Effects of Relative Prices and Exchange Rates on Domestic Market Share of U.S. Red-Meat Utilization

Keithly Jones

The author is an Agricultural Economist with the Animal Products Branch, Markets and Trade Economics Division, Economic Research Service, USDA. Contact authors at 1800 M Street NW, Washington DC. Phone 202-694-5172 and e-mail kjones@ers.usda.gov**.**

Contributed paper prepared for presentation at the International Association of Agricultural Economists Conference, Gold Coast, Australia,
August 12-18, 2006

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Abstract

The study examines the effects of relative meat price changes (domestic and imported), the exchange rates and their volatilities, and the effects of BSE on U.S. red-meat trade. The results show that the relative meat price and exchange rate indices as well as their volatilities significantly affect the domestic share of total U.S. meat utilization. The BSE dummy variable was statistically significant with an expected positive sign.

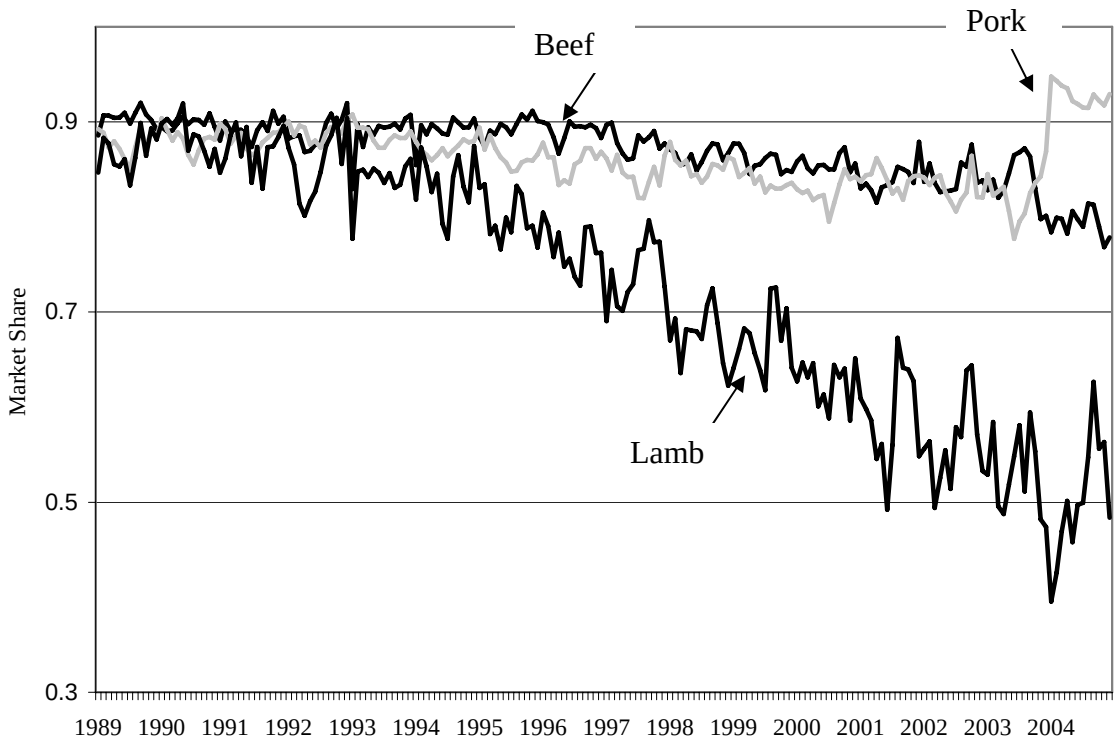
Keywords: red meats, market share, relative price index exchange rates, panel estimation

JEL Code: C23, F1, Q17

INTRODUCTION

The share of domestic red-meat (beef, pork, and lamb) production that is sold to domestic consumers in the United States has been decreasing steadily over the past two decades, from an average 88 percent in 1989 to less than 75 percent in 2004. The domestic market share of all three red-meats has declined, with lamb market share exhibiting the largest decline and pork holding almost constant for the duration of the review period (Figure 1).

Figure 1. Domestic Share of Total Beef, Pork, and Lamb Utilized in the United States



The domestic market share for each red-meat has been affected differently. The United States, while the largest producer of beef in the world, is a net beef importer. Most beef produced and exported from the United States is grain-finished, high-quality choice cuts. Most beef that the United States imports is grass-fed beef, destined for processing, primarily as ground beef to satisfy the hamburger market. As such, U.S. high quality beef exports have increased

while at the same time the lower quality beef imports have increased. U.S. beef exports have grown steadily since the early 1980s. These now represent about 9 percent of U.S. beef production.

The lamb industry dynamics are different. The U.S. lamb production contracted over the study period while per capita consumption remained fairly constant. As a result, lamb and mutton imports significantly increased to supplement domestic supply. Since the mid-1980's, sharp increases are seen in the per capita retail consumption of imported lamb. Unlike beef, lamb imports constitute high quality high-value cuts. Lamb imports, which currently account for nearly half of U.S. lamb and mutton consumption, are primarily from Australia and New Zealand, accounting for 99 percent of all U.S. imports.

The pork industry, too, has different dynamics from beef and lamb. Since the mid-1980s, the industry has gradually shifted to larger operations, with increased contracting and vertical coordination to optimize year-round slaughter capacity utilization. This restructured U.S. pork industry produces more pork. Productivity gains have allowed the industry to export a higher percentage of U.S. commercial pork production. Still, the United States is a major importer of specialized pork products, mainly from Canada and Denmark.

Although all three red-meats have different production dynamics that influence their market shares, trade factors play an important role in the U.S. market share. Australia and New Zealand have become export-oriented economies and have been highly competitive in the lamb and beef trade. Other foreign countries have significantly increased their market share in the United States and have capitalized on exporting specialty products.

This study investigates the trade-related factors influencing the decline in domestic market share of U.S. red meats. The objectives of the study are to examine the effects of relative

meat price changes (domestic versus imported) and price volatility, the U.S. dollar exchange rate and its volatility, and the effect of BSE on U.S. red-meat trade.

When the U.S. dollar appreciates in value imports become cheaper in U.S. dollar terms, creating competitive pressure for U.S. produced substitutes. These effects are reversed when the U.S. dollar depreciates in value. Changes in the exchange rate will likely have two effects on trading countries. First, it changes relative prices of imported or exported goods. Second, it changes the volumes traded, which ultimately changes the market share of domestic and imported products.

Numerous studies have looked at the effect of exchange rate volatility on trade flows, but there appears to be no consensus on its impact. Negative effects of real exchange rates volatility on trade flows were observed by Cushman (1988), Pick (1990) and Chowdhury (1993) while positive effects of exchange rate volatility on trade flows were observed by Asseery and Peel (1991). However, many other studies do not find a strong relationship (e.g. Jin and Koo, 2003).

In this study the relative price and relative exchange rate volatility could be generated from two sources: 1) the domestic price and dollar value and 2) the imported price or imported currency value. Assuming that the source of the volatility is generated from domestic price or dollar value, it is expected that the increase in domestic price or dollar value volatility could result in some substitution away from domestic purchases to the less risky import purchases, resulting in reduced share of domestic consumption. In this case the signs on the price and exchange rate volatility variables would be negative. If on the other hand, the source of the risk is from the imported country's price and currency value, an increase in volatility would reduce U.S. meat purchase from that country to avoid that risk. This increased volatility would reduce imported meat purchase and domestic market share of U.S red meat utilization would increase,

resulting in a positive sign on the volatility variable. Since the sources of the risks are not known, it becomes an empirical question as to what sign would appear on the relative price and exchange rate volatility.

Relative prices and relative exchange rate indices have been formulated for all the major countries from which the U.S. imports red-meat. The U.S prices were divided by a weighted average price of the importing country to form the relative price index. Jarvis et al. (2003) points out that there is significant convergence in beef export price of different countries over the last three decades, so wide variances in country prices are not expected. Still, weights determined by the exporting country's share of total U.S. imports for each meat product were used. Analysis is conducted on monthly data for the period 1989 to 2004. Cross-section, time-series panel data for three red-meats – beef, pork, and lamb were used in the analysis. A two-way random effects moving-average error variance component model was estimated (Fuller and Battesse, 1974).

The paper is organized as follows. The next section provides the model specification. This is followed by a description of the data. Then, the empirical results follow. Finally, the paper closes with a summary and conclusion.

MODEL SPECIFICATION

Following Feige (1974), Kenen and Rodrick (1986), Asseery and Peel (1991) and Jin and Koo (2003), a long-run relationship model is specified. This relationship can be conceived as a long run solution of a behavioral demand and supply system for meat. The model captures the long-run total demand for red meats in the United States. It allows for the estimation of source country meat demand with two equations where the source countries are the United States and all other foreign country imports combined. In this two-share equation model, the foreign import share equation is omitted to avoid singularity. The dependent variable is the market share held

by the United States for its red meat utilization (beef, pork and lamb). The exogenous variables are an index of U.S. meat price relative to imported meat prices, the relative volatility of this price index, an index of exchange rates, which is the U.S. dollar value relative to currencies of countries from which it imports meat, and the volatility of this exchange rate index. The equation is expressed as follows:

$$y_{it} = \alpha_0 + \beta_1 Px_{it} + \beta_2 V(Px)_{it} + \beta_3 Rx_{it} + \beta_4 V(Rx)_{it} + \varepsilon_{it} \quad (1)$$

where *y* denotes the level of market share held by the United States for its red meat; *Px* is the U.S. meat price divided by an index of imported meat prices; *Rx* represents the U.S. dollar value divided by an index of currencies from countries from which it imports meat; *V(Px)* the volatility of the relative price index; and *V(Rx)* denotes the relative volatilities of the exchange rate index in the three red-meat categories; ε is the error term ; and α_0 and β_i are unknown parameters. Both the price and exchange rate variables are time and cross-section variant. The subscript i denotes the cross-sectional changes for the 3 meats—beef, pork and chicken and the subscript t denote monthly time changes from January 1989 to December 2004.

A measure of the standard deviation of price variation is developed to capture the volatility (Morgan, 1999). The price and exchange rate volatility indices are expressed as:

$$V(Px)_{it} = ((Px_{it} - Px_{it-1})^2)^{1/2} \quad (2)$$

$$V(Rx)_{it} = ((Rx_{it} - Rx_{it-1})^2)^{1/2} \quad (3)$$

where $V(\cdot)$ is the volatility.

Assuming substitutability between U.S. and imported meats, an increase in U.S. meat prices is expected to reduce the demand for U.S. meat. Conversely, an increase in imported meat price would discourage purchase of imported meats and increase the demand for domestic meats.

As such, the sign on the relative price index (U.S. price divided by imported price) is expected to be negative.

An appreciation of the U.S. dollar relative to another country's currency increases U.S. import demand by lowering the dollar price of imports. The increased demand for foreign products could in turn hurt U.S. producers who compete with imports from this country, thereby lowering domestic production. The reverse is expected when the U.S. dollar depreciates in value against another country's currency. As such, domestic market share is expected to be inversely related to the exchange rate index.

Economic shocks and trade policy also affect trade and can alter market shares (Gehlhar and Vollrath, 1997). In December 2003, the discovery of BSE in a dairy cow, which had been imported from Canada, led many importing countries to either ban or restrict beef and cattle imports from the United States. Since then, the United States has reported another case of BSE, this time in a cow native to Texas. Though the test results in that case turned out to be negative, U.S. beef exports have not returned to normal. U.S. beef exports were down more than 80 percent in 2004. It is expected that with this trade disruption U.S. beef market share sold to domestic consumers would increase, because the U.S. is unable to export its normal volumes and would therefore substitute domestic meat for imported. To capture this trade disruption, a dummy variable was used to represent the BSE period. The value of the dummy variable is set to 1 from January 2004 to December 2004, otherwise zero. It is expected to have a positive sign since domestic market share would increase due to the inability to export.

Economic and market shocks are often associated with time lags as it relates to trade. For example, meat shipped from Australia spends at least 1 month at sea. Thus, a policy or price shock may have a lagged effect on delivery to its final destination. This could result in serially

correlated time series data. As such, a 3-month moving average model was used. The Hausman (1978) specification test was also used to test for bias or inconsistency of the estimators. In the random effects specification, the null hypothesis of no correlation between effects and regressors implies that ordinary least squares (OLS) estimates are consistent, but inefficient. The Hausman test resulted in a test statistic of 5.34, which is less than the critical value of the Chi-square distribution of 7.78 at the 10 percent level with 4 degrees of freedom. Therefore we failed to reject the null hypothesis. This suggests that a random effects model using general least squares (GLS) estimates is more appropriate with the meat effects (beef, pork and lamb) and the time effects treated as random.

DATA

The data consist of domestic meat market shares for 3 red meats—beef, pork and lamb. A meat price index and an exchange rate index from monthly data from January 1989 to December 2004 are used in this analysis. U.S. domestic market shares for beef, pork and lamb are calculated. The U.S. market share is calculated as the proportion of total domestic supply not imported but, rather produced domestically. Total domestic supply for each month is calculated by summing commercial production plus farm production, beginning stocks held in cold storage, imports, and subtracting exports and ending stocks held over in cold storage for the next month. Likewise, the foreign market share is the sum of each country's market share of meat supplied to the United States. Table 1 presents the descriptive statistics of the major meat suppliers to the United States.

Table 1. Descriptive Statistics of Import Shares of the Major U.S Meat Importing Countries

Country/Meat	Mean	Standard Deviation	Minimum	Maximum
Beef				
Canada	0.24	0.10	0.00	0.48
Brazil	0.05	0.02	0.00	0.10
Uruguay	0.02	0.03	0.00	0.13
Argentina	0.06	0.03	0.01	0.15
Australia	0.35	0.09	0.01	0.63
New Zealand	0.23	0.09	0.01	0.42
Pork				
Canada	0.67	0.12	0.41	0.88
Denmark	0.21	0.08	0.06	0.37
Poland	0.03	0.03	0.01	0.18
Lamb				
Australia	0.67	0.08	0.42	0.85
New Zealand	0.32	0.08	0.15	0.58

[1]Data are from January 1989 through December 2004

Monthly import quantities and expenditures on each meat were obtained from the U.S. Department of Agriculture, Foreign Agricultural Service, Foreign Agricultural Trade Status. All expenditures are on a free on board (FOB) basis, meaning that transportation costs, insurance and custom duties are not included. This makes the import price (unit value) fairly representative of the wholesale U.S. domestic price. Expenditures and quantities, per-unit values ($/lb) for each country were calculated and multiplied by that country's nominal exchange rate. This makes the unit value fairly representative of that exporting country's wholesale domestic price. A price-weighted importing country price index was calculated by multiplying each country's price by its share of total meat exported to the United States. A relative price index for each of the meats was then calculated as the ratio of the U.S. wholesale price to the imported price index. The U.S. wholesale prices for beef, pork and lamb are provided by the U.S. Department of Agriculture, Agricultural Marketing Service (USDA-AMS). The descriptive statistics for the meat prices from the United States and major exporting countries are presented in Table 2.

Table 2. Descriptive Statistics of Meat Prices of the Major U.S Meat Importing

Price	Mean	Standard Deviation	Minimum	Maximum
Beef				
Canada	134.37	65.27	86.13	721.28
Uruguay	777.48	603.17	26.39	2351.04
Argentina	96.91	54.45	0.09	253.46
Brazil	90.66	80.86	0.00	293.74
Australia	103.29	23.70	61.78	161.43
New Zealand	132.52	30.87	73.28	215.53
United States	179.95	21.21	147.00	271.48
Pork				
Canada	130.40	19.70	79.55	176.28
Denmark	870.87	192.16	582.20	1557.20
Poland	361.79	158.10	4.06	639.80
United States	110.81	11.75	81.10	135.97
Lamb				
Australia	120.69	41.43	54.53	231.83
New Zealand	185.71	48.33	98.26	301.48
United States	76.84	13.49	41.78	95.32

[1]Each country price is the average monthly unit price multiplied by its nominal exchange rate to reflect the country's currency. U.S. prices are average wholesale value for the respective meats.
[2]Data are from January 1989 through December 2004

Similarly, a trade-weighted exchange rate index is calculated. Exchange rate data for each importing country are used to develop a supplier index for each of the red-meats. The real exchange rate is converted to an index by multiplying each country's share of the total meat supply to the United States. The combined exchange rate index is a weighted average of all the countries that supply that particular meat product. The descriptive statistics for the exchange rates of the major exporting countries are presented in Table 3.

Table 3. Descriptive Statistics of Exchange rates of the Major U.S Meat Importing Countries against the U.S. Dollar

Country	Mean	Standard Deviation	Minimum	Maximum
Canada	1.3	0.2	1.0	1.6
Uruguay	14.7	3.9	10.5	24.0
Argentina	1.4	0.8	0.9	4.6
Denmark	6.6	0.9	5.4	8.8
Poland	4.7	1.4	2.9	13.2
Brazil	1.5	0.6	0.6	3.4
Australia	1.5	0.2	1.1	2.0
New Zealand	1.7	0.3	1.3	2.5

[1]The exchange rates are average monthly real rates
[2]Data are from January 1989 through December 2004.

RESULTS

The results from the two-way random effects panel estimation method are presented in Table 4. The DaSilva (variance component moving average method), which assumes a mixed variance component for the error structure, was compared the Fuller and Battesse method (which assumes a variance component model for the error structure) and the Parks Method (which assumes a first-order autoregressive model with contemporaneous correlation between cross sections). All three models performed fairly well though the relative meat price variable for the Parks method, was not statistically significant, and the relative meat price volatility variable for the Battesse and Fuller model had a positive signs while in either case the other two models had negative signs.

Table 4. Estimation Results for Red-Meats

	DaSilva (Variance Component Method MA=3)		Battesse and Fuller Method		Parks Method	
Variable	Estimate	t-statistic	Estimate	t-statistic	Estimate	t-statistic
Intercept	1.034**	(14.50)	1.171**	(15.98)	0.93**	(28.72)
Relative Meat Price	-0.046**	(-26.43)	-0.111**	(-5.59)	0.0002	(0.011)
Relative Meat Price Volatility	-0.007**	(-4.16)	0.142**	(4.07)	-0.033**	(-2.79)
Real Exchange Rate Index	-0.032**	(-34.24)	-0.078**	(-7.61)	-0.011*	(-2.17)
Real Exchange Rate Index Volatility	-0.024**	(-23.12)	-0.014	(-0.73)	-0.0003	(-0.06)
Dummy for BSE impact on U.S.	0.027**	(13.11)	0.030*	(2.73)	0.036**	(-3.29)
Time Trend	-0.001**	(-78.91)	-0.001**	(-17.89)	-0.001**	(-3.14)
Number of Cross Sections	3		3		3	
Length of time Series	192		192		192	
R^2	0.25		0.52		0.52	

As expected, the negative sign on the statistically significant relative price variable suggest that increases in U.S. red-meat price would result in an increase in the relative price index and a corresponding decrease in the domestic market share of the total red-meat utilized. Conversely, decreases in the imported meat price index would increase the value of the relative price index and cause a decrease the domestic market share of total red meat utilization.

The relative price volatility variable was also statistically significant with a negative sign, suggesting that the source of the volatility dominated by U.S. red meat prices. These results suggest that relative prices and their volatilities are economically meaningful in determining the U.S. meat market share. While the relative price variable is consistent with the findings of some studies, the price volatility is inconsistent with the findings of Jin and Koo (2003) who found estimated positive effects of price volatilities on annual data. The data used in this study were monthly, which makes it more likely that we capture the effects of volatility than if we had used more aggregated annual data.

The real exchange rate index and its volatility estimation were also statistically significant with negative signs, suggesting that the monthly red-meat market share is sensitive to the currency values of these meat exporting countries. The negative sign on the exchange rate and volatility indices suggests that an appreciation of the U.S. dollar decreases the dollar price of imported meat and encourages the U.S. to import more meat. This will in turn reduce the share of domestic meat on the U.S. market. These are consistent with the findings of Langley, et al (2000).

The BSE dummy variable was statistically significant with an expected positive sign. This may have to do with substitution effects as well as export trade restrictions. Though the effect of BSE may have had a positive effect on the domestic market share of beef (and to a lesser extent lamb) because less was exported during that period, it was not likely to have a positive effect on domestic market share of pork. Since all three meats are substitutes, an increase in the share and domestic volume of beef and/or lamb is likely to result in a reduction in price of these meats, resulting in some substitution away for domestic pork, thereby, reducing domestic market share of pork. However, the results suggest that the effects of trade restrictions

dominated the offsetting effect of pork, resulting in BSE having a net positive effect on U.S domestic red meat utilization.

The trend variable was added to capture the decrease in market share of meat and to help to reduce nonstationarity in the panel data. Again, the expected negative sign confirmed the declining U.S. market share observed in all three meats in Figure 1.

CONCLUSIONS

The results show that the relative meat price and exchange rate indices as well as their volatilities significantly affect the U.S. market share of its total meat utilization. This suggests that the monthly red-meat market share is sensitive to the U.S. meat prices relative to the meat prices of countries from which it imports. Market-share was also sensitive to the relative currency values of these countries. The BSE dummy variable was statistically significant with an expected positive sign as share of domestic red meat utilization increased due to export trade restrictions. The overall results suggest that relative price and exchange rates and their volatilities are relevant explanatory factors for changes in U.S. meat market shares.

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