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## **The Effect of Lost Exports on U.S. Beef Prices**

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## Table of Contents

List of Tables .....	ii
List of Figures .....	ii
Abstract .....	iii
Highlights .....	iv
Introduction .....	1
The History of BSE Cases and Consumer Response .....	1
The European Cases .....	2
Japanese Cases .....	3
The Canadian and U.S. Cases .....	4
Changes in U.S. Beef Exports and Prices .....	4
Estimating Meat Prices .....	9
Data .....	10
Results .....	11
Conclusions .....	14
References .....	15

## List of Tables

No.		Page
1	Estimated Results of the Beef, Pork and Chicken Price Equations .....	11
2	The Effect of Reduced Exports on Prices and Revenue .....	13
3	The Effects of Increasing Exports on Beef and Cattle Prices .....	13

## List of Figures

No.		Page
1	Monthly U.S. Beef Exports .....	5
2	Comparison of Monthly U.S. Beef Exports, 2001-2004 .....	5
3	U.S. Monthly Beef Exports to Major Markets, 1998-2004 .....	6
4	Percentage of U.S. Beef Production Exported .....	7
5	U.S. Domestic Beef Consumption, Retail Weight .....	8
6	Retail Beef and Cattle Prices .....	9

## **Abstract**

Since the discovery of Bovine Spongiform Encephalopathy (BSE) in the United States in December 2003, U.S. beef exports have declined approximately 85 percent. A number of countries, including Japan and Korea (the top export markets for U.S. beef), have banned imports of beef from the United States, while U.S. exports to other important markets, such as Mexico and Canada, have been well below previous levels. Domestic demand in the United States was not significantly affected by the BSE discovery, but the effect of decreased beef exports on U.S. price is significant. This study examines the effect of exports and other supply and demand factors on U.S. meat prices, and estimates the effect of the drop in exports on U.S. beef and cattle prices. Results indicate that if all other factors remain the same, the drop in exports results in a \$0.22 per pound reduction in retail beef prices and a \$0.04 per pound reduction in the slaughter steer price. Prices in 2004 remained relatively high, however, possibly due to a decline in U.S. production and strong domestic demand.

**Keywords:** Bovine Spongiform Encephalopathy, beef, pork, chicken, exports

## Highlights

After the discovery of bovine spongiform encephalopathy (BSE) in the United States in December 2003, U.S. exports of beef nearly stopped as the major export markets no longer accepted U.S. beef. U.S. beef exports totaled 145 thousand metric tons in 2004, which is an 83 percent decline compared to the 858 thousand metric tons exported in 2003. In terms of value, U.S. beef exports sank from \$3.15 billion in 2003 to \$550 million in 2004, which is an 82.5 percent decrease. Prior to the BSE discovery, U.S. beef exports had been steadily increasing over time. The United States did not export any beef to Japan, Korea, Hong Kong, Taiwan, Egypt, and China (among others) in 2004.

The importance of exports for U.S. beef producers has been increasing over time. Prior to the mid-1980s, less than 2 percent of U.S. beef production was exported. This percentage has steadily increased over the last 30 years. In 2003, almost 10 percent of U.S. beef production was exported. The percentage of beef production exported dropped to less than 2 percent in 2004. The BSE case in the United States does not appear to have had any significant effect on domestic beef demand, but the growing importance of exports suggests that a loss of major foreign markets could have significant effects on the U.S. beef and cattle industry.

An econometric model is developed for U.S. domestic retail beef, pork, and chicken prices, where price is expressed as a function of supply and demand variables. The price of each meat is estimated as a function of supply, exports, the prices of substitutes, per capita disposable income, seasonal dummy variables to account for seasonal changes in demand, and a lagged dependent variable.

Supply is found to have a significant, negative effect on beef, pork, and chicken prices, as expected, and exports have a positive and significant effect on beef and pork prices. Per capita disposable income is found to have a positive effect on beef and chicken prices, and the prices of all three meats are found to be higher during summer months. The prices of substitute meats, however, are not found to have significant impacts.

U.S. beef exports averaged 473 million pounds (retail weight) per quarter in 2003 and dropped to 80 million pounds per quarter in 2004, which is a decrease of 393 million pounds. According to the results of our model, a 393 million pound decline in exports, with all other factors remaining the same, would cause price to decrease by \$0.22 per pound. Therefore, if exports had remained at the same level as in 2003, the U.S. beef price would be \$0.22 per pound higher, which represents a 6 percent price change.

The drop in exports and the resulting negative impact on beef prices also has a negative effect on U.S. cattle price, which is estimated to be approximately \$0.04 per pound. A \$0.04 per pound price reduction results in a \$1.38 billion loss in revenue for the U.S. cattle industry, which would be a 4 to 5 percent reduction in revenue.

U.S. beef exports in 2004 were at about 17 percent of the level of exports in 2003. Exports will increase if major beef importing countries remove their bans on U.S. beef. However, it may be unlikely that beef exports will return to previous levels because of consumer concerns and changes in consumer preference within the importing countries. If exports increase from 17 percent to 50 percent of the 2003 level, with all other factors remaining the same, retail beef price increases by \$0.09 per pound and slaughter steer price increases \$0.02 per pound . If exports increase to 75 percent of the 2003 level, then retail beef prices increase by \$0.16 per pound and slaughter steer price increases \$0.03 per pound. Retail beef prices and slaughter steer prices increase by \$0.22 and \$0.04 per pound, respectively, if exports return to 100 percent of the 2003 level.

Since the results from our model do not show that beef prices have a significant impact on pork and chicken prices, the \$0.22 per pound negative effect of BSE on beef price does not significantly influence prices of these other meats. However, a significant increase in pork exports, which may have been caused in part by countries importing pork instead of beef, has had a positive effect on pork prices. Pork exports averaged 429 million pounds per quarter in 2003 and 545 million pounds per quarter in 2004. This increase has had a \$0.05 per pound positive impact on pork price, according to the results from our model.

Despite the major reduction in exports, actual U.S. beef and cattle prices have not declined substantially and are actually higher than in the years prior to 2003, which suggests the BSE case may have prevented further price increases. These relatively high prices could be due to reductions in cattle inventories and beef production, the ban on imports from Canada, and a strong domestic demand. These prices could lead to expansion in production, but the current uncertainty regarding export markets could restrain expansion. The reduction in production in 2004 essentially offsets the drop in exports. If production returned to previous levels or if domestic demand declined, the loss of exports would be more noticeable.





# **The Effect of Lost Exports on U.S. Beef Prices**

**Jeremy W. Mattson, Hyun J. Jin, and Won W. Koo\***

## **INTRODUCTION**

A case of Bovine Spongiform Encephalopathy (BSE), commonly referred to as mad-cow disease, was discovered in Washington state on December 23, 2003. This discovery of the first BSE case in the United States shut down major export markets for U.S. beef. A year later, exports to Japan and Korea, the top destinations for U.S. beef exports, are still banned, as are exports to a number of other countries. Exports to Mexico have somewhat rebounded, but exports to Canada are still greatly reduced. The BSE discovery did not significantly impact domestic beef consumption in the United States, but since nearly 10 percent of U.S. beef production is exported, a loss of major export markets could have a significant impact on U.S. beef and cattle prices. Exports during the first nine months of 2004 were 15 percent of the level of exports during the same period in 2003.

The objective of this study is to determine the importance of export markets for U.S. beef prices and the effects on beef and cattle prices from losing major export markets. A secondary objective is to determine how the prices of other meats (pork and poultry) are affected. The remainder of this paper is organized as follows. In the second section, a history of BSE cases and consumer response around the world is presented. Changes in U.S. beef exports and prices over time are discussed in the third section, with attention given to the impact of the BSE discovery. An empirical model for estimating beef, chicken, and pork prices is presented in the fourth section, and the estimated effects of supply and demand factors on prices are discussed. In the fifth section, the impact of the BSE discovery on U.S. beef and cattle prices is estimated. A summary and conclusions are presented in the final section of the paper.

## **THE HISTORY OF BSE CASES AND CONSUMER RESPONSE**

BSE is a lethal, central nervous system disease, which specifically targets cattle. The disease is characterized by the appearance of vacuoles, or clear holes, in neurons in the brains of affected cattle. These vacuoles give the brain the appearance of a sponge or spongiform. There is no known treatment, and infected cattle die. Most cases in the United Kingdom have occurred in dairy cows between three and six years of age. The primary means of transmission in cattle is by eating feed contaminated with rendered material from BSE-infected cattle. There is no evidence that BSE is transmitted directly from animal to animal. It is believed that there is a link between

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consumption of BSE-infected meat and the development of a variant form of Creutzfeldt-Jacob disease (vCJD) in humans.

### The European Cases

The occurrence of BSE in cattle was initially recognized in the United Kingdom in 1986. The disease reached epidemic proportions in Europe by 1992, with more than 1,000 reported cases. Within the period from 1987 to 2000, the total number of infected cattle increased to 180,000 in the United Kingdom, Ireland, Portugal, France, and Switzerland.<sup>1</sup> Consumer alert to the danger was further augmented by the U.K. government's announcement, on March 20, 1996, that there is a possible link between consumption of BSE-infected meat and the development of vCJD.

The announcement of this finding generated considerable media attention and resulted in an immediate and significant decline in beef consumption in Europe. Consumers' concerns over the disease have grown around the world. Authorities in European countries have banned suspect animal feed and launched offensives against fears of BSE-infected meat, but it has been difficult to lessen consumer concern. Beef sales in Europe fell after the news. Some governments outside Europe banned beef imports from European countries.

According to the report *Livestock and Poultry – World Markets and Trade*, released by the Foreign Agricultural Service of the U.S. Department of Agriculture (FAS/USDA 1998), beef consumption in the EU countries fell by about 7 percent and remained stagnant in 1997. Substitution with other meats was evident almost immediately following the crisis, as U.K. and French consumers began purchasing more lamb. EU consumers turned to poultry and, to a lesser extent, pork. Some U.K. consumers switched from domestic beef to U.S. beef. According to the report, EU beef exports dropped significantly in 1996 but rebounded in 1997, partly due to export subsidies. The report also indicates that while food safety is a factor in the minds of EU consumers, price is also important in deciding whether or not to purchase beef. In other words, if the price of beef is attractive enough to consumers, they may buy it despite any lingering concerns over BSE.

BSE has occurred mostly in European countries and, therefore, studies of the BSE outbreak and consumer response have focused on the cases in Europe. Latouche, Rainelli, and Vermersch (1998) conducted a survey using a contingent valuation method to analyze consumer behavior in the area of Rennes after the BSE crisis. Their survey revealed that consumers are waiting for greater transparency and that they would be willing to pay for it. In regard to the issue of consumers' preferences after the BSE outbreak, Mangen and Burrell (2001) investigated a structural change in Dutch consumers' preferences for meat and fish following the U.K. government's announcement. They used a switching Almost Ideal Demand System (AIDS) model and a sample period that covered January 1994 through May 1998. The hypothesis of

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<sup>1</sup>Refer to, e.g., *the Official BSE Homepage*, <http://www.defra.gov.uk/animalh/bse/>, U.K. Department for Environment, Food, & Rural Affairs, London, the United Kingdom.

constancy of the parameters of the AIDS model for meat and fish was rejected against a more general time-varying parameter model. The combined effects of the underlying trends and the irreversible components of the BSE effect were against beef, minced meat, and meat products, and in favor of pork, prepared meat, poultry, and fish.

Adda (2002) investigated the effects of past consumption of risky goods on current consumption patterns, using the "mad cow" crisis as a natural experiment. He found that new health information interacted with prior exposure to risks. Consumers with intermediate levels of past consumption decreased their demand for beef and sought higher quality products, while low- and high-stock consumers did not alter their behavior after the crisis. Verbeke and Ward (2001) investigated fresh meat consumption in Belgium during the period from 1995 through 1998 using an AIDS model. In specifying the demand system, they incorporated a media index mainly pertaining to BSE; their results show that television publicity has a negative impact on beef expenditure, in favor of pork. Burton and Young (1996) investigated the impact of BSE on the demand for beef and other meats in the United Kingdom. Indices of media coverage of BSE were incorporated in a dynamic AIDS model of meat demand. The publicity about BSE was found to have had significant effects on the allocation of consumer expenditure among the meats. A short-run impact was identified which accounts in large part for the discernible drop in the market share of beef in the early 1990s. There also appears to be a significant long-run impact of BSE, which by the end of 2003 reduced beef market share by 4.5 percent.

### Japanese Cases

After the 1996 announcement made by the U.K. government concerning the link between BSE and vCJD, beef consumption in Japan began to gradually decline, but it was not a pronounced decline since beef consumption in Japan came mostly from domestic production and imports from BSE-free countries, such as the United States and Australia. Amid signs of the spreading of BSE and vCJD across Europe, the Japanese government banned EU beef and tried to prevent the disease from entering its borders. However, on September 10, 2001, the Japanese government reported the first case of BSE within the country. The case was the first outside of Europe.

The Japanese beef industry reeled under the combined reaction in its domestic and export markets. South Korea and Singapore announced a ban on Japanese beef, joined after by China, Malaysia, and the Philippines. Strict European standards were adopted by the Japanese government and one million cattle were tested in an effort to fight the spread of the disease. At the same time, officials scrambled to reassure Japanese consumers and to persuade other countries to drop bans imposed on its meat after the announcement. Despite these measures, worries over food safety have taken a toll on the country's meat industry. Many wholesalers and retailers have suffered drops in sales ranging from 5-50 percent due to the concern over BSE. Consumption of beef in Japan has fallen sharply, and beef prices have dropped significantly. During the period from 1998 through 2001, about 66 percent of beef sold in Japan was imported, and most imports came from the United States and Australia, where BSE had not been found.

According to the *International Agricultural Trade Report* (February 2002) by the FAS/USDA, nearly 60 percent of Japanese consumers have stopped eating beef since the first case of BSE. The damage was compounded by the discovery of a second infected cow two months later. Third and fourth suspected cases were reported during the next month, and the recurrent cases of BSE continued to fuel consumer concern and harm Japan's beef industry.

Jin and Koo (2003), using a nonparametric approach, show that there is an ongoing structural change in Japanese consumers' preferences for meat; the consumers' tastes for meat have systematically moved away from beef to its substitutes. Peterson and Chen (2003) found that the Japanese meat system underwent structural change within five months of the BSE discovery because of the change in consumer preferences.

### *The Canadian and U.S. Cases*

The first case of BSE in Canada was found in May 2003. The cow came from a commercial farm in northern Alberta. Canadians consume only half the beef produced in the country, with much of the rest shipped to the United States. With the discovery of BSE, the United States banned imports of Canadian cattle and beef. The single case of BSE and the U.S. ban caused a sharp decline in prices of cattle for slaughter in Canada.

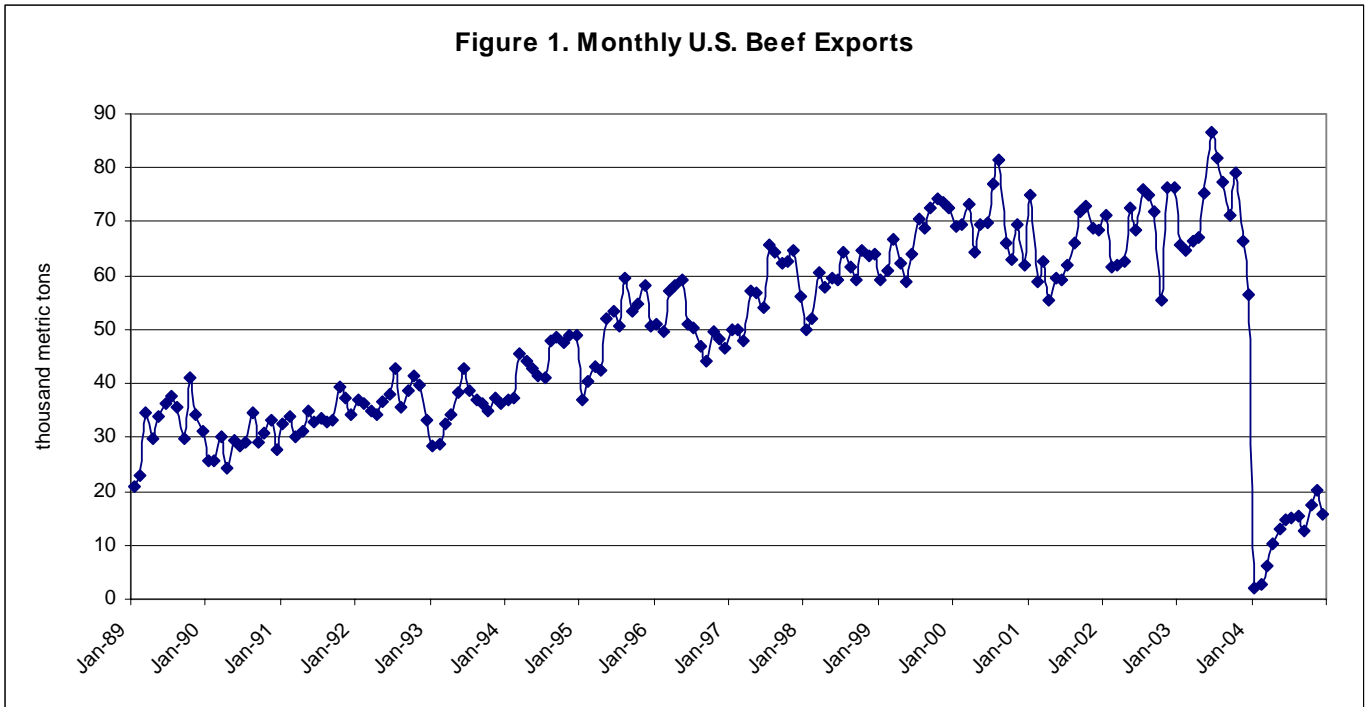
Prior to the ban, in 2002, the United States imported 1.7 million head of live cattle, most for the purpose of slaughter, and 389 thousand metric tons (retail weight) of beef from Canada. The United States eventually lifted the ban on imports of beef from animals 30 months or younger, and the flow of beef imports from Canada started to resume again in the Fall of 2003. In 2004, it returned to levels only slightly lower than those from before the BSE discovery. The U.S. ban on imports of live cattle and beef from animals older than 30 months, however, remained in place throughout 2004.

In December 2003, the first case of BSE was found in the United States. Consumer concern in Canada and the United States has not been as great as in European and Asian countries. Domestic beef consumption in the United States and Canada was not significantly impacted by the BSE discovery. Canadian consumption actually increased because of lower beef prices, and U.S. demand has been strong. However, many countries banned imports of beef from the United States and Canada. The loss of exports has had a significant impact on the beef industries in these two countries.

## **CHANGES IN U.S. BEEF EXPORTS AND PRICES**

After the discovery of BSE in the United States in December 2003, U.S. exports of beef nearly stopped as the major export markets no longer accepted U.S. beef (Figure 1). U.S. beef exports averaged 73 thousand metric tons (retail weight) per month from January to November 2003. Exports declined to 56 thousand metric tons in December and then dropped to just 2 thousand

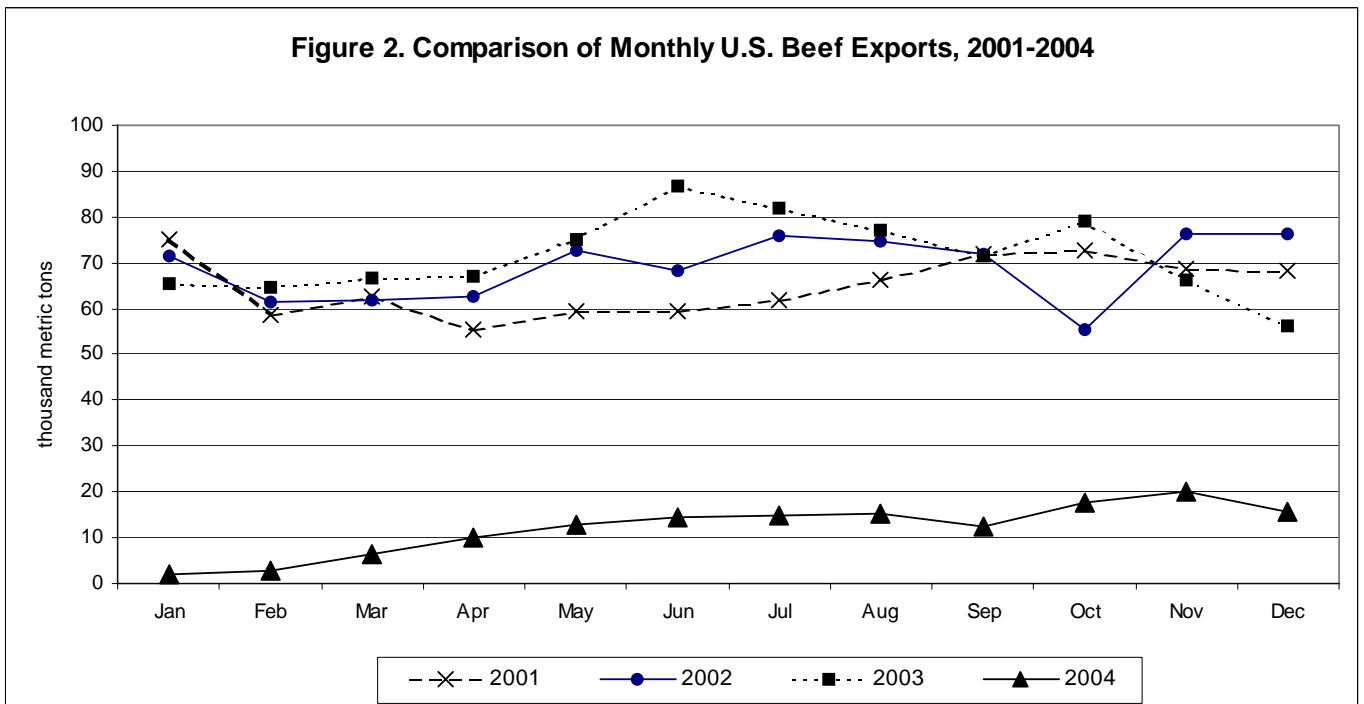
**Figure 1. Monthly U.S. Beef Exports**



Source: FAS/USDA

metric tons in January 2004. Since January, beef exports gradually increased to 20 thousand metric tons in November (Figure 2). U.S. beef exports totaled 145 thousand metric tons in 2004, which is an 83 percent decline compared to the 858 thousand metric tons exported in 2003. In terms of value, U.S. beef exports sank from \$3.15 billion in 2003 to \$550 million in 2004, which is an 82.5 percent decrease. Prior to the BSE discovery, U.S. beef exports had been steadily increasing over time.

**Figure 2. Comparison of Monthly U.S. Beef Exports, 2001-2004**

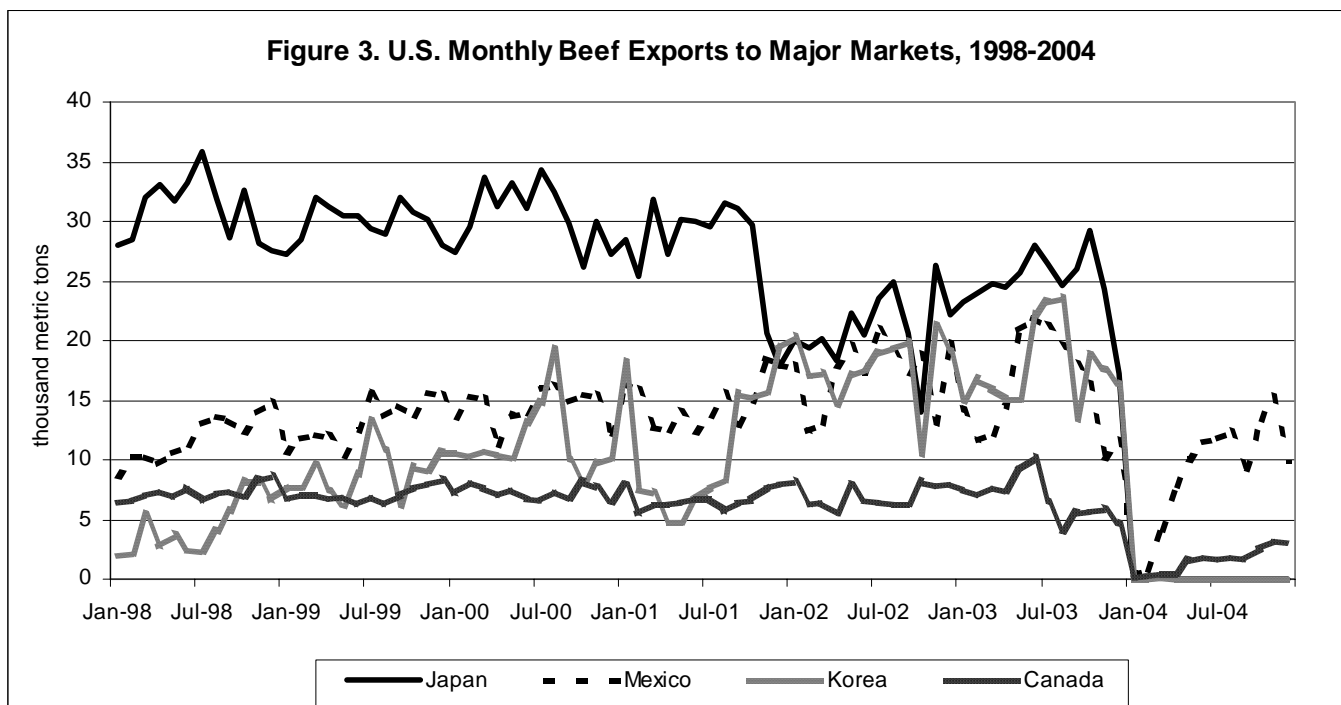


Source: FAS/USDA

The major export markets for U.S. beef are Japan, Korea, Mexico, and Canada. These four markets in the past have accounted for over 90 percent of U.S. beef exports. In 2003, the United States exported 298 million metric tons to Japan, 213 million metric tons to Korea, 192 million metric tons to Mexico, and 81 million metric tons to Canada. The next biggest markets include Taiwan, Hong Kong, Egypt, Russia, the Bahamas, and China. Many of these countries banned the import of U.S. beef after the discovery of BSE. The United States did not export any beef to Japan, Korea, Hong Kong, Taiwan, Egypt, and China (among others) in 2004.

Exports to Mexico and Canada declined substantially during the first months after the discovery but have since increased, especially to Mexico (Figure 3). In January 2004, Canada began allowing imports of U.S. boneless beef from animals less than 30 months of age, and Mexico followed suit in early March. Exports to Mexico from June through December 2004 were at about 70 percent of the level of exports to the country during the same months in 2003. Exports to Canada during the second half of 2004 were at 38 percent of the level from the previous year. The low level of demand for U.S. beef in Canada could be due to a large supply and low prices of Canadian-produced beef (ERS, September 2004). In 2004, 74 percent of U.S. beef exports (in terms of quantity) was exported to Mexico, and 13 percent was exported to Canada. The next biggest export market in 2004 was the Bahamas, where the BSE case did not have any noticeable effect.

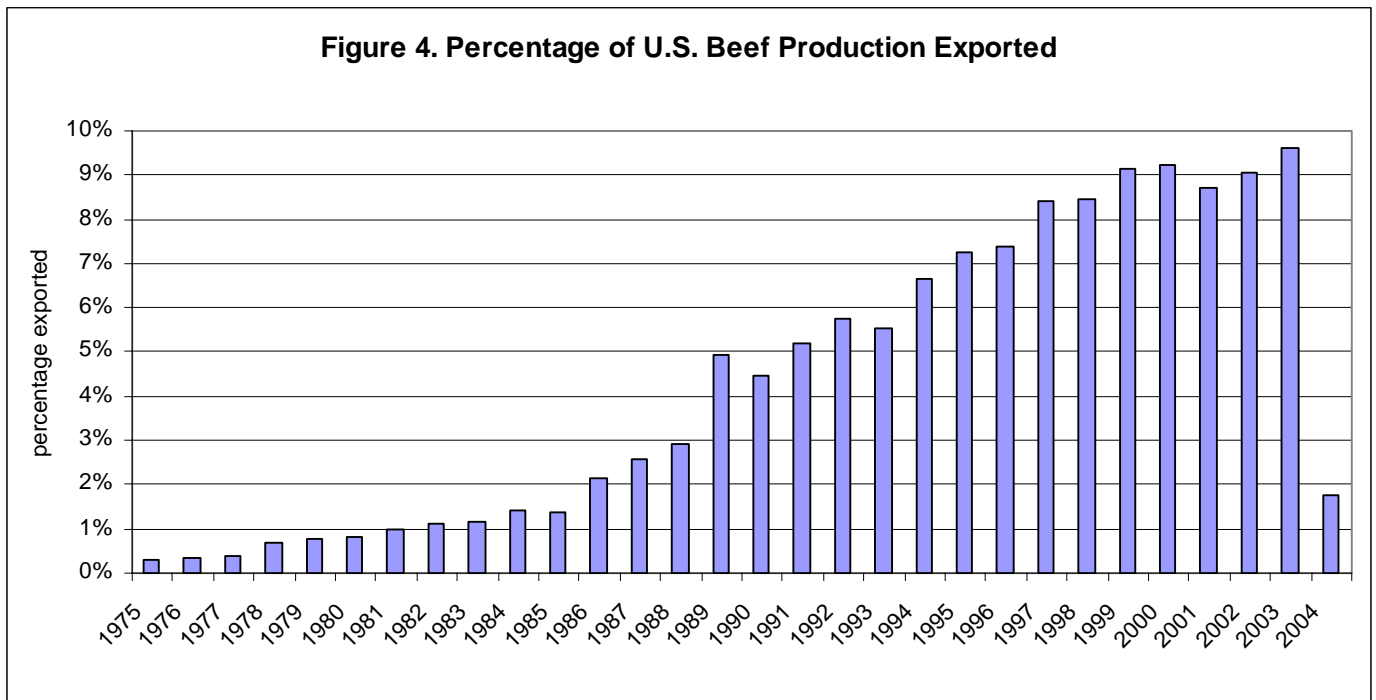
The USDA announced in October 2004 that the United States has reached agreements to resume trade with Japan and Taiwan, but these agreements did not allow for the immediate resumption of trade. The agreement with Japan is a framework agreement that requires the completion of regulatory processes in both countries before trade can resume. This agreement allows sales to Japan of beef from animals 20 months old or younger, which is about 70 percent of the cattle slaughtered.



Source: FAS/USDA

When beef exports to these countries resume, it is not likely to return immediately to levels found prior to the BSE discovery because of consumer concerns and changing consumer preferences in these countries. Consumers in Japan and Korea could be less likely to purchase U.S. beef than they were previously.

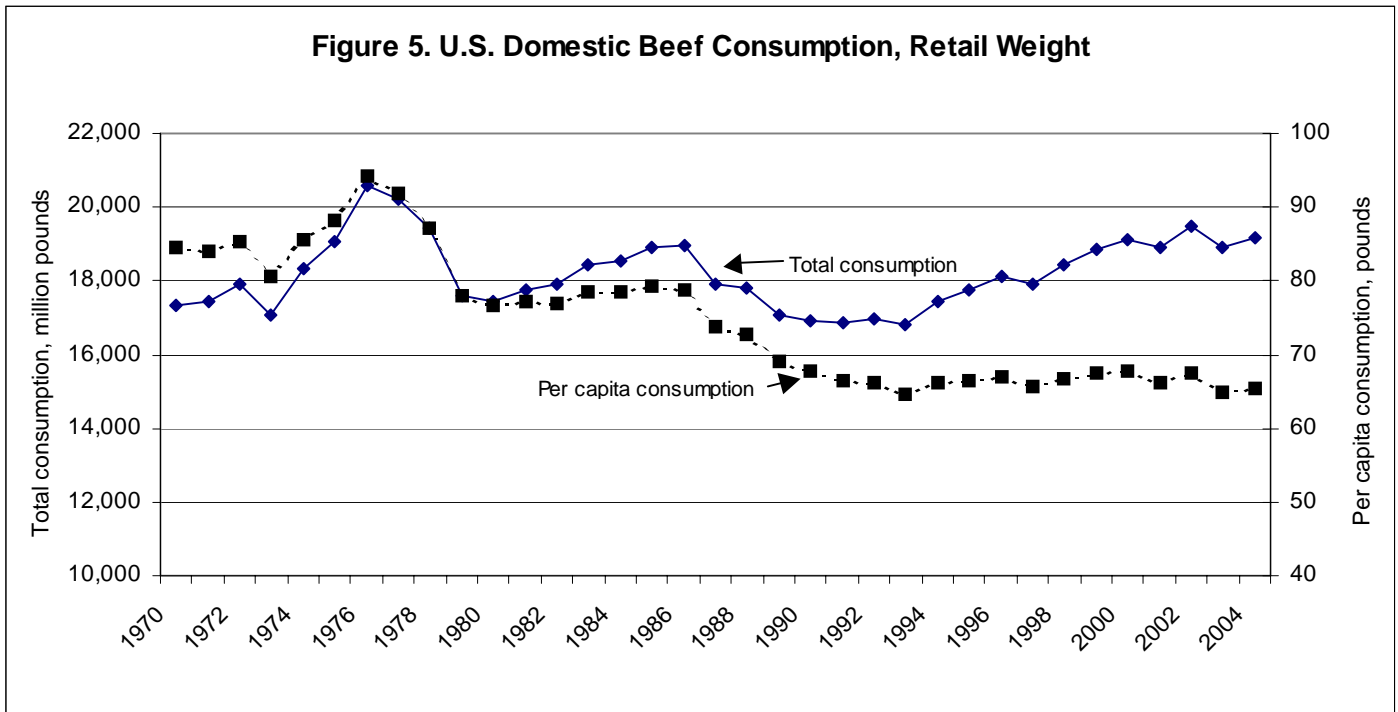
The importance of exports for U.S. beef producers has been increasing over time. Prior to the mid-1980s, less than 2 percent of U.S. beef production was exported. This percentage has steadily increased over the last 30 years (Figure 4). In 2003, almost 10 percent of U.S. beef production was exported. The percentage of beef production exported dropped to less than 2 percent in 2004.



Source: *Red Meat Yearbook*, ERS/USDA

The BSE case in the United States does not appear to have had any significant effect on domestic beef consumption. Time processes of domestic beef consumption and prices after the BSE outbreak in Washington state indicate that U.S. consumers are not as sensitive to the BSE issue as consumers in other countries are, such as those in Europe and Japan. If there was any effect on domestic consumption, it was a short-term effect. Domestic beef consumption in the United States is at the same level in 2004 as it was in recent years (Figure 5). The fact that consumption has not declined when prices have been relatively high shows that domestic demand has been strong. The growing importance of exports, however, suggests that a loss of major export markets could have significant effects on the U.S. beef and cattle industry.

**Figure 5. U.S. Domestic Beef Consumption, Retail Weight**

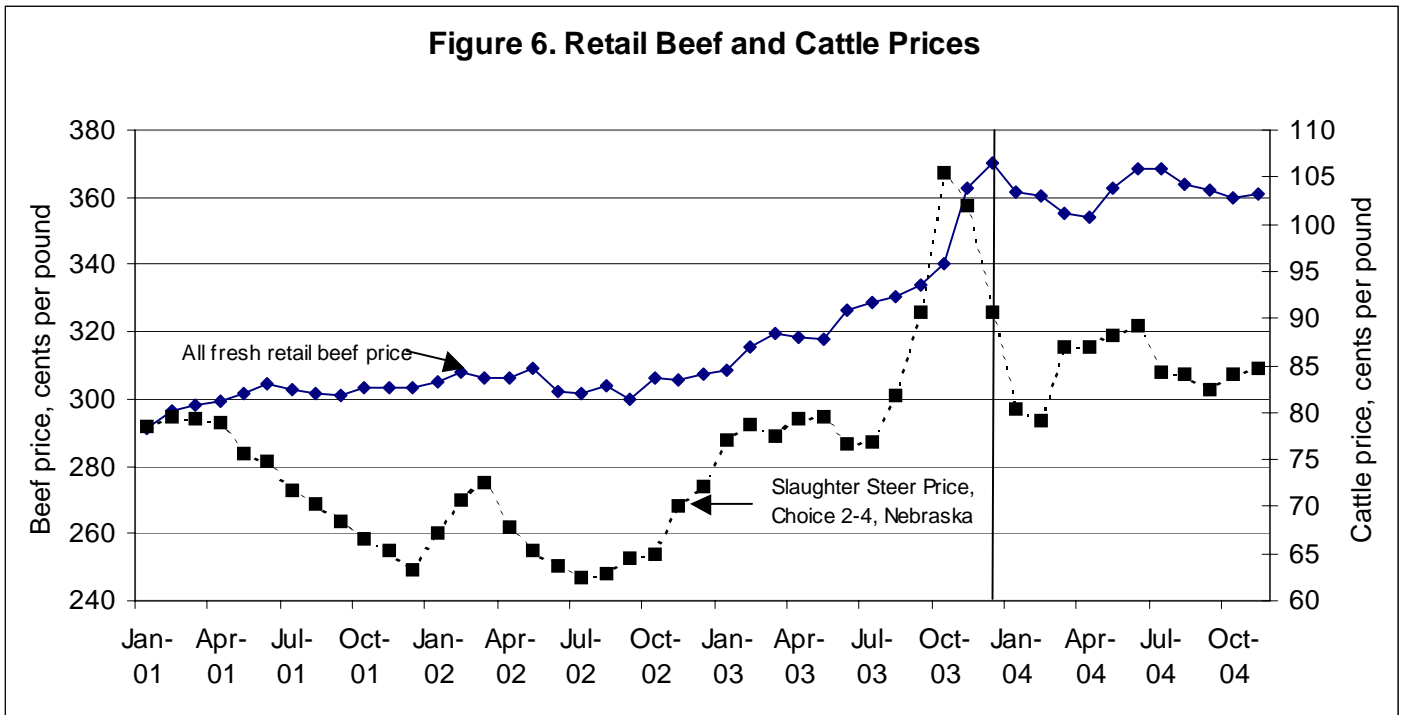


Source: *Red Meat Yearbook*, ERS/USDA

Figure 6 shows monthly U.S. beef and cattle prices over the last few years. The BSE case occurred in late December 2003. The vertical line in Figure 6 is drawn through December 2003 to correspond with this occurrence. Beef and cattle prices were increasing significantly throughout 2003 and declined in the months following the BSE case, suggesting that the loss in exports had a negative effect on prices. However, the effect seems to have been short and weak, since price levels in 2004 are just as high or higher than the price levels from previous years. These relatively high prices may be due to decreasing cattle inventories and beef production and high domestic demand. The price increase in 2003 may be due to tight supplies and the ban on imports from Canada.



**Figure 6. Retail Beef and Cattle Prices**



Source: ERS/USDA

Possible beef substitutes such as pork and chicken could also be affected by BSE. Since domestic beef demand did not appear to change because of the BSE discovery, there was no shift in domestic preferences that would benefit pork or chicken. However, pork and chicken exports may have benefitted, as countries that banned or reduced U.S. beef imports may have imported more substitute meats. U.S. pork exports, in terms of quantity, increased 29 percent in 2004. Pork exports increased by 57 percent to Mexico, 27 percent to Canada, and 16 percent to Japan. This significant increase in pork exports may have been due in part to BSE. U.S. exports of chicken and other poultry meats neither increased nor decreased in 2004. The BSE case, though, may have had an invisible, positive effect on poultry exports because the industry was simultaneously being affected by avian influenza. The detection of avian influenza in the United States in early 2004 led some countries to ban imports of poultry products from the United States.

### ESTIMATING MEAT PRICES

An econometric model is developed for U.S. domestic retail beef, pork, and chicken prices, where price is expressed as a function of supply and demand variables. Supply in a given time period is determined by beginning stocks, production, imports, and exports. Our model separates exports and combines beginnings stocks, production, and imports into one variable. Factors affecting demand include the prices of substitutes, per capita disposable income, and changes in consumer tastes and preferences. In our model, the price of each meat is estimated as a function of supply, exports, the prices of substitutes, per capita disposable income, seasonal

dummy variables to account for seasonal changes in demand, and a lagged dependent variable. The lagged dependent variable is included to correct for autocorrelation, capture dynamic effects, and may possibly capture changes in demand due to consumer preferences, which are not captured by the other variables. Explicit forms of the simultaneous equations for beef, pork, and chicken prices are as follows:

$$P_{bt} = a_0 + a_1P_{pt} + a_2P_{ct} + a_3S_{bt} + a_4X_{bt} + a_5PCI_{bt} + a_6Q1_t + a_7Q2_t + a_8Q3_t + a_9P_{bt-1} + e_t \quad (1)$$

$$P_{pt} = b_0 + b_1P_{bt} + b_2P_{ct} + b_3S_{pt} + b_4X_{pt} + b_5Q1_t + b_6Q2_t + b_7Q3_t + b_8P_{pt-1} + e_t \quad (2)$$

$$P_{ct} = g_0 + g_1P_{bt} + g_2P_{pt} + g_3S_{ct} + g_4X_{ct} + g_5PCI_{ct} + g_6Q1_t + g_7Q2_t + g_8Q3_t + g_9P_{ct-1} + v_t, \quad (3)$$

where  $P$  is price;  $S$  is supply, consisting of beginning stocks, production, and imports;  $X$  is exports;  $PCI$  is per capita disposal income; subscripts  $b$ ,  $p$ , and  $c$  represent beef, pork, and chicken, respectively; subscript  $t$  denotes time; and  $e_t$ ,  $e_t$ , and  $v_t$  are error terms. Quarterly data are used, and  $Q1$ ,  $Q2$ , and  $Q3$  are quarterly dummy variables for the first, second, and third quarters of the year. The fourth quarter is used as the reference. The prices of beef, pork, and chicken are endogenous, and the other variables are assumed to be exogenous.

Supply is expected to have a negative impact on prices, and exports should have a positive effect on prices. If beef, pork, and chicken are substitutes, then the prices of these goods should positively affect each other. For example, if the price of pork increases, demand will likely shift to beef and other substitutes, and the price of beef should increase. Per capita disposable income is expected to have a positive effect on price because an increase in income would likely cause an increase in demand for meats. Per capita disposable income was not included in the pork price equation because a high correlation between this variable and pork exports caused a multicollinearity problem. Quarterly dummy variables are included in the model because it is expected that demand may vary depending on the season of the year. Demand for beef, for example, may be higher in the summer. A linear model is used, and the three equations are estimated simultaneously using three stage least squares (3SLS) estimation.

### Data

Quarterly data from the first quarter of 1989 to the fourth quarter of 2004 are used in the estimation. The beef and pork data were obtained from the *Red Meat Yearbook* from the USDA's Economic Research Service (ERS), and the data for 2004 were obtained from various issues of the ERS's *Livestock, Dairy, and Poultry Outlook*. Beef export data were also obtained from the FAS/USDA's U.S. Trade Internet System. Data for chicken were obtained from the ERS's *Poultry Yearbook* as well as the *Livestock, Dairy, and Poultry Outlook*. The beef price is defined as the all fresh retail beef value, the pork price is defined as the retail pork value, and the chicken price is the retail composite broiler price. Per capita disposable income data were obtained from the Bureau of Economic Analysis. Price and income data were adjusted using the CPI. All quantities are denoted in million pounds and prices in cents per pound.

## Results

The estimated results are shown in Table 1. Supply is found to have a significant, negative effect on beef, pork, and chicken prices, as expected. Exports have a positive and significant effect on beef and pork prices and a positive but statistically insignificant effect on chicken price. As expected, per capita disposable income is found to have a significant, positive impact on beef and chicken prices. Beef and chicken prices are found to be significantly higher during the second and third quarters (April - September), and pork price is significantly higher during the third quarter (July - September), indicating that demand for these meats is higher during the summer.

Table 1. Estimated Results of the Beef, Pork, and Chicken Price Equations

	Beef Price	Pork Price	Chicken Price
Explanatory Variable	Coefficients (t-values in parentheses)		
Constant	25.052 (1.00)	64.974 (2.20)*	38.309 (1.97)*
Chicken price ( $P_c$ )	-0.073 (-0.98)	0.165 (1.56)	
Pork price ( $P_p$ )	-0.043 (-1.12)		-0.015 (-0.43)
Beef price ( $P_b$ )		-0.019 (-0.64)	-0.036 (-1.24)
Supply (S)	-0.023 (-7.85)*	-0.011 (-3.41)*	-0.007 (-3.42)*
Exports (X)	0.057 (7.47)*	0.043 (3.70)*	0.003 (0.70)
Per capita disposable income (PCI)	0.005 (7.58)*		0.003 (2.75)*
Quarter 1 (Q1)	1.179 (0.86)	-2.274 (-1.07)	0.482 (0.37)
Quarter 2 (Q2)	4.991 (3.15)*	-2.882 (-1.21)	4.096 (3.02)*
Quarter 3 (Q3)	5.528 (3.10)*	5.191 (2.34)*	4.194 (3.15)*
Lagged dependent variable ( $P_{t-1}$ )	1.030 (34.86)*	0.856 (17.50)*	0.692 (7.78)*

Note: \* denotes significance at the 5 percent level.

The prices of substitute meats are not found to have significant impacts. The effect of chicken and pork prices on beef price, the effect of pork and beef prices on chicken price, and the effect of beef price on pork price are all estimated to be negative. The negative signs are puzzling since it is expected that prices of substitutes should have a positive impact. These results, however are all statistically insignificant, suggesting that the prices of other meats do not significantly impact prices of these meats. Chicken price is found to have a positive impact on pork price, but this result is only marginally significant.

Results from the beef price equation indicate that the decrease in U.S. beef exports after the BSE discovery has had a negative impact on U.S. beef price. The estimated coefficient shows that a 1 million pound decrease (increase) in quarterly exports leads to a 0.057 cent per pound decrease (increase) in beef price. Results from the pork and chicken equations suggest that the decrease in beef price did not significantly impact U.S. pork and chicken prices. However, pork prices are found to be positively impacted by exports, so the increase in pork exports in 2004, which was possibly influenced by the drop in beef exports, had a positive effect on pork prices. The estimates show that a 1 million pound increase in pork exports results in a 0.043 cent per pound increase in pork price.

The results from this model can be used to show how much of an impact the BSE case has had on domestic beef price. U.S. beef exports averaged 473 million pounds (retail weight) per quarter in 2003 and dropped to 80 million pounds per quarter in 2004, which is a decrease of 393 million pounds. According to the results of our model, a 393 million pound decline in exports, with all other factors remaining the same, would cause price to decrease by \$0.22 per pound. Therefore, if exports had remained at the same level as in 2003, the U.S. beef price would be \$0.22 per pound higher, which represents a 6 percent price increase.

The drop in exports and the resulting negative impact on beef prices also has a negative effect on U.S. cattle prices. There is a correlation between the retail beef price and the slaughter cattle price of about 0.6. Marsh (2003) shows that changes in retail beef demand are transferred to slaughter and feeder cattle prices. Marsh estimates that a 1 percent increase (decrease) in retail beef demand causes the slaughter cattle price and the feeder cattle price to increase (decrease) by 0.6 percent and 0.72 percent, respectively. The decline in U.S. exports following the BSE discovery is roughly equal to 8 percent of the demand for U.S. beef. According to results from Marsh, an 8 percent decrease in retail beef demand would cause the slaughter cattle price to decline by 4.8 percent, or about 4.1 cents per pound, and the feeder cattle price by 5.8 percent. Given that there were 16.2 million steers and 10.3 million heifers slaughtered in 2004 at an average weight of about 1240 pounds (National Agricultural Statistics Service, January 2005), a 4.1 cent per pound price reduction results in a \$1.38 billion loss in revenue for the U.S. cattle industry, which would be a 4 to 5 percent reduction in revenue (Table 2).

Table 2. The Effect of Reduced Exports on Prices and Revenue

Retail beef price decrease	22.3 cents/pound
Slaughter cattle price decrease	4.1 cents/pound
Cattle industry reduction in revenue	\$1.38 billion

U.S. beef exports in 2004 were at about 17 percent of the level of exports in 2003. Exports will increase if major beef importing countries remove their bans on U.S. beef. However, it may be unlikely that beef exports will return to previous levels because of consumer concerns and changes in consumer preference within the importing countries. Consumers in Japan and South Korea, the two most important markets for U.S. beef, are highly sensitive to BSE and prefer domestic beef or beef from BSE-free countries. It is difficult to estimate the level of exports after countries lift their bans. Exports to Mexico, Canada, and some other countries could return to 100 percent of previous levels since consumer concern in these countries is not as great as it is in Japan and South Korea.

Table 3 demonstrates how much the level of exports affects U.S. beef and cattle prices. The increments in beef price are based on the results in Table 1, while the increments in slaughter cattle price are based on the estimates from Marsh (2003). If exports increase from 17 percent to 50 percent of the previous level, with all other factors remaining the same, retail beef price increases by \$0.09 per pound and slaughter steer price increases \$0.02 per pound. If exports increase to 75 percent of the previous level, then retail beef prices increase by \$0.16 per pound and slaughter steer price increases \$0.03 per pound. Retail beef prices and slaughter steer prices increase by \$0.22 and \$0.04 per pound, respectively, if exports return to 100 percent of the previous level.

Table 3. The Effects of Increasing Exports on Beef and Cattle Prices

Export Level	Quarterly exports (million lbs)	Retail beef price increase (per pound)	Slaughter cattle price increase (per pound)
17%	80	-	-
50%	237	\$0.09	\$0.02
75%	355	\$0.16	\$0.03
100%	473	\$0.22	\$0.04

Since the results from our model do not show that beef prices have a significant impact on pork and chicken prices, the \$0.22 per pound negative effect of BSE on beef price does not significantly influence prices of these other meats. However, the increase in pork exports has had a positive effect on pork prices. Pork exports averaged 429 million pounds per quarter in 2003 and 545 million pounds per quarter in 2004. This increase has had a \$0.05 per pound positive impact on pork price, according to the results from our model.

## CONCLUSIONS

Since exports have become increasingly important for the U.S. beef industry, losing major export markets is a significant concern. After the BSE discovery in the United States in December 2003, beef exports to Japan and Korea, the most important export markets, were banned, while exports to other important markets, such as Mexico and Canada, dropped considerably. Demand in the United States was not significantly affected by the BSE case, as consumer concern in this country is not as great as in European countries and Japan. However, as U.S. beef exports had been steadily increasing, the effect of beef exports on U.S. prices has become significant. This study examines the effect of exports and other supply and demand factors on U.S. beef price.

Results show that supply has a significant, negative effect on beef price while exports have a significant, positive effect on price. These results are used to show the magnitude of the impact that the BSE case has had on domestic beef price. U.S. beef exports averaged 473 million pounds per quarter (retail weight) in 2003 but just 80 million pounds per quarter in 2004. Our results indicate that a 393 million pound decline in exports would cause beef price to decrease by \$0.22 per pound, if all other factors remain the same. The drop in exports also has a negative effect on U.S. cattle prices. If exports had remained at the same level as in 2003, the slaughter steer price would be about \$0.04 per pound higher. Results from pork and chicken price equations suggest that the decrease in beef price did not significantly impact U.S. pork and chicken prices, but pork price was positively affected by an increase in pork exports, which may have been caused in part by countries importing pork instead of beef.

Despite the major reduction in exports, actual U.S. beef and cattle prices have not declined substantially and are actually higher than in the years prior to 2003, which suggests the BSE case may have prevented further price increases. These relatively high prices could be due to reductions in cattle inventories and beef production, the ban on imports from Canada, and a strong domestic demand. These prices could lead to expansion in production, but the current uncertainty regarding export markets could restrain expansion. The reduction in production in 2004 essentially offsets the drop in exports. If production returned to previous levels or if domestic demand declined, the loss of exports would be more noticeable.

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