Welfare Implications of Animal Disease-Related Trade Restrictions:

Case of BSE-Related Export Bans on Cattle and Beef

Jeevika Weerahewa
Senior Lecturer
Department of Agricultural Economics and Business Management
Faculty of Agriculture
University of Peradeniya
Peradeniya, Sri Lanka

Maury Bredahl
Professor
Department of Food, Agricultural and Resource Economics
University of Guelph
Guelph
Ontario N1G 2W1, Canada

Randall Wigle[1]
Professor
Economics Department
Wilfrid Laurier University
Waterloo
Ontario N2L 3C5, Canada

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Abstract

Trade restrictions are sometimes necessary to ensure food safety and animal and plant health protection. Between 2003 and 2006, Canada faced a series of trade restrictions related to BSE. Some refer to the events as a crisis for the Canadian cattle and beef sector, and some estimates placed the loss for Canada s high as $5 billion. This paper examines the impacts of BSE related trade bans on cattle and beef on economic welfare and trade flows. While our analysis is global, the discussion focuses somewhat on Canada. The analysis was performed using GTAP and the GTAP data aggregated to 15 sectors and 10 regions. Four policy experiments simulated actual trade bans placed on Canadian and the US products soon after the BSE crisis were simulated. The results suggest a Canadian welfare loss of between $70 and $700 million depending on the extent of the export ban. The US, Canada and Japan were the most adversely affected. Australia and New Zealand acquired welfare gains. Not surprisingly (given the huge volume of bilateral trade) Canada's welfare is very sensitive to access to the US market, especially for cattle trade. Price and trade impacts were visible on grain and other agricultural markets as well.

Key Words: BSE, Welfare, GTAP

Introduction

The objective of this study is to quantify the welfare impacts of BSE related trade restrictions paying special emphasis on Canadian welfare and the distribution of welfare effects among major cattle and beef importing and exporting countries. It investigates the impacts of such trade restrictions, not only on cattle and beef markets, but also on other related markets such as grains, other primary agriculture, other meat products etc. To best of our knowledge, this study will provide the first quantitative assessment of the impacts of BSE crisis on the world market prices, quantities produced, consumed and traded and welfare.

The paper is organized as follows. The next section gives a brief background to the studies of BSE trade restrictions faced by Canada. The next section shows method and data. We then present the policy experiments considered. The fifth and sixth sections provide

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welfare and detailed price and trade impacts respectively. The paper ends with a summary and conclusion.

1. Background

Amid growing concern on food safety and animal and plant health protection issues around the world, there is concern that the application of sanitary and phytosanitary (SPS) measures may become a more common barrier to trade in food. For countries with heavily export oriented sectors, such trade restrictions cause greater concern. Among the SPS measures, trade bans are the most stringent and provide absolute protection from disease infestations. During the past decade, trade restrictions on live animals and meat products due to animal disease outbreaks have been prominent in this regard (Blayney et al., 2006). Export bans on poultry, chicken meat and meat products, and eggs have been used to protect birds and human from Avian Influenza and Exotic Newcastle Disease, and export bans on live ruminant animals and their meat products have been used to protect ruminants and humans from Food-and-Mouth (FMD) disease and Bovine Spongiform Encephalopathy (BSE). FMD related restrictions were applied to swine and pork trade as well.

BSE, a neurological disease of cattle, is thought to be spread primarily through consumption of animal feed containing protein from ruminants infected with BSE. Appendix table A1 shows the extent to which BSE was infected in different countries since 1990. Even though the threat of BSE on humans is considered to be small, a number of export bans on cattle and beef was imposed with diagnosis of BSE cases in the United Kingdom (in 1986), Canada (May 2003) and the United States (November 2003). While such regulations helped to minimize the risk of diseases to birds, animals and humans, they have caused substantial financial hardships on the producers and exporters in disease affected countries that relied on trade as a significant outlet for their products. In the case of BSE, the perceived risk and the fear of the disease appear to far out-weigh the actual risk and trade disruptions due to this disease have been significant.

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The estimates of losses due to BSE related trade restrictions in Canada vary widely depending upon thet assumptions underlying the calculations. According to Mitura and Di Pitro (2004) losses to a single-unincorporated beef cattle farm would be $20,000 indicating an economy-wide loss of net farm operating income of $0.22 million. By contrast, other estimates are dramatically higher. Calberg and Brewin (2005) suggested that the direct industry losses would be around $5.5 billion. According to Le Roy.et.al, (2006) they would be around $4.9 billion when loss due to reduced exports, imports and extra processing and redistribution costs are considered. These estimates focus on lost earnings, but do not account for changes in input prices or prices in other export markets. Samarajeewa et al (2006) use Statistics Canada's Input Output model and estimate an economy-wide loss of $51.2 million due to an export ban. Weerahewa, Meilke and LeRoy (2007) estimate a loss of gross revenue by $1100 million when the economy moves from free trade in cattle and beef in to autarky.

However, none of the above studies considered price adjustments in the other markets in Canada and/or other countries due to the recent BSE related export bans, when the losses were estimated. The changes happened to the equilibrium in other countries should not be considered small as some of the affected countries, such as Canada and the US, were significant trading partners. Even with reductions in exports from BSE affected countries, the global beef trade levels have not significantly declined after the BSE events, suggesting an increase in exports by BSE free exporters such as Australia, Brazil, New Zealand and Argentina to meet the demand. This study uses a general equilibrium model that captures changes in all the markets. The estimates from such models are normally smaller as demand and supply curves are considered to be imperfectly elastic.

2. Method and Data

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The global trade model of the Global Trade Analysis Project (GTAP) is used to quantify the impacts of trade actions on the world market. The GTAP model is a well-known CGE model of world trade and production with an associated highly disaggregated data set (Hertel, 2006). Products are treated as Armington substitutes. We aggregate the GTAP (version 6 with base data reflecting 2001 equilibrium) data to identify major players in the beef market (Canada, United States, Japan, South Korea, Argentina, Brazil, Australia, New Zealand, European Union and Rest of the World) and focus on 16 sectors (including cattle and other ruminant animals, beef and other ruminant meat, grains, other primary agriculture, other meat products, processed food etc.) for this study. Table 1 shows the sectoral aggregation.

3. Policy Experiments

BSE-based import restrictions imposed by beef importing countries were implemented within "cattle and other ruminants" and "beef and other ruminant meat". The closure condition of the standard GTAP model was modified to make export levels of beef and cattle exogenous. Consequently, export taxes became endogenous in the model. Four policy experiments were developed to represent selected past episodes of trade restrictions based on the actual trade restrictions (Table 2).

NoCanEx: No exports from Canada are allowed

The first experiment was to simulate the situation with bans of exports of cattle and beef from Canada by all the importing countries including the US. It reflects the environment soon after a BSE infected cow was found in Canada. This experiment depicts a situation where a small exporting country is subjected to restrictive SPS regulation.

Cattle and beef exports from Canada are among the exogenous variables in the model. Exports of all other products by all the countries are endogenous.

NoExCaUS: No exports from Canada and US are allowed

The second experiment was to simulate bans on cattle and beef exports from both the US and Canada (including one another's border). It reflects the environment with the identi-

fication of BSE infected cow in the US.   This experiment depicts a situation where two of the major exporters are subjected to restrictive SPS regulation.

Cattle and beef exports from Canada and US are among the exogenous variables in the model. Exports of all other products by all the countries are endogenous.

BeefCanUS: Beef trade is almost free between Canada and US

The third experiment was to reduce restrictions on trade of cattle between Canada and US and to reduce restrictions on beef trade. It closely reflects the current situation in the cattle and beef markets which are characterized by export bans on cattle over 30 months and beef produced from cattle over 30 months. This experiment depicts a situation where two affected exporting countries relax the restrictions on the value added product.

Cattle and beef exports from Canada and US are among the exogenous variables in the model. Exports of all other products by all the countries are endogenous.

FreeCaUS: Canada and US freely trades cattle and beef

The fourth experiment was to reduce restrictions on trade of cattle and beef between Canada and US.   It reflects the situation in the cattle and beef markets in the end of 2004 which is characterized by export bans on cattle over 30 months and beef produced from cattle over 30 months. This experiment depicts a situation where gains from trade can be achieved when affected countries get together and freely trade with each other.

Cattle and beef exports from Canada and US to the rest of the world are among the exogenous variables in the model. Exports of all other products by all the countries including cattle and beef exports between Canada and US are endogenous.

4. Results of the Welfare Analysis under Alternative Scenarios

The alternative policy scenarios were simulated to assess the economic impacts of trade bans and comparisons were made between the equilibrium in 2001. In the baseline equilibrium, Canada and the US freely trade with each other. While Japan, Korea, Argentina, Brazil and EU are having import tariffs on beef and Japan, Korea and EU are having import tariffs on cattle. Tables 3-6 show the bilateral trade flows and tariff rates for cattle and beef.

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The results of the analysis indicate that there are significant global welfare losses due to BSE related trade restrictions. Table 7 shows the loss in welfare levels under alternative scenarios. The global welfare losses amounted to $1177, 3479 and 3196 and 2222 million under first, second, third and forth scenarios respectively. The US occupied 20% of the global beef trade and 12% of the global cattle trade in the base year and export restrictions both on the US and Canada created the biggest global welfare losses as shown by the second policy experiment. Even though Canada was the biggest exporter of live cattle in 2001 occupying 19% of the market, restrictions on Canadian cattle and beef exports alone created relatively smaller global welfare losses (little over one third of the global welfare loss in the second scenario). The third scenario shows that resumption of beef trade between Canada and the US only marginally helps to reduce welfare losses. In contrast, the forth scenario shows that by resuming cattle and beef trade between the two key trading partners, Canada and the US, the global welfare loss can be reduced.

The distribution of welfare differs across regions. The BSE export restrictions were on the exports from Canada and US hence they incurred the biggest losses among the exporting countries. Japan, the biggest importer of US beef, also suffered significant losses due to the missing opportunity to trade. Losses were incurred by other importers such as EU and ROW. Among the scenarios, Canada incurred the greatest loss when the exports from US were also banned since Canada was not only an exporter, but also an importer of cattle and beef from the US. With the resumption of cattle and beef trade between Canada and US, which used to trade heavily with each other prior to BSE crisis, the welfare status of the former recovered substantially. This improvement was visible when Canada-US border was opened only for beef. The winners of the trade restrictions were BSE free exporters such as Australia, New Zealand, Brazil and Argentina under all the scenarios

Table 7 also shows the decomposition of welfare losses to assess how much of the trade restriction are attributable to given commodity and given region. The region specific

changes in allocative efficiency are further decomposed into commodity classes Huff and Hertel, 2001).

The results show that under all the scenarios investigated, the loss in welfare is mainly due to drop in allocative efficiency in the economy. The contribution of terms of trade effect and I-S effect for the welfare loss is rather small. Furthermore, among the commodities, allocative inefficiency is prominent in cattle and beef sectors.

5. Price and Trade effects under alternative scenarios

With an export ban, the prices in the infected countries will be determined internally, hence local prices in such countries will go down. Prices in the importing countries will go up as the quantities to trade will reduce. The fob prices in the remaining exporting countries will go up and subsequently prices facing the producers in such countries will go up.

The prices determined in the above manner influence trade flows. The higher the prices, the lower the imports and higher the exports are. Of course, policy experiments impose the restrictions on trade as they are exogenous under certain scenarios.

NoCanEx: No exports from Canada are allowed

In this scenario, exports of beef and cattle from Canada to the rest of countries in the world are prohibited. The percentage changes in exports from Canada, the US, supply prices in the regions and aggregate imports by regions are presented in table 8. The reduction in exports of beef and cattle increases exports of grains and other agricultural products by Canada to all other countries by approximately 7 percent and 9 percent respectively. Recall, both Canada and the US both exporters and importers of cattle and beef to each other. With the imposition of this trade ban, the exports of beef and cattle from the US to Canada decreases. It increases exports of US beef to Japan but reduces the same to all of other the countries. There is a small increase in cattle exports from the US to Japan, Korea, Australia and New Zealand, along with a small decrease in US cattle exports to Argentina, Brazil, EU and ROW.

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The prices of beef, cattle, grains and other agricultural products decrease by 2.77, 4.72, 1.38 and 1.87 percent in Canada. There is a sharp drop in land prices (by 19.52 percent) along with small reductions in wage rates of skilled and unskilled labor. The prices of cattle, beef and related sectors rise by less than one percent in other countries.

Aggregate imports of cattle and beef into Canada, the US, Japan and Korea decrease. While both cattle and beef imports by Canada decreases by 18 percent, cattle and beef imports by the US decreases by 42.63 and 19.32 percent. Imports into the major beef importing countries such as Japan and Korea decrease only by 3.45 and 2.04 percent respectively. There are very small increases in imports of the same products into Australia and New Zealand.

NoExCaUS: No exports from Canada and US are allowed

In this scenario, exports of beef and cattle from Canada and the US to the rest of countries in the world are prohibited, including the trade between the two countries. The percentage changes in exports from Canada, the US, supply prices in the regions and aggregate imports by regions are presented in table 9. The reduction in exports of beef and cattle significantly increases exports of grains and other agricultural products from Canada to all other countries. The exports of grains and other agricultural products from the US to Canada decrease by 4.78 and 0.75 percent respectively. The exports of the same from the US to other countries increase slightly.

The prices of beef, cattle, grains and other agricultural products decrease in Canada, largest reduction being the cattle price by 4.23 percent. There is a sharp drop in land price by 17.90 percent along with small reductions in wage rates of skilled and unskilled labor. The prices of cattle, beef and related sectors decrease in the US and increase in other countries by less than one percent.

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Aggregate imports of cattle into Canada, the US, Japan, Korea and Argentina decrease by 58.22, 46.32, 40.21, 19.38 and 11.86 percent respectively. Aggregate imports of beef into Canada, the US, Japan, Korea and Argentina decrease by 37.90, 22.83, 34.56, 27.83 and 6.73 percent respectively. There is an increase in imports of the same product into Australia and New Zealand by 3.24 and 1.18 percent respectively.

BeefCanUS: Beef trade is almost free between Canada and US

In this scenario, exports of cattle and beef from Canada and the US to the rest of countries in the world are prohibited but beef is freely traded between Canada and the US. The percentage changes in exports from Canada, the US, supply prices in the regions and aggregate imports by regions are presented in table 10. The reduction in exports of beef and cattle due to the ban increases exports of grains and other agricultural products from Canada to the US and other countries. Grain and other agricultural products exports from the US to Canada decreases by 3.33% but they increase to other countries, especially to Australia.

The prices of beef, cattle, grains and other agricultural products decrease in Canada by 0.78, 3.05, 0.95 and 1.28 percent respectively. There is a sharp drop in land prices, by 13.61 percent, along with small reductions in wage rates of skilled and unskilled labor by less than one percent. The prices of cattle, beef and related sectors drops marginally in the US and they rise in other countries.

Aggregate imports of cattle into Canada, the US, Japan and Korea decrease by 56.76, 46.55, 40.20 and 19.25 percent respectively. Beef imports into all the countries decrease, except for Australia which shows a small rise by 1.41 percent.

FreeCaUS: Canada and US freely trades cattle and beef

In this scenario, exports of beef and cattle from Canada to the rest of countries in the world are prohibited yet trade in cattle and beef between Canada and US is free. The

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percentage changes in exports from Canada, the US, supply prices in the regions and aggregate imports by regions are presented in table 11.

Exports of cattle from Canada to the US go down by 3.74 percent but exports of beef from Canada to the US increases by 3.23 percent compared to free trade scenario. The exports of cattle from the US to Canada go down by 3.76 percent and exports of beef from the US to Canada decreases by 0.94 percent compared to free trade scenario.

Land prices in Canada and the US go down only by 3.67 and 1.56 respectively. Almost all the prices in Canada and the US go down, but prices in other countries go up marginally.

Cattle and beef imports to Japan go down by 40.18 and 34.02 percent respectively and to Korea go down by 19.16 and 27.48 percent respectively. Aggregate imports of cattle and beef into the US and Canada decrease by around 5 percent.

6. Summary and Conclusion

In summary, BSE related trade restrictions caused significant welfare losses to BSE affected exporting regions and their traditional importers. Japan, in particular faces significant welfare losses in most scearios as a result of terms of trade deterioration and allocative efficiency losses. Japan suffers as they produce more cattle and beef domestically. The restrictions on Canadian and/or US exports benefited the welfare of their export competitors but caused a net welfare loss at the global level. Canada and the US recover, to a significant extent, with the resumption of the bilateral trade.

7. Extensions

Two additional questions interest us. First, this paper uses a standard long run closure of GTAP. This implies fluid movement of factors between sectors, and doesn't reflect the challenge faced when an unexpected export ban comes about. We would also like to compare our welfare losses from the trade barriers to estimates of the benefits (from risk reduction) associated with the trade bans.

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Table 1: Sectoral Aggregation

Number	Code	Description
1	CCF	Cattle,sheep,goats,horses
2	BFM	Meat: cattle,sheep,goats,horse
3	GRA	Paddy rice, Wheat, Cereal grains nec., Oil seeds
4	OAG	Vegetables, fruit, nuts, Sugar cane, sugar beet, Plant-based fibers, Crops nec, Sugar
5	PRI	Wool, silk-worm cocoons, Forestry, Fishing, Minerals nec.
6	MFD	Animal products nec., Raw milk, Meat products nec., Dairy products
7	PFD	Vegetable oils and fats, Processed rice, Food products nec., Beverages and tobacco products
8	TCL	Textiles, Wearing apparel
9	FUEL	Coal, Oil, Gas, Petroleum, coal products
10	MF1	Leather products, Wood products, Paper products, publishing, Chemical, rubber, plastic products, Mineral products nec, Ferrous metals, Metals nec, Metal products
11	MF2	Motor vehicles and parts, Transport equipment nec, Electronic equipment, Machinery and equipment nec., Manufactures nec.
12	CON	Construction
13	TUC	Electricity, Gas manufacture, distribution, Water, Transport nec., Sea transport, Air transport, Communication
14	BSV	Trade, Financial services nec, Insurance, Business service nec., Dwellings
15	PUB	PubAdmin/Defence/Health/Educat
16	AME	Recreation and other services

Table 2: BSE Trade restrictions: Chronological Order

Month and year	BSE Trade Restrictions	Other BSE Events
May 20, 2003	International borders were closed for all bovine products, live animals and beef from Canada	Canadian official announced that a BSE infected cow was discovered.
August 08, 2003	US relaxed its ban on imports of Canadian beef from cattle less than 30 months age.	
December 23, 2003	All the beef importing countries banned U.S. cattle and beef prod-ucts.	Second BSE case hit in Washington (the cow was born in a Canadian farm)
October, 2004	U.S. and Japan negotiated a new threshold for beef: Beef from cattle under 20 months of age	
December 01, 2004	Hong Kong has agreed to resume trade in Canadian beef from cattle under 30 months.	
December 14, 2004	Cuba has agreed to reopen its bor-der for Canadian beef products	
December 29, 2004		US recognized Canada as a low BSE risk country
January, 2005		Two more BSE cases were confirmed in Canada
May, 2005		New country categories were announced by OIE: • Negligible BSE Risk • Controlled BSE Risk • Undertermined BSE Risk
July 08, 2005	New Zealand agreed to lift its re-maining BSE related restrictions on Canadian beef	
July, 2005	US border opened for Canadian cat-tle under 30 months.	
December 11, 2005	Japan agreed to reopen its border for Canadian beef from cattle under 20 months.	
February 01, 2006	Mexico has announced its decision to access to a wide range of Cana-dian beef products.	
August 24, 2006		Another BSE infected cow in Canada

Table 3: Exports of cattle in 2001 (*export sales of commodity cattle from r to region s*)in $US million

From—To	1 Canada	2 US	3 Japan	4 Korea	5 Argentina	6 Australia	7 NewZealand	8 Brazil	9 EU	10 ROW	Total
1 Canada	0	1287.52	5.8	0.24	0	0.15	0.01	0.08	1.67	23.62	1319.1
2 US	209.4	0	95.8	3.6	0.9	7.26	0.51	0.63	188.59	270.62	777.31
3 Japan	0	11.67	0	0.04	0	0.5	0.05	0	16.74	1.36	30.37
4 Korea	0	0	0	0	0	0	0	0	0.09	0.01	0.11
5 Argentina	0.02	11.94	0	0	0	0	0	0.36	6.07	2.76	21.14
6 Australia	0.09	24.56	21.85	2.84	0.07	0	17.26	0	0.77	776.69	844.12
7 NewZealand	3.88	5.93	3.04	0.16	0.15	23.94	0	0.02	4.96	23.03	65.1
8 Brazil	0	4.38	0	0	0.08	0	0	0	0.72	0.56	5.74
9 EU	4.08	278.3	28.39	1.65	0.56	4.92	0.31	1.28	1697.09	330.85	2347.43
10 ROW	5.69	522.96	11.29	2.55	3.09	2.23	0.46	7.54	615.69	783.93	1955.4
Total	223.16	2147.26	166.17	11.08	4.84	39	18.61	9.9	2532.38	2213.42	7365.83

Source: GTAP database

Table 4: Exports of beef in 2001 (*export sales of commodity beef from r to region s*)in in $US million S$

From—To	1 Canada	2 US	3 Japan	4 Korea	5 Argentina	6 Australia	7 NewZealand	8 Brazil	9 EU	10 ROW	Total
1 Canada	0	1201.35	219.75	27.7	0.26	0.3	0.64	0.2	63.76	297.5	1811.44
2 US	310.07	0	2833.48	617.08	4.89	3.22	0.7	1.51	162.16	1442.38	5375.49
3 Japan	0.11	6.49	0	7.87	0.02	0.27	0.01	0.11	7.83	7.11	29.82
4 Korea	0.14	2.07	3.1	0	0.05	0.06	0.01	0.04	2	4.92	12.39
5 Argentina	13.8	96.78	7.16	0.33	0	0.11	0.03	24.11	237.3	103.92	483.53
6 Australia	160.47	1233.25	1621.06	225.53	0.06	0	22.87	0.11	131.54	986.64	4381.53
7 NewZeal-and	164.19	676.24	134.27	45.44	0.1	6.82	0	0.07	751.69	519.37	2298.18
8 Brazil	3.25	109.49	6.92	0.22	7.08	0.27	0.22	0	1360.49	539.17	2027.1
9 EU	10.65	80.23	58.6	7.25	4.75	5.65	1.18	5.45	5965.03	1203.42	7342.21
10 ROW	97.91	195.75	84.14	16.89	20.71	9.02	2.08	50.59	874.1	1515.94	2867.13
Total	760.6	3601.63	4968.46	948.3	37.92	25.72	27.75	82.18	9555.88	6620.37	26628.81

Source: GTAP database

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Table 5: Bilateral Import Tariffs on Cattle in 2001

rTMS	1 Canada	2 US	3 Japan	4 Korea	5 Argentina	6 Australia	7 NewZealand	8 Brazil	9 EU	10 ROW
1 Canada	0	0	23.78	0.08	0	0	0	0.03	0.57	6.13
2 US	0	0	15.68	5.91	0.76	0	0	0.34	0.73	0.25
3 Japan	0	0	0	8.12	0	0	0	0	0.33	0
4 Korea	0	0	6.28	0	0	0	0	0	3.43	1.38
5 Argentina	0	0	0	0	0	0	0	0	5.35	5.34
6 Australia	0	0	52.29	13.17	0.29	0	0	0	3.78	2.88
7 NewZealand	0	0	44.03	8	0.56	0	0	0.53	1.46	1.38
8 Brazil	0	0	0	0	0	0	0	0	2.1	2.86
9 EU	0	0	13.64	7.04	3.46	0	0	1.7	0	2.47
10 ROW	0	0	5.19	1.08	0.95	0	0	0.07	15.93	5.91

Source: GTAP database

Table 6: Bilateral Import Tariffs on Beef in 2001

rTMS	1 Canada	2 US	3 Japan	4 Korea	5 Argentina	6 Australia	7 NewZealand	8 Brazil	9 EU	10 ROW
1 Canada	0	0	40.56	33.64	10.19	0	0	11.58	9.85	9.12
2 US	0.01	0	43.25	38	10.86	0	0.06	11.25	19.81	9.07
3 Japan	0	1.43	0	10.35	0	0	5	8.5	7.83	10.96
4 Korea	6.54	0.38	26.18	0	0	0	0	0	0	20.16
5 Argentina	13.22	4.89	0.07	40.9	0	0	0	0	29.59	16.78
6 Australia	11.7	4.51	45.55	37.77	0	0	0	11.5	10.99	13.82
7 NewZealand	9.66	4.48	28.68	35.38	13.5	0	0	11.5	2.61	14.16
8 Brazil	2.81	4.09	6.6	40.9	0	0	0	0	112.91	10.08
9 EU	1.92	1.38	80.61	8.31	4.6	0	0.64	10.23	0	26.08
10 ROW	17.11	2.56	22.07	16.1	0.61	0	0.15	0.51	51.15	16.72

Source: GTAP database

Table 7: Results of the Welfare Analysis (Equivalent Variation in $US million)

Experiment	Region	EV	Allocative efficiency effect	Terms of trade effect	IS effect	Allocative efficiency breakdown by commodity				
						CCF	BFM	GRA	OAG	MFD
NoCanEx: Canadian exports are restricted	Canada	-535.57	-855.12	268.86	50.7	-574.86	-307.79	3.32	11.7	-12.67
	US	-357.69	-11.29	-304.38	-42.02	-7.15	29.48	-8.78	2.96	-0.16
	Japan	-90.38	-36.62	-53.38	-0.39	-3.13	-47.28	17.22	-2.62	5.6
	Korea	-23.38	-7.17	-18.5	2.3	0.01	-4.85	-1.46	0.66	0.18
	Argentina	9.09	2.49	7.38	-0.78	2.22	1.33	-0.44	-0.34	-0.07
	Australia	87.4	3.43	85.36	-1.39	-0.08	0	0.12	-0.25	-0.04
	NewZealand	35.49	2.18	37.28	-3.96	-0.04	-0.01	-0.01	0	0
	Brazil	11.97	1.25	11.11	-0.39	-0.39	1.8	0.11	0.03	0.01
	EU	-196.41	-221	31.92	-7.32	-2.47	-60.32	-0.74	-2.24	-7.73
	ROW	-117.02	-54.92	-65.43	3.32	8.87	-9.93	-5.51	4.69	-1.5
	Total	-1176.5	-1176.78	0.21	0.07	-577.03	-397.58	3.83	14.59	-16.37
NoExCaUS: Both Canadian and US exports are restricted	Canada	-713.65	-844.45	59.45	71.35	-557.24	-294.51	2.77	10.45	-14.75
	US	-1278.93	-1233.38	240.1	-285.65	-423.47	-769.51	9.71	-6.5	-2.32
	Japan	-999.21	-570.86	-468.98	40.63	-30.05	-553.53	69.57	-13.31	30.25
	Korea	-159.57	-36.24	-139.74	16.41	-0.1	-93.42	62.01	3.8	0.05
	Argentina	22.37	5.95	16.37	0.05	3.85	2.52	-0.7	-0.57	-0.07
	Australia	397.4	17	381.73	-1.32	-0.32	0	0.48	-0.98	-0.09
	NewZealand	98.39	6.45	102.08	-10.13	-0.11	-0.04	-0.02	-0.01	0
	Brazil	54.81	7.42	44.26	3.13	-1.07	5.42	0.2	0.08	0.11
	EU	-576.34	-675.53	49.42	49.77	-2.39	-277.48	-2.54	-4.16	-25.83
	ROW	-324.67	-154.74	-285.71	115.78	27.82	-39.64	16.85	5.99	-1.52
	Total	-3479.4	-3478.38	-1.02	0.02	-983.07	-2020.2	158.33	-5.22	-14.18

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Table 7 (ctd): Results of the Welfare Analysis (Equivalent Variation in $US million)

Experiment	Region	EV	Allocative efficiency effect	Terms of trade effect	IS effect	Allocative efficiency breakdown by commodity				
						CCF	BFM	GRA	OAG	MFD
BfCanUS: US relaxes restrictions on Canadian beef	Canada	-471.39	-650.72	126.24	53.1	-553.46	-98.48	1.83	7.46	-10.71
	US	-1233.26	-1202.53	242.82	-273.55	-425.93	-742.51	9.46	-6.52	-1.89
	Japan	-980.04	-564.63	-456.2	40.78	-29.65	-547.03	66.6	-11.11	29
	Korea	-153.98	-35.62	-134.22	15.85	-0.1	-92.45	61.36	3.5	0.23
	Argentina	15.52	3.71	11.11	0.7	2.62	1.14	-0.44	-0.38	-0.05
	Australia	332.96	13.96	319.52	-0.52	-0.27	-0.01	0.39	-0.84	-0.07
	NewZealand	63.37	4.27	65.38	-6.28	-0.07	-0.04	-0.02	-0.01	-0.01
	Brazil	48.38	6.52	38.77	3.09	-0.89	4.42	0.14	0.05	0.1
	EU	-528.48	-629.97	49.51	51.98	-2.24	-250.87	-2.71	-3.54	-21
	ROW	-289.28	-140.61	-263.47	114.8	27.16	-38.72	18.63	5.34	0.6
	Total	-3196.2	-3195.61	-0.54	-0.04	-982.83	-1764.55	155.24	-6.05	-3.78
FreeCaUS: US and Canada freely trades with each other	Canada	-61.8	-100.19	14.2	24.19	-7.45	-95.18	0.35	1.67	-2.78
	US	-748.09	-959.8	432.21	-220.5	-185.41	-760.39	17.86	-8.52	-2.36
	Japan	-976.49	-568.64	-442.69	34.84	-29.03	-544.72	59.69	-10.55	28.01
	Korea	-145.8	-31.28	-127.17	12.66	-0.09	-92.13	65.08	3.32	0.04
	Argentina	11.54	3.22	7.64	0.68	1.59	1.09	-0.29	-0.22	0
	Australia	316.16	13.7	302.81	-0.34	-0.25	-0.01	0.36	-0.78	-0.05
	NewZealand	46.45	3.18	48.43	-5.17	-0.05	-0.03	-0.01	0	0.01
	Brazil	45.05	6.5	35	3.55	-0.79	4.17	0.13	0.06	0.11
	EU	-414.24	-472.69	6.82	51.63	0.44	-246.42	-1.12	-1.71	-15.62
	ROW	-294.59	-115.29	-277.7	98.4	17.53	-38.07	20.65	2.19	1.5
	Total	-2221.81	-2221.29	-0.45	-0.06	-203.52	-1771.69	162.72	-14.53	8.87

Table 8: The percentage changes in exports from Canada, the US, supply prices in the regions and aggregate imports by regions: Experiment 'NoCanEX' (*No exports from Canada are allowed*)

Variable	Sector	Canada	US	Japan	Korea	Argentina	Australia	NewZealand	Brazil	EU	ROW
Exports from Canada	CCF	0.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00
	BFM	0.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00
	GRA	2.34	6.72	7.29	8.08	8.10	9.43	9.14	7.89	7.72	7.64
	OAG	8.68	8.88	8.08	8.31	8.87	9.70	9.51	8.89	8.93	9.01
	PRI	0.59	0.01	0.03	0.06	0.01	0.20	-0.19	-0.01	0.01	0.01
	MFD	4.31	4.64	5.32	5.61	5.49	5.89	6.02	5.53	5.28	5.45
Exports from US	CCF	-18.18	88.49	2.68	0.87	-1.00	0.96	3.26	-0.50	-1.23	-0.13
	BFM	-20.56	24.47	0.05	-0.03	-4.89	-1.80	-0.86	-5.67	-5.47	-1.99
	GRA	-6.01	-1.83	-1.01	-0.33	-0.46	0.88	0.65	-0.50	-0.66	-0.75
	OAG	-1.50	-0.70	-0.25	-0.20	-0.31	0.18	0.21	-0.33	-0.34	-0.34
	PRI	0.59	0.00	0.02	0.06	0.00	0.19	-0.20	-0.02	0.00	0.00
	MFD	-2.02	-1.63	-0.85	-0.53	-0.68	-0.33	-0.20	-0.60	-0.85	-0.70
Supply prices	Land	-19.52	0.87	0.08	0.14	0.33	1.60	2.53	0.26	0.25	0.12
	UnSkLab	-0.30	0.01	0.00	-0.01	0.03	0.16	0.28	0.02	0.00	0.00
	SkLab	-0.21	0.00	0.00	-0.01	0.03	0.14	0.21	0.02	0.00	0.00
	Capital	-0.32	0.01	0.00	-0.01	0.03	0.12	0.19	0.02	0.01	0.00
	NatRes	1.12	-0.02	0.04	0.07	-0.09	-0.38	-0.69	-0.06	-0.01	-0.02
	CCF	-4.72	0.53	0.05	0.07	0.20	0.63	0.54	0.08	0.08	0.10
	BFM	-2.77	0.89	0.04	0.05	0.13	0.32	0.39	0.05	0.03	0.06
	GRA	-1.38	0.13	0.00	0.06	0.05	0.21	0.37	0.03	0.02	0.02
	OAG	-1.87	0.09	0.01	0.04	0.06	0.25	0.29	0.03	0.02	0.02
	PRI	0.00	0.01	0.01	0.01	0.02	0.08	0.13	0.01	0.01	0.00
	MFD	-0.74	0.14	0.04	0.03	0.05	0.22	0.25	0.03	0.01	0.02
Aggregate Imports	CCF	-18.12	-42.63	-1.37	-1.61	0.23	0.76	2.88	0.08	0.27	-0.66
	BFM	-18.41	-19.32	-3.45	-2.04	-0.41	1.66	0.84	-0.16	-0.48	-3.28
	GRA	-5.95	3.55	0.39	0.10	0.00	1.21	2.11	0.00	0.06	0.30
	OAG	-1.41	0.48	0.01	-0.03	0.09	0.42	0.15	0.04	0.02	0.03
	PRI	0.58	0.00	-0.01	-0.02	-0.01	0.15	-0.21	-0.02	-0.01	-0.02
	MFD	-1.88	1.32	0.04	-0.07	0.08	0.69	0.55	0.04	0.00	-0.09

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Table 9: The percentage changes in exports from Canada, the US, supply prices in the regions and aggregate imports by regions: Experiment *'NoExCaUS' (No exports from Canada and US are allowed)*

Variable	Sector	Canada	US	Japan	Korea	Argentina	Australia	NewZealand	Brazil	EU	ROW
Exports from Canada	CCF	0.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00
	BFM	0.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00
	GRA	1.45	4.48	8.48	8.15	7.74	13.81	14.33	7.79	7.35	7.22
	OAG	7.66	7.94	8.27	8.49	8.55	11.06	10.60	8.59	8.53	8.68
	PRI	0.60	-0.01	0.23	0.30	0.11	0.90	-0.35	0.03	0.15	0.15
	MFD	3.91	4.06	6.55	6.13	5.75	8.82	8.83	5.98	5.38	5.81
Exports from US	CCF	-100.00	0.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00
	BFM	-100.00	0.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00
	GRA	-4.78	-1.74	2.22	1.87	1.34	7.16	7.69	1.53	1.12	0.99
	OAG	-0.75	0.20	1.43	1.53	1.04	3.10	2.82	1.06	0.96	1.03
	PRI	0.62	0.03	0.25	0.32	0.14	0.93	-0.33	0.05	0.17	0.17
	MFD	-1.40	-1.15	1.31	0.95	0.57	3.44	3.47	0.82	0.23	0.64
Supply prices	Land	-17.90	-0.88	1.72	1.09	0.67	7.25	8.20	0.81	0.74	0.35
	UnSkLab	-0.33	-0.05	0.02	-0.04	0.08	0.72	0.78	0.07	0.02	0.03
	SkLab	-0.24	-0.04	0.01	-0.05	0.07	0.63	0.58	0.07	0.01	0.01
	Capital	-0.34	-0.05	0.02	-0.04	0.07	0.55	0.53	0.08	0.03	0.02
	NatRes	1.20	0.12	0.20	0.45	-0.16	-1.56	-1.76	-0.16	0.02	-0.02
	CCF	-4.23	-0.18	1.05	0.63	0.38	2.72	1.62	0.26	0.24	0.25
	BFM	-1.17	0.61	0.70	0.48	0.26	1.40	1.15	0.17	0.17	0.32
	GRA	-1.29	-0.17	0.18	0.38	0.13	0.98	1.12	0.12	0.06	0.09
	OAG	-1.74	-0.14	0.18	0.31	0.14	1.13	0.86	0.12	0.06	0.08
	PRI	-0.01	-0.02	0.06	0.06	0.07	0.36	0.39	0.06	0.03	0.03
	MFD	-0.71	0.03	0.47	0.27	0.11	0.96	0.75	0.12	0.04	0.07
Aggregate Imports	CCF	-58.22	-46.32	-40.21	-19.38	-11.86	-6.93	3.82	-2.77	-3.31	-9.03
	BFM	-37.90	-22.83	-34.56	-27.83	-6.73	3.24	1.18	-1.08	-1.30	-16.33
	GRA	-4.94	1.31	2.41	0.76	0.28	6.22	4.91	0.07	0.15	0.53
	OAG	-1.30	-0.12	0.37	0.20	0.15	2.01	0.32	0.12	0.04	0.05
	PRI	0.54	-0.12	-0.05	-0.11	-0.03	0.69	-0.50	-0.06	-0.02	-0.09
	MFD	-1.80	0.49	0.96	0.45	0.11	2.36	0.55	0.30	0.01	-0.19

Table 10: The percentage changes in exports from Canada, the US, supply prices in the regions and aggregate imports by regions: Experiment *'BeefCanUS' (Beef trade is almost free between Canada and US)*

Variable	Sector	Canada	US	Japan	Korea	Argentina	Australia	NewZealand	Brazil	EU	ROW
Exports from Canada	CCF	0.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00
	BFM	0.00	-10.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00
	GRA	0.99	2.97	6.66	6.13	5.66	10.71	10.36	5.73	5.42	5.31
	OAG	5.52	5.75	6.20	6.36	6.27	8.30	7.81	6.32	6.29	6.41
	PRI	0.39	-0.01	0.21	0.25	0.11	0.75	-0.16	0.04	0.15	0.14
	MFD	2.71	2.78	5.05	4.52	4.16	6.61	6.45	4.36	3.92	4.25
Exports from US	CCF	-100.00	0.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00
	BFM	0.00	0.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00
	GRA	-3.33	-1.29	2.38	1.84	1.28	6.21	5.90	1.46	1.16	1.05
	OAG	-0.43	0.32	1.38	1.47	1.00	2.71	2.36	1.03	0.97	1.03
	PRI	0.40	0.02	0.23	0.27	0.14	0.77	-0.14	0.06	0.16	0.16
	MFD	-0.96	-0.82	1.44	0.95	0.59	2.92	2.78	0.81	0.37	0.69
Supply prices	Land	-13.61	-0.92	1.72	1.06	0.49	6.12	5.66	0.69	0.73	0.34
	UnSkLab	-0.21	-0.06	0.02	-0.04	0.06	0.60	0.51	0.06	0.02	0.03
	SkLab	-0.16	-0.04	0.02	-0.05	0.05	0.53	0.38	0.06	0.01	0.01
	Capital	-0.23	-0.05	0.03	-0.04	0.05	0.46	0.35	0.07	0.03	0.02
	NatRes	0.78	0.12	0.18	0.40	-0.11	-1.30	-1.10	-0.13	0.02	-0.02
	CCF	-3.05	-0.21	1.06	0.62	0.27	2.30	1.10	0.23	0.23	0.24
	BFM	-0.78	0.55	0.70	0.47	0.18	1.18	0.78	0.14	0.17	0.31
	GRA	-0.95	-0.18	0.19	0.37	0.10	0.83	0.75	0.11	0.06	0.08
	OAG	-1.28	-0.14	0.18	0.30	0.11	0.95	0.58	0.10	0.06	0.08
	PRI	-0.02	-0.02	0.05	0.05	0.05	0.30	0.27	0.05	0.03	0.03
	MFD	-0.51	0.00	0.47	0.26	0.08	0.81	0.51	0.10	0.04	0.07
Aggregate Imports	CCF	-56.76	-46.55	-40.20	-19.25	-12.18	-7.42	0.80	-3.16	-3.39	-8.89
	BFM	-5.93	-3.48	-34.17	-27.58	-6.94	1.41	-1.16	-1.13	-1.20	-16.13
	GRA	-3.49	0.60	2.32	0.76	0.21	5.30	3.23	0.08	0.13	0.46
	OAG	-0.95	-0.20	0.38	0.22	0.10	1.71	0.13	0.10	0.04	0.06
	PRI	0.32	-0.12	-0.04	-0.10	-0.02	0.57	-0.30	-0.05	-0.02	-0.07
	MFD	-1.30	0.17	0.99	0.48	0.04	2.05	0.10	0.27	0.01	-0.11

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Table 11: The percentage changes in exports from Canada, the US, supply prices in the regions and aggregate imports by regions: Experiment *'FreeCaUS' (Canada and US freely trades cattle and beef)*

Variable	Sector	Canada	US	Japan	Korea	Argentina	Australia	NewZealand	Brazil	EU	ROW
Exports from Canada	CCF	-2.79	-3.74	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00
	BFM	0.72	3.23	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00
	GRA	-0.35	-0.56	2.93	1.98	1.51	6.09	5.41	1.73	1.45	1.37
	OAG	1.15	1.21	2.09	2.12	1.75	3.42	2.98	1.81	1.72	1.80
	PRI	0.09	-0.05	0.15	0.18	0.06	0.66	-0.16	0.00	0.09	0.09
	MFD	0.55	0.34	2.29	1.55	1.34	3.70	3.55	1.53	1.17	1.40
Exports from US	CCF	-3.76	-3.97	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00
	BFM	-0.94	1.66	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00	-100.00
	GRA	-0.24	-0.38	3.08	2.13	1.62	6.23	5.55	1.87	1.59	1.52
	OAG	0.41	0.71	1.59	1.65	1.22	2.80	2.36	1.27	1.19	1.24
	PRI	0.16	0.03	0.22	0.25	0.13	0.73	-0.09	0.06	0.16	0.16
	MFD	0.37	0.20	2.13	1.39	1.18	3.53	3.38	1.37	1.01	1.25
Supply prices	Land	-3.67	-1.56	1.71	1.00	0.30	5.63	3.59	0.58	0.43	0.21
	UnSkLab	-0.05	-0.06	0.02	-0.03	0.04	0.57	0.40	0.06	0.02	0.02
	SkLab	-0.03	-0.04	0.02	-0.05	0.04	0.50	0.30	0.06	0.01	0.01
	Capital	-0.05	-0.05	0.03	-0.04	0.04	0.43	0.28	0.07	0.02	0.02
	NatRes	0.23	0.13	0.16	0.39	-0.07	-1.22	-0.87	-0.11	0.03	0.00
	CCF	-0.80	-0.63	1.05	0.60	0.17	2.14	0.77	0.20	0.16	0.15
	BFM	-0.47	-0.26	0.70	0.45	0.12	1.11	0.57	0.13	0.14	0.28
	GRA	-0.24	-0.27	0.19	0.34	0.07	0.77	0.56	0.09	0.04	0.06
	OAG	-0.33	-0.21	0.18	0.28	0.07	0.89	0.43	0.09	0.04	0.05
	PRI	0.00	-0.02	0.05	0.05	0.04	0.28	0.21	0.05	0.03	0.02
	MFD	-0.13	-0.11	0.47	0.25	0.06	0.75	0.38	0.09	0.03	0.05
Aggregate Imports	CCF	-3.95	-5.10	-40.18	-19.16	-12.23	-7.33	0.42	-3.17	-3.55	-8.94
	BFM	-4.60	-2.62	-34.02	-27.48	-7.06	1.16	-1.73	-1.06	-1.14	-16.06
	GRA	-0.45	-1.33	2.21	0.73	0.24	5.10	1.83	0.10	0.09	0.29
	OAG	-0.19	-0.46	0.40	0.24	0.05	1.64	0.00	0.10	0.03	0.03
	PRI	0.09	-0.12	-0.04	-0.09	-0.02	0.56	-0.25	-0.04	-0.01	-0.06
	MFD	-0.12	-0.56	1.03	0.56	0.01	1.89	-0.16	0.31	0.01	-0.08

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Appendix Table A1: Number of reported cases of bovine spongiform encephalopathy (BSE) in farmed cattle worldwide

Country/Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Austria	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	2	
Belgium	0	0	0	0	0	0	0	1	6	3	9	46	38	15	11	2	2	
Canada	0	0	0	1(b)	0	0	0	0	0	0	0	0	0	2(a)	1	1	5	1(c)
Czech Republic	0	0	0	0	0	0	0	0	0	0	0	2	2	4	7	8	3	
Denmark	0	0	1(b)	0	0	0	0	0	0	0	1	6	3	2	1	1	0	
Finland	0	0	0	0	0	0	0	0	0	0	0	1(a)	0	0	0	0	0	
France	0	5	0	1	4	3	12	6	18	31(a)	161(d)	274(e)	239(f)	137(g)	54(h)	31	8	
Germany	0	0	1(b)	0	3(b)	0	0	2(b)	0	0	7	125	106	54	65	32	9(j)	
Greece	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	
Ireland	14(a)	17(a)	18(a)	16	19(a)	16(a)	73	80	83	91	149(d)	246(e)	333(f)	183(g)	126(h)	69(i)	41(j)	6(c)
Israel	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	
Italy	0	0	0	0	2(b)	0	0	0	0	0	0	48	38(a)	29	7	8	7	
Japan	0	0	0	0	0	0	0	0	0	0	0	3(e)	2	4(g)	5	7	10	1(c)
Liechtenstein	0	0	0	0	0	0	0	0	2(a)	0	0	0	0	0	0	0	0	
Luxembourg	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0(c)
Netherlands	0	0	0	0	0	0	0	2	2	2	2	20	24	19	6	3	...	
Poland	0	0	0	0	0	0	0	0	0	0	0	0	4(f)	5	11	19	10(j)	
Portugal	1(b)	1(b)	1(b)	3(b)	12	15	31	30	127	159	149(a)	110	86	133	92(a)	46	...	
Slovakia	0	0	0	0	0	0	0	0	0	0	0	5	6	2	7	3	0	
Slovenia	0	0	0	0	0	0	0	0	0	0	0	1	1	1	2(a)	1	1	
Spain	0	0	0	0	0	0	0	0	0	0	2	82	127	167	137	98	41(j)	
Sweden	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1(j)	
Switzerland	2	8	15	29	64	68	45	38	14	50	33(d)	42	24	21(g)	3	3(i)	5	
United Kingdom	14407	25359	37280	35090	24438	14562	8149	4393	3235	2301	1443	1202	1144	611	343	225	114	
United States of America	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	

Source: World Organization for Animal Health (OIE) http://www.oie.int/eng/info/en_esbmonde.htm