# Assessment of Import Restrictions on the U.S. Meat and Livestock Markets: An Application to the Case of Discovery of BSE on Canadian Cattle

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**Abstract**

The objective of this study is to investigate the impact of the discovery of BSE in Canadian cattle on the imported and domestic demand for livestock and meat in the United States. A multi-market partial equilibrium model is utilized to simulate the effects of policy-induced shifts in quantities of imports supplied from Canada on the meat and livestock industries. Our simulation results predict small effects on cattle.

**Keywords:** BSE, A multi-market partial equilibrium model, Cattle, Meat

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## 1. Introduction

The markets for meat and livestock products in the United States and Canada are highly integrated. Therefore, a shock occurring in one of the markets will affect the others. For example, changes in imported quantities of Canadian cattle to the U.S. market have impacts not only on the market for domestic livestock but also on the wholesale and retail meat markets.

Prior to the discover of Bovine Spongiform Encephalopathy (BSE) in Canadian cattle in May of 2003, the livestock and meat markets in U.S. and Canada had become almost like a single market due to the several trade liberalization agreements. The Canada-U.S. Free Trade Agreement (CUSTA) in 1989, the North American Free Trade Agreement (NAFTA) in 1994 and the Uruguay Round trade negotiation in 1995 created more open and integrated markets and provided more opportunities for cross-border trade.

The objective of this study is to investigate the effects on the U.S. imported and domestic meat and livestock markets of the discovery of BSE in Canada. To analyze the effects of the discovery of BSE on meat producers and consumers in the United States, this study examines a shift in the supply (reduction) of Canadian cattle imported to the U.S. cattle market.

A multi-market partial equilibrium approach is utilized to analyze these effects. This approach allows computing the changes in quantities and prices in the U.S. meat and livestock markets from a given percentage shift in import supply or shift in import demand. Multi-market partial equilibrium models have been used by several researchers such as Sarwar and Fox (1992) and Shui et al. (1993).

### 1.1. Beef and Cattle Trade between Canada and U.S.

Under the free trade agreements, U.S. cattle and beef imports from Canada had been increased substantially over time. The imports of Canadian slaughter cattle grew and reached a

peak of 385,582 heads in 1996:1 and declined over time until 1999 because of the expansion of slaughter capacity in Canada between 1996 and 1999 (Wohlgenant and Schmitz, 2005).

Live cattle imports are a small share of the U.S. cattle market (around 4%), most of which comes from Canada. However, these imports play an important role as an input for the U.S. meat packing industry plants since they usually have excess capacity. These plants with excess capacity rely on imports to reduce average slaughter costs (Brester and Marsh, 1999). Imports from Canada are also important since U.S. prices of livestock, in general, are higher than Canadian prices of livestock.

With exception of a temporary (June 1999- October 1999) countervailing duty (CVD) of 5.57 percent placed on the value of live cattle imported from Canada, the U.S. and Canadian livestock and meat market did not have any restrictions until the discovery in Canada of an animal infected with BSE in May 2003. This discovery prompted the United States to close its border to cattle from Canada. However, the U.S. allowed imports of Canadian boxed beef from cattle that were under 30 months of age.

In December 2003, another BSE case was found in a dairy cow of Canadian origin located in the state of Washington. Live cattle trade between the U.S. and Canada remained blocked until July 2005 and then the U.S. border was reopened to exports of live Canadian cattle that are under thirty months of age. Currently, trade of beef and cattle between the United States and Canada is still under this regulation.

### 1.2. Literature Review on the Effects of BSE on the U.S. Markets

BSE-commonly known as “mad cow disease” was originally found in the United Kingdom (UK) in 1986 and by 1992 more than 1,000 cases had been reported in Europe (Jin et al., 2004). On September 10, 2001, the first case of BSE in Japan was reported by the Japanese government. Canada’s first case of BSE was discovered in 1993 in a cow that had been imported

from the UK in 1987. There were no serious trade consequences of the discovery of BSE in 1987. On May 20, 2003, Canada confirmed that BSE was found in a single cow in northern Alberta. By the end of 2003, both beef and cattle prices went up because the United States banned imported beef and live cattle from Canada, which coincided with already tight U.S. supplies and strong demand.

In December 2003, the first case of cattle infected with BSE was found in Washington State (a dairy animal of Canadian origin). After discovery of BSE, the US reduced exports of live cattle and beef to Canada, Mexico, Japan and South Korea. As a result, beef prices declined 29 percent between December 2003 and March 2004 (Almas et al., 2005).

Marsh, Brester and Smith (2005) estimated the effects of BSE on U.S. fed steer prices between 2002 and 2004. They showed that the import share of U.S. beef supplies fell from 15.89 percent in 2002 to 14.39 percent in 2004, corresponding to the ban of live cattle imported from Canada. The decrease of the import share by 1.5 percentage resulted in an estimated $1.70/cwt increase in fed steer prices (or $20.4 per head for 1200 pound of fed steer).

VanSickle and Hodges (2005) analyzed the economic impact of the discovery of the BSE-infected Canadian cow in the United States. They concluded that the ban on importing Canadian cattle is hurting some U.S. processors because of reducing the number of slaughter cattle in the market, but their impacts are more than offset by the gains to producers by increasing herd size and gains to processors in the long run due to more domestic cattle.

## 2. Cattle/Beef Market Structure

Figure 1 shows the flowchart of the interactions among the farm sector, the processing sector, retail sector and consumer of meat production in the United States. The flowchart ignores exports because we are interested in domestic and imported demand for meat and livestock.

In the farm sector, livestock feedlots demand feeder live cattle either from the cow-calf domestic sector or from foreign countries. The feeder animals are fed until they grow up and are ready for slaughter. Hence, the feedlots supply fed animals to the processing sector. Meat processors buy fed animals from feedlots and also import fed animals from foreign countries.

Meat outputs are the final product from the meat packing industries and are shipped to the wholesale sector (supermarkets). Supermarkets order not only meat products from processors but also imported meat from Canada. Supermarkets sell both domestic meat and imported meat demanded by final consumers in the United States.

## 3. Model Development: Structural Equations

For simplicity, we assume that there are only two countries – the United States and Canada- that trade in cattle/beef. The United States is a net importer of cattle/beef, and Canada is a net exporter of cattle/beef. In order to understand the trade issues in the cattle/beef industry, a multi-market partial equilibrium model is utilized. This model allows us to examine changes in prices and quantities of livestock and meat commodities but price and quantities of other goods are fixed.

The market-level input demands are based on firm optimization (i.e., profit maximization) behavior and the market-level output demands are based on consumer maximization. Assuming perfect competition in the input and output markets, the complete structure for input and output markets of slaughter cattle is:

Input market for slaughter cattle at the processing sector:

(1) $$\frac{w_1^d}{p_1} = f_1(\frac{x_1}{z}, \frac{x_2}{z}, \frac{w_3}{p_1}, \frac{w_4}{p_1})$$ Inverse input demand for domestic slaughter cattle

(2) $$\frac{w_2^d}{p_1} = f_2(\frac{x_1}{z}, \frac{x_2}{z}, \frac{w_3}{p_1}, \frac{w_4}{p_1})$$ Inverse input demand for imported slaughter cattle

$$\frac{w_1^s}{p_1} = g_1(x_1^s),\ x_1^s \text{ is fixed}$$

$$\frac{w_2^s}{p_1} = g_2(x_2^s),\ x_2^s \text{ is fixed}$$

Output market for wholesale beef at the wholesale sector:

(3) $q_1^d = D_1(p_1, p_2, p_3, p_4, p_5, p_6, Y)$ Wholesale demand for domestic beef

(4) $q_4^d = D_4(p_1, p_2, p_3, p_4, p_5, p_6, Y)$ Wholesale demand for imported beef

$q_1^s = S_1(p_1, w_1, w_2)$ Wholesale supply for domestic beef

$q_4^s = S_2(p_4, w_2)$ Wholesale supply for imported beef

Market clearing condition for input and output market:

$\frac{w_1^d}{p_1} = \frac{w_1^s}{p_1} = \frac{w_1}{p_1}$ Market clearing domestic input price identity

$\frac{w_2^d}{p_1} = \frac{w_2^s}{p_1} = \frac{w_2}{p_1}$ Market clearing imported input price identity

$\frac{x_1^d}{z} = \frac{x_1^s}{z} = \frac{x_1}{z}$ Market clearing domestic input quantity identity

$\frac{x_2^d}{z} = \frac{x_2^s}{z} = \frac{x_2}{z}$ Market clearing imported input quantity identity

$q_1^d = q_1^s = q_1$ Market clearing domestic output quantity identity

$q_4^d = q_4^s = q_4$ Market clearing imported output quantity identity

where $x_1^d$ and $x_1^s$ are the demand and supply of slaughter domestic cattle; $x_2^d$ and $x_2^s$ are the demand and supply of slaughter imported cattle; $w_1$ and $w_2$ are the slaughter domestic and imported cattle prices; $w_3$ is the average wage rate in the meat processing industry; $w_4$ is the energy price; $q_1^d$ and $q_1^s$ are the demand and supply of domestic beef in the wholesale market;

$q_4^d$ and $q_4^s$ are the demand and supply of imported beef in the wholesale market; $p_{1,}$ $p_2$, $p_3$, $p_4$, $p_5$ and $p_6$ are the wholesale price of domestic beef, domestic pork, domestic poultry, imported beef, imported pork and non-meat, respectively; and $Y$ is the real food expenditure deflated by Stone's index.

Price linkages between farm and wholesale levels:

(5) $p_1 = h_1(w_1, w_2)$

(6) $p_4 = h_4(w_2)$

With competitive markets and with the assumption of constant returns to scale, the wholesale price of domestic beef and imported beef can be characterized by equation (5) and (6), respectively where the wholesale price of domestic beef is a function of domestic slaughter cattle price and import slaughter cattle price, and the wholesale price of imported beef is a function of imported slaughter cattle price.

Equation (1) to (6) can be totally differentiated and the partial derivatives converted into elasticities as follows:

(1)′ $d \ln w_1 = \varepsilon_{11} d \ln x_1 + \varepsilon_{12} d \ln x_2 + (1 - \phi_{13}^*(w_3/w_1) - \phi_{14}^*(w_4/w_1)) d \ln p_1$

(2)′ $d \ln w_2 = \varepsilon_{21} d \ln x_1 + \varepsilon_{22} d \ln x_2 + (1 - \phi_{23}^*(w_3/w_2) - \phi_{24}^*(w_4/w_2)) d \ln p_1$

(3)′ $d \ln q_1 = \eta_{11} d \ln p_1 + \eta_{14} d \ln p_4$

(4)′ $d \ln q_4 = \eta_{41} d \ln p_1 + \eta_{44} d \ln p_4$

(5)′ $d \ln p_1 = e_{11} d \ln w_1 + e_{12} d \ln w_2$

(6)′ $d \ln p_4 = e_{42} d \ln w_2$

where $\varepsilon_{11}$ is the own-price elasticity of demand for domestic slaughter cattle, $\varepsilon_{12}$ is the cross-price elasticity of demand for domestic slaughter cattle, $\varepsilon_{21}$ is the cross-price elasticity of demand for imported slaughter cattle, $\varepsilon_{22}$ is the own price elasticity of demand for imported slaughter

cattle, $\eta_{11}$ is the own-price elasticity of demand for domestic beef, $\eta_{14}$ is the cross price elasticity of demand for domestic beef, $\eta_{41}$ is the cross-price elasticity of demand for imported beef, $\eta_{44}$ is the own-price elasticity of demand for imported beef, $e_{11}$ is the percentage change in the domestic price of beef given a one percent change in the price of domestic slaughter cattle, $e_{12}$ is the percentage change in the domestic price of beef given a one percent change in the imported price of slaughter cattle, $e_{42}$ is the percentage change in the imported price of beef given a one percent change in the imported price of slaughter cattle, $\phi_{13}^{*}$ and $\phi_{14}^{*}$ are parameter estimated of $(w_3/w_1)$ and $(w_4/w_1)$ variable, respectively in inverse derived demand functions for domestic slaughter cattle, $\phi_{23}^{*}$ and $\phi_{24}^{*}$ are parameter estimated of $(w_3/w_2)$ and $(w_4/w_2)$ variables, respectively in inverse derived demand functions for imported slaughter cattle.

### 3.1. Economic Model of the Impact of Decrease in Supply of Canadian Cattle

We utilized the supply-demand framework to analyze the decrease in supply of Canadian cattle imports to the U.S. market. In this framework, prices and quantities of imported and domestic cattle and beef are determined by the intersection of supply and demand for cattle and beef (Figure 2). This framework contains input and output markets. The relationship between wholesale and farm price is utilized to link input and output markets.

In the Figure 2, the diagram on the left-hand side represents the U.S. market for Canadian slaughter cattle (bottom left) and the U.S. market for import beef (top left). On the U.S. market for Canadian slaughter cattle, $D_m$ denotes the derived demand for Canadian slaughter cattle by U.S. processors and $S_m$ is the supply of imported slaughter cattle from Canada which is assumed to be fixed in the short run. On the U.S. market for imported beef, $D_m$ represents the demand for

imported beef from Canada by the retail sector (supermarkets) and $S_m$ is the supply of imported beef supplied by Canadian processors to U.S. beef market.

The diagram on the right-side in Figure 2 represents the U.S. market for domestic slaughter cattle (bottom right) and the U.S. market for domestic beef (top right). On the U.S. market for domestic slaughter cattle, $D_d$ denotes the derived demand for domestic slaughter cattle by U.S. processors and $S_d$ is the supply of domestic slaughter cattle in the U.S. which is assumed to be fixed in the short run. On the U.S. market for domestic beef, $D_d$ denotes the demand for domestic beef demanded by retail sector (supermarket) and $S_d$ represents the supply of domestic beef from U.S. processors.

Suppose that the supply of cattle imports to United States from Canada decreases due to a restriction on imports of Canadian cattle. This effect is shown by a shift leftward in the Canadian supply of cattle to the United from $S_m^0$ to $S_m^1$. As result of this decrease in supply of slaughter cattle from Canada, the new equilibrium of import price and quantity becomes $w_2^1$ and $x_2^1$ where the demand of import slaughter cattle $(D_m)$ intersects with the new supply of import slaughter cattle $(S_m^1)$.

In the U.S. market for domestic slaughter cattle, the demand for domestic slaughter cattle will increase due to the increase of price of imported slaughter cattle. The increase in demand of domestic slaughter cattle will shift rightward from $D_d^0$ to $D_d^1$. The domestic cattle price will go up from $w_1^0$ to $w_1^1$. The supply of domestic slaughter cattle does not change because it is fixed in the short run.

In the U.S. market for domestic beef, the supply of domestic meat shifts upward from $S_d^0$ to $S_d^1$ because of increased costs of processing meat due to increase in domestic and imported

cattle prices. The demand for domestic meat shifts rightward from $D_d^0$ to $D_d^1$ because the price of imported beef goes up. As the result, the domestic price and quantity goes up from $p_1^0$ to $p_1^1$ and $q_1^0$ to $q_1^1$.

The increase in price of import cattle from Canada drives the beef import price up. In the U.S. market for imported beef, the supply of imported meat shifts upward from $S_m^0$ to $S_m^1$ and the demand of imported meat shifts rightward from $D_m^0$ to $D_m^1$ due to an increase in price of domestic cattle. As a result, the imported price of meat goes up from $p_4^0$ to $p_4^1$ and the quantity of imported meat goes down from $q_4^0$ to $q_4^1$ because the increase in imported price of beef has more impact than the shift in demand.

The model outlined in figure 2 is different from models that are based on the assumption of homogeneous goods. In the homogeneous-goods model, there is a single price for both imported and domestic products. In the case of live cattle, we found that imported cattle are not perfect substitutes for domestic cattle. This finding can be explained by the fact that cattle imported from Canada is generally different than the U.S. cattle since Canadian producers use different breeds and feed that cause differences in the final quality of the slaughter cattle (Wohlgenant and Schmitz, 2005).

## 4. Simulation Results of the Effect of Discovery BSE of Canadian Cow

The previous section presented a qualitative analysis of the impact of a decrease in the supply of imports of Canadian cattle to the U.S. market. This section intends to quantify the effect of such a shock. This shock is similar to the effect of discovery of BSE in Canada.

The quantification of the effect of the shocks on prices and quantities requires information on demand elasticities for each commodity in both meat and livestock markets, the

price linkage between output and input markets, the output price effect on demand for domestic cattle, and the output price effect on demand for imported cattle.

The output price effect on demand of domestic cattle is $[1-\phi_{13}^{*}(w_3/w_1)-\phi_{14}^{*}(w_4/w_1)] = A$ and the output price effect on demand of imported cattle is $[1-\phi_{23}^{*}(w_3/w_2)-\phi_{24}^{*}(w_4/w_2)] = B$. Demand elasticities for the beef market and demand elasticities for the cattle market were obtained from the elasticity results of Boonsaeng (2006). To obtain information on the price linkage between the retail and farm prices some equations had to be estimated.

Let $\ln w = k_1 \ln w_1 + k_2 \ln w_2$, where $k_1 = w_1x_1/(w_1x_1 + w_2x_2)$ and $k_2 = w_2x_2/(w_1x_1 + w_2x_2)$, then the price linkage equations of domestic and imported retail price were estimated by the log linear function and corrected for autocorrelation. These equations excluded intercept and time trend variables because the parameter results of these variables are insignificant. The estimation results were:

$$d\ln p_1 = \underset{(0.0021)^{*}}{0.7064}\, d\ln w$$

$$d\ln p_4 = \underset{(0.0051)}{0.7146}\, d\ln w_2$$

*Significant at 5 percent level of significant

Based on the results of the parameter estimates, $e_{11} = 0.7064^{*} k_1$, $e_{12} = 0.7064^{*} k_2$, and $e_{42} = 0.7146$. Table 4.1 summarizes the parameter values used in this study. The values in the bracket for beef demand equation are the Marshallian demand elasticities.

In case of the decrease in supply of imports on the U.S. cattle market, the equations $(1')$ to $(6')$ can be solved simultaneously and written in matrix form as R*EN = L*EX, where R is a (6×6) non-singular matrix of parameters, EN is the (6×1) vector of endogenous variables ($d\ln w_1$, $d\ln w_2$, $d\ln p_1$, $d\ln q_1$, $d\ln p_4$, and $d\ln q_4$), L is a (6×1) matrix of parameters, and

EN is the exogenous variable ($d \ln x_2$). In the short run, there is no change in domestic cattle supply because $x_1$ is fixed. The solution of the matrix above can be solved as EN = $R^{-1}$*L*EX. Based on parameter values in table 1, the results of this solution are showed in table 2.

Table 2 shows the effects of a one percent decrease in the supply of imported cattle. This causes the price of imported cattle to increase by 0.0734 percent, the price of domestic cattle to increase by 0.0131, the quantity of domestic beef to increase by 0.0011 (0.0006) percent, the price of domestic beef to increase by 0.0100 percent, the price of imported beef to increase by 0.0525 percent, and the quantity of imported beef to decrease by 0.0120 (0.0124). The values in the bracket are calculated by using the Marshallian demand elasticites.

The analysis can be applied in the case of a Countervailing duty and BSE. Wohlgenant and Schmitz (2005) analyzed the effect of the countervailing duty case. In their study, they found that the increase in the supply of imports by 7.2 percent causes the price of imported cattle to decrease by 2.3 percent and the price of U.S.-produced cattle to fall by 0.14 percent. Using the estimations in table 2, we find that if the supply of imports decreases by 7.2 percent, the price of imported cattle will increase by 0.5285 percent and the price of domestic cattle will increase by 0.0943 percent. Notice that the percentage increase in the U.S. cattle price is less than the percentage increase in the Canadian cattle price. Our results are qualitatively similar to Wohlgenant and Schmitz's results but are smaller in magnitude.

Suppose that the supply of imports decreases by 100 percent because the trade of live cattle between U.S. and Canada is blocked after discovery of BSE in Canada. This causes the price of domestic cattle to increase by 1.31 percent. If the initial price value of domestic cattle was $809.39 per head in 2002:4, then the expected impact on domestic cattle price would be (1.31×$809.39)/100 = $10.60 per head. Marsh, Brester and Smith (2005) found that fed steer prices would increase by $20.4 per head for a 1200 pound of fed steer.

## 5. Conclusion

Our empirical analysis of the discovery of BSE on Canadian cattle showed that the impact of the reduction of live animal exports from Canada to the United States is small. This result is similar to Wohlgenant and Schmitz's (2005) study analyzing the effect of the countervailing duty imposed to Canadian cattle in 1998. Wohlgenant and Schmitz analyzed the increase in supply of imported cattle from Canada. They showed that there is little injury to the U.S. cattle producers. We analyzed the decrease in supply of imported cattle from Canada and our result showed that there is little benefit to the U.S. cattle producers.

We found that domestic cattle price increases only 10.60 dollars per head above the price of slaughter cattle in the long run. Marsh, Brester and Smith (2005) estimated the effects of BSE on U.S. fed steer prices between 2002 and 2004. They found that fed steer price increases 20.4 dollar per head for 1200 pound.

Table 1: Parameter Values for Beef Demand, Cattle Demand and Price Linkage

| | Parameter Values |
|---|---|
| Beef Demand Equation[1] | |
| $\eta_{11}$ | -0.1636 (-0.2077)[2] |
| $\eta_{14}$ | 0.0527 (0.0496) |
| $\eta_{41}$ | 0.7582 (0.7336) |
| $\eta_{44}$ | -0.3741 (-0.3758) |
| Inverse Demand Equation for Cattle[1] | |
| $\varepsilon_{11}$ | -0.3675 |
| $\varepsilon_{12}$ | -0.0040 |
| $\varepsilon_{21}$ | -0.1818 |
| $\varepsilon_{22}$ | -0.0693 |
| Output Price Effect on Inverse Demand[1] | |
| $A^*$ | 0.9050 |
| $B^*$ | 0.4100 |
| Price Linkage Equation | |
| $e_{11}$ | 0.6939 |
| $e_{12}$ | 0.0129 |
| $e_{42}$ | 0.7146 |

[1] Parameter values are obtained from the results of Boonsaeng (2006).
[2] Numbers in beef demand equation are Hicksian (Marshaliian) elasticities.
[*] $A$ and $B$ evaluated at the mean value

Table 2: The Effect of Decrease in Canadian Live-Cattle Imports on Prices and Quantities

| | $d \ln x_2$ (Hicksian Elasticities) | $d \ln x_2$ (Marshallian Elasticities) |
|---|---|---|
| $d \ln w_1$ | -0.0131 | -0.0131 |
| $d \ln w_2$ | -0.0734 | -0.0734 |
| $d \ln q_1$ | -0.0011 | -0.0006 |
| $d \ln q_4$ | 0.0120 | 0.0124 |
| $d \ln p_1$ | -0.0100 | -0.0100 |
| $d \ln p_4$ | -0.0525 | -0.0525 |

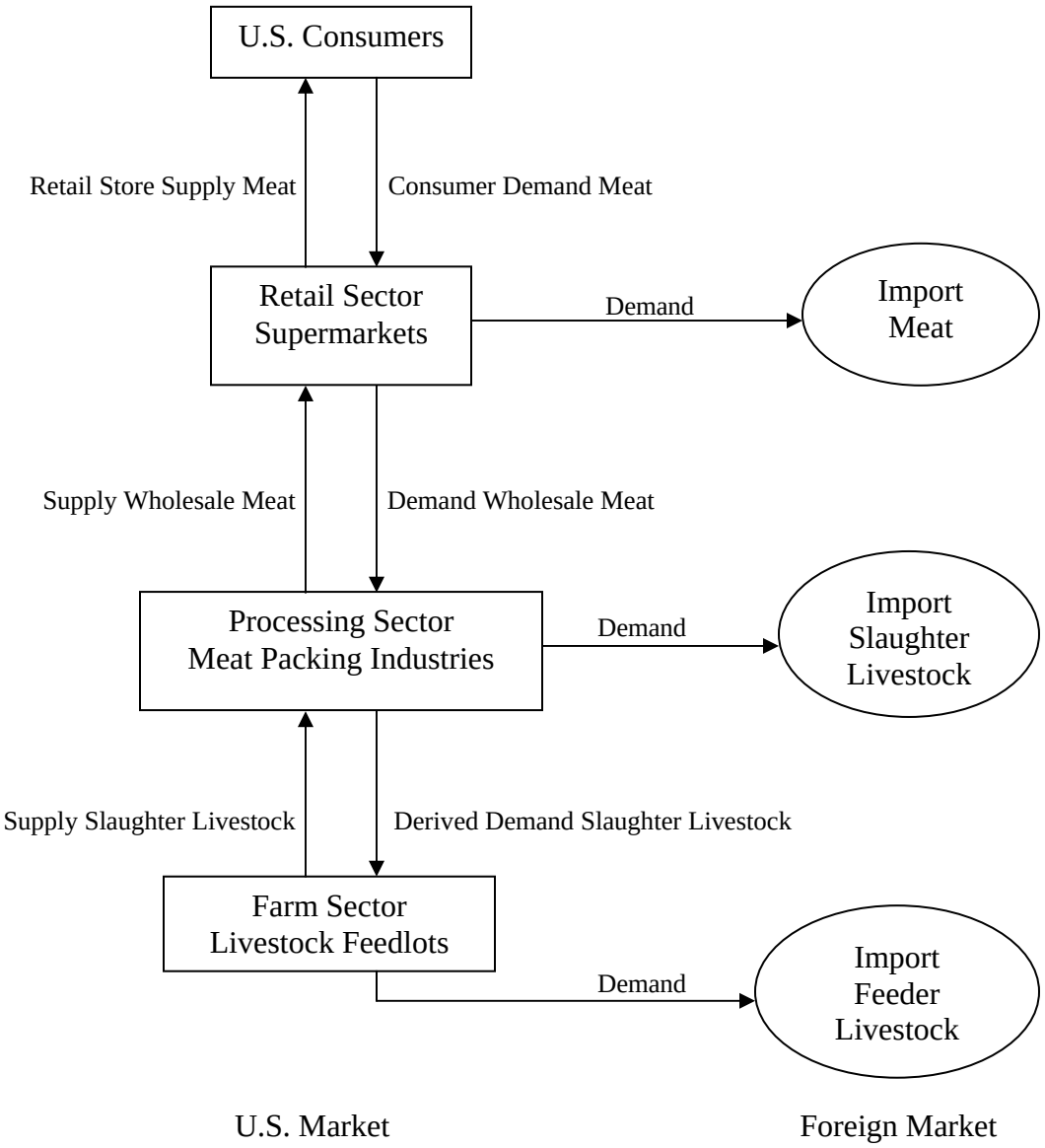
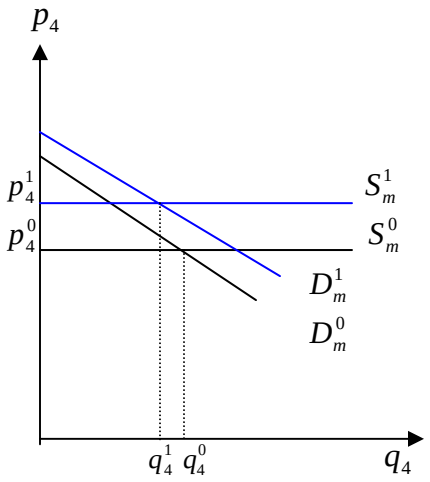
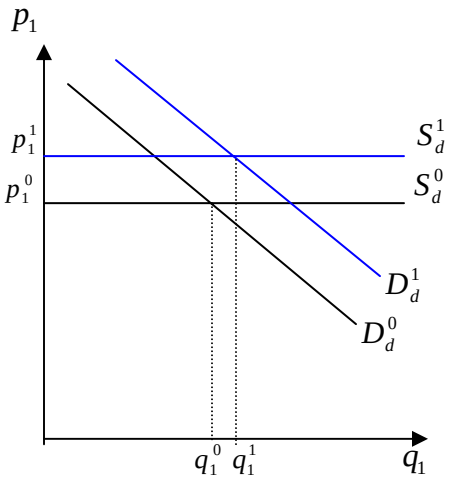



Figure 1: Flowchart of Farm Level to Consumer

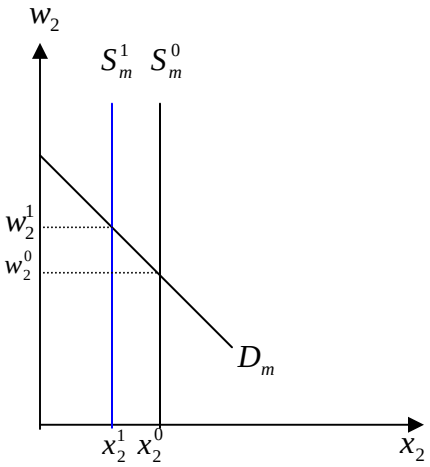
(a) The U.S. Market for Import Beef




(b) The U.S. Domestic Market for Beef




(c) The U.S. Market for Canadian Slaughter Cattle




(d) The U.S. Domestic Market for Slaughter Cattle

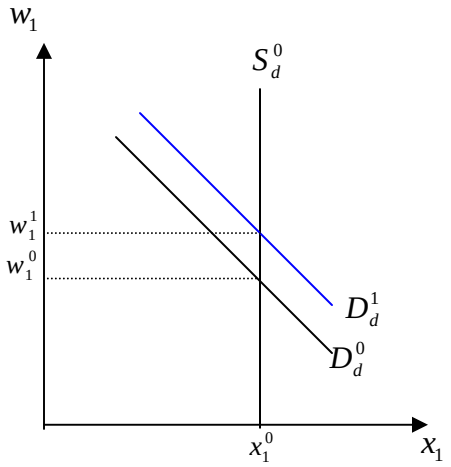



Figure 2: U.S. Markets for Canadian and U.S. Cattle and Beef

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