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Japanese Import Demand for U.S. Beef and Pork: Effects on U.S. Red Meat Exports and Livestock Prices

Dragan Miljkovic, John M. Marsh, and Gary W. Brester

Japanese import demand for U.S. beef and pork products and the effects on domestic livestock prices are econometrically estimated. Japan is the most important export market for U.S. beef and pork products. Results indicate foreign income, exchange rates, and protectionist measures are statistically significant. The comparative statics quantify the effects of recent economic volatility. For example, the 1995–1998 depreciation in the Japanese yen (39%) reduced U.S. slaughter steer and hog prices by $1.29 per cwt and $0.99 per cwt, respectively, while the 1994–1998 reduction in tariffs (14%) increased slaughter steer and hog prices by $0.49 per cwt and $0.33 per cwt, respectively. Livestock producers will continue to have a vested interest in Asian trade liberalization policies.

Key Words: elasticities, exchange rates, import demand, income, tariffs

JEL Classifications: Q17, F14, C32

Foreign demand for U.S. red meat (beef and pork) products has increased substantially since the mid-1980s and is an important factor affecting U.S. livestock prices (Brester and Wohlgenant; Capps et al.). For example, from 1985 to 1998, U.S. beef exports, as a percentage of domestic beef supplies, increased from 1.3% to 7.5%, and U.S. pork exports, as a percentage of domestic pork supplies, increased from 1.0% to 6.1%. Increases in export demand for U.S. red meats have been attributed to increasing foreign incomes, evolving dietary preferences for animal-source proteins, and reductions in tariff and nontariff trade barriers (Brester and Wohlgenant; Capps et al.).

Japan, Mexico, Canada, and South Korea have consistently been the major export markets for U.S. beef and pork. In 1998, these countries constituted about 90 and 65% of U.S. beef and pork exports, respectively. Japan has been the major single market outlet, representing about 52 and 40%, respectively, of U.S. beef and pork exports in 1998. Japan primarily imports U.S. beef cuts of choice and prime grades, while other importers purchase U.S. cuts of choice, select, and standard grades.

Although U.S. livestock producers benefit from expanding red meat exports, particularly to Japan, export markets also are a source of price risk. The objectives of this article are twofold: (1) to econometrically estimate market factors that affect Japanese import demand for U.S. beef and pork products and (2) to estimate the effects of changes in Japanese de-

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Dragan Miljkovic is associate professor, Department of Agriculture, Southwest Missouri State University. John M. Marsh and Gary W. Brester are professors, Department of Agricultural Economics and Economics, Montana State University, Bozeman, MT.

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mand for U.S. beef and pork on U.S. meat exports and livestock prices. An econometric model is developed that estimates Japanese-derived (import) demands for U.S. wholesale beef and pork. Comparative statics are used to estimate export quantity and livestock price effects by relating import demand shocks to export market shares and livestock price flexibilities. It is hypothesized that Japanese national income, exchange rates and risk, and tariffs and subsidies shift import demands and U.S. meat exports. U.S. beef and pork prices are subsequently affected through changing supplies available for domestic use.

The current study extends previous red meat research on Japanese demand preferences, trade liberalization, and institutional constraints (Capps et al.; Gorman, Mori, and Lin; Hayes, Wahl, and Williams; Wahl, Hayes, and Johnson) by relating Japanese demand factors to the U.S. farm level. The results quantify Japan's impact (as a major customer) on the U.S. livestock industry and the degree to which trade liberalization and internal Japanese policies affect U.S. red meat exports.

Exchange Rate Risk

Economic volatility in the Asia-Pacific regions may result in changes in demand for U.S. agricultural products. A few empirical studies have suggested that increases in exchange rate risk reduce trade (Akhtar and Hilton; Clark; Cushman 1983, 1988; Hooper and Kohlhagen; Kenen and Rodrik; Thursby and Thursby). Strong empirical support is found in Cushman (1988) and Bahmani-Oskooee and Ltaifa. The Asian financial crisis of 1997 exemplified risk as currency depreciation and declining Asian stock market values and incomes may have increased the costs of purchasing U.S. beef and pork.

Several factors contributed to the Asian financial crisis (Gajewski and Langley; Ianchovichina, Hertel, and McDougall). For a variety of reasons, most Asian governments opened their economies to foreign capital in the 1990s. After 1995, appreciation of the U.S. dollar relative to Asian currencies reduced export competitiveness. Capital inflows exacerbated real exchange rate appreciation, resulting in large current account deficits in some countries. Capital inflows also contributed to credit excesses and a growing portfolio of poor investments. Foreign investors were providing funds to Asian firms with high debt ratios and developing long-term alliance relationships that were quite risky. The financial crisis resulted in large capital outflows that exacerbated economic problems (Adelman).

Beef and Pork Market Background

The United States is one of the world's largest producers and exporters of beef. For example, in 1996, U.S. beef exports accounted for approximately 17% of world beef exports. Major U.S. customers for beef have been Japan, Mexico, Canada, and South Korea (USDA/AMS). Although the United States is the world's largest importer of beef and live cattle combined, Japan is the world's largest importer of beef. Japan purchases about 90% of its fed beef imports from the United States (the remainder from Canada). Most nonfed beef imports are supplied by Australia and New Zealand (USDA/ERS). Until 1988, the Japanese domestic market was highly protected by import quotas and *ad valorem* tariffs (Jeong). However, beef import quotas were relaxed in 1989 and 1990. In 1991, import quotas were replaced by a 70% *ad valorem* tariff, which was subsequently reduced to 60% in 1992 and 50% in 1993 (Doyle et al.). Under the 1994 Uruguay Round of the General Agreement on Tariffs and Trade (GATT), the tariff-rate quota would be gradually reduced to 38.5% by 2001. However, Japan retained the right to reinstate the higher rate under safeguard provisions if imports of frozen or chilled beef over a specified period are greater than 17% of import levels for the corresponding period in the previous year. The safeguards have been employed frequently in the past few years.

World pork production is larger than for any other species. World pork exports, however, are less than 50% of world beef and poultry exports. The United States is the third largest pork exporter, with a 20% market share. Historically, major U.S. markets have included Japan, Canada, and Mexico. However, since 1994, the Russian Federation has emerged as an important importer of U.S. pork. Japan accounts for more than one third of world pork imports and is by far the largest single market for the U.S. pork industry (USDA/ERS). Japanese pork trade policies are similar to those for beef. Domestic protection safeguards have been almost continually binding.

Red Meat Import Demand: Model Development

We use a modified version of Hooper and Kohlhagen's trade model, which assumes that the demands for beef and pork imports are derived demands (i.e., wholesale beef and pork imports are used for production of retail products). An importer faces a domestic demand for its output (Q), which is a function of own-price (P), prices of substitutes and complements (PD), and domestic income (Y). Written in linear form, the relation is

(1) $$Q = aP + bPD + cY.$$

A risk-averse importer is assumed to 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). It is assumed that an importer receives orders for its output in the first period and pays for imports and receives payments for its output in the second period. Thus, prices are determined in the first period, and the expected utility problem is

(2) $$\max_{Q} EU(\Pi) = E(\Pi) - \lambda(V(\Pi))^{1/2},$$

where EU represents expected utility and Π is profits. The parameter λ is the relative measure of risk preference ($\lambda > 0$ is risk aversion, $\lambda < 0$ is risk taker, and $\lambda = 0$ is risk neutral), while V is the variance operator. An importer's profits are represented by

(3) $$\Pi = P(Q)Q - UCQ - HP^*q,$$

where UC is the unit cost of production, H is the foreign exchange variable, P^* is import price denominated in foreign currency, and q is the imported input. Assuming a constant input-output ratio, derived demand for q can be presented as

(4) $$q = \gamma Q,$$

where γ is a fixed input-output coefficient. Substituting equation (4) into equation (3) yields

(5) $$\Pi = P(Q)Q - UCQ - HP^*\gamma Q.$$

The model in equation (5) distinguishes between imports denominated in both an importer's and exporter's currencies. It further distinguishes between those imports denominated in an exporter's currency that are hedged—versus those that remain unhedged—in the forward exchange market. The foreign exchange cost variables can be presented as

(6) $$H = \beta(\mu F + (1 - \mu)R_1) + (1 - \beta)F,$$

where β is the share of imports denominated in the exporter's currency, $(1 - \beta)$ is the share of imports denominated in an importer's currency, μ 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. If all imports are denominated in the importer's currency ($\beta = 0$) or denominated in foreign currency and hedged ($\mu = 1$), then import costs would be known with certainty. However, in many cases, importers and/or exporters may choose to not fully hedge transactions in foreign exchange markets. Thus, it may be that $\beta > 0$ and $\mu < 1$, and risk is introduced because R_1 is unknown in the first period. Exchange rate risk introduces profitability risk, which is represented by

(7) $$V(\Pi) = [P^*\gamma Q\beta(1 - \mu)]^2\sigma^2_{R1},$$

where $V(\Pi)$ is the variance of profits and σ^2_{R1} is the variance of the exchange rate R_1.

Following Cushman (1988), Kenen and Rodrik, and Pick, a reduced-form model of import demand (for the firm) can be developed by defining the above profits in real terms. Hooper and Kohlhagen derive reduced-form import demands and their economic arguments by substituting equations (5) and (7) into equation (2) and then differentiate with respect to Q to obtain first-order conditions (FOC). The FOC is

$$(8)\quad Q/a + P - UC - HP^*\gamma - P^*\gamma\lambda\xi\sigma_{R1} = 0,$$

where $\xi = \beta(1 - \mu)$. Substituting for P in equation (1) and q/γ for Q in equation (4) and then entering into the FOC gives the solved equation for q,

$$(9)\quad q = (\gamma b/2)PD + (\gamma c/2)Y(\gamma a/2)UC + (\gamma^2 a/2)P^*H + (\gamma^2 a/2)P^*\lambda\xi\sigma_{R1}.$$

Equation (9) is the basis of specifying the general model of beef import demand

$$(10)\quad Q_{iM} = \alpha + \delta P_{im} + \iota PD + \eta Y + \rho UC_{im} + \zeta R + \kappa M + \nu S,$$

where Q_{iM} is the firm's real value of import demand for beef or pork (as a measure of quantity), Y is the importing country's real income (GDP), UC_{im} is the importer's real unit production cost, P_{im} is the import price of beef or pork, PD is the importing country's price of competitive red meats and poultry, R is the foreign currency per U.S. dollar real exchange rate, M is a four-quarter moving-average of percent changes in R (used as a proxy of expected real exchange rates), and S is a risk measure represented by absolute quarterly percent changes in real exchange rates in absolute value. The variables M and S are adopted from Cushman (1983, 1988) and Kenan and Rodrik as representations of σ_{R1} in equation (9). Extending firm-level demand to the market level gives

$$(11)\quad Q^d = f(P_{iM}, PD, Y, UC, R, M, S, PSE, Tar, \bar{D}) \qquad \text{(import demand)}$$

$$(12)\quad Q^s = \text{infinitely elastic} \qquad \text{(import supply)}$$

$$(13)\quad Q^d = Q^s = Q^* \qquad \text{(market clearing)}.$$

Import demand (Q^d) of equation (11) also includes protectionist measures that would affect Japanese demand for U.S. red meat exports, i.e., producer subsidy equivalents (PSE), and tariffs (Tar). Because quarterly observations are used, seasonality ($\bar{D}$) is also added. Import supply (or U.S. export supply) to Japan is assumed to be infinitely elastic (equation (12)). Thus, for any quarter, Japan is assumed to be a price taker in purchases of U.S. beef and pork. This short-run assumption appears reasonable given that the United States supplies Japan's import demands for beef and pork (under tariffication) in competition with other major export suppliers (Canada, Australia, and New Zealand for beef; Canada, South Korea, Denmark, and Mexico for pork). Thus, an exclusive change in Japanese demand for U.S. beef or pork does not influence world price of red meats. With supply assumed infinitely elastic, Japan's demand impact on U.S. beef and pork prices occurs through changing meat supplies available in the U.S. market. Equation (13) represents market clearing of import quantities demanded and supplied.

The expected competitive effects of Japanese red meat and poultry prices (PD) in equation (11) are positive because higher domestic prices of substitutes would encourage additional beef imports. Also included in PD is the price of Australian nonfed beef, which accounts for competition with U.S. fed beef. Japan obtains approximately one half of its beef imports from Australia (primarily nonfed beef) and one half from the United States (primarily fed beef) (USDA/AMS). The expected effect of real income (Y) is positive for an imported normal good. The production cost (UC) impact is expected to be positive, i.e., an increase in Japanese domestic costs would increase demand for less expensive imports. Appreciation of the U.S. dollar (i.e., an increase in R) is expected to decrease import demand because imports become relatively more costly. Assuming risk-averse agents, the effects of M and S are also expected to be negative. Because producer subsidy equivalents (PSE) and tariffs (Tar) represent trade restrictions, their increase (decrease) would be expected to decrease (increase) import demand.

Effects on U.S. Livestock Prices

Increases in foreign demand for U.S. beef and pork products conceptually affect U.S. wholesale prices of beef and pork and derived (farm-level) prices of livestock (Tomek and Robinson). For example, let the Japanese demand for U.S. boxed beef increase. Given equation (12) and a fixed supply of U.S. beef in any quarter, an increase in U.S. beef exports reduces U.S. wholesale supplies available for domestic use.[1] Assuming no reduction in domestic demand, the result is an increase in wholesale beef price and the derived (farm) price of live cattle (Tomek and Robinson, pp. 117–19). We use U.S. export market shares (meat exports as a percentage of domestic meat supplies) and livestock price flexibilities to link shifts in foreign import demand to changes in U.S. cattle and hog prices. The goal is to quantify the effects of changes in Japanese demand factors (i.e., exchange rates, income growth, etc.) on U.S. livestock prices.

Beef and pork imports and exports are important components of respective U.S. red meat supplies and disposition. Expressing exports as percentages of U.S. meat supplies permits quantifying shocks in foreign demand on U.S. livestock markets. For example, let U.S. slaughter cattle price be represented by an inverse (derived) demand,

$$(14)\quad P_t = f(Q_t, Z_t),$$

which indicates U.S. slaughter cattle price, P_t, is determined by beef supplies, Q_t, and exogenous shifters, Z_t, in the production/marketing channel. Suppose the exchange rate, R, in equation (11) changes. In general, its marginal percent impact on U.S. slaughter price would be

$$(15)\quad \left(\frac{\partial P_T}{\partial R_T}\frac{R_T}{P_T}\right) = \left(\frac{\partial Q_T^*}{\partial R_T}\frac{R_T}{Q_T^*}\right)\left(\frac{\partial Q_T}{\partial Q_T^*}\frac{Q_T^*}{Q_T}\right)\left(\frac{\partial P_T}{\partial Q_T}\frac{Q_T}{P_T}\right).$$

Equation (15) indicates that the percent change in U.S. slaughter price given a 1% change in the exchange rate (left side of equation) is a product of (a) the percent change in import demand for U.S. meat given a 1% change in the exchange rate (first term in parentheses on the right side of the equation), which is based on equation (11); (b) the percent change in supplies available for domestic use, given the percent change in import demand (second term in parentheses); and (c) the percentage change in U.S. slaughter price, given the percentage change in supplies available for domestic use (third term in parentheses), which is based on equation (14). The partial derivative $\partial Q_T/\partial Q_T^*$ is assumed to be -1.0, i.e., for every one pound increase in U.S. meat exports, one less pound is available for domestic use. The term Q_T^*/Q_T represents U.S. meat exports to Japan as a share of U.S. meat supplies.

Data and Tests

Quarterly data from 1989:1 thru 1997:4 were used to estimate separate Japanese import demands for beef and pork in equation (11). Japanese import quantities of U.S. beef and pork and corresponding wholesale trading prices were obtained from Agriculture & Livestock Industries Corporation (ALIC) Monthly Statistics. Wholesale Japanese prices for beef, pork, and poultry were also obtained from ALIC Monthly Statistics. Japanese real GDP and exchange rates were obtained from the International Financial Statistics CD (International Monetary Fund). Because relative Japanese unit production costs are unavailable, the ratio of Japanese wholesale beef (pork) price to U.S. wholesale beef (pork) price is used as a proxy, assuming each price reflects respective production costs. U.S. wholesale prices were obtained from the USDA's *Red Meats Yearbook*. Producer subsidy equivalents (PSE) and

[1] The balance equation for red meats is supply = disposition. Supply consists of production + imports + beginning stocks, while disposition consists of consumption + exports + ending stocks. Subtracting exports from both sides gives: supplies − exports = consumption + ending stocks, or supplies available for domestic use. These available supplies are an integral part of the analysis of import/export effects on U.S. livestock prices.

tariff rate variables (Tar) were obtained from the Organization for Economic Cooperation and Development (OECD). Seasonality was accounted for by quarterly binary variables (intercept shifts).

The import demand equations were subjected to a variety of specification tests. Using ordinary least squares (OLS), they included contemporaneous correlation of residuals, autocorrelation (Durbin-Watson test), heteroscedasticity (White and Glejser tests), joint dependency (Hausman specification test), and the presence of unit roots (augmented Dickey-Fuller unit root test, or ADF). Test results, though they may be sensitive to small sample size, did not indicate the presence of either autocorrelation or heteroscedasticity in the residuals. Contemporaneous correlation of the estimated errors between the two equations showed a correlation coefficient (ρ) of .383. Based on the ADF test, model variables were found to be nonstationary. Consequently, the residuals of the equations were tested for stationarity or equation cointegration (Johnston and DiNardo, pp. 259–69). The null hypothesis of unit root residuals was rejected at the α = .05 level. This indicated the equations were cointegrated (though the test has low power in small samples) and could be estimated with data in levels. Import prices of beef and pork were tested for endogeneity in their respective demand relations. Hausman specification tests failed to reject the null hypothesis of no simultaneous equations bias at the α = .05 level.

Based on the above statistical tests, the beef and pork import demand equations were estimated by OLS.[2] The equations were estimated in double logs because it was assumed variables enter the equations multiplicatively. Because of short-run (quarterly) observations, import demand responses could be dynamic, i.e., distributed lag adjustments may exist due to uncertainty and institutional constraints. We follow Cushman's (1988) and Pick's approach by initially estimating both equations with lag specifications for the exogenous variables. The highest order lag was $t - 1$ based on the Akaike information criterion (AIC) and Schwarz information criterion (SIC). A Koyck (or first-order) lag on the dependent variables was also tested, but the asymptotic t-ratios rejected partial adjustments for both equations (Pindyck and Rubinfeld, p. 234).

Empirical Results

Table 1 defines the variables in the empirical model of equation (11) and Table 2 gives the regression results. The statistical results show an adjusted R-squared ($\bar{R}^2$) and standard error of equation (SE) of 0.82 and 0.16, respectively, for beef, and an $\bar{R}^2$ and SE of 0.57 and 0.33, respectively, for pork. In the beef import equation, the significant variables (at the α = .10 level) are beef import price, income, exchange rate, subsidy equivalent, and tariffs. Substitute prices, production costs, and exchange rate risk (M and S) are not significant. The Australian beef price displays a weak substitution relationship with U.S. fed beef. For pork imports, the significant variables are income, exchange rate, subsidy equivalent, and tariffs. Japanese trade restrictions on imports of U.S. red meats historically have been significant (Capps et al.). However, the 1994 GATT Uruguay Round reduced agricultural import barriers via declining tariff schedules (Brester and Wohlgenant). Consequently, prolonged trade restrictions may account for the insignificant own-price effect for pork import demand. Insignificant effects of exchange rate risk on both import demands may be attributed to Japanese importers hedging currency fluctuations (yen to dollar) (Raj and Mbodja; Ziemba).

In both equations, the signs of the parameter estimates for the statistically significant variables are theoretically consistent. Specifically, these include the negative effect of beef import price on beef import demand, the pos-

[2] The contemporaneous correlation of equation residuals (ρ = 0.383) is not particularly large. However, as an alternative, the equations were estimated by seemingly unrelated regression (SUR). Results indicated some gains in efficiency (standard errors of equation and t-values) in the pork equation with little gain in the beef equation. However, because of potential specification errors and a small sample, the SUR estimates revealed some parameter sensitivity in both equations. The SUR results are available upon request from the authors.

Table 1. Definitions of Model Variables for Japanese Import Demand of U.S. Beef and Pork

Variable Name	Variable Definition
Q^*_b	Japanese imports of U.S. beef (tons)
Q^*_p	Japanese imports of U.S. pork (tons)
$Y_{(t)}$	Japanese real GDP (yen)
$UC_{im(t)}$	Japanese unit production costs of beef and pork (ratio of Japanese wholesale beef [pork] price to U.S. wholesale beef [pork] price)
$P_{im(t)}$	Import price of beef or pork (yen/kg)
$PD_{beef(t)}$	Wholesale Japanese price for beef (yen/kg)
$PD_{pork(t)}$	Wholesale Japanese price for pork (yen/kg)
$PD_{poultry(t)}$	Wholesale Japanese price for poultry (yen/kg)
$PA_{beef(t)}$	Wholesale price of Australian beef (yen/kg)
$R_{(t)}$	Real exchange rate (yen per dollar)
$M_{(t)}$	Expected real exchange rate, four-quarter moving-average of percentage changes in R
$S_{(t)}$	Exchange rate risk, absolute quarterly percentage changes in real exchange rate
PSE_t	Producer subsidy equivalent (billions of yen)
Tarrif_t	Tariff rate on Japanese imports of beef and pork
$D2$, $D3$, and $D4$	Quarterly dummies for seasonal effects, representing second, third and fourth quarters, respectively (quarter 1 omitted)

itive effects of income on beef and pork import demands, negative effects of both subsidy equivalents and tariffs on import demands, and negative impacts of the level of exchange rates. The income coefficients for both commodities are inelastic, although Japan's income effect on pork imports (0.83) is considerably larger than its income effect on beef (0.25). The difference may reflect pork's relatively larger budget share of Japanese red meat and poultry consumption (excluding fish), i.e., 44% for pork and 32% for beef (Capps et al.). The tariff coefficient for beef and the tariff, PSE, and exchange rate coefficients for pork are relatively large. For example, a 1% increase in tariff rates for beef and pork reduces import demands by 0.95 and 2.06%, respectively. The fact that import tariffs were continually binding over the sample period may account for the elastic effects. Currency valuation affects the cost of red meat imports. Results indicate the effects are quite important, i.e., a 1% increase in the exchange rate (yen depreciation relative to the dollar) reduces Japanese beef and pork import demand by 0.91 and 2.22%, respectively. In light of Japan's recent economic recession, these statistical impacts imply nontrivial effects for U.S. beef and pork producers (USDA/AMS). Overall, the significant effects of PSE, tariff, and exchange rates indicate, e.g., that increasing protectionist policies and currency depreciation adversely affect Japanese demand for U.S. beef and pork products.

Effects of Japanese Import Demand on U.S. Cattle and Hog Prices

U.S. beef and pork producers have a vested economic interest in factors that affect Japanese import demand. Equation (15) provides the general framework to link shocks in foreign income, exchange rates, and protectionist policies to U.S. farm prices. Estimated elasticities give the percent changes in farm (slaughter) prices due to 1% changes in the foreign variables. These elasticicities are applied to nominal mean prices of slaughter cattle and hogs to give dollar per cwt effects (see Table 3). For example, the effect of a 1% increase in the exchange rate (or yen depreciation against the dollar) on U.S. cattle price is given by

$$(16)\quad \frac{\partial \ln P_\tau}{\partial \ln R_\tau}\bar{P} = \left[(E_{JR})\left(\frac{Q_{EX}}{Q_T}\right)\frac{\partial \ln P_\tau}{\partial \ln Q_\tau}\right]\bar{P},$$

Table 2. Regression Results of Japanese Import Demand for U.S. Beef and Pork, Double Logs

Variables/Statistics	Beef Imports (Q^*_b)		Pork Imports (Q^*_p)	
Constant	14.10	(3.11)	11.70	(1.59)
$Y_{(t-1)}$	0.25	(1.75)	0.83	(1.87)
$UC_{im(t)}$	0.02	(0.65)	0.04	(0.01)
$P_{im(t-1)}$	−0.25	(−1.75)	1.37	(1.23)
$PD_{beef(t-1)}$			0.88	(0.69)
$PD_{pork(t-1)}$	0.14	(0.90)		
$PD_{poultry(t-1)}$	0.05	(0.31)	−0.68	(−0.62)
$PA_{beef(t-1)}$	0.14	(1.29)		
$R_{(t-1)}$	−0.91	(−1.81)	−2.22	(−1.83)
$M_{(t-1)}$	−0.20	(−0.44)	−0.16	(−0.48)
$S_{(t-1)}$	−0.39	(−0.55)	−0.45	(−0.27)
PSE_t	−0.59	(−1.74)	−1.96	(−1.84)
Tar_t	−0.95	(−2.98)	−2.06	(−2.30)
$D2$	0.60	(3.01)	0.18	(0.81)
$D3$	0.31	(2.11)	−0.01	(−0.03)
$D4$	0.10	(1.75)	0.48	
R^2	0.88		0.72	
Adj R^2	0.82		0.57	
Standard error	0.155		0.326	
Durbin-Watson	1.92		1.95	

Note: Numbers in parentheses are the t-values. Critical t-values at the $\alpha = 0.10$ and $\alpha = 0.05$ levels are 1.717 and 2.074, respectively (22 degrees of freedom). R^2 is the unadjusted R-squared, Adj R^2 is the adjusted R-squared, and Standard error is the standard error of the equation.

where $(\partial \ln P_T/\partial \ln \partial R_T)\bar{P}$ represents the change in U.S. slaughter cattle price (dollars per cwt) due to a 1% increase in the exchange rate. The log (ln) term, $\partial \ln P_T/\partial \ln \partial R_T$, is a percentage or elasticity corresponding to the bracketed calculation on the right side of the equation. Equation (16) is decomposed as follows: (1) E_{fR} is the exchange rate elasticity of beef imports, or −0.91 in Table 2; (2) Q_{EX}/Q_T is quantity of U.S. beef exports to Japan (Q_{EX}) divided by U.S. beef supplies (Q_T), or the meat import share [sample (1989–1997) average of 3.0%]; (3) $\partial \ln P_T/\partial \ln \partial Q_T$ is the estimated U.S. beef price flexibility coefficient,[3] or −1.699 (the percentage change in slaughter cattle price, P_t, due to a 1% change in beef supplies, Q_T); and (4) $\bar{P}$ is the sample mean of nominal U.S. slaughter steer price, or \$71.66 per cwt. Substituting these numbers into equation (16) results in the beef price decreasing by 0.046%, or by about 3.3 cents per cwt (−\$0.033 per cwt), for a 1% increase in exchange rate (Table 3).

For pork, Q_{EX}/Q_T is 1.5%, the estimated pork price flexibility coefficient is −1.610, and the sample mean of nominal U.S. slaughter hog price is \$47.33 per cwt. Applied to

[3] The U.S. beef and pork price flexibility coefficients are econometrically estimated based on the inverse demand function of equation (14). The results are given in the Appendix. The slaughter price equations use the same sample period (1989:1–1997:4) as that of the import demand functions.

Table 3. Effects of 1% Changes in Japanese Import Demand Variables on U.S. Beef and Pork Exports and U.S. Slaughter Cattle and Hog Prices

Export, Prices	Demand Factors: Japanese Income	Tariff	Exchange Rate	Subsidy
Beef exports	0.250	−0.950	−0.910	−0.590
Beef price	0.013	−0.049	−0.046	−0.031
	(\$0.010 per cwt)	(\$−0.035 per cwt)	(\$−0.033 per cwt)	(\$−0.022 per cwt)
Pork exports	0.830	−2.060	−2.220	−1.960
Pork price	0.019	−0.050	−0.054	−0.048
	(\$0.010 per cwt)	(\$−0.024 per cwt)	(\$−0.026 per cwt)	(\$−0.023 per cwt)

Notes: Top rows for Beef Exports and Pork Exports are the regression coefficients of income, tariffs, exchange rate, and subsidy from the empirical model of Table 2. Top rows of Beef Price and Pork Price are the elasticities for 1% changes in income, tariff, exchange rate, and subsidy. The numbers in parentheses are in dollars per cwt and are obtained by multiplying the elasticities (÷ 100.0) by mean slaughter steer price (\$71.66 per cwt) and mean slaughter hog price (\$47.33 per cwt).

equation (16), results indicate pork price declines by 0.054%, or about 2.6 cents per cwt (−$0.026), from the 1% increase in exchange rate.

Table 3 gives the changes in U.S. beef and pork exports and impacts on beef and pork slaughter prices given 1% shocks in Japanese income, tariffs, exchange rates, and producer subsidy equivalents. Export responses are in percentage terms, while price responses are in percentage and dollar per cwt terms. For example, a 1% increase in the Japanese PSE would decrease import demand for U.S. beef and pork by 0.59% and 1.96%, respectively. Corresponding reductions in cattle and hog prices would be 0.031% ($0.022 per cwt) and 0.048% ($0.023 per cwt), respectively.

Overall, Table 3 shows that shifts in Japanese import demands yield varying impacts on U.S. beef and pork exports and livestock prices. For example, tariffs and exchange rates dominate the effects on beef and pork exports. The elasticities also show that the Japanese exchange rate effect on beef price (0.046%) is about 3.5 times its income effect (0.013%). The Japanese exchange rate effect on pork price (0.054%) is about 2.8 times its income effect (0.019%). U.S. beef and pork exports to Japan constitute a relatively small proportion of domestic beef and pork supplies. Thus, the farm price elasticities with respect to Japanese income, exchange rate, and protectionist policies are relatively small.

The recent economic volatility in the Asian economies indicates that the export quantity and price effects are important (Table 4). Specifically, from 1995 to 1998, the Japanese yen depreciated (relative to the dollar) by 39%. This implied about a 35% reduction in U.S. beef exports, or about a $1.29 per cwt reduction in slaughter steer price. Or consider the GATT-generated reductions in Japanese tariff rates, which declined by 14% between 1994 and 1998. The effect was to increase U.S. beef exports to Japan by about 13%, or increase slaughter steer price by about $0.49 per cwt. For the 1988–1998 period, Japanese income (GDP) growth was about 36%, which translates into a 9% increase in beef exports, or about a $0.32 per cwt increase in slaughter steer price.

The recent Japanese market fluctuations also affected the U.S. pork sector. Briefly, results reveal (1) exchange rate depreciation between 1995 and 1998 reduced slaughter hog price by $0.99 per cwt, (2) tariff rate reductions between 1994 and 1998 increased slaughter hog price by $0.33 per cwt, and (3) income growth between 1988 and 1998 increased slaughter hog price by $0.35 per cwt.

Conclusions and Implications

Japan is an important export market for U.S. beef and pork products. Regression results of meat import demands indicate that Japanese trade restrictions, currency fluctuations, and income growth significantly affect U.S. beef and pork exports. Although the marginal impacts of U.S. livestock prices with respect to

Table 4. Effects of Economic Changes in the Japanese Market on U.S. Beef and Pork Exports and Prices

	Changes in Demand Factors		
Export, Prices	Exchange Rate (39% ↓, 1995–1998)	Tariff Rate (14% ↓, 1994-1998)	Japanese Income (36% ↑, 1988–1998)
Beef exports	35% ↓	13% ↑	9% ↑
Beef prices	1.81% ↓	0.69% ↑	0.45% ↑
	($1.29/cwt) ↓	($0.49/cwt) ↑	($0.32/cwt) ↑
Pork exports	87% ↓	29% ↑	30% ↑
Pork prices	2.09% ↓	0.69% ↑	0.69% ↑
	($0.99/cwt) ↓	($0.33/cwt) ↑	($0.35/cwt) ↑

Notes: Responses of exports and prices are based on the percentage changes of exchange rate, tariff rate, and income for the years designated under Changes in Demand Factors. Direction of changes are given by arrows (↑ or ↓).

changes in Japanese import demand factors are relatively inelastic, recent Asian economic problems were not inconsequential to the livestock industry. For example, the sharp depreciation of the Japanese yen alone reduced U.S. slaughter steer and hog prices by $1.29 per cwt and $0.99 per cwt in the 1995–1998 period. Based on U.S. average cattle and hog slaughter production (liveweight) for this period, beef industry revenue was reduced by $550.2 million, or about $15.30 (2.0%) per head. Hog industry revenue was reduced by $243.8 million, or about $2.50 (2.1%) per head.

Our results indicate that economic volatility in the Japanese market increases price and revenue risk to U.S. livestock producers even though U.S. beef and pork exports to Japan constitute relatively small percentages of domestic supplies. Thus, U.S. producers have a vested interest in trade liberalization policies that impact market access, import costs, and volume of red meat exports. For example, Japanese trade liberalization is expected to stimulate import demand for U.S. red meats. U.S. beef producers, therefore, should opt for continuing provisions of the 1994 GATT agreement whereby Japan's tariff rate quota is reduced in conjunction with less restrictive safeguard provisions. The expected benefits, e.g., can be demonstrated by the GATT-mandated drop in the Japanese tariff rate quota for beef from 50.0% in 1993 to 38.5% in 2001, or 21.9%. Using the model coefficients and year 2000 data, we estimate this tariff-rate quota reduction would add $1.03 per cwt to slaughter steer price (nominal) and about $457.0 million (nominal) to U.S. producers of slaughter cattle. Producers also have a stake in Japanese macro policies that affect national income and exchange rates, as these factors have an important effect on meat import demands.

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References

Adelman, I. "Financial Crisis: Causes, Consequences, and Remedies." *Choices* (Second Quarter, 1999):1.

Agriculture and Livestock Industries Corporation (ALIC). *ALIC Monthly Statistics*. Denver, CO, monthly issues 1992–1999.

Akhtar, M.A., and R.S. Hilton. "Effects of Exchange Rate Uncertainty on German and U.S. Trade." *Federal Reserve Bank of New York Quarterly Review* 9(September 1984):7–16.

Bahmani-Oskooee, M., and N. Ltaifa. "Effects of Exchange Rate Risk on Exports: Crosscountry Analysis." *World Development* 20(August 1992):1173–81.

Brester, G.W., and M.K. Wohlgenant. "Impacts of the GATT/Uruguay Round Trade Negotiations on U.S. Beef and Cattle Prices." *Journal of Agricultural and Resource Economics* 22(July 1997):145–56.

Capps, O., Jr., R. Tsai, R. Kirby, and G.W. Williams. "A Comparison of Demands for Meat Products in the Pacific Rim Region." *Journal of Agricultural and Resource Economics* 19(July 1994):210–24.

Clark, P.B. "Uncertainty, Exchange Risk, and the Level of International Trade." *Western Economic Journal* 11(September 1973):302–13.

Cushman, D.O. "The Effects of Real Exchange Rate Risk on International Trade." *Journal of International Economics* 15(August 1983):45–63.

———. "U.S. Bilateral Trade Flows and Exchange Risk During the Floating Period." *Journal of International Economics* 24(May 1988):317–30.

Doyle, S., A. Bui-Lan, A. Rodriguez, A. Benard, and P. Whish-Wilson. "Pacific Basin Beef Trade: The Influence of South Korea." *Australian Commodities* 2(September 1995):326–39.

Gajewski, G., and S. Langley. "Events in Asia Lower Prospects for U.S. Farm and Rural Economy." *Agricultural Outlook*. Washington, DC: U.S. Department of Agriculture/Economic Research Service, February 1998.

Gorman, W.D., H. Mori, and B.H. Lin. "Beef in Japan: The Challenge for U.S. Exports." *Journal of Food Distribution Resources* 21(February 1990):17–29.

Hayes, D.J., T.I. Wahl, and G.W. Williams. "Testing Restrictions on a Model of Japanese Meat Demand." *American Journal of Agricultural Economics* 27(August 1990):556–66.

Hooper, P., and S.W. Kohlhagen. "The Effects of Exchange Rate Risk and Uncertainty on the Prices and Volume of International Trade." *Journal of International Economics* 8(November 1978):483–511.

Ianchovichina, E., T. Hertel, and R. McDougall. "The East Asian Economic Crisis: It's Not All Bad News." *Choices* (Second Quarter 1999): 20–25.

International Monetary Fund. *International Financial Statistics.* Washington, DC, September 1998.

Jeong, K.S. "The Welfare Economics and the Political Economy of Japanese Beef Trade Liberalization: An Empirical Application of New Political Economy Theory." Ph.D. dissertation. University of Illinois at Urbana–Champaign. 1995.

Johnston, J., and J. DiNardo. *Econometric Methods,* 4th ed. New York: McGraw-Hill, Inc., 1997.

Kenen, P., and D. Rodrik. "Measuring and Analyzing the Effects of Short-Term Volatility in Real Exchange Rates." *Review of Economics and Statistics* 68(May 1986):311–15.

Organization for Economic Cooperation and Development (OECD). *Agricultural Databases* (on CD, 2001 ed.). Paris, October 2001.

Pick, D. "Exchange Rate Risk and U.S. Agricultural Trade Flows." *American Journal of Agricultural Economics* 72(August 1990):694–700.

Pindyck, R.S., and D.L. Rubinfeld. *Econometric Models and Economic Forecasts,* 4th ed. Boston: Irwin/McGraw-Hill, 1998.

Raj, A., and M. Mbodja. "Common Stochastic Trends Among Asian Currencies: Evidence for Japan, ASEANs, and the Asian Tigers." *Review of Quantitative Finance and Accounting* 10(March 1998):193–206.

Thursby, J., and M. Thursby. "Bilateral Trade Flows, the Linder Hypothesis, and Exchange Risk." *Review of Economics and Statistics* 69(August 1987):448–95.

Tomek, W.G., and K.L. Robinson. *Agricultural Product Prices,* 3rd ed. Ithaca and London: Cornell University Press, 1990.

U.S. Department of Agriculture, Economic Research Service (USDA/ERS). *Foreign Agricultural Trade of the United States (FATUS).* Washington, DC, various issues.

———. *Red Meats Yearbook Statistical Series, 1970–1998.* ERS Statistical Bulletin No. 921. Washington, DC. Internet site: http://usda.mannlib.cornell.edu/data-sets/livestock/94006/ (Accessed August 2000).

U.S. Department of Agriculture, Agricultural Marketing Service (USDA/AMS). *International Meat Review (IMR), Livestock and Grain Market News Service.* Washington, DC, September 1998.

Wahl, T.I., D.J. Hayes, and S.R. Johnson. "Impacts of Liberalizing the Japanese Pork Market." *Journal of Agricultural and Resource Economics* 17(July 1992):121–37.

Ziemba, W.T. "Currency Hedging Strategies for U.S. Investment in Japan and Japanese Investment in the U.S." *Financial Optimization.* Stavros A. Zenios, ed., pp. 210–35. Cambridge: Cambridge University Press, 1993.

Appendix: Estimated Beef and Pork Price Flexibilities

The beef and pork slaughter price flexibilities used in equation (16) are based on estimating the inverse slaughter demands of equation (14). The empirical specification is

$$\text{(A1)} \qquad P^j = f(Q^j, B^j, M, T, \bar{S}) + \mu, \qquad j = b, p,$$

where $j = b$ = beef and $j = p$ = pork. P^j is slaughter steer price (choice 2–4, 1,100–1,300 lbs., Nebraska direct) or slaughter barrow and gilt price (no. 1–3, 230–250 lbs., Iowa/S. Minnesota) in dollars per cwt; Q^j is commercial production of beef or commercial production of pork, carcass weight, in millions of lbs.; B^j is beef slaughter byproducts or pork slaughter byproducts (hide and offal) in cents per lb.; M is index of food marketing costs (1967 = 100); T is trend; and $\bar{S}$ represents seasonal dummy variables, S_2, S_3, and S_4 with quarter 1 (S_1) omitted. Slaughter prices, byproduct values, and marketing costs were deflated by the Consumer Price Index (CPI, 1982–1984 = 100). The error term, μ, is assumed to be white noise.

Due to biological lags, Q^j is assumed predetermined. The OLS estimates of the double log equations for cattle and hog prices, respectively, are

$$\text{(A2)} \quad \ln P^b_\tau = \underset{(0.591)}{3.283} - \underset{(-7.138)^*}{1.699} \ln Q^b_\tau + \underset{(2.569)^*}{0.182} \ln B^b + \underset{(0.540)}{0.563} \ln M - \underset{(-1.430)}{0.004}T + \underset{(3.949)^*}{0.065}S_2 + \underset{(3.786)^*}{0.088}S_3 + \underset{(1.987)}{0.026}S_4$$

$$\bar{R}^2 = 0.974 \quad SE = 0.024 \quad DW = 1.957$$

$$\text{(A3)} \quad \ln P^p_\tau = \underset{(5.214)^*}{30.549} - \underset{(-4.109)^*}{1.610} \ln Q^p_\tau + \underset{(4.935)}{0.567} \ln B^p_\tau - \underset{(-4.124)^*}{4.442} \ln M - \underset{(-3.201)^*}{0.011}T - \underset{(-0.921)}{0.018}S_2 - \underset{(-1.493)}{0.028}S_3 + \underset{(2.765)^*}{0.086}S_4$$

$$\bar{R}^2 = 0.949 \quad SE = 0.037 \quad DW = 1.500$$

$\bar{R}^2$ is the adjusted R-squared, SE is the standard error of the equation, and DW is the Durbin-Watson statistic. The τ ratios are given in parentheses, with the asterisk (*) indicating significance at the α = .05 level (28 degrees of freedom). A first-order lag on each dependent variable was initially specified, but neither was statistically significant.