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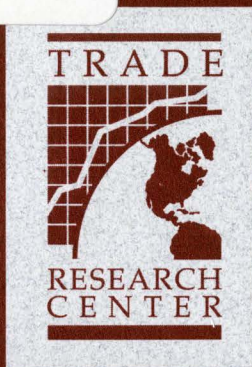
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Japanese Import Demand for U.S. Beef and Pork: Effects on U.S. Red Meat Exports and Livestock Prices

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Objective Analysis
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**Japanese Import Demand for
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U.S. Red Meat Exports
and Livestock Prices**

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

Abstract: Econometric estimation is used to analyze the effects of Japanese meat import demand on U.S. beef and pork exports and livestock prices. Japan is the most important export market for U.S. beef and pork products. Results indicate statistical significance of income growth, exchange rates, and protectionist measures (tariffs and Producer Subsidy Equivalents) on import demand. Their transformation effects on U.S. livestock prices are relatively small. Nevertheless, recent economic volatility and policy measures in Asia demonstrates their importance. For example, the 1995–1998 depreciation in Japanese yen (39 percent) reduced U.S. slaughter steer and hog prices by \$0.75/cwt and \$0.52/cwt, respectively; the 1994–1998 reduction in tariffs (14 percent) increased slaughter and hog prices by \$0.69/cwt and \$0.17/cwt, respectively.

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

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

Introduction

Foreign demand for U.S. red meat products (beef and pork) has become an important determinant of U.S. livestock prices (Capps et al.; Brester and Wohlgenant). As domestic demand for beef and pork has declined (Purcell), foreign demand for U.S. beef and pork has increased.¹ Foreign demand has increased because of increasing per capita incomes, evolving dietary preferences for animal-source proteins, and reductions in trade restrictions (Capps et al.; Brester and Marsh). From 1987 to 1998, U.S. beef exports increased from 0.61 billion pounds to 2.17 billion pounds, or from 2.3 percent of total beef supplies (production, imports, and beginning stocks) to 7.5 percent. During this period, U.S. pork exports increased from 0.11 billion pounds to 1.23 billion pounds, or from about 0.50 percent of total pork supplies to 6.1 percent. The largest growth markets have been the Asia-Pacific region, Mexico, and Canada.

As U.S. livestock producers depend more upon red meat exports, export markets will likely become a source of price variability. For example, adverse shifts in foreign exchange rates, economic growth, or trade policies can negatively impact both foreign purchases of red meats and domestic producer prices and incomes. Therefore, the objectives of this paper are twofold: (1) to quantify changes in foreign market factors on import demand for U.S. beef and pork products, and (2) to relate changes in foreign import demand to domestic livestock prices. Specifically, we focus on Japan as it is the largest export customer for U.S. beef and pork,

¹ Retail demand declines (inward shifts) are evidenced by decreasing per capita consumption and decreasing real retail prices. From 1980 to 1998, per capita beef consumption and real retail beef price declined by 11.1 percent and 40.0 percent, respectively. Over the same period, per capita pork consumption and real retail pork price declined by 9.5 percent and 11.9 percent, respectively.

averaging 51 percent of U.S. beef exports and 43 percent of U.S. pork exports in 1997 and 1998 (excluding by products).

Previous research on foreign market effects on the U.S. beef and pork sectors has focused on foreign demand preferences, trade liberalization, and institutional constraints (Capps et al; Gorman, Mori, and Lin; Hayes, Wahl, and Williams; Lambert; Wahl, Hayes, and Johnson). However, their economic implications for U.S. exports and effects on U.S. beef and pork producers have not been quantitatively addressed. We econometrically estimate Japanese import demands for U.S. wholesale beef and pork and measure the impacts of exogenous shocks in the Japanese market on U.S. export quantities and derived slaughter prices. The economic volatility recently experienced in the Asia-Pacific region suggests this information is critical to understanding Japan's impact as a major customer on the U.S. livestock industry.

Exchange Rate Risk

Economic volatility in the Asia-Pacific regions often result in changes in demand for U.S. agricultural products. Through exchange rate variability and changing incomes, a few empirical studies have suggested that increases in exchange rate risk reduce trade (Clark; Hooper and Kohlhagen; Cushman 1983, 1988; Akhtar and Hilton; 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 the risk problem as severe currency depreciation commensurate with declining Asian stock markets and incomes increased the cost of purchasing U.S. beef and pork.

Several factors contributed to the Asian crisis (Gajewski and Langley; Lanchovichina, 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 which exacerbated economic problems (Adelman).

Beef and Pork Market Background

The United States is one of world's largest producers and exporters of beef. For example, in 1996 U.S. beef exports account for approximately 17 percent of world beef exports. Major U.S. customers for beef have been Japan, Mexico, Canada, and South Korea while major U.S. customers for pork have been Japan, Mexico, Hong Kong, Canada, and more recently, the Former Soviet Union (USDA *IMR*). 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 percent 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 *FATUS*). 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 percent *ad valorem* tariff which was subsequently reduced to 60

percent in 1992 and 50 percent in 1993 (Doyle et al.). Under the 1994 GATT/Uruguay Round agreement, the tariff-rate quota will be gradually reduced to 38.5 percent by 2001. However, Japan retains 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 percent of import levels for the corresponding period in the previous year. The safeguards have been frequently employed in the past few years.

World pork production is larger than for any other species. World pork exports, however, are less than 50 percent of world beef and poultry exports. The United States is the third largest pork exporter with a 20 percent 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 *FATUS*). 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 demand for beef and pork imports is a derived demand (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:

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

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:

$$(2) \quad \underset{Q}{\text{Max}} EU(\Pi)$$

where EU represents expected utility, and Π is profits.

Assuming a constant input-output ratio, derived demand (q) can be presented as:

$$(3) \quad q = \gamma Q,$$

where γ is a fixed input-output coefficient. An importer's profits are represented by:

$$(4) \quad \Pi = P(Q)Q - UC Q - HP^* q,$$

where UC is the unit cost of production, H is the foreign exchange variable, and P^* is import price denominated in foreign currency. Substituting (3) into (4) yields:

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

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 which are hedged—versus those which remain unhedged—in the forward exchange market. The foreign exchange cost variables can be presented as:

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

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 since R_1 is unknown in the first period.

Exchange rate risk (R_1) introduces profitability risk which is represented by:

$$(7) \quad V(\Pi) = [P^* \gamma Q \beta (1 - \mu)]^2 \sigma_{R_1}^2,$$

where $V(\Pi)$ is the variance of profits, and $\sigma_{R_1}^2$ is the variance of R_1 .

An exporter's behavior can be modeled in a similar fashion:

$$(8) \quad \underset{Q}{\text{Max}} EU^*(\Pi^*)$$

where the asterisk denotes exporter's variables (counterparts to the importer's variables).

Exporter's profits can be represented as

$$(9) \quad \Pi^* = q^* P^* H^* - q^* UC^*.$$

Following Cushman (1988, pp. 322), Kenen and Rodrik (pp. 313), and Pick (pp. 695) a reduced form model of import demand (for the firm) can be developed by defining the above profits in real terms. Hooper and Kohlhagen (pp. 490–493) derive reduced form import demands and their economic arguments first by mathematical substitutions involving equations (1), (5), (6), (7), and (9) above and then using first-order derivatives. The following reduced form equation is obtained by following their procedures:

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

Applying equation (10) to beef and pork import demand, 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 percentage changes in R (used as a proxy of expected real exchange rates), and S is a risk measure represented by absolute quarterly percentage changes in real exchange rates. Extending firm-level demand to the market level gives:

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

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

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

Market-level import demand (Q^d) of equation (11) is augmented to include 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. For any quarter, import supply (or U.S. export supply) to Japan is assumed to be completely elastic (equation (12)), i.e., Japan is a price taker in purchases of U.S. beef and pork. This short-run assumption appears reasonable given that the U.S. supplies Japan's import demands for beef and pork (under tariffication) in competition with other export suppliers (Canada, Australia, and New Zealand for beef; Canada, South Korea, Denmark, and Mexico for pork). Equation (13) indicates that import quantities demanded and supplied clear the market at Q^* .

The expected effects of competitive prices (PD) are positive since higher domestic prices of substitutes would encourage additional beef imports. 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 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 since 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. For a given U.S. supply of beef, a subsequent increase in U.S. beef exports reduces wholesale supplies available for domestic consumption.² 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. 117–119). We use U.S. import/export market shares and livestock price flexibilities to link shifts in foreign demand for U.S. beef and pork exports to marginal changes in U.S. cattle and hog prices. The goal is to quantify changes in Japanese exchange rates, tariffs, and income growth on U.S. livestock prices.

Beef and pork imports and exports are important components of U.S. red meat supplies and disposition (USDA *LDP*). Expressing these components as percentages of total U.S. supplies

² The balance equation for red meats is total supplies = total disposition. Total supplies consist of production + imports + beginning stocks, while total disposition consists of consumption + exports + ending stocks. Subtracting exports from both sides gives: total 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.

supplies allows for the quantification of shocks in foreign demand to 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 total 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 theoretical (marginal) effect on U.S. slaughter price would be:

$$(15) \quad \partial P_t / \partial R_t = (\partial Q_t^* / \partial R_t) (\partial Q_t / \partial Q_t^*) (\partial P_t / \partial Q_t).$$

Equation (15) indicates the impact of an exchange rate shock on U.S. slaughter price ($\partial P_t / \partial R_t$) is the product of its direct effect on import demand for U.S. beef exports ($\partial Q_t^* / \partial R_t$) of equation (11), the change in U.S. beef supplies available for domestic consumption as a result of the export shift ($\partial Q_t / \partial Q_t^*$), and the change in U.S. slaughter price due to the subsequent change in beef supplies available for consumption ($\partial P_t / \partial Q_t$).

Data and Tests

Quarterly data from 1989:1 thru 1997:4 were used to estimate separate Japanese import demands for beef and pork (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 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. U.S. wholesale prices were obtained from

the Livestock Marketing Information Center. The Producer Subsidy Equivalents (*PSE*) and 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).

Initial OLS regression results were subjected to a variety of specification tests. These include contemporaneous correlation of residuals, autocorrelation (Durbin-Watson test), heteroskedasticity (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 did not indicate the presence of either autocorrelation or heteroskedasticity in the residuals. Furthermore, a diagonal covariance matrix of errors resulted as cross-equation correlations of the estimated errors were insignificant. Based on the ADF test, model variables were determined 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 $\alpha = 0.05$ level. Thus, the equations were cointegrated and estimated in data level form. Import prices of beef and pork (P_{IM}) were tested for endogeneity in the demand relations. Hausman specification tests could not to reject the null hypothesis of no simultaneous equations bias at the $\alpha = 0.05$ level.

Based upon the above statistical tests, the beef and pork import demand equations were estimated by Ordinary Least Squares using double log transformations. Because of short-run (quarterly) observations, it was hypothesized that import demand response to changes in exchange rates, import prices, and other variables could be dynamic, i.e., finite lag adjustments 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 being t-1 based upon 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 used in the empirical model based on equation (11) and Table 2 gives the regression results.³ The statistical results between the beef and pork import demands differ, with an adjusted R-squared (\bar{R}^2) and standard error of equation (SE) of 0.81 and 0.16, respectively, for beef, and an \bar{R}^2 and SE of 0.57 and 0.33, respectively, for pork. The lower regression fit for pork, in part, reflects the small sample variance of U.S. pork exports to Japan (compared to U.S. beef exports). In both equations the effects of direct and substitute prices, production costs, and exchange rate risk (M and S) are not significantly different from zero. The dominant (significant) variables are those representing income growth (GDP), protectionist measures (Producer Subsidy Equivalents and tariffs) and currency values (exchange rates). Japanese trade restrictions on imports of U.S. red meats historically have been significant (Capps et al.); however, as a result of the 1994 Uruguay Round (GATT), agricultural import barriers have been reduced via declining tariff schedules (Brester and Wohlgenant). Consequently, within the sample, prolonged trade restrictions may account for insignificant market price effects (direct and competitive) on import demands. Insignificant effects of exchange rate risk on red meat

³ Full results not reported in Table 3 are available from the authors upon request.

import demand may be attributed to Japanese importers hedging currency fluctuations (yen to dollar) (Raj and Mbodha; Ziemba).

In both equations, coefficient signs of the statistically significant variables are theoretically consistent. Specifically, note the positive effects of income on beef and pork import demand, negative effects of both subsidy equivalents and tariffs on import demand, 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 (0.28). The difference may reflect pork's relatively larger budget share of Japanese red meat and poultry consumption (excluding fish), i.e., 44 percent for pork and 32 percent for beef (Capps et al.). The tariff coefficient for beef and the coefficients of tariffs, subsidy equivalents, and exchange rates for pork all exceed unity. For example, a one percent increase in tariff rates for beef and pork reduces import demands by 1.9 and 2.1 percent, 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 one percent increase in the exchange rate (yen depreciation relative to the dollar) reduces Japanese beef and pork import demand by 0.74 and 2.22 percent, respectively. In light of Japan's recent economic recession, these statistical impacts may imply non-trivial effects for U.S. beef and pork producers (USDA *IMR*). The effect of Japan's Producer Subsidy Equivalent on beef imports is statistically weak ($\alpha = 0.15$). However, its effect on pork is relatively stronger ($\alpha = 0.10$) with an elastic coefficient of -1.96. In essence, these results show that increasing protectionist policies and currency depreciation reduce the demand for U.S. beef and pork products due to increasing costs of trade.

Changes in 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 the effects of Japanese growth, exchange rates, and protectionist policies (or foreign shocks) to U.S. farm prices. However, each partial derivative of the equation is in percentage terms to accommodate parameter estimates from the double log specifications. Our procedure in equation (15) is to measure foreign shocks as standard deviations of the variables divided by their sample means (S_x/\bar{x}), and apply these percentages to 1989–1997 nominal mean prices for slaughter cattle and hogs. For example, the following equation calculates the effect of an increase in the exchange rate (or yen depreciation against the dollar) on U.S. cattle price:

$$(16) \quad \partial P_t / \partial R_t \cdot \bar{P} = [(S_R / \bar{R}) (E_{JR}) (Q_{EX} / Q_T) (-1.213)] \cdot \bar{P}$$

where $\partial P_t / \partial R_t \cdot \bar{P}$ represents the change in U.S. slaughter cattle price (dollars/cwt) due to a certain percentage increase in the exchange rate. Equation (16) is decomposed for beef as follows: (1) S_R / \bar{R} is the standard deviation of the exchange rate divided by its sample mean (0.120 or 12.0 percent); (2) E_{JR} is the exchange rate elasticity of beef imports (-0.74 in Table 2); (3) Q_{EX} / Q_T is quantity of U.S. beef exports to Japan (Q_{EX}) divided by total U.S. beef supplies (Q_T) (an average of 3.0 percent for 1989–1997); (4) -1.213 is the U.S. beef price flexibility coefficient as estimated by Marsh (i.e., the percentage change in slaughter cattle price, P_t , due to a one percent change in total beef supplies, Q_t); and (5) \bar{P} is the sample mean of nominal U.S. slaughter steer price, or \$71.66/cwt. For pork, Q_{EX} / Q_T is 1.5 percent, the pork price flexibility coefficient is -0.838, and the sample mean of nominal U.S. slaughter hog price is \$47.33/cwt.

Table 3 gives the dollar/cwt impacts on U.S. beef and pork slaughter prices given the defined (S_x/\bar{x}) percentage shocks in Japanese income, tariffs, exchange rates, and Producer Subsidy Equivalents. (The numbers in parentheses represent one percent changes in the four variables.) Changes in import demand quantities from the market shocks are also given. For example, consider the 11.7 percent shock in Japanese Producer Subsidy Equivalent. If the PSE increased, import demand for U.S. beef and pork would decline by 5.1 percent and 22.5 percent, respectively, with corresponding reductions in cattle and hog prices of \$0.13/cwt and \$0.14/cwt.

Overall, the estimates in Table 3 suggest that exogenous shifts in Japanese import variables yield relatively small impacts on U.S. beef and pork exports and livestock prices. This is sensible in light of the fact that U.S. beef and pork exports constitute a small proportion of total U.S. beef and pork supplies (6–8 percent), with slightly over 40 percent of pork exports and 50 percent of beef exports destined for Japan. However, given the magnitude of deviations in Japanese income, Japan/U.S. exchange rates, and Japanese protectionist policies, the export quantity and price effects are not zero. For U.S. beef, the greatest impacts have resulted from changes in tariffs and exchange rates. Specifically, the 17.6 percent change in tariffs affected beef exports by 33.3 percent and slaughter price by \$0.87/cwt, while the 12.0 percent change in exchange rates affected beef exports by 8.9 percent and slaughter price by \$0.23/cwt. Japan's income deviation of 4.8 percent produced a small impact on beef exports of 1.4 percent and on cattle price of \$0.04/cwt. For pork, the tariff change affected pork exports by 36.3 percent and hog price by \$0.22/cwt, while the exchange rate affected pork exports by 26.7 percent and hog price by \$0.16/cwt. The 11.7 percent change in subsidy equivalent impacted pork exports by 22.9

percent and hog price by \$0.14/cwt, and the small Japanese income deviation meant a 4.0 percent change in pork exports and a small \$0.02/cwt impact on hog price.

Conclusions and Implications

Japan has become an important export market for U.S. beef and pork. Regression results indicate that Japanese trade restrictions, currency fluctuations, and income growth significantly affect U.S. beef and pork exports to Japan. However, the marginal impacts on domestic livestock prices are relatively small since U.S. beef and pork exports constitute a relatively small percentage of domestic red meat supplies. Japanese trade restrictions were binding over the sample period, which probably accounts for insignificant direct and competitive price effects on import demand for U.S. red meats.

Recent economic volatility of Asian markets has been of concern to U.S. livestock producers. The coefficients in Table 3 can be applied to these changes to evaluate impacts on U.S. prices. Specifically, from 1995 to 1998, the Japanese yen (relative to the dollar) depreciated by 39 percent. *Ceteris paribus*, this implied about a 29 percent reduction in U.S. beef exports, or about a \$0.75/cwt reduction in slaughter steer price. Or, consider the GATT-generated reductions in Japanese tariff rates which declined by 14 percent between 1994 and 1998. The effect was to increase U.S. beef exports to Japan by about 26 percent, or increase slaughter steer price by about \$0.69/cwt. For the 1988–1998 period, Japanese income (GDP) growth was about 36 percent, which translates into a 10 percent increase in beef exports or about a \$0.26/cwt increase in slaughter steer price.

Recent market fluctuations can also be applied to the U.S. pork sector. Briefly, results reveal: (1) exchange rate depreciation between 1995 and 1998 reduced slaughter hog price by

\$0.52/cwt; (2) tariff rate reductions between 1994 and 1998 increased slaughter hog price by \$0.17/cwt; and (3) income growth between 1988 and 1998 increased slaughter hog price by \$0.18/cwt. Producer Subsidy Equivalents were not important for beef, but were important for pork. From 1994 to 1997, the Japanese subsidy equivalent declined by almost 13 percent, indicating nearly a 25 percent increase in pork exports or a \$0.15/cwt increase in hog price.

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 cost 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).
$R_{(t)}$	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).
Tariff _t	Tariff rate on Japanese imports of beef and pork.
D2, D3 and D4	Quarterly dummies for seasonal effects, representing 2 nd , 3 rd , and 4 th quarters, respectively (quarter 1 omitted).

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

Variables/Statistics	Equations	
	Beef Imports (Q^*_b)	Pork Imports (Q^*_p)
Constant	15.13 (3.40)	11.70 (1.59)
$Y_{(t-1)}$	0.28 (1.73)	0.83 (1.87)
$UC_{im(t)}$	0.03 (0.73)	0.04 (0.01)
$P_{im(t-1)}$	-0.03 (-0.08)	1.37 (1.23)
$PD_{beef(t-1)}$		0.88 (0.69)
$PD_{pork(t-1)}$	-0.25 (-0.44)	
$PD_{poultry(t-1)}$	0.11 (0.22)	-0.68 (-0.62)
$R_{(t-1)}$	-0.74 (-1.68)	-2.22 (-1.83)
$M_{(t-1)}$	-0.17 (-0.31)	-0.16 (-0.48)
$S_{(t-1)}$	-0.50 (-0.59)	-0.45 (-0.27)
PSE_t	-0.43 (-1.46)	-1.96 (-1.84)
Tar_t	-1.89 (-4.24)	-2.06 (-2.30)
D2	0.43 (3.97)	0.18 (0.81)
D3	0.36 (2.77)	-0.01 (-0.03)

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

Variables/Statistics	Equations	
	Beef Imports (Q^*_b)	Pork Imports (Q^*_p)
D4	0.27 (2.51)	0.48
R ²	0.87	0.72
Adj R ²	0.81	0.57
Standard Error	0.161	0.326

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). R² is the unadjusted R-squared, Adj R² is the adjusted R-squared, and Standard Error is the standard error of the equation.

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

Variables Responding	Variables Changing			
	Japanese Income (4.8%)	Tariff (17.6%)	Exchange Rate (12.0%)	Subsidy (11.7%)
Beef Exports	1.36% (0.28%)	-33.25% (-1.89%)	-8.92% (-0.74%)	-5.09% (-0.44%)
Beef Price	\$0.04/cwt (\$0.01/cwt)	\$-0.87/cwt (\$-0.05/cwt)	\$-0.23/cwt (\$-0.02/cwt)	\$-0.13/cwt (\$-0.01/cwt)
Pork Exports	3.99% (0.83%)	-36.33% (-2.06%)	-26.69% (-2.22%)	-22.93% (-1.96%)
Pork Price	\$0.02/cwt (\$0.01/cwt)	\$-0.22/cwt (\$-0.01/cwt)	\$-0.16/cwt (\$-0.01/cwt)	\$-0.14/cwt (\$-0.11/cwt)

Notes: Beef and Pork Exports and Beef and Pork Prices (i.e., slaughter) under "Variables Responding" show their respective percentage and dollar/cwt responses under "Variables Changing." Percentage changes directly under the four variables in "Variables Changing" are given in parentheses and are calculated by dividing the standard deviation of each variable by its sample mean. In each row the top figures are a result of standard deviation ÷ mean changes, while the bottom figures (in parentheses) are a result of one percent changes.

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