risk was important for agricultural exports to developing countries because of a lack of well-developed financial and commodity markets.

Beef By-Products Research

Meat slaughtering firms rely upon the sale of by-products to cover slaughter costs and provide profits since the value of carcasses or boxed beef obtained from slaughter cattle is often less than the value of live cattle inputs (Ward). Changes in the value of by-products significantly affect packer bid prices for slaughter cattle (Marsh 1988).

Ward (1988) considered the impact of by-products on meat packers' profits using the equation:

$$(2.20) \qquad \pi = (P_m Q_m + P_b Q_b) - (P_l Q_l + C_p Q_l),$$

where π is total profit, P_m is price of meat sold, Q_m is quantity of meat sold, P_b is price of by-products sold, Q_b is quantity of by-products sold, P_l is price of livestock purchased, Q_l is quantity of livestock (weight) purchased, and C_p is cost per unit of slaughtering and processing livestock. In 1997 and 1998, the value of beef by-products averaged about 15 percent of packers gross revenue.

Economic and quantitative research involving beef by-products is relatively scarce, particularly research involving international trade of beef by-products. However, several studies have incorporated beef by-product values as explanatory factors in the behavior of domestic derived demands. Marsh (1988) examined the impacts of the 1985 Dairy Termination Program (DTP) on live cattle and wholesale beef prices. The following reduced-form price equations were estimated:

(2.21) $P_j = (L)\, f_j\, (D, QF, QNF, IM, K, QS, Y, BPV, PCN, QFR, U_j) \quad j = 1,\ldots 5,$

where P_1, P_2, P_3, P_4, P_5 are prices of steer carcasses, cow carcasses, slaughter steers, utility grade cows, and feeder steers, respectively; D is a set of quarterly binary variables; QF and QNF are quantities of commercial fed and nonfed beef production, respectively; QS is the quantity of substitute meat production; K is beginning quarter beef cold storage holdings; IM is imports of fresh and frozen beef and veal; Y is disposable income; BPV is steer by-product values; PCN is the price of corn; QFR is thirteen-state net placements of cattle on feed; U is an error term; and L represents a distributed lag structure.

To evaluate the effects of the DTP on beef cattle prices, supply responses were also estimated:

(2.22) $QF = (L_1)\, f_6\, (D, P_3/PCN, U_6),$

(2.23) $QNF = (L_2) f_7 (D, P_3/PCN, U_7)$,

where P_3/ PCN is the steer-corn price ratio. Marsh concluded that the DTP increased nonfed beef production (over eighteen months) by 5.5% of the sample average. Using the estimated eighteen-month price flexibilities in conjunction with production responses, the DTP resulted in a 5.3% reduction in carcass prices, a 4.6% reduction in slaughter prices, and a 6.4% reduction in feeder cattle prices. Regarding by-products, the estimated model indicated a 1 percent increase in real by-product values increased real slaughter steer price by 0.24 percent.

Marsh (1992) also included beef by-product effects in a model designed to determine the market effects of USDA beef data revisions. He concluded that a 1 percent increase in real by-product values increased real slaughter prices by 0.24 to 0.30 percent.

Brester and Marsh (1983) developed a dynamic econometric model using rational distributed lags to estimate the demand and supply structure of the primary and derived production and marketing levels of the U.S. beef industry. The empirical results indicated that consumer behavior is critical in establishing the structure of primary and derived demand prices for beef, with shocks in consumer habits, real income, and market substitutes of the retail rational lag structure affecting the entire marketing system. Carcass and farm by-products were important determinants of wholesale and slaughter beef prices. Results indicated that 1 percent increases in carcass by-product and farm by-product values increased steer carcass and steer slaughter prices by 0.34 and 0.10 percent, respectively.

Blake and Clevenger (1980) quantified the effects of U.S by-product exports on U.S. beef by-product values. They indicated that previous researchers (e.g.,Edwards, Ehrich and Usman; Folwell and Shapouri; Freebairn and Rausser; Houck 1974, 1977; Langemeier and Thompson; Schmitz and Nelson) focused on the impact of beef imports on domestic live cattle prices, but were neglecting the impact of beef by-product exports on domestic live cattle prices. In their model, the price of beef by-products was considered a function of demand factors alone, since live cattle are purchased and slaughtered primarily for their value as beef, not for their by-product value. Consequently, the value of beef by-products was a function of exports of beef by-products and domestic demand for beef by-products:

$$(2.24) \qquad BP = f\{E, DDBP\},$$

where BP is the value of beef by-products (the portion of live cattle price attributable to farm by-products), E is the export quantity of beef by-products, and DDBP is the domestic demand for beef by-products. Dividing net exports by domestic production of by-products provides a quantity share measure for each by-product, and allows evaluation of its impact on the portion of live cattle price attributable to by-product exports. The portion of annual average live weight farm price of cattle attributable to beef by-products (FBPA) was regressed on annual net exports of inedible tallow (PCTIT), edible tallow (PCTET), hides and skins (PCTSH), and offal (PCTO). The OLS model for the time period 1958-77 was:

$$\text{(2.25)} \quad \underset{(1.69)}{\text{FBPA} = 3.66} - \underset{(-1.66)}{0.09\ \text{PCTIT}} + \underset{(1.77)}{0.10\ \text{PCTET}} + \underset{(1.15)}{0.03\ \text{PCTSH}}$$

$$+ \underset{(1.48)}{0.11\ \text{PCTO}}$$

$$R^2 = 0.763, \; F = 12.09,$$

where t-values are shown in parentheses.

Except for inedible tallow, the estimated coefficients have expected positive signs. They hypothesized the negative impact of inedible tallow on domestic live cattle prices may be attributed to the large percentage of total world exports of inedible tallow accounted for by U.S. exports. A 1% change in edible tallow, hide and skin, and offal exports, positively affects live cattle prices by 0.1 cents, 0.03 cents, 0.11 cents per pound, respectively. The authors indicated that the positive impacts of beef by-product exports were larger than Freebairn and Rausser's (1975) estimate of the negative impact of beef imports on live cattle prices.

Smith and Goodwin (1992) used logit models to evaluate the influences of several economic and demographic variables on U.S. demand for beef specialty products. Variables included were age, income, household size, gender, and educational and ethnic background. Products considered were liver, kidney, heart, tongue, tripe, sweetbreads, and brains. Survey data from three cities in Kansas were collected (approximate 3000 responses), with logit equations estimated by maximum likelihood. They found that, for most beef specialty products, increases in household incomes and decreases in household size (increase in income per capita) are likely to reduce the demand for beef specialty products in the U.S. The finding suggests that beef specialty products are inferior commodities. They also found age had significant effects on the probability that individuals will purchase beef specialty products. Older individuals are more likely to purchase the product because of the "age-cohort" effects. That is, older age cohorts are more likely to have acquired the human capital needed to prepare and enjoy specialty meats due to their rural backgrounds. In addition, men are more likely to purchase beef specialty products than women, and with the exception of tongue, college-educated individuals are less likely to purchase specialty products. Finally, positive coefficients occur for the ethnic variables, indicating people with ethnic backgrounds are more likely to purchase beef specialty meats.

In summary, this chapter presents three different theoretical models widely used in international trade analysis: excess demand/excess supply model, Armington trade model, and Hooper-Kohlhagen trade model. All three are appropriate for modeling and estimating foreign trade impacts, but their application depends upon the nature of the trade problems, objectives of the researcher, and assumptions and restrictions required. The Hooper-Kohlhagen trade model will be used in this study because its theoretical base is consistent with a generalized structural specification of economic factors expected to affect import demand. Therefore, the model is conducive to econometric estimation of marginal impacts of foreign shocks such as those emanating from income, exchange rates, and prices.

CHAPTER 3

THEORETICAL MODEL

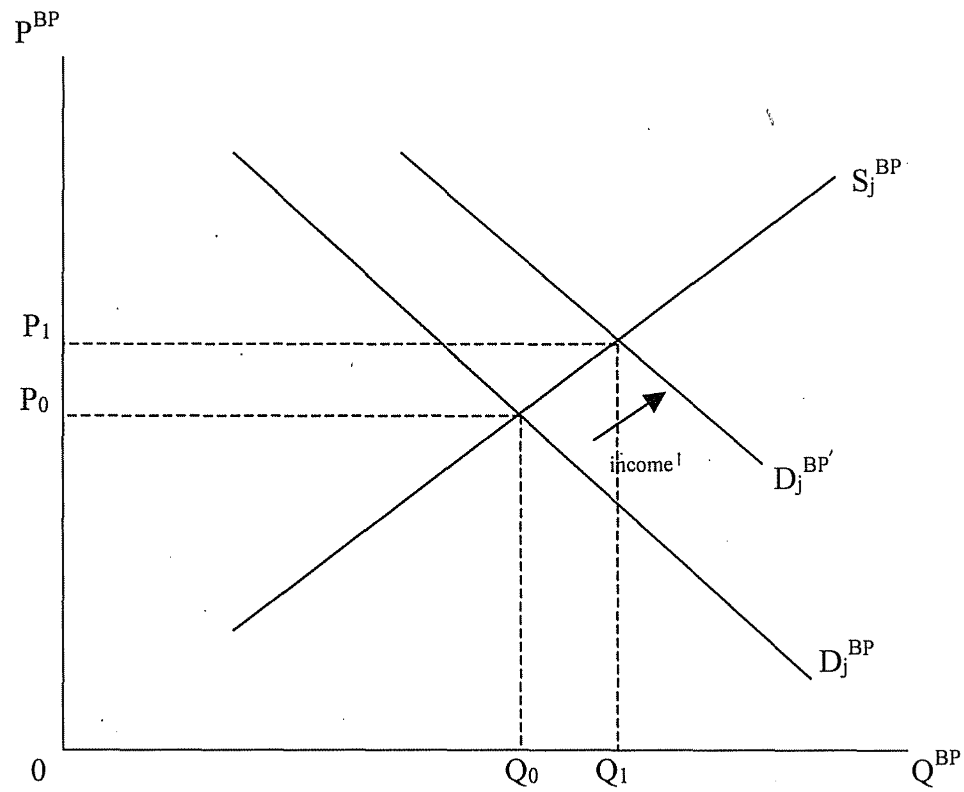
In this chapter, a theoretical model of foreign beef by-product demand and its impact on U.S. domestic slaughter steer prices is presented. By-product trade and its economic implications are investigated within the context of a partial equilibrium framework. In partial equilibrium models, subsets of the economy are examined that are sufficiently small to permit incomes and prices of many other goods to be viewed as exogenous (Takayama and Judge).

A sector or set of markets is said to be in a partial competitive spatial equilibrium if the following conditions are satisfied or can reasonably be approximated. First, commodity prices and transport costs have to be homogenous and unique. Second, markets have to clear and be spatially efficient; that is, there can be no excess demands for transportation between any pair of countries and transportation shipments have to be efficient.

Brester and Wohlgenant (1997) used a partial equilibrium model to analyze the impact of the GATT/Uruguay round trade negotiations on U.S. beef and cattle prices. They predicted that the GATT/Uruguay Round will cause asymmetric effects on consumers of ground and table cut beef. Fed cattle and cow/calf producers will benefit from trade liberalization because of increases in fed and feeder cattle prices, but nonfed cattle price will decrease.

In the model presented here, import demand schedules for U.S. beef by-products by foreign countries are assumed to be downward sloping.[11] According to Blake and Clevenger (1980), beef by-products are produced in fixed proportions to slaughter cattle and carcasses. Thus the supply schedule for beef by-products can be represented by U.S. cattle supply to foreign countries. According to Marsh (1994), the fed cattle supply schedule is not perfectly inelastic within any given year as feeder cattle placements respond to price incentives. The export market for U.S. beef by-product is illustrated in Figure 3, where the initial equilibrium is at P_0 and Q_0.

Figure 3. The Effect of a Change in Income on By-Product Import Demand.



[11] In other words, beef by-products are assumed not to be Giffen goods.

Given a demand side shock to an exogenous variable such as foreign income, the derived demand schedule shifts out, resulting in higher import prices and export quantities (illustrated by P_1 and Q_1 in Figure 3). Supply shocks such as changing feed prices cause prices and quantities to move in opposite directions.

The following equations represent the import demand and export supply for beef by-products:

(3.1) $QD_j^{BP} = f(P^{BP}, Y_j, Ex_j, P_j^{output}, INV_j^{cattle})$ (import demand)

(3.2) $QS_{usj}^{BP} = g(P_{sl}^{US}, P_{feeder}^{US}, P_{feed}^{US})$ (export supply)

(3.3) $QD_j^{BP} = QS_j^{BP} = Q_j^{BP}$, $j = 1,2,\ldots J$, (market clearing)

where,

QD_j^{BP}: Country j's import demand for U.S. beef by-products.

QS_{usj}^{BP}: U.S.supply of beef by-products to country j.

P^{BP}: Export price of beef by-products in U.S. dollars.

Y_j: National income of country j.

Ex_j: Exchange rate for country j.[12]

P_j^{output}: Price of output made from imported beef by-products in country j.

INV_j^{cattle}: Cattle inventory in country j.

P_{sl}^{US}: U.S. slaughter cattle price.

P_{feeder}^{US}: U.S. feeder cattle price.

P_{feed}^{US}: U.S. corn price.

[12] Currencies of importing countries per U.S. dollar (Won/\$, Yen/\$, etc).

Import demands (by country) for U.S. beef by-products are determined by U.S. export prices, incomes in importing countries, exchange rates, prices of beef by-product outputs, and cattle inventory in the importing countries. It is assumed that increases (decreases) in U.S. export prices are associated with increases (decreases) in import prices in country j.

By-product export prices are included in the import demand function since they are direct cost factors for importing countries purchasing beef by-products from the U.S. A priori, an increase in U.S. export prices would decrease quantities of imports demanded by foreign countries. National incomes are included to account for income effects on the derived demand for beef by-products. For example, if a country's national income increases and import demand for U.S. beef by-products shifts outward, then the import is considered a normal good. Exchange rates are defined as foreign currency prices for one U.S. dollar. Thus, the higher is the value of the exchange rate, the lower is the value of the importing country's currency in terms of U.S. dollar. A priori, currency depreciations are expected to reduce import demand since the purchasing power of the importing country's currency declines and the imported good becomes more expensive.

A country's import demand for a U.S. beef by-product is a derived demand. Many countries import beef by-products as inputs in producing final products (for example, hides are made into leather). Consequently, prices of final outputs are also included in the equation. A priori, a positive (negative) change in the price of the final good is expected to increase (reduce) import demand. Cattle inventory in each importing country is included in the model to serve as a stock variable. A large cattle inventory indicates that an importing country has a relatively large capacity to produce beef by-products. Consequently, other factors constant, the result is likely to be a lower import demand by that country.

As mentioned at the beginning of this chapter, the supply of beef by-products is hypothesized to be determined by the supply of slaughter cattle. Houck shows that joint product elasticities determine a commodity elasticity in the case where the joint products are in fixed proportions and the only available outlet for the commodity is the manufacture of its joint products. In the case of cattle, where meat is the largest component of packer total revenue, Houck's effects are likely to be relatively small for by-products. If hide value increases, to produce more hides packers would need to offer higher cattle/beef prices for cattle supply to increase. Considering finished (fed) cattle, supply is considered a function of slaughter steer price, feeder cattle price, and corn price. The supply of fed cattle/beef by-products should be positively correlated with output price of slaughter cattle and negatively correlated with input prices for feeder cattle and feed corn.

To link country import demands of by-products to the U.S. slaughter cattle market and slaughter price, the following U.S. by-product value equation is specified:

(3.4) $BP = f(Q^{sl}, Wc, Y_{us}, P^{H}, P^{VM}, P^{ET}, P^{IE})$,

where,

BP: aggregate U.S. farm beef by-product value (cents/pound).

Q^{sl}: number of commercial cattle slaughtered (million head).

Wc: average slaughter weight of all cattle (pounds).

Y_{us}: U.S. personal income (million dollars).

P^H: weighted average of import prices of cattle hides by four countries.

P^{VM}: weighted average of import prices of variety meats by four countries.

P^{ET} : weighted average of import prices of edible tallow by four countries.

P^{IE} : weighted average of import prices of inedible tallow by four countries[13].

Equation (3.4) represents U.S. by-product value as a function of domestic supply factors and consumer income and foreign market factors represented by the weighted by product prices (Blake and Clevinger). The second step in linking country import demands of by products to the U.S. cattle market is to specify meat packer demand for slaughter cattle. In the U.S. beef market, slaughter cattle demand serves as the basis for specifying inverse derived demand, or the behavior of slaughter cattle price. Slaughter cattle demand is represented as:

(3.5) $Q_{sl}{}^{d} = h_1(P_{sl}{}^{d}, P^{bx}, M_c, BP, Wc)$ (slaughter cattle demand)

(3.6) $Q_{sl}{}^{s}$ = previous specification (slaughter cattle supply)

(3.7) $Q_{sl}{}^{d} = Q_{sl}{}^{s} = Q_{sl}$ (market clearing)

where,

$Q_{sl}{}^{d}$: Quantity demanded of commercial slaughter cattle by meat packers (million head).

$P^{d}{}_{sl}$: Price of choice 2-4 slaughter steers, 1100-1300 lbs, Nebraska direct ($/cwt).

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[13] P^H, P^{VM}, P^{ET} and P^{IE} are calculated later in Chapter 6 on page 65.

P^{bx}: Price of boxed beef, cutout value of choice 2-4 550-700 lb beef carcass, Omaha ($/cwt).

M_c: Index of food labor processing cost (1967=100).

Wc: Average slaughter weight of commercial cattle slaughter (pounds).

BP: Farm by-product value (cents/pound).

It is hypothesized that the domestic demand for slaughter cattle is a decreasing function of the slaughter cattle (input) price, labor processing (input) cost, and average slaughter weights; it is assumed to be an increasing function of boxed beef (output) prices and beef by-product (joint product) prices. The domestic supply of slaughter cattle (number of head) assumes the same right-hand side specification as in equation (3.2), although the function is not used in calculations that follow. Marketing clearing conditions are assumed.

Solving for the slaughter demand price in equation (5.5) yields the derived inverse slaughter demand:

(3.8) $P_{sl} = h(Q^{sl}, P^{bx}, BP, M_c, Wc)$.

Changes in foreign demand for U.S. beef by-products are of concern to meat packers due to their effects on value of by-products. Similarly, beef producers are concerned about related impacts on cattle prices. Shifts in demand for by-products can occur because of changes in factors such as foreign income or foreign exchange rates. Because different by-products are exported, their impacts on U.S. aggregate by-product value are not expected to be identical, as indicated in equation (3.4). Thus, equations

(3.1), (3.2), (3.4) and (3.8) link the effects of a shock to a particular by-product demand on U.S. cattle prices. Sequential derivatives can be used to illustrate the effects of, say, a change in import demand for hides in country j on U.S. slaughter price. Using equation 3.4, it is assumed that a one unit change in export price of a particular by-product to any country j will have the same effect on the U.S. by-product price. The catalyst for the import demand shift is assumed to be a shift in income (Y). Thus:

(3.9). $(\partial \ln P_{sl}/\partial \ln(QD_j^H|Y_j)) = (\partial \ln QD_j^H/\partial \ln Y_j)(\partial \ln P_H/\partial \ln QS_j^H)(\partial \ln BP/\partial \ln P_H)(\partial \ln P_{sl}/\partial \ln BP)$,

where the left-hand side derivative is the change in U.S. slaughter price resulting from a change in the demand for hides in country j, given an income shift in country j. In this example, the remaining partial derivatives are estimated coefficients: $(\partial \ln QD_j^H/\partial \ln Y_j)$ is estimated from equation (3.1), $(\partial \ln P_H/\partial \ln QS_j^H)$ is estimated from equation (3.2), $(\partial \ln BP/\partial \ln P_H)$ is estimated from equation (3.4), and $(\partial \ln P_{sl}/\partial \ln BP)$ is estimated from equation (3.8). Equation (3.9) indicates that a shock in foreign income affects import demand and price, and then reverberates through the U.S. by-product market and slaughter cattle price. Other types of shocks will be analyzed in a similar way and have similar effects on U.S. domestic slaughter cattle price. The shocks considered in this work are foreign incomes and exchange rates for Japan, Korea, Canada and Mexico.

Conclusion

This chapter has presented the theoretical structure of the empirical model to be estimated below. Data needed for estimating import demand include import prices and quantities of beef by-products for Japan, Korea, Canada and Mexico, each country's Consumer Price Index (CPI), each country's real GDP (1990 prices), and real exchange rates during the period of 1980 to 1997. Data needed to estimate impacts of by-products prices on U.S. beef by-product

value include U.S. real by-product value, number of cattle slaughtered, average slaughter weight, and real personal consumption expenditures. Data needed to estimate inverse demand for U.S. fed cattle include real prices of slaughter steers, prices of boxed beef and corn, commercial cattle slaughter and average live weights, wholesale quantities of poultry and pork, and food marketing cost (index). These data are presented and discussed in the next chapter.

CHAPTER 4

DATA

The sample period for the beef by-product import demand model consists of annual data from 1980 to 1997. Separate import quantities and values for foreign countries are not available on an annual basis prior to 1980. The USDA at that time only provided five-year averages from 1975 to 1979.

Data For Import Demand Functions

All import prices and quantities of beef by-products for Japan, Korea, Canada and Mexico were obtained from the USDA, *Dairy, Livestock and Poultry: U.S. Trade and Prospects*. The definitions of variables are in table 1. The data are listed in table 2 to table 5.

Table 1. Definition of Import Demand Model Variables.

Variable Notation	Definition
CVMQ	Canadian import quantities of variety meats (metric tons).
CVMPR	real price of Canadian import of variety meats (thousands of dollars).
CEDTAQ	Canadian import quantities of edible tallow (metric tons).
CEDTAPR	real price of Canadian import of edible tallow (thousands of dollars).
CINEDTAQ	Canadian import quantities of inedible tallow (metric tons).
CINEDTAPR	real price of Canadian import of inedible tallow (thousands of dollars).
CHWQ	Canadian import quantities of hides (in pieces).
CHWPR	real price of Canadian import of hides (thousands of dollars).
CGDP1990	Canadian GDP based on 1990 prices.
RCXRATES	Canadian real exchange rate (Canadian dollars per U.S. dollar).
MVMQ	Mexican import quantities of variety meats (metric tons).
MVMPR	real price of Mexican import of variety meats (thousands of dollars).
MEDTAQ	Mexican import quantities of edible tallow (metric tons).
MEDTAPR	real price of Mexican import of edible tallow (thousands of dollars).
MINEDTAQ	Mexican import quantities of inedible tallow (metric tons).
MINEDTAPR	real price of Mexican import of inedible tallow (thousands of dollars).
MHWQ	Mexican import quantities of hides (in pieces).
MHWPR	real price of Mexican import of hides (thousands of dollars).
MGDP1990	Mexican GDP based on 1990 prices.
RMXRATES	Mexican real exchange rate (Pesos per U.S. dollar).
JVMQ	Japanese import quantities of variety meats (metric tons).
JVMPR	real price of Japanese import of variety meats (thousands of dollars).
JEDTAQ	Japanese import quantities of edible tallow (metric tons).
JEDTAPR	real price of Japanese import of edible tallow (thousands of dollars).
JINEDTAQ	Japanese import quantities of inedible tallow (metric tons).
JINEDTAPR	real price of Japanese import of inedible tallow (thousands of dollars).
JHWQ	Japanese import quantities of hides (in pieces).
JHWPR	real price of Japanese import of hides (thousands of dollars).
JGDP1990	Japanese GDP based on 1990 prices.
RJXRATES	Japanese real exchange rate (Yen per U.S. dollar).
KVMQ	Korean import quantities of variety meats (metric tons).
KVMPR	real price of Korean import of variety meats (thousands of dollars).
KEDTAQ	Korean import quantities of edible tallow (metric tons).
KEDTAPR	real price of Korean import of edible tallow (thousands of dollars).
KINEDTAQ	Korean import quantities of inedible tallow (metric tons).
KINEDTAPR	real price of Korean import of inedible tallow (thousands of dollars).
KHWQ	Korean import quantities of hides (in pieces).
KHWPR	real price of Korean import of hides (thousands of dollars).
KGDP1990	Korean GDP based on 1990 prices.
RKXRATES	Korean real exchange rate (Won per U.S. dollar).

Table 2. Import Values and Quantities of By-Products for Japan, 1980 to 1997.

YEAR	JVMV	JVMQ	JEDTAV	JEDTAQ	JINEDTAV	JINEDTAQ	JHWV	JHWQ
1980	84,135	28,567	4,817	10,122	50,183	106,113	251,474	7,460,358
1981	99,471	32,105	1,029	2,166	39,780	87,521	255,121	7,495,175
1982	96,823	31,404	1,045	2,172	33,870	69,332	207,170	6,443,988
1983	83,947	33,652	1,737	4,107	23,840	56,354	224,111	6,388,331
1984	76,941	34,539	207	400	19,519	40,814	305,022	7,333,641
1985	76,138	36,408	1,508	2,622	15,989	38,405	276,077	6,824,464
1986	119,864	48,352	1,165	2,305	13,600	38,022	304,737	6,681,864
1987	140,428	54,188	946	1,998	11,324	31,852	332,600	5,929,002
1988	176,697	67,392	726	1,691	15,143	39,498	415,598	7,004,914
1989	209,254	90,712	3,135	8,701	16,093	45,927	353,197	6,206,193
1990	211,306	79,564	2,425	6,528	13,350	37,115	411,581	6,754,969
1991	289,614	98,737	5,387	8,105	16,809	48,183	250,661	4,660,759
1992	362,300	113,665	3,726	3,980	14,692	42,255	258,143	4,632,569
1993	325,672	112,474	2,194	2,509	11,905	34,222	235,373	4,167,324
1994	281,958	94,808	661	1,038	12,394	36,215	197,361	3,131,500
1995	416,495	156,649	862	1,500	21,352	44,429	221,969	3,244,535
1996	422,181	177,862	806	1,600	17,510	39,958	154,160	2,372,025
1997	254,895	88,826	754	1,707	15,781	37,663	117,389	1,800,433

Source: Livestock, Dairy and Poultry Situation and Outlook (USDA).

Note: For the definitions and units of the variables, see table 1.

Table 3. Import Values and Quantities of By-Products for Korea, 1980 to 1997.

YEAR	KVMQ	KVMV	KEDTAQ	KEDTAV	KINEDTAQ	KINEDTAV	KHWQ	KHWV
1980	267	424	250	120	114,577	52,404	2,654,680	88,953
1981	293	436	1,475	688	80,061	35,336	3,572,262	117,491
1982	320	428	500	192	64,269	28,958	4,569,450	143,030
1983	29	61	898	511	80,952	33,839	4,614,161	165,354
1984	217	472	1,295	829	82,952	40,519	5,422,989	242,639
1985	12	28	996	399	79,247	33,663	6,441,235	267,353
1986	36	78	607	153	66,342	17,514	9,405,711	449,955
1987	32	26	1,970	771	76,536	24,170	10,141,196	577,469
1988	449	1,150	3,332	1,389	77,321	29,526	9,960,174	636,864
1989	1,774	2,089	5,709	2,184	52,429	17,718	10,313,028	604,022
1990	465	1,052	6,655	2,641	41,854	13,487	9,838,708	615,169
1991	3,551	8,336	4,251	1,507	32,821	10,222	9,285,219	517,210
1992	3,779	5,286	6,074	2,307	45,859	14,735	8,569,022	480,652
1993	9,150	11,480	7,028	2,651	37,529	12,623	7,851,241	432,878
1994	12,429	12,904	8,862	3,898	35,555	12,758	7,472,478	448,919
1995	13,471	12,689	13,024	6,618	47,018	22,194	8,282,245	511,086
1996	10,589	10,155	10,786	5,054	26,271	11,395	7,955,679	452,138
1997	5,576	8,189	6,929	3,648	4,862	2,278	7,467,896	454,646

Source: Livestock, Dairy and Poultry Situation and Outlook (USDA).

Note: For the definitions and units of the variables, see table 1.

Table 4. Import Values and Quantities of By-Products for Canada, 1980 to 1997.

YEAR	CVMV	CVMQ	CEDTAV	CEDTAQ	CINEDTAV	CINEDTAQ	CHWV	CHWQ
1980	9,055	12,936	242	425	890	2,011	28,472	964,160
1981	9,318	14,167	355	666	848	1,955	29,764	1,122,903
1982	10,933	16,099	1,009	1,952	2,138	5,343	25,162	955,078
1983	10,604	14,180	1,641	3,348	665	1,515	34,048	1,086,702
1984	17,427	14,968	3,533	6,371	893	1,870	41,778	1,072,149
1985	18,775	9,069	1,514	3,367	208	452	25,307	728,929
1986	13,007	5,615	2,642	6,530	274	533	25,723	667,647
1987	20,520	8,954	2,663	6,754	286	595	36,003	829,135
1988	24,653	9,561	2,564	6,365	574	1,508	34,117	732,439
1989	1,495	1,372	4,185	10,856	402	690	28,781	587,987
1990	10,958	10,987	4,446	11,405	1,336	2,695	38,635	674,402
1991	9,539	10,416	4,180	10,887	2,215	4,244	27,762	561,003
1992	9,844	9,993	6,931	19,058	1,607	3,332	34,861	683,887
1993	11,065	10,588	7,042	17,868	2,179	4,806	43,228	955,948
1994	10,974	12,164	7,034	16,186	3,834	8,789	49,670	995,171
1995	9,315	10,757	8,563	17,693	4,882	11,856	47,755	951,071
1996	9,014	10,378	10,222	20,612	8,049	18,252	52,253	1,148,716
1997	9,994	11,298	10,745	19,570	8,328	18,807	64,883	1,247,952

Source: Livestock, Dairy and Poultry Situation and Outlook (USDA).

Note: For the definitions and units of the variables, see table 1.

Table 5. Import Values and Quantities of By-Products for Mexico, 1980 to 1997.

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YEAR	MVMV	MVMQ	MEDTAV	MEDTAQ	MINEDTAV	MINEDTAQ	MHWV	MHWQ
1980	17,426	18,988	5,021	9,118	43,404	78,878	61,109	1,969,703
1981	10,935	11,707	4,185	7,281	34,596	64,431	67,128	2,480,847
1982	12,531	14,354	9,283	17,252	27,149	60,818	53,344	1,869,109
1983	10,370	15,435	6,675	16,198	30,485	70,668	40,700	1,293,090
1984	24,040	26,720	3,028	6,380	55,998	103,935	81,673	1,858,145
1985	35,488	37,796	4,871	9,647	47,948	105,219	91,519	2,286,881
1986	21,679	30,303	4,290	12,470	32,900	94,626	41,979	1,002,102
1987	15,823	22,895	7,837	20,430	51,986	144,363	65,841	1,426,742
1988	44,917	36,545	19,060	44,166	50,048	120,905	89,616	1,833,103
1989	40,031	35,025	21,635	54,278	44,099	111,403	62,886	1,282,480
1990	31,611	27,357	29,654	80,427	27,673	78,734	69,537	1,377,448
1991	49,363	42,266	34,438	97,191	33,515	96,228	119,201	2,574,482
1992	48,509	40,356	28,142	75,886	39,904	108,129	113,295	2,524,410
1993	47,474	40,870	35,214	93,061	51,108	136,874	92,213	2,035,137
1994	48,468	45,377	33,293	81,964	57,892	147,179	87,721	1,545,012
1995	30,165	25,491	33,287	71,314	73,926	164,621	50,553	893,019
1996	35,288	30,490	28,112	58,088	76,541	180,722	102,245	2,117,135
1997	45,233	39,444	25,618	49,940	94,583	192,581	125,361	2,467,432

Source: Livestock, Dairy and Poultry Situation and Outlook (USDA).

Note: For the definitions and units of the variables, see table 1.

Real import prices were obtained by dividing import values by import quantities and then deflating by the relevant country's CPI (1990=100). The country CPI's, country real GDP's (1990 prices), and real exchange rates were obtained from *International Financial Statistics* of the International Monetary Fund (IMF). The data are listed in table 6 for Japan and Korea and in table 7 for Canada and Mexico.

Table 6. GDP, CPI and Real Exchange Rate for Japan and Korea, 1980 to 1997.

YEAR	JGDP	JCPI	RJXRATES	KGDP	KCPI	RKXRATES
	Base Year: 1990	(1990=100)	Base Year: 1990	Base Year: 1990	(1990=100)	Base Year: 1990
	(Billions of Yen)		(Yen per U.S.$)	(Billions of Won)		(Won per U.S.$)
1980	287,441	81.7	175.1	74,345	54.4	704.0
1981	297,728	85.7	179.3	79,338	66.0	717.4
1982	307,141	88.0	209.2	85,130	70.9	762.1
1983	315,438	89.7	202.0	95,155	73.3	807.2
1984	328,893	91.8	206.0	104,803	74.9	855.0
1985	345,285	93.6	209.9	111,330	76.8	933.1
1986	354,358	94.2	150.2	124,194	78.8	941.4
1987	368,906	94.3	133.5	138,499	81.2	879.8
1988	391,808	95.0	122.3	154,111	87.0	760.0
1989	410,282	97.1	134.9	163,950	92.0	691.7
1990	430,040	100.0	144.8	179,539	100.0	707.9
1991	446,371	103.3	136.0	195,936	109.2	698.7
1992	450,981	105.1	129.5	205,860	116.1	721.9
1993	452,339	106.4	115.6	217,699	121.6	729.3
1994	455,254	107.2	108.2	236,376	129.1	704.9
1995	461,514	107.1	102.5	257,501	135.0	665.9
1996	477,931	107.2	121.9	275,851	141.6	681.7
1997	482,282	109.0	136.4	288,659	147.9	788.7

Source: International Financial Statistics of International Monetary Fund.

Table 7. GDP, CPI and Real Exchange Rate for Canada and Mexico, 1980 to 1997.

YEAR	CGDP	CCPI	RCXRATES	MGDP	MCPI	RMXRATES
	Base Year: 1990	(1990=100)	Base Year: 1990	Base Year: 1990	(1990=100)	Base Year: 1990
	Billions of Canadian$		Canadian$ per U.S$	Millions of Peso		Peso per U.S$
1980	502.93	56.2	1.31	577	0.70	2.18
1981	521.4	63.2	1.32	627	0.81	2.01
1982	504.63	70.1	1.30	623	1.39	3.02
1983	520.59	74.1	1.27	602	2.70	3.38
1984	553.43	77.3	1.33	622	4.49	2.97
1985	579.81	80.3	1.40	636	7.19	2.95
1986	599.04	83.7	1.39	616	13.26	3.83
1987	624.59	87.4	1.32	627	30.79	3.95
1988	655.06	90.8	1.23	635	65.84	3.14
1989	671.09	95.4	1.18	661	79.10	2.96
1990	669.51	100.0	1.17	695	100.00	2.82
1991	657.55	105.6	1.13	724	122.70	2.57
1992	662.58	107.2	1.21	750	141.80	2.35
1993	677.29	109.2	1.31	765	155.73	2.22
1994	704.86	109.4	1.42	799	166.52	2.32
1995	721.26	111.7	1.43	750	224.72	3.35
1996	731.87	113.5	1.44	788	302.02	3.03
1997	760.93	115.3	1.48	841	364.27	2.68

Source: International Financial Statistics of International Monetary Fund.

Data for Japanese edible tallow value and quantity were not available in 1997, so linear interpolation was used to obtain this value. Time series leather prices for the individual countries were not consistently reported. Consequently, the U.S. price of leather was used as a proxy given that U.S. and foreign leather prices are likely to be highly correlated in a global trading economy. Leather price was deflated by the U.S. CPI (1990=100), which was obtained from the *President's Economic Report.*

Data For U.S. By-Product Functions

U.S. by-product values, number of cattle slaughtered, average slaughter weight and personal consumption expenditures were obtain from the *Red Meat Yearbook (USDA), Livestock, Dairy and Poultry and Situation Outlook (USDA),* and the *Livestock Marketing Information Center (LMIC, Lakewood Colorado).* The data are presented in table 8. By-product values and personal consumption expenditures were deflated by the U.S. CPI (1990=100).

Table 8. U.S. Real By-Product Value, Cattle Slaughtered, Average Slaughter Weight, and Real Personal Consumption Expenditures, 1980 to 1997.

YEAR	BPVR	CATTLESL	ALWC	EXPENDPERSD
	Cents per Pound	Millions of Head	Pounds	Millions of Dollars
1980	15.12	33.81	1080	1632.61
1981	12.96	34.95	1083	1634.00
1982	11.41	35.84	1072	1644.91
1983	11.51	36.65	1077	1752.31
1984	13.11	37.58	1073	1835.31
1985	10.45	36.29	1103	1923.31
1986	10.46	37.29	1106	2017.54
1987	12.73	35.65	1109	2084.19
1988	13.66	35.08	1124	2168.27
1989	12.40	33.92	1138	2218.08
1990	12.00	33.24	1140	2247.51
1991	10.22	32.69	1167	2233.04
1992	10.41	32.87	1173	2301.22
1993	10.32	33.33	1164	2361.10
1994	10.54	34.20	1192	2435.24
1995	10.60	35.64	1187	2487.06
1996	10.48	36.58	1173	2543.40
1997	10.53	36.32	1177	2617.25

Sources: USDA Red Meat Yearbook.
USDA Livestock, Dairy and Poultry and Situation Outlook.
Livestock Marketing Information Center.

Data Used to Estimate Inverse Demand For U.S. Fed Cattle

U.S. prices for slaughter steers and boxed beef, number of cattle slaughtered, average slaughter weight, and by-product values were obtained from *Red Meat Yearbook (USDA)*, *Livestock, Dairy and Poultry and Situation Outlook (USDA),* and *Livestock Marketing Information Center (LMIC, Lakewood Colorado).* All prices were deflated by the CPI (1990=100). The Marketing Cost Index (1967=100) was obtained from *Agricultural Outlook (USDA)* and was deflated by the CPI (1990=100). U.S. real corn price and commercial pork and poultry production were obtained from the above USDA and LMIC sources. Pork and poultry production, though not included in structural specification, are used as instrumental variables (following). Table 9 presents the data described in this section.

Table 9. Real U.S. Prices of Slaughter Steers, Boxed Beef, and Corn, Wholesale Quantities of Poultry and Pork, and Food Marketing Cost (Index), 1980 to 1997.

YEAR	PSLSTEERD	PBOXBEEFD	PCORND	QPOULT	QPORK	MKCOSTD
	$/cwt	$/cwt	$/bu	Billions of Pounds	Billions of Pounds	(1967=100)
1980	62.73	102.69	2.79	11.25	16.4	265.24
1981	54.22	88.60	2.66	11.87	15.7	267.24
1982	51.75	83.71	1.99	12	14.1	264.54
1983	48.83	78.25	2.47	12.33	15.1	263.22
1984	49.18	76.43	2.39	12.92	14.7	262.30
1985	42.49	69.65	1.88	13.52	14.7	254.99
1986	41.32	65.98	1.45	14.13	14	247.53
1987	44.64	69.95	1.15	15.41	14.3	242.73
1988	46.08	71.43	1.59	16.01	15.6	241.06
1989	45.57	70.82	1.58	17.23	15.8	238.17
1990	45.99	72.13	1.47	18.43	15.3	233.40
1991	41.69	66.46	1.38	19.59	15.9	228.97
1992	41.09	63.66	1.32	20.9	17.2	226.10
1993	40.43	62.87	1.26	22.02	17	224.55
1994	35.54	56.00	1.30	23.67	17.7	224.58
1995	33.25	53.56	1.38	25.02	17.8	224.91
1996	31.80	50.27	1.87	26.29	17.1	219.88
1997	31.39	49.20	1.25	27.27	17.2	219.10

Sources: USDA Red Meat Yearbook.
USDA Livestock, Dairy and Poultry and Situation Outlook.
Livestock Marketing Information Center.

CHAPTER 5

ESTIMATION PROCEDURES

Introduction

In the previous chapter, the data to be used in this study were presented. In this chapter, important estimation issues will be discussed. These issues include whether the data exhibit stationarity, serial correlation, heteroscedasticity, normality, and simultaneity. Tests for the presence or absence of these characteristics will determine the choice of econometric estimation methods, whether ordinary least squares, two- stage least squares, three-stage least squares, or maximum likelihood methods should be used. Since annual time series data is employed, stationarity is of concern because if the data are nonstationary, normally the equations can not be estimated with fixed coefficients and in data-level form. Deciding the presence or absence of serial correlation, heteroscedasticity, simultaneity, and error term normality are always important.

Stationarity Analysis

In econometric estimation using time series data, information about a variable's underlying stochastic process is important (that is, whether or not its mean and variance are time invariant). If the stochastic process is stationary, the process can be modeled via equation(s) with fixed coefficients and in data-level form. If the process is nonstationary, a regression of one variable against another can lead to spurious results. Ordinary Least

Squares (OLS) is not a consistent parameter estimator since a random walk lacks a finite variance, and the conventional significance tests will tend to indicate a relationship between the variables when in fact none exists (Pindyck and Rubinfeld pp507).

Numerous time series variables in the by-product model may display stochastic trends and, thus, are likely to be nonstationary. However, if such variables are differenced one or more times, the resulting series will be stationary. OLS would be applicable to equations with such transformed data.

Unit root tests introduced by Dickey and Fuller have been used to test for stationarity. Suppose a random variable, Y_t, is described by the following autoregressive equation:

$$(5.1) \qquad Y_t = \alpha + \beta t + \rho Y_{t-1} + \varepsilon_t,$$

where ε_t is a white noise disturbance and t is a trend. Using OLS, one first runs the unrestricted regression,

$$(5.2) \qquad Y_t - Y_{t-1} = \alpha + \beta t + (\rho-1)Y_{t-1},$$

And then the restricted regression is run,

$$(5.3) \qquad Y_t - Y_{t-1} = \alpha .$$

The standard F ratio is calculated to test whether the restriction (null hypothesis β=0 and ρ=1, or nonstationarity) holds using the distributions tabulated by Dickey and Fuller.[14]

[14] F is calculated as follows:
$F = (N-K)(ESS_R - ESS_{UR}) / q\,(ESS_{UR})$ where ESS_R and ESS_{UR} are the sums of squared residuals in the restricted and unrestricted regressions, respectively, N is the number of observations, K is the number of estimated parameters in the unrestricted regression, and q is the number of parameter restrictions.

Allowing for serial correlation in the error term, ε_t, the augmented Dickey-Fuller unit root test (ADF) can be utilized. This test includes lagged changes in Y_t on the right-hand side of the equation:

$$(5.4) \qquad Y_t = \alpha + \beta t + \rho Y_{t-1} + \sum_{j=1}^{p} \lambda_j \Delta Y_{t-j} + \varepsilon_t,$$

where $\Delta Y_t = Y_t - Y_{t-1}$. Specifying how many lags (P) to include is usually performed by experimentation.[15] Using OLS, one first runs the unrestricted regression:

$$(5.5) \qquad Y_t - Y_{t-1} = \alpha + \beta t + (\rho-1)Y_{t-1} + \sum_{j=1}^{P} \lambda_j \Delta Y_{t-j},$$

and then the restricted regression ,

$$(5.6) \qquad Y_t - Y_{t-1} = \alpha + \sum_{j=1}^{p} \lambda_j \Delta Y_{t-j}.$$

The standard F ratio is then calculated and Dickey-Fuller tabulated distribution are used to test whether β=0 and ρ=1 hold.

If the ADF test fails to reject the null hypothesis of a random walk (or unit root) for, say, two variables (Y and X) used in a regression, each series can be differenced prior to estimation. However, differencing may result in a loss of information about the long-run relationship between the variables. Consequently, the researcher is interested in whether the variables are cointegrated (i.e., unit root variables that wander together). If so, one can run an OLS regression in a data-level form without biasing statistical inference of the parameters (Gujarati; Johnston and DiNardo). Greene indicates that for large samples, the data should be differenced and an Error Correction Model should be

[15] There are two popular criteria: adjusted R^2 and Akaike information criteria (AIC).

run. Tests for equation cointegration can be conducted via the ADF test on the estimated residuals, or the Johansen cointegration test among the variables (Johnston and DiNardo). However, for small samples, such tests are relatively weak against the trend stationary alternative (DeJong; Gujarati). Furthermore, if the model is jointly dependent, tests for unit roots and cointegration are not necessary and conventional simultaneous equations methods can be used (Johnston and DiNardo).

Serial Correlation and Heteroscedasticity

In the classical normal linear regression model, it is assumed that the equation errors are spherical (white noise), i.e., drawn from a normal population with zero expected value, independently distributed, and with a constant variance. However, the assumption of independent distributions often breaks down with time-series data. Serial correlation often occurs in time-series regressions because of correlated measurement errors or, more likely, because of the high degree of correlation in the cumulative effects of omitted variables (Pindyck and Rubinfeld). Serial correlation does not affect unbiasedness or consistency of the OLS estimator, but it does affect their efficiency. In the case of positive serial correlation, the estimated standard errors from OLS regression will be smaller than the true standard errors, thus, the tendency is to falsely reject the null hypothesis. Under appropriate conditions, the more popular tests for serial correlation are the Durbin-Watson test and Durbin-h test.

In time-series modeling, but more so with cross-section modeling, the assumption of constant error variance may be violated. When heteroscedasticity is present, OLS estimation places more weight on observations with large error variances relative to those with smaller error variances. Because of this implicit weighting, OLS parameter estimators are unbiased and consistent, but the estimated standard errors will be biased, resulting in incorrect statistical inferences. Popular tests for heteroscedasticity include the Goldfeld-Quandt test, Breusch-Pagan test, and White test. In the import demand model, the White test is used for residual variance and Generalized Least Squares is used to correct for serial correlation or heteroscedasticity.

Test For Normality

In regression analysis, the error terms are usually assumed normally distributed, thus, the conventional t and F tests are valid in hypothesis testing. However, normality is not always satisfied, particularly in small samples. A formal test of normality for random variables is given by the Jarque-Bera Statistic:

$$JB = [N/6][S^2 + (K-3)^2 /4] ,$$

where N is the number of observations, S is the skewness of a probability distribution, and K is kurtosis, or "thickness" of the tails of a distribution. The JB statistic follows a chi-square distribution with 2 degrees of freedom. If the JB statistic is greater than the critical value of the chi-square, which is 5.99 at the $\alpha = 0.05$ level, the null hypothesis of a normal distribution is rejected (Pindyck and Rubinfeld, pp 47-48).

Hausman Specification Test

For the import demands, the Hausman specification test was used to test for simultaneity between the import quantities and prices of all equations by countries and by by-products. If there is no simultaneity, OLS should generate efficient and consistent parameter estimators. If simultaneity exists, OLS will be inconsistent and an instrumental-variables estimator (i.e., 2SLS) should be employed to obtain consistent estimators (Pindyck and Rubinbeld pp353).

Simultaneity is tested in a two-stage procedure. Take the Korean edible tallow equation, for example. First, the import price of edible tallow is regressed on all exogenous variables in the system, specifically, Korean real GDP, real exchange rate, price of leather, trend and a constant term. The residual series is then obtained. Second, the import quantity of edible tallow is regressed on all explanatory variables in the equation (i.e., import price of edible tallow, Korean real GDP, real exchange rate, trend) plus the residuals. The t-value on the coefficient of the residuals is then evaluated. Under the null hypothesis of no simultaneous equations bias, the residual coefficient will not be significantly different from zero at some designated level of significance.

Tariff Considerations

Import tariffs may have played a role in affecting import demands for U.S. beef by-products over the sample period. That is, protectionist measures through import tariffs or other nontariff barriers normally existed for U.S. table cut beef, but were also relevant to U.S. joint products in beef production. As in the U.S., prices received by Asian beef producers are also affected by domestic market conditions for hides, offal, and tallow. The following tables provide a brief summary of limited tariff information specific to U.S. beef by-products, by country. Because of incomplete foreign tariff information on a time-series basis, import tariffs were not included in the structural import demand functions.

Japan, Korea and Mexico imposed ad valorem tariffs on certain types of imported U.S. beef by-products during the 1980 to 1997 period. Table 10 presents the country tariffs only for 1995 based upon the Most-Favored-Nation (MFN) status (WTO: Uruguay Round Agreement tariff schedules).

Table 10. Most-Favored-Nation Tariffs in 1995 (By Country and By-Product Category).

	Japan	Korea	Mexico	Canada
Variety meats	15.0-93.0*	23.7	25.0	0.0
Edible tallow	0.0	20.0	20.0	0.0
Inedible tallow	0.0	20.0	20.0	0.0
Hides	0.0	20.0	10.0	0.0

*The tariff for tongues, livers and internal organs is 15.0%.
The tariff for cheek meat and head meat is 93.0%

Source: WTO: Uruguay Round Agreement tariff schedules.

Korea and Mexico imposed ad valorem tariffs on all four by-product categories. Japan imposed tariffs only on variety meats and Canada imposes no tariffs due to the U.S.-Canadian Free Trade Agreement and NAFTA. In the year 2000, most tariffs of the three countries are expected to decrease. Table 11 presents the by-product tariffs scheduled for the year 2000.

Table 11. Most-Favored-Nation Tariffs in 2000 (By Country and By-Product Category).

	Japan	Korea	Mexico	Canada
Variety meats	12.8-50.0	18.0	22.5	0.0
Edible tallow	0.0	18.0	18.0	0.0
Inedible tallow	0.0	18.0	18.0	0.0
Hides	0.0	5.0	9.0	0.0

* The tariff for tongues, livers and internal organs is 15.0%.
The tariff for cheek meat and head meat is 93.0%

Source: WTO: Uruguay Round Agreement tariff schedules

Conclusion

This chapter has examined several estimation issues vital in choosing the optimal estimation method. These include stationarity, serial correlation, heteroscedasticity, normality, and simultaneity. Due to data deficiency, tariffs were not included in the empirical model. Empirical results are presented in chapter 6.

CHAPTER 6

EMPIRICAL RESULTS

In this chapter, econometric results are presented for equations 6.1 through 6.4 for import demand, equation 6.5 for aggregate U.S. by product value, and equation 6.6 for U.S. fed slaughter inverse demand. Test results for time-series data and econometric relationships discussed in chapter 5 are also addressed.

Import Demand Tests

Augmented Dickey-Fuller unit root tests (ADF) were used to test the model variables for stationarity. The null hypothesis of unit roots could not be rejected for several variables, i.e., country GDPs and prices. All nonstationary variables were integrated of order one (I (1)). To remedy the implied problems of spurious regression, the data could be first differenced to correct for nonstationarity. If the equations are cointegrated, error correction models may then be used for parameter estimation (Greene). However, data in first-difference (or higher order) form may not reflect long-run relationships among variables. Johnston and DiNardo (pp259-269) suggest that a multiple regression equation involving nonstationary variables (and is cointegrated) alternatively can be estimated in data-level form. Cointegration implies that meaningful long-run relationships exist among unit root variables, which are confirmed by the ADF residual test or the Johansen cointegration test. The ADF residual tests applied to the model indicated that equations for Japanese edible tallow, inedible tallow, and hides were cointegrated at the α=0.05 level, with the remaining model equations cointegrated at α=0.01 level. However, DeJong et al. argue that unit root and cointegration tests have low power against the trend stationary alternative for small samples. Thus, because of the small sample employed, the import demand model is estimated with the data in level form.

The residuals of all equations were tested for first-order autoregressive behavior [AR(1)] and heteroskedasticity using OLS regressions. Durbin-Watson tests could not reject AR(1) disturbances for the equations of Canadian variety meats, Japanese hides and inedible tallow, and Korean inedible tallow and hides. Using White's test for heteroskedasticity (Johnston and DiNardo,pp.166-67), the null hypothesis of constant variance could not be rejected at the α=0.10 level for all equations. In addition, the residuals were tested for normality. The Jarque-Bera (JB) statistic failed to reject the null hypothesis of normality at the α=0.10 level for all equations (Pindyck and Rubinfeld, pp 47-48).

Equation error terms across countries for all by products were hypothesized to be uncorrelated, but the equation error terms of different by-products within one country were hypothesized to be contemporaneously correlated. The reasoning is that factors such as GDP and exchange rates tend to affect all beef by-product of imports, and that substitution may occur among these imports. In addition, any missing information in the specification could be common to the equations. Tables 12 through 15 show the residual correlation matrix of the by-product equations for Canada, Mexico, Japan and Korea, respectively.

Table12.Residual Correlation Matrix of Canadian Beef By-Product Imports.

	Variety Meats	Edible Tallow	Inedible Tallow	Hides
Variety Meats	1.000	-0.150	0.418	0.384
Edible Tallow	-0.150	1.000	-0.159	0.092
Inedible Tallow	0.418	-0.159	1.000	0.554
Hides	0.384	0.092	0.554	1.000

Table 13.Residual Correlation Matrix of Mexican Beef By-Product Imports.

	Variety Meats	Edible Tallow	Inedible Tallow	Hides
Variety Meats	1.000	-0.491	0.392	0.331
Edible Tallow	-0.491	1.000	-0.616	-0.510
Inedible Tallow	0.392	-0.616	1.000	0.484
Hides	0.331	-0.510	0.484	1.000

Table 14. Residual Correlation Matrix of Japanese Beef By-Product Imports

	Variety Meats	Edible Tallow	Inedible Tallow	Hides
Variety Meats	1.000	0.440	-0.079	-0.223
Edible Tallow	0.440	1.000	-0.094	-0.367
Inedible Tallow	-0.078	-0.094	1.000	0.163
Hides	-0.223	-0.367	0.163	1.000

Table 15. Residual Correlation Matrix of Korean Beef By-Product Imports.

	Variety Meats	Edible Tallow	Inedible Tallow	Hides
Variety Meats	1.000	-0.103	0.023	-0.073
Edible Tallow	-0.103	1.000	0.207	0.575
Inedible Tallow	0.023	0.207	1.000	0.064
Hides	-0.073	0.575	0.064	1.000

From the tables, it is evident that residual correlations between different beef by-products within the countries are nonzero and in some cases relatively high, i.e., exceeding 0.5 (i.e., correlation between Canada inedible tallow and hides.)

Hausman specification tests (Johnston and DiNardo, pp338-42) were conducted to test simultaneity relationships between import prices and import demand quantities of by-products for all countries. Results indicate that the null hypothesis of no simultaneous equations bias could not be rejected at the α=0.10 level for Korean variety meats and at the α=0.05 level for all other by-products.

As a result of the above tests, each block of by-product equations (by country) are estimated using Iterative Seemingly Unrelated Regressions (ISUR), and where appropriate, corrections for AR(1) error terms. The equations were estimated in double log form to obtain the elasticity coefficients.

Regression Results – Import Demand

The following sections address the econometric results of the by-product import demands for each country.

Japan

Table 16 presents the ISUR results for Japanese import demand.

Table 16. Iterative Seemingly Unrelated Regression Results of Japanese Import Demand for U.S. Beef By-Products.

Equations	Regressors/Statistics		
LOG(JVMQ)	= -12.76	-0.35 *LOG(JVMPR)	+0.22 *LOG(JGDP1990)
	(-0.87)	(-1.87)	(1.97)
		-0.80 *LOG(RJXRATES	-0.002 *(trend)
		(-2.78)	(-0.04)
	R-squared = 0.94	Adjusted R-squared=0.92	S.E.E=0.17
LOG(JEDTAQ)	= -18.49	-0.65 *LOG(JEDTAPR)	+0.16 *LOG(JGDP1990)
	(-4.38)	-1.37)	(4.75)
		-0.45 *LOG(RJXRATES	-0.53 *(trend)-0.31*Ut-1
		(-1.89)	(-4.53) (-1.81)
	R-squared = 0.68	Adjusted R-squared=0.42	S.E.E = 0.35
LOG(JINEDTAQ)	= -0.32	-0.77 *LOG(JINEDTAP	+0.98 *LOG(JGDP1990)
	(-0.016)	(-2.79)	(0.65)
		-0.11 *LOG(RJXRATES	-0.04 *(trend)+0.307*Ut-1
		(-1.97)	(-0.91) (2.17)
	R-squared = 0.72	Adjusted R-squared=0.60	S.E.E = 0.26
LOG(JHWQ)	=-38.04	-0.30 *LOG(JHWPR)	+0.432 *LOG(JGDP1990)
	(-3.71)	(-1.84)	(4.50)
		-0.37 *LOG(RJXRATES	+0.47 *LOG(PLEATHER)
		(-1.88)	(0.59)
		-0.25*(trend)	
		(-11.17)	
	R-squared = 0.95	Adjusted R-squared=0.93	S.E.E = 0.11

Note: Numbers in parentheses below the estimated parameters are the asymptotic t ratios. S.S.E. is the standard error of equation. Trend is the trend variable and Ut-1 is the AR(1) error term.
The critical t values for the 5% and 10% significance levels are 2.101 and 1.734, respectively (18 degrees of freedom).

The regression fits were relatively high for variety meats and hides, with adjusted R^2's of 0.916 and 0.927, respectively. However, the adjusted R^2's were relatively lower for edible and inedible tallow. The relative fits are also reflected in respective lower and higher standard errors of equation. Trend was added to each equation to allow for time effects in the dependent variables.

All coefficients of the regressors have the expected theoretical signs. Most variables are statistically significant at either the α=0.05 or α=0.10 level. The exceptions are price in the edible tallow equation, GDP in the inedible tallow equation, and leather price in the hide equation.

The exchange rate coefficients for Japan are significant for all by-product import demands. Results indicate a one percentage increase in the U.S.-Japanese exchange rate will decrease Japanese imports of variety meats by 0.80%, edible tallow by 0.45%, inedible tallow by 0.10% and hides by 0.37%. These results are consistent with the hypothesis that an increase in exchange rates (or yen depreciation) will make U.S. goods more expensive to importers, thus, import demand will shift to the left.

Japanese GDP is not significant in the inedible tallow equation. However, results indicate statistical significance for GDP in the remaining equations, and that by-products are normal goods due to positive income effects. The coefficients are inelastic. For example, a ten percent increase in GDP increases the Japanese import demand for variety meats by 2.19%, edible tallow by 1.55%, and hides by 4.32%. Own price elasticities, except for edible tallow, are statistically significant and relatively price inelastic. However, the elasticities display a range in values, i.e., one percent increases in the import prices of hides and inedible tallow reduce import quantities demanded by –0.30 and –0.77 percent, respectively. Substitute relationships between the end (consumer) products of the imports and substitution between imports and domestic-produced by-products could affect the size of the own price elasticity coefficients.

Korea

Table 17 presents the ISUR results for Korean import demand. The adjusted R^2's for the equations of variety meats, edible tallow, and hides are satisfactory at 0.88. 0.86, and 0.89, respectively. The adjusted R^2 was considerably lower at 0.62 for inedible tallow. Most trend coefficients were statistically significant.

Table 17. Iterative Seemingly Unrelated Regression Results of Korean Import Demand for U.S. beef By-Products.

Equations	Regressors/Statistics			
LOG(KVMQ)	=18.48	-0.19 *LOG(KVMPR)	+0.94 *LOG(KGDP1990)	
	(3.49)	(-0.35)	(2.17)	
		-1.14 *LOG(RKXRATES)	+1.07 *(trend)-0.63*Ut-1	
		(-2.52)	(2.93)	(-2.64)
	R-squared = 0.92	Adjusted R-squared=0.88	S.E.E. = 0.19	
LOG(KEDTAQ)	=-47.22	-0.42 *LOG(KEDTAPR)	+0.612 *LOG(KGDP1990)	
	(-1.22)	(-1.82)	(1.88)	
		-2.26 *LOG(RKXRATES)	-0.30 *(trend)	
		(-2.16)	(-1.14)	
	R-squared = 0.89	Adjusted R-squared=0.86	S.E.E. = 0.26	
LOG(KINEDTAQ)	=-80.9	-0.22 *LOG(KINEDTAPR)	+0.921 *LOG(KGDP1990)	
	(-1.49)	(-0.40)	(2.11)	
		-1.54 *LOG(RKXRATES)	-0.9 *(trend)+0.63*Ut-1	
		(-1.96)	(-2.66)	-2.43
	R-squared = 0.76	Adjusted R-squared=0.65	S.E.E. = 0.41	
LOG(KHWQ)	=-48.93	-0.68 *LOG(KHWPR)	+0.659 *LOG(KGDP1990)	
	(-2.56)	(-2.22)	(3.88)	
		-0.47 *LOG(RKXRATES)	+2.46 *LOG(PLEATHER)	
		(-1.76)	(2.27)	
		-0.41 *(trend)		
		(3.17)		
	R-squared = 0.93	Adjusted R-squared=0.89	S.E.E. = 0.12	

Note: Numbers in parentheses below the estimated parameters are the asymptotic t ratios. S.E.E. is the standard error of equation. Trend is the trend variable and Ut-1 is the AR(1) error term.

All variables have the expected or theoretical signs. In the variety meats equation, both GDP and exchange rates are significant at the 5% level while the price of variety meats is not significant. For edible tallow, both the price of edible tallow and GDP are significant at the 10% level, while exchange rate is significant at the 5% level. For inedible tallow, GDP is significant at the 5% level, exchange rate is significant at the 10% level, while the price of inedible tallow is not significant. For hides, the price of hides, GDP and price of leather are significant at the 5% level while the exchange rate is significant at the 10% level.

The coefficients of exchange rate for Korea are relatively elastic, except for hides, indicating Korean import sensitivity to fluctuating currency value. Results indicate a one percentage increase in exchange rate (Won per U.S. dollar) reduces Korean imports of variety meats by 1.14%, edible tallow by 2.26%, inedible tallow by 1.54% and hides by 0.47%. For Korean GDP, its statistical significance and positive coefficients in all by-product equations indicate that U.S. beef by-products are normal goods. The results show that a ten percent increase in GDP will increase Korean imports of variety meats by 9.4%, edible tallow by 6.12%, inedible tallow by 9.2% and hides by 6.59%.

Canada

Table 18 presents the ISUR results for Canadian import demand. The adjusted R^2 for the equations of variety meats, edible tallow, inedible tallow and hides are 0.40, 0.84, 0.80 and 0.45, respectively. The low adjusted R^2 for hides reflects only two significant variables in the equation. Trend, except for hides, is highly significant in the equations.

Table 18. Iterative Seemingly Unrelated Regression Results of Canadian Import Demand for U.S. Beef By-Products.

Equations	Regressors/Statistics		
LOG(CVMQ)	=11.2	-1.65 *LOG(CVMPR)	+0.50 *LOG(CGDP1990)
	(5.14)	(-4.72)	(1.85)
		+0.76 *LOG(RCXRATES)	+0.42 *(trend)-0.48*Ut-1
		(0.73)	(4.13) (-2.51)
	R-squared = 0.56	Adjusted R-squared=0.36	S.E.E. = 0.45
LOG(CEDTAQ)	=21.4	-1.63 *LOG(CEDTAPR)	+2.35 *LOG(CGDP1990)
	(1.33)	(-2.51)	(0.91)
		-0.71 *LOG(RCXRATES)	+0.16 *(trend)
		(-1.85)	(2.57)
	R-squared = 0.91	Adjusted R-squared=0.88	S.E.E. = 0.17
LOG(CINEDTAQ)	=11.15	-0.81 *LOG(CINEDTAPR)	+0.36 *LOG(CGDP1990)
	(3.49)	(-0.42)	(1.75)
		-0.98 *LOG(RCXRATES)	+0.56 *(trend)+0.32*Ut-1
		(-1.76)	(4.36) -1.35
	R-squared = 0.84	Adjusted R-squared=0.79	S.E.E. = 0.22
LOG(CHWQ)	=28.96	-0.15 *LOG(CHWPR)	+0.382 *LOG(CGDP1990)
	(2.02)	(-0.24)	(2.27)
		-0.55 *LOG(RCXRATES)	+1.88 *LOG(PLEATHER)
		(-2.03)	(1.02)
		+0.02 *(trend)	+0.20 *Ut-1
		(0.36)	(0.77)
	R-squared = 0.61	Adjusted R-squared=0.55	S.E.E. = 0.30

Note: Number in parentheses below the estimated parameters are the asymptotic t ratios. S.E.E. is the standard error of equation. Trend is the trend variable and Ut-1 is the AR(1) error term.

The critical t values for the 5% and 10% significance levels are 2.101 and 1.734, respectively (18 degrees of freedom).

Most variables have the expected sign, the exceptions being the exchange rate in the variety meats equation and price of inedible tallow in the inedible tallow equation. However, both variables are not significant. In the variety meats equation, price of variety meats and GDP are significant at the 5% level and 10% level, respectively. For edible tallow, the price of edible tallow and exchange rate are significant at the 10% level while GDP is not significant. For inedible tallow, GDP and exchange rate are both significant at the 10% level. For hides, GDP and exchange rate are significant at the 5% level while the price of hides and price of leather are not significant, though the coefficient signs are correct.

Except for variety meats (as stated), the effects of the exchange rate are significant and theoretically correct in all equations. The results indicate the coefficients are inelastic, except that of inedible tallow, which is near unity. For example, a one percent increase in the exchange rate decreases Canadian imports of edible tallow by 0.70%, inedible tallow by 0.98% and hides by 0.55%. These results are noteworthy in light of the fact that the U.S. – Canadian exchange rate has been more stable than the exchange rates of the other three countries.

The Canadian GDP coefficients are positive in all equations, indicating normal goods for the by-product categories. The marginal impacts indicate a one percent increase in Canadian GDP increases Canadian imports of variety meats by 0.50%, inedible tallow by 0.36%, and hides by 0.382%. Own price elasticities are only significant for variety meats and edible tallow equations, the coefficients exceeding unity (i.e., -1.65 and –1.63, respectively).

Mexico

Table 19 presents the ISUR results for Mexican import demand.

Table 19. Iterative Seemingly Unrelated Regression Results of Mexican Import Demand for U.S. Beef By-Products.

Equations	Regressors/Results		
LOG(MVMQ)	=15.82 (0.85)	-0.33 *LOG(MVMPR) (-2.32)	-0.61 *LOG(MGDP1990) (-0.21)
		-0.67 *LOG(RMXRATES) (-1.98)	-0.05 *(trend) (-0.54)
	R-squared = 0.68	Adjusted R-squared=0.59	S.E.E. = 0.26
LOG(MEDTAQ)	=-0.95 (-0.03)	-0.56 *LOG(MEDTAPR) (-3.06)	-0.204 *LOG(MGDP1990) (-0.41)
		-0.95 *LOG(RMXRATES) (-1.72)	-0.11 *(trend) (-0.69)
	R-squared = 0.85	Adjusted R-squared=0.80	S.E.E. = 0.13
LOG(MINEDTAQ)	=36.9 (2.94)	-0.16 *LOG(MINEDTAPR) (-2.15)	+0.409 *LOG(MGDP1990) (2.10)
		-0.13 *LOG(RMXRATES) (-0.40)	+0.20 *(trend) (3.22)
	R-squared = 0.81	Adjusted R-squared=0.75	S.E.E. = 0.17
LOG(MHWQ)	=-0.28 (-0.01)	-0.45 *LOG(MHWPR) (-2.77)	+0.474 *LOG(MGDP1990) (1.62)
		-0.72 *LOG(RMXRATES) (-1.86)	+3.28 *LOG(PLEATHER) (1.80)
		-0.15 *(trend) (-1.38)	
	R-squared = 0.84	Adjusted R-squared=0.78	S.E.E. = 0.15

Note: Numbers in parentheses below the estimated parameters are the asymptotic t ratios. S.E.E. is the standard error of equation. Trend is the trend variable and Ut-1 is the AR(1) error term.

The adjusted R^2's for the equations of variety meats, edible tallow, inedible tallow and hides are 0.59, 0.80, 0.75 and 0.37 respectively. Except for inedible tallow, the trend effects were not statistically significant.

Most variables have coefficient signs consistent with normal goods except for Mexican GDP in the variety meats and edible tallow equations. The negative coefficients, however, are not statistically significant. For variety meats, variety meats price and exchange rate are significant at the 5% level and 10% level, respectively. For edible tallow, the price of edible tallow and exchange rate are significant at the 1% and 10% level, respectively. For inedible tallow, the price of inedible tallow and GDP are significant at the 5% level while exchange rate is not significant. For hides, the price of hides is significant at the 1% level, the exchange rate and the price of leather are significant at the 10% level, while GDP is not significant.

The significance of the U.S.-Mexican exchange rate in the by-product equations (except for inedible tallow), is consistent with a weakening peso decreasing import demand for U.S. beef by-products. For example, the results indicate a one percent increase in the exchange rate reduces Mexican imports of variety meats by 0.67%, edible tallow by 0.95%, and hides by 0.72%. Mexican GDP is only significant in the case of inedible tallow, which shows a one percent increase in GDP increases Mexican imports of inedible tallow by 0.409%. The own price effects, all statistically significant, are relatively inelastic as they range from –0.16 to –0.56. The inelasticity of derived demands normally reflects inelastic demands of the end products at the consumer level of the market (Tomek and Robinson).

In summary, the effects of import demand shifters of income (GDP) and exchange rates on the U.S. by-product categories are statistically significant in general, with the GDP effects supporting the normal goods theory. However, the marginal effects appear to be more robust in the Asian economies compared to the North American economies. One major factor, extrapolating from data or statistical problems, may be that the Asian nations have experienced relatively greater volatility in these variables. For example, assume the ratio of the standard deviation of a variable divided by its mean value represents a measure of a variable's volatility. Applying this to the country GDPs and exchange rates, the combined ratios for Japanese and Korean GDPs and exchange rates averaged 0.30 and 0.18, respectively. The combined ratios for Canadian and Mexican GDPs and exchange rates averaged 0.12 and 0.11, respectively. Another factor may be that the Asian countries have smaller beef industries than Canada and Mexico and are relatively more dependent on by- product imports to satisfy domestic demand for the end products.

Calculation of Weighted By-Product Prices

In order to link exogenous shifts in import demand and by-product import price to aggregate U.S. by-product value, a weighted average price of each by-product across countries is calculated. The weights are the country import volume of each by-product. Aggregate U.S. by-product value plays a major role in determining domestic cattle inverse demand, and in this study is the link between import demand and U.S. slaughter cattle price.

It is assumed from the calculation that a one-dollar increase in a specific by-product price to one country will affect U.S. beef by-product value the same as it would to another country. For example, a one-dollar increase in hide price to Japan (due to an economic change) would affect U.S. beef by-product value the same as a one-dollar increase in hide price to Korea (due to an economic change). The weighted average prices for hides, variety meats, edible tallow and inedible tallow across countries are computed as follows:

(6.1) $P^{H} = (P^{HJ} Q^{HJ} + P^{HK}Q^{HK} + P^{HM}Q^{HM} + P^{HC}Q^{HC}) / (Q^{HJ} + Q^{HK} + Q^{HM} + Q^{HC})$

(6.2) $P^{VM} = (P^{VMJ}Q^{VMJ} + P^{VMK}Q^{VMK} + P^{VMM}Q^{VMM} + P^{VMC}Q^{VMC}) / (Q^{VMJ} + Q^{VMK} + Q^{VMM} + Q^{VMC})$

(6.3) $P^{ET} = (P^{ETJ} Q^{ETJ} + P^{ETK}Q^{ETK} + P^{ETM}Q^{ETM} + P^{ETC}Q^{ETC}) / (Q^{ETJ} + Q^{ETK} + Q^{ETM} + Q^{ETC})$

(6.4) $P^{IE} = (P^{IEJ} Q^{IEJ} + P^{IEK}Q^{IEK} + P^{IEM}Q^{IEM} + P^{IEC}Q^{IEC}) / (Q^{IEJ} + Q^{IEK} + Q^{IEM} + Q^{IEC})$.

The P^{H}, P^{VM}, P^{ET} and P^{IE} variables are the weighted average prices of hides, variety meats, edible tallow and inedible tallow, respectively. The right-hand side variables are: P^{Hi}, Q^{Hi} are the respective deflated import hide prices and imported hide quantities for country i, i=J(Japan), K(Korea), M(Mexico) and C(Canada); P^{VMi}, Q^{VMi} are the respective deflated import variety meats prices and imported variety meat quantities for country i; P^{ETi}, Q^{ETi} are the respective deflated import edible tallow prices and imported edible tallow quantities for country i; and P^{IEi}, Q^{IEi} are the respective deflated import inedible tallow prices and imported inedible tallow quantities for country i.

Estimation of U.S. By-Product Value

The weighted by-product prices above constitute important arguments in determining the behavior of aggregate U.S. by-product value. U.S. by-product value is an important joint product factor in affecting inverse slaughter cattle demand (Brester and Marsh; Marsh 1988). The equation specification for U.S. by-product value is given by the following:

(6.5) $BPV^{US} = f(Q^{sl}, Y^{US}, P^{H}, P^{VM}, P^{ET}, P^{IE})$,

where: BPV^{US} is real U.S. beef by-product value (cents per lb), Q^{sl} is slaughter cattle production, or commercial cattle slaughter multiplied by average slaughter weight (million lbs), Y^{US} is U.S. real personal consumption expenditures (million dollars), and the remaining four variables are the weighted by-product prices given by equations 6.1 through 6.4. Equation 6.5 is specified similar to that of Blake and Clevinger in that supply and demand domestic factors (Q^{sl},Y) and foreign factors (weighted import prices) are hypothesized to determine U.S. by-product value. Since fixed proportions between quantities of by-products and slaughter production are assumed, Q^{sl} represents by-product supply. The variable Y^{US} is specified to allow for consumer income effects on by-product demand. The weighted price variables account for the effects of import demand on by-product value. For example, an increase in Japanese import demand for

U.S. hides, through the subsequent increase in the P^H variable, is expected to have a positive marginal impact on U.S. by-product value.

Table 20 presents the empirical results of the U.S. by-product value equation.

Table 20. Regression Results of U.S. Beef By-Product Value.

Equation	Regressors/Results				
$LOG(BPV^{us})$	= 11.69 (1.86)	-0.476 (-0.327)	$*LOG(Q^{sl} * W_C)$	1.53 (0.82)	$*LOG(Y^{us})$
		+0.071 (2.50)	$*LOG(P^{VM})$	+0.103 (2.28)	$*LOG(P^{ET})$
		+0.172 (2.92)	$*LOG(P^{H})$	+0.156 (1.73)	$*LOG(P^{IE})$
	R-squared = 0.74			Adjusted R-squared = 0.59	
	S.E.E. =0.076			DW = 1.64	

Note: Numbers in parentheses below the estimated parameters are the asymptotic t ratios. S.E.E. is the standard error of equation. DW is the Durbin-Watson statistic.

Q^{sl} is commercial cattle slaughter (mil.head) and Wc is average liveweight of commercial cattle slaughter (pounds). The equation was estimated by OLS in double log form under the usual classical assumptions. Results indicate the coefficients of by-product prices are positive and statistically significant (weighted prices of hides, variety meats, and edible tallow are significant at the 5% level, while inedible tallow is significant at the 10% level). These price transmission coefficients are also relatively inelastic. For example, 10 percent increases in prices of hides, variety meats, edible tallow and inedible tallow increase U.S. beef by-product value by 1.72%, 0.71%, 1.03% and 1.56%, respectively.

In this particular specification, beef production and income are not statistically significant.

Consequently, an alternative by-product specification was considered, with number of cattle slaughtered (Q^{sl}) and average slaughter weight (Wc) entered as separate regressors in the equation. The empirical results are presented in table 21.

Table 21. Regression Results of U.S. Beef By-product Value (Alternative Specification).

Equation	Regressors/Results					
$LOG(BPV^{us})$	= 38.40	+0.06	$*LOG(Q^{sl})$	-5.09	$*LOG(W_C)$	
	(3.80)	(0.05)		(-2.36)		
		+0.19	$*LOG(Y^{us})$	+0.09	$*LOG(P^{VM})$	
		(0.13)		(1.72)		
		+0.12	$*LOG(P^{ET})$	+0.1	$*LOG(P^{IE})$	
		(2.04)		(2.22)		
		+0.17	$*LOG(P^{H})$			
		(3.84)				
	R-squared = 0.87		Adjusted R-squared = 0.77			
	S.E.E. =0.057		DW = 1.90			

Note: Numbers in parentheses below the estimated parameters are the asymptotic t ratios. S.E.E. is the standard error of equation. DW is the Durbin-Watson statistic.

Results indicate that the coefficients of beef by-products are statistically significant and change very little compared to their estimates in table 20. Note that average slaughter weight is statistically significant, suggesting that slaughter weight pounds importantly reflect by-product supplies. However, the coefficient for cattle slaughter is slightly positive but not significant. Income displays a positive coefficient although it is not statistically significant.

Because of potential multicollinearity problems, the weighted by-product prices were also specified separately in the equation of table 21. Results (not shown) indicate that the coefficients of by-product prices again changed very little. The other regressors of number of cattle slaughtered, average slaughter weight, and income, however, are all statistically significant. However, employing the number of cattle slaughtered multiplied by average slaughter weight to represent slaughter quantity (Q^{sl}), resulted in an insignificant supply effect. The insignificance of their multiplication may be due to the negative correlation between slaughter numbers and average slaughter weight in the sample period, reducing the variance of their combined effect relative to those of the individual variables.

Inverse Demand For U.S. Fed Cattle

Specification and estimation of by-product import demands and aggregate U.S. by-product value is followed by specification and estimation of U.S. fed cattle inverse demand. Introduction of the latter function theoretically and quantitatively establishes the linkage that permits foreign market shocks to be transferred to U.S. fed cattle price.

Fed cattle inverse demand is the derived (input) demand for slaughter cattle by U.S. beef packers. Because of excess capacity in beef packing, slaughter demand is for domestically produced and Canadian slaughter imports (Brester and Marsh). Deflated slaughter steer price is hypothesized to be a function of quantity of slaughter cattle, average slaughter weight, beef by-product value (joint products), price of boxed beef (output price), and marketing costs (margin shifter) (Marsh 1988). The equation is specified as:

(6.6) $P_{sl} = f(Q^{sl}, Wc, P^{bx}, BPV^{US}, Mc)$,

where, P_{sl} is the price of choice 2-4, 1100–1300 lbs U.S. slaughter steers (nebraska direct (\$/cwt)), Q^{sl} is quantity of commercial cattle slaughter (million head), Wc is the average slaughter weight of commercial cattle (pounds), P^{bx} is the price of boxed beef (cutout value of 550-700 lb, choice, 2-4 carcasses (\$/cwt)), BPV^{US} is U.S. beef by product value (cents/lb), and M^c is the index of food marketing costs (1967=100). All price variables are deflated by the CPI (1990 = 100).

The empirical results of derived slaughter price are presented in table 22.

Table 22. Regression Results of U.S. Slaughter Steer Inverse Demand.

Equation	Regressors/Results			
$LOG(P_{sl})$	=14.43 (1.86)	-1.51 *$LOG(W_C)$ (-1.84)	-0.84 *$LOG(Q^{sl})$ (-2.18)	
		+0.14 *$LOG(BPV^{us})$ (2.95)	+0.62 *$LOG(P^{bx})$ (3.86)	
	R-squared = 0.996		adjusted R-squared = 0.995	
	S.E.E. = 0.013		DW = 2.19	

Note: Numbers in parentheses below the estimated parameters are the asymptotic t ratios. S.E.E. is the standard error of equation. DW is the Durbin-Watson statistic. The critical t value for the 5% and 10% significance levels are 2.101 and 1.734, respectively (18 degrees of freedom).
Marketing cost (Mc) was not statistically significant and therefore dropped in the final version.

The equation was estimated by two-stage least squares in double log form.[16] The regression results and statistical tests are quite strong, the coefficient signs also demonstrating consistency with economic reasoning. Real marketing cost was omitted since its t-value nearly equaled zero. The effect of by-product value, a critical linkage in the equation, is significant at the α=0.01 level. The marginal impact indicates a one percent increase (decrease) in by-product value increases (decreases) real slaughter price by 0.14 percent. Its inelastic coefficient is consistent with the fact that by- products, though critical to meat packers, constitute a relatively small proportion of live animal value. For example, in 1998 the value of a 1,000-pound steer was $617.96 and the total value of its by-products was 88.53, or the proportion being 0.143 (LMIC). Inverse demand estimation by Brester and Marsh and Marsh (1992) indicated the impact of by-product value on slaughter steer price was 0.10 and 0.23, respectively.

Application of Results

Given the model equations of import demands, U.S. by product value, and U.S. inverse slaughter demand, interest centers on the effects of shocks in foreign exchange rates and country GDP's on U.S. fed cattle prices. This interest is a result of recent (later 1990's) currency depreciations and economic downturns that occurred particularly in the Asian economies. U.S. beef producers were concerned about the potential economic

[16] It was hypothesized that Wc, Q^{sl}, P^{bx} are jointly endogenous with P_{sl}. Beef by-product value, quantity of poultry, quantity of pork, marketing cost, real price of corn, real personal consumption expenditure, lagged average slaughter weight and lagged number of cattle slaughtered were the instruments.

effects on domestic cattle prices through changing exports (or import demands) of U.S. beef table cuts and by-products.

The impacts of changes in foreign exchange rates and country GDP's on U.S. slaughter prices (through by-product import demands) are presented in table 23 and 24 respectively.

Table 23. Impact of One Percent Changes in Exchange Rates On U.S. Slaughter Steer Price.

	Variety Meats	Edible Tallow	Inedible Tallow	Hides	Total
Japan	-0.130%	-0.011%	-0.004%	-0.015%	-0.160%
Korea	-0.019%	-0.054%	-0.056%	-0.019%	-0.148%
Canada	--------	-0.017%	-0.035%	-0.022%	-0.074%
Mexico	-0.011%	-0.023%	-0.005%	-0.029%	-0.068%

Note: The blank is due to the insignificant exchange rate coefficient in the Canadian variety meats import demand equation.

Table 24. Impact of One Percent Changes in Country GDPs On U.S. Slaughter Steer Price.

	Variety Meats	Edible Tallow	Inedible Tallow	Hides	Total
Japan	0.0036%	0.0368%	------	0.0172%	0.0576%
Korea	0.0154%	0.0146%	0.0332%	0.0262%	0.0894%
Canada	0.0080%	--------	0.0130%	0.0152%	0.0362%
Mexico	--------	--------	0.0150%	--------	0.0150%

Note: The blanks result from the insignificance of country GDP's in the relevant import demand equations.

An example of how the slaughter price effects are calculated is given for a one percent change in the Japanese exchange rate. Note, in table 23 that the impact of a one percent depreciation (appreciation) in the Japanese Yen is to decrease (increase) U.S. slaughter steer price by 0.16%. This percentage is the sum of partial derivatives involving all imports categories of beef by-products for Japan:

$$(6.7)\quad \frac{\partial LOG(P_{sl})}{\partial LOG(Ex_J)} = \frac{\partial LOG(P^{VM}{}_J)}{\partial LOG(Ex_J)} * \frac{\partial LOG(BPV^{us})}{\partial LOG(P^{VM})} * \frac{\partial LOG(Psl)}{\partial LOG(BPV^{us})}$$

$$+ \frac{\partial LOG(P^{ET}{}_J)}{\partial LOG(Ex_J)} * \frac{\partial LOG(BPV^{us})}{\partial LOG(P^{ET})} * \frac{\partial LOG(P_{sl})}{\partial LOG(BPV^{us})}$$

$$+ \frac{\partial LOG(P^{IE}{}_J)}{\partial LOG(Ex_J)} * \frac{\partial LOG(BPV^{us})}{\partial LOG(P^{IE})} * \frac{\partial LOG(P_{sl})}{\partial LOG(BPV^{us})}$$

$$+ \frac{\partial LOG(P^{H}{}_J)}{\partial LOG(Ex_J)} * \frac{\partial LOG(BPV^{us})}{\partial LOG(P^{H})} * \frac{\partial LOG(P_{sl})}{\partial LOG(BPV^{us})}$$

The left-hand term in equation 6.7 is the percentage change in real U.S. steer price due to a one percent change in the U.S.-Japanese exchange rate. The first right-hand term of each additive component is the percentage change in a by-product price due to a one percent change in the exchange rate. The second term is the percentage change in U.S. by product value due to a one percent change in a Japanese by product import price, and the third term is the percentage change in U.S. slaughter steer price due to a one percent change in U.S. by-product value. The relevant coefficients for the second and third terms of each additive component are taken directly from the empirical results of equations 6.5 and 6.6.

Based on the theoretical model in Chapter 3, the first partial derivative in the right-hand side of equation 6.7 is indirectly estimated. It is given by:

$$(6.8)\quad \frac{\partial LOG(P_J{}^{BPi})}{\partial LOG(Ex_J)} = \frac{\partial LOG(QD_J{}^{BPi})}{\partial LOG(Ex_J)} * \frac{\partial LOG(P_J{}^{BPi})}{\partial LOG(QS^{BP})},$$

where: $P_J{}^{BPi}$ is the Japanese import price for by-product i. It equals $P^{VM}{}_J$ when i=variety meats; $P^{ET}{}_J$ when i= edible tallow; $P^{IE}{}_J$ when i= inedible tallow, and $P^{H}{}_J$ when i= hides.

QD_J^{BPi} is the Japanese import demand for by-product i. It equals JVMQ when i=variety meats; JEDTAQ when i=edible tallow; JINEDTAQ when i=inedible tallow, and JHWQ when i=hides. The coefficients for the partial derivatives of the first right hand term in equation 6.8 are given in Table 16. Specifically,

$$\frac{\partial LOG(JVMQ)}{\partial LOG(Ex_j)} = -0.80, \quad \frac{\partial LOG(JEDTAQ)}{\partial LOG(Ex_J)} = -0.45,$$

$$\frac{\partial LOG(JINEDTAQ)}{\partial LOG(Ex_J)} = -0.11, \quad \frac{\partial LOG(JHWQ)}{\partial LOG(Ex_J)} = -0.37.$$

The partial derivative of second right-hand term in equation 6.8 represents the inverse of the conceptual by-product supply function. Since by-product supply was not estimated, the term is based on the fed cattle supply function (equation 3.2) and supply elasticity (0.606) estimated by Marsh (1994).

Therefore, evaluation of equation 6.8 for each by-product, which is necessary to evaluate equation 6.7, is:

$$\frac{\partial LOG(P^{VM}{}_J)}{\partial LOG(Ex_J)} = -0.80/0.606 = -1.32,$$

$$\frac{\partial LOG(P^{ET}{}_J)}{\partial LOG(Ex_J)} = -0.45/0.606 = -0.743,$$

$$\frac{\partial LOG(P^{IE}{}_J)}{\partial LOG(Ex_J)} = -0.11/0.606 = -0.182,$$

$$\frac{\partial LOG(P^{H}{}_J)}{\partial LOG(Ex_J)} = -0.37/0.606 = -0.611.$$

Finally, summing the effects of the Japanese exchange rate on each by-product in equation 6.7 gives the marginal impact of a one unit (percent) change in exchange rate on U.S. slaughter price:

$$\frac{\partial LOG(P_{sl})}{\partial LOG(Ex_J)} = -1.32 * 0.071 * 0.14 + (-0.743) * 0.103 * 0.14$$

$$+(-0.182) * 0.156 * 0.14 + (-0.611) * 0.172 * 0.14$$

$$= (-0.13) + (-0.011) + (-0.004) + (-0.015)$$

$$= -0.16.$$

The coefficient indicates, for example, that one percent depreciation in the Japanese exchange rate reduces import demand for all U.S. by-products, resulting in a 0.16 percent decrease in U.S. slaughter steer price.

The impacts of changing exchange rates for South Korea, Canada, and Mexico are calculated by the same procedure. The impacts of changes in country GDP's on U.S. slaughter steer price are also calculated by the same procedures as those of exchange rates. Results in Table 24 indicate, for example, that a one percent increase in Japanese GDP would increase the slaughter steer price by 0.058 percent, or that a one percent increase in Canadian GDP would increase slaughter steer price by 0.036 percent. Based upon U.S. slaughter steer price of $61.48/cwt in 1998, this amounts to $0.04/cwt and $0.02/cwt, respectively.

CHAPTER 7

POLICY SIMULATION

The model developed in previous chapters is used to evaluate the impacts of changes in macroeconomic variables in foreign countries on U.S. beef markets. Simulations are based on actual changes in importing countries' real GDP's and currency exchange rates between 1997 and 1998. In 1998, the year immediately following the estimating sample period, significant changes took place that had effects on U.S. beef by-product prices and cattle prices. Simulations are based upon incorporating the 1997-1998 real GDP and exchange rate changes into the partial derivative procedures of equations (6.7) and (6.8). The partial derivatives and their applications are based upon point estimates of the model parameters. The simulated effects, by country, assume no structural changes among domestic and foreign beef markets relative to 1997. In the Asian markets, the GDP and currency valuation changes reflected economic downturns that began in 1996, and subsequently, affected import demands for U.S. agricultural exports.

Analysis of 97-98 Changes

The GDP and exchange rate changes for Japan, Korea, Canada and Mexico are presented in table 25.

Table 25. Changes in GDP and Exchange Rate For Selected Countries From 1997 to 1998.

	GDP	Exchange Rate
Japan	-1.93%	8.20%
Korea	-5.80%	9.50%
Mexico	4.80%	15%
Canada	3.12%	-6%

In 1998, real Japanese GDP declined to 497,218 billion yen from 506,977 billion yen in 1997 (IMF: *International Financial Statistics*), and the Japanese yen depreciated by 8.2% from 120.99 per U.S. dollar in 1997 to 130.91 per U.S. dollar in 1998 (IMF: *International Financial Statistics*). The structural model indicates that foreign GDP declines and currency depreciations could decrease import demand for U.S. beef by-products, hence, negatively affect U.S. beef by-product values and cattle prices.

The affect on U.S. beef by-product values due to the Japanese GDP decrease was calculated through four beef by-product categories: variety meats, edible tallow, inedible tallow and hides. The impact of GDP changes on Japanese import quantities of by-products were presented in table 16. The impacts of changes in prices of various by-products on U.S. beef by-product value were presented in table 20. The parameter estimates presented in Chapter 6 imply that the value of U.S. beef by-products decreased by 0.8% because of the 1998 decrease in Japan's GDP, and by 9.4% because of the 1998 depreciation of the yen. The combined effects of the currency depreciation and the decrease in GDP resulted in a decrease of 10.2% in the value of U.S. beef by-product values.[17]

Real Korean GDP also declined by 5.8% between 1997 and 1998 from 290,888 billion won (measured in 1990 prices) to 274,021 billion won (IMF: *International Financial Statistics*). Concurrently, the won also depreciated by 9.5% from 951.29 won per U.S. dollar in 1997 to 1,401.44 won per U.S. dollar in 1998. Using the parameter estimates presented in chapter 6, the decrease in U.S. domestic beef by-product values caused by the decline in Korea's GDP was 4.0% and the decrease caused by the decline in the value of the won was 10.0%. The combined effects of won depreciation and the decline in Korea's GDP amounted to 14.0%. Overall, the Japanese and Korean income and exchange rate shocks in 1997 and 1998 resulted in a decrease in U.S. domestic beef by-product values of an estimate of 24.2%.

The effects of income and currency valuation changes on the value of U.S. beef by-products for Mexico and Canada were also simulated. The impacts of Mexican and Canadian income and exchange rate changes on U.S. domestic by-product value were relatively small compared to those of Japan and Korea. Mexican real GDP increased by 4.8% and Mexico's currency (the peso) depreciated by 15% between 1997 and 1998. Canada's real GDP increased by 3.12% and the Canadian dollar appreciated by 6%

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[17] The effects were estimated as follows:

$$\frac{\partial \ln BPV^{us}}{\partial \ln Y_J} = \frac{\partial \ln P^{VM}}{\partial \ln Y_J} * \frac{\partial \ln BPV^{us}}{\partial \ln P^{VM}} + \frac{\partial \ln P^{ET}}{\partial \ln Y_J} * \frac{\partial \ln BPV^{us}}{\partial \ln P^{ET}} + \frac{\partial \ln P^{IE}}{\partial \ln Y_J} * \frac{\partial \ln BPV^{us}}{\partial \ln P^{IE}} + \frac{\partial \ln P^{H}}{\partial \ln Y_J} * \frac{\partial \ln BPV^{us}}{\partial \ln P^{H}}$$

$$= (0.219*0.071 + 0.155*0.103 + 0.98\ 0.156 + 0.432*0.172)/0.606$$

$$= 0.427$$

and $\partial \ln BPV^{us}$ (due to change inY_J) $= (\partial \ln BPV^{us}/\partial \ln Y_J)* \partial \ln Y_J$

$$= 0.427 * (-1.93) = -0.82$$

Changes in the BPV^{us} due to change in Japanese exchange rate are calculated in a similar fashion.

during the same period. The positive real GDP changes and appreciation of Canadian's currency are expected to increase beef by-product values by increasing import demand. The percentage change in U.S. domestic by-product values due to macroeconomic changes in Mexico was –2.8%. Canadian income and currency appreciation increased U.S. by-product values by 4.0%.

Table 26 presents the summary of the changes in U.S. beef by-product value due to the GDP and exchange rate changes in Japan, Korea, Mexico and Canada during 1997 to 1998.

Table 26. Changes in U.S. By-Product Value Due To the GDP and Exchange Rate Changes in Selected Countries From 1997 to 1998.

	GDP	Exchange Rate	Total
Japan	-0.80%	-9.40%	-10.20%
Korea	-4%	-10.00%	-14%
Mexico	0.60%	-3.40%	-2.80%
Canada	0.40%	3.60%	4%

Table 22 indicates that a one percent increase in U.S. beef by-product values positively affect real slaughter steer prices by 0.14 percent. Based on USDA data, nominal slaughter steer prices in 1997 and 1998 averaged \$64.40/cwt. Thus, the dollar decrease in U.S. slaughter steer prices due to the income and exchange rate changes in the Asian market are estimated below:

(7.1) 24.2%*0.14*\$64.40/cwt =\$2.18/cwt , where 24.2% is the combined negative impact on U.S. beef by-product value of Japanese and Korean income and exchange rate shocks, 0.14 is the price transmission between U.S. beef by-product value and slaughter steer price, and \$64.40/cwt is the average slaughter steer price for 1997 and 1998. The dollar value of this decrease was \$1.35/cwt, measured in terms of the average purchasing power of a dollar between 1997 and 1998.[18]

[18] The calculation is as follows: \$2.18/cwt/((1.606+1.631)/2) =\$1.35/cwt, where 1.606 and 1.631 are CPIs for 1997 and 1998, respectively (1982-84=100).

CHAPTER 8

SUMMARY AND CONCLUTIONS

The objectives of this study were to econometrically estimate the effects of economic factors such as income and exchange rates in Asian and North American countries on import demands for U.S. beef by-products, by-product values, and slaughter cattle prices. By-products are an important source of income for U.S. meat packers. The international market is a crucial outlet for U.S. by-products, and plays an important role in affecting export values of by-products and, subsequently, prices received by U.S. beef producers. Recently economic volatility in Asian markets has affected not only import demand for high quality U.S. meat products, but also import demand for by-products such as hides, offal, and tallow. In fact, the USDA attributed 1998 slaughter cattle price declines, in part, to weaknesses in the Asian export market for U.S. beef by-products. The data show that by-product values per 1,000 pound steer fell from $103.29 in 1997 to $81.92 in 1998.

Four countries (Japan, Korea, Mexico and Canada) and four beef by-products (variety meats, edible tallow, inedible tallow and hides) were considered in the econometric study. Given the maintained hypothesis, the empirical model consisted of three stages. First, structural import demand equations were specified by country and according to by-product class, and were estimated using a systems (SUR) approach. Import demand quantities of individual by-products were estimated as a function of corresponding real import prices, importing countries' real GDP, real exchange rates, a trend variable, and when applicable output price. Most estimated coefficients were statistically significant and had the expected (theoretical) signs. In the case of Japan, the estimated coefficients for GDP and the exchange rate had the expected signs (positive and negative, respectively) and were significant in all four equations. Import prices of variety meats, edible tallow, inedible tallow and hides also had the expected negative signs and were significant. In the case of Korea, both GDP and the exchange rate had the expected signs and are significant in all four by-product equations. Import price coefficients were negative, but only significant in the models for edible tallow and hides. In the case of Canada, the exchange rate had the expected sign and was significant in the edible tallow, inedible tallow, and hide import equations. Exchange rate had the expected sign in the case of variety meats equation, but was not significant. Canadian GDP coefficient had the expected sign in all equations and was significant except for in edible tallow model. The own price coefficients all had the expected negative signs and were significant in variety meats and edible tallow equations. In the case of Mexico, the exchange rate coefficient had the expected sign in all four equations and was significant in the variety meats, edible tallow and hides equations. The GDP coefficient had the expected sign in the inedible tallow and hide equations but was only significant in the inedible tallow equation. The import price coefficients had the expected negative signs and were all significant.

In the second stage of the analysis, U.S. beef by-product value was estimated to provide a linkage between the foreign sector and U.S. slaughter cattle price. The by-product equation was estimated (by OLS) as function of the product of number of cattle slaughtered and average slaughter weight, deflated personal consumption expenditures, and quantity-weighted beef by-product import prices. The first two regressors account for domestic effects while the weighted prices account for foreign import demand effects on by-product values. All weighted prices are positive and significant, which is consistent with the maintained hypothesis. The empirical results indicated that one percent increases in the weighted prices of hides, variety meats, edible tallow and inedible tallow increase U.S. beef by-product values by 0.172%, 0.071%, 0.103% and 0.156%, respectively.

The third stage included the estimation of a U.S. slaughter steer inverse demand, which was used to calculate the impact of foreign factors on prices received by U.S. beef producers. The slaughter steer price (measured in constant dollars) was estimated as a function of average slaughter weight, number of cattle slaughtered, U.S. beef by-product value, marketing cost, and the deflated price of boxed beef. Two stage least squares was the estimator used. All coefficients were statistically significant and had the expected signs except in the case of the marketing cost variable. The empirical results indicated that a one percent increase in U.S. beef by-product value increases real slaughter steer price by 0.14 percent.

The effects of exogenous shocks in country exchange rates and real GDPs on U.S. fed cattle prices were estimated using the estimated import demand equations, U.S. by-product values, and U.S. inverse slaughter steer demand. This framework was used to evaluate 1998 cattle market effects caused by currency and national income changes of major U.S. beef by-product customers. U.S. beef producers were particularly concerned about the potential economic damages to import demands and subsequent effects on beef, beef by-product, and slaughter cattle prices of these macroeconomic changes. The results indicate, for example, that one percent depreciations in the Japanese yen, Korean won, Canadian dollar and Mexican peso decreased U.S. slaughter steer prices by 0.160%, 0.148%, 0.074% and 0.068%, respectively, due to decreasing by-product import demands. One percent decreases in real GDP in Japan, Korea, Canada and Mexico decreased U.S. slaughter steer price by 0.058%, 0.089%, 0.036% and 0.015%, respectively.

Post-sample analysis for 1998 was carried out. Between 1997 and 1998, Japan's real GDP decreased by 1.93%, the Japanese yen depreciated by 8.2%; Korea's real GDP declined by 5.8% and the value of won depreciated by 9.5%; Mexico's real GDP increased by 4.8% and the Mexican peso depreciated by 15%; Canadian real GDP increased by 3.12% and the Canadian dollar appreciated by 6% (IMF: *International Financial Statistics*). The currency depreciations and real GDP decreases from the Asian markets were to reduce nominal slaughter steer prices by $2.18/cwt and real steer price by $1.35/cwt in 1998 relative to 1997.

Limitations and Implications

The empirical results of the annual model are based upon assumed minimal specification errors. However the results may require careful interpretation due to the relatively small sample employed. A larger sample extending back into the 1970's or earlier may be preferred since a longer estimation period would probably permit improved statistical analysis and facilitate more precise economic inferences. Additionally, a larger sample defined in terms of potential shorter units of observation (that is, quarterly demands) may be preferred since estimation of potential market dynamics such as partial adjustment processes could be captured. However, quarterly data were not reported for many of the required variables. Time-series analyses such as unit root and cointegration tests were also severely limited by sample size. Conceptually, such tests are necessary to detect potential spurious regression and incorrect statistical inference in data-level models. DeJong et al. and Johnston and DiNardo argue that unit root and cointegration tests have low power against the trend stationary alternative for small samples. Conventionally, these tests involve the ADF unit root tests for model variables and equation residuals as well as the Johansen cointegration test.

Historical information indicates that ad valorem tariffs have been imposed on imports of U.S. beef by-products in the four countries over the period 1980 to 1997. However, due to inconsistent and incomplete reporting of tariff data by these countries, tariffs were omitted in the empirical estimation model. The ability to include tariffs in the structural model, depending upon their relative importance, could strengthen the empirical results and marginal impact analysis of foreign shocks.

Overall, policy implications regarding beef by-products may be important. Model simulations indicate the magnitude of foreign shocks on U.S. cattle price, via the by-product market, is not trivial (i.e., over $2/cwt). Consequently, less politically sensitive avenues in foreign trade to improve U.S. beef producer returns may lie in liberalizing trade barriers in beef by-products. The latter may be less costly to achieve compared to further liberalized trade of high quality beef table cuts, although table cuts will continue as the primary trade target in the beef sector.

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APPENDIX

BEEF BY-PRODUCT EXPORTS FOR SELECTED YEARS AND BEEF BY-PRODUCT IMPORTS FOR SELECTED COUNTRIES AND YEARS

Table 27.Value of U.S. Beef By-Product Exports, Selected Years (Thousands of Dollars).

Commodity	Cattle hides	Variety meat	Edible tallow	Inedible tallow
1980	118,831	243,819	21,089	677,214
1985	991,894	248,557	10,692	545,220
1990	1,286,637	297,527	42,637	311,849
1995	1,224,577	614,505	61,204	570,186
1996	1,125,072	616,896	50,590	412,976
1997	1,134,285	468,190	43,672	371,716
1998	871,099	477,732	53,517	464,027

Source: Dairy, Livestock and Poultry: U.S. Trade and Prospects, USDA.

Table 28. Volume of U.S. Beef By-Product Exports, Selected Years.

Commodity	Cattle hides	Variety meats	Edible tallow	Inedible tallow
	(in pieces)	(metric tons)	(metric tons)	(metric tons)
1980	(See below)	132,526	39,855	1,411,641
1985	24,955,830	189,673	22,918	1,229,067
1990	21,323,825	160,399	114,121	920,054
1995	20,044,489	342,646	126,685	1,212,749
1996	20,289,294	355,789	103,982	905,568
1997	18,990,623	284,453	83,851	767,534
1998	17,805,080	308,458	111,799	1,041,350

Source: Dairy, Livestock and Poultry: U.S. Trade and Prospects, USDA.
Note: Quantity of cattle hides in 1980 is measured in weight: 3958 metric tons.

Table 29. Cattle Hide Imports For Selected Countries and Years.

Year/Value/Volume	South Korea	Japan	Mexico	Canada
1990 ($1000)	615,169	411,581	69,537	38,635
1996 ($1000)	452,138	154,160	102,245	52,253
1997 ($1000)	454,646	117,389	125,361	64,883
1990 (in pieces)	9,838,708	6,754,969	1,377,448	674,402
1996 (in pieces)	7,955,679	2,372,025	2,117,135	1,148,716
1997 (in pieces)	7,467,896	1,800,433	2,467,432	1,247,952
%change in volume 90 to 97	-24.1%	-73.3%	79.1%	85.0%
%change in value 90 to 97	-26.1%	-71.5%	80.3%	67.9%
%change in volume 96 to 97	-6.1%	-24.1%	16.5%	8.6%
%change in value 96 to 97	0.6%	-23.9%	22.6%	24.2%

Source: U.S. Department of Commerce, Bureau of Census.

Table 30. Variety Meats Imports For Selected Countries and Years.

Year/Value/Volume	Japan	South korea	Mexico	Canada
1990 ($1000)	211,306	1,052	31,611	10,958
1996 ($1000)	422,181	10,155	35,288	9,014
1997($1000)	254,895	8,189	45,233	9,994
1990 (metric tons)	79,564	465	27,357	10,987
1996 (metric tons)	177,862	10,589	30,490	10,378
1997 (metric tons)	88,826	5,576	39,444	11,298
%change in volume 90 to 97	11.6%	1099.1%	44.2%	2.8%
%change in value 90 to 97	20.6%	678.4%	43.1%	-8.8%
%change in volume 96 to 97	-50.1%	-47.3%	29.4%	8.9%
%change in value 96 to 97	-39.6%	-19.4%	28.2%	10.9%

Source: U.S. Department of Commerce, Bureau of Census.

Table 31. Edible Tallow Imports For Selected Countries and Years.

Years/Value/Volume	Japan	South Korea	Mexico	Canada
1990 ($1000)	2,425	2,641	29,654	4,446
1996 ($1000)	806	5,054	28,112	10,222
1997 ($1000)		3,648	25,618	10,745
1990 (metric tons)	6,528	6,655	80,427	11,405
1996 (metric tons)	1,600	10,786	58,088	20,612
1997 (metric tons)		6,929	49,940	19,570
%change in volume 90 to 97		4.1%	-37.9%	71.6%
%change in value 90 to 97		38.1%	-13.6%	141.7%
%change in volume 96 to 97		-35.8%	-14.0%	-5.1%
%change in value 96 to 97		-27.8%	-8.9%	5.1%

Source: U.S. Department of Commerce, Bureau of Census.

Table 32. Inedible Tallow Exports For Selected Countries and Years.

Years/Value/Volume	Japan	South Korea	Mexico	Canada
1990 ($1000)	13,350	13,487	27,673	1,336
1996 ($1000)	17,510	11,395	76,541	8,049
1997 ($1000)	15,781	2,278	94,583	8,328
1990 (metric tons)	37,115	41,854	78,734	2,695
1996 (metric tons)	39,958	26,271	180,722	18,252
1997 (metric tons)	37,663	4,862	192,581	18,807
%change in volume 90 to 97	1.5%	-88.4%	144.6%	597.8%
%change in value 90 to 97	18.2%	-83.1%	241.8%	523.4%
%change in volume 96 to 97	-5.7%	-81.5%	6.6%	3.0%
%change in value 96 to 97	-9.9%	-80.0%	23.6%	3.5%

Source: U.S. Department of Commerce, Bureau of Census.