Number 5/2004/p.1-22 www.CAFRI.org

Current Agriculture, Food & Resource Issues

A Journal of the Canadian Agricultural Economics Society

Modeling Bioterrorism in the Livestock Sectors of NAFTA Members[1]

Karen M. Huff
Associated Graduate Faculty, Department of Agricultural Economics and Business, University of Guelph

Karl D. Meilke
Professor, Department of Agricultural Economics and Business, University of Guelph

Calum G. Turvey
Department of Agricultural, Food and Resource Economics and Director, Food Policy Institute, Rutgers University

John Cranfield
Assistant Professor, Department of Agricultural Economics and Business, University of Guelph

This paper was presented at the annual meeting of the Canadian Agricultural Economics Society (Montreal, July 2003) in a session entitled "Agroterrorism, Hysteresis, Trade and Economics". Papers presented at CAES meetings are not subjected to the journal's standard refereeing process.

The Issue

Until two years ago, most citizens of Canada, the United States and Mexico experienced terrorism as a distant reality viewed from the safety of their living rooms. Today, North Americans encounter constant reminders of the aggravation and economic costs imposed on them by the now real threat of terrorism. The United States, the most obvious target for new terrorist activity, has responded by tightening its border security with all countries including its NAFTA partners.[2] Canada and Mexico joined the NAFTA to obtain preferred and more secure access to the United States market. The increased threat of terrorist activity in North America raises three crucial questions for

NAFTA members. First, how real is a bioterrorism threat? Second, how can the United States maintain access to its market for its NAFTA partners and at the same time meet its legitimate security concerns? Third, what are the potential economic effects of a bioterrorism attack on North America? While it is generally assumed that the United States would be the primary target of a terrorist attack, Canada, Mexico or all three NAFTA countries could be targeted.

How real is the biosecurity threat? United States agriculture is considered vulnerable to such an attack given its size and importance to the U.S. economy as well as its accessibility, lack of genetic diversity, and susceptibility to foreign diseases. The U.S. National Research Council came to the following conclusion when assessing the ability of animal health officials to cope with bioterrorism:

> The U.S. livestock industry … is extremely vulnerable to a host of highly infectious and often contagious biological agents … . APHIS … would probably be unable to help eradicate intentional introduction, especially if this were done at multiple sites (National Research Council, 2002).

The lack of legislation in Canada or Mexico to deal directly with the threat of bioterrorism suggests that neither country is adequately prepared to manage a bioterrorist attack. Given the susceptibility of North America to such an attack, it is important to address the economic implications in order to provide insight into the potential costs resulting from such an unfortunate incident. Given the scarcity of funds to spend on prevention (e.g., increased supply-chain and on-farm security), an understanding of the economic costs is important for policy makers faced with the difficult decision of where to allocate scarce security resources.

Implications and Conclusions

The results of this modeling exercise suggest that an outbreak of foot-and-mouth disease (FMD) in North America would have an economically significant impact on the domestic economy – even before the substantial costs of fighting and containing the outbreak are considered. The economic costs of an attack depend crucially on which NAFTA countries are attacked and on the NAFTA countries' own border policies when a NAFTA partner faces an outbreak of FMD. The economic costs to each NAFTA member, and especially to Canada, are significantly larger when their NAFTA partners close their borders following an outbreak of FMD. In an ideal world such a costly attack on any NAFTA member can be avoided entirely. However, having a plan in place for dealing with such an outbreak quickly and effectively is vital to the domestic economy. Failure to contain an outbreak would surely spell disaster for livestock, meat and dairy product exports, and its impact on an uneasy public could have a serious effect on domestic demand as well.

Objective

The objective of this study is to examine the economy-wide effects of a bioterrorist attack, such as the introduction of FMD, on the North American food system. Foot-and-mouth disease would be reasonably easy to transport into any of the NAFTA countries and disseminate among wild animals and in feedlots and farms across the country. Not only would the disease have an immediate effect on the productivity of the livestock sector, it could also have a potentially disastrous effect on trade in livestock, meat, and dairy products, depending upon the extent of the outbreak and the global response to it. Although FMD poses virtually no risk to human health, the potential for an erroneous linkage in the public's mind between animal health and food safety, reinforced by newscasts featuring gruesome images of burning animal corpses that would result from an eradication program, could have a negative impact on consumer preferences for domestic meat and dairy products (Huff, Meilke and Turvey, 2003).

In order to quantify the impacts of the introduction of FMD into the North American agri-food system, an applied general equilibrium (AGE) model of the global economy is employed (Hertel, 1997). The immediate impact of FMD on the outputs of livestock, raw milk and "other animal products" sectors (swine and poultry are in this latter sector), is modeled via supply shifts achieved through negative productivity shocks to the primary producing sectors.[3] The details of the simulated policy scenarios are discussed later in the article.

Foot-and-mouth Disease and International Trade Rules

The host animals for FMD include bovidae (cattle, zebus, domestic buffaloes and yaks), sheep, goats, swine, all wild ruminants and suidae. Camelidae (camels, dromedaries, llamas and vicunas) have low susceptibility. As one of the most contagious animal diseases, FMD frequently results in heavy economic losses to the affected industry. Although the disease has a low mortality rate in adult animals, there is often high mortality in young animals due to myocarditis. FMD is spread easily through direct contact between animals or indirectly through the movement of contaminated vehicles, shoes, clothing or food. Recommended prevention and control measures include the following: 1) protection of disease-free zones by border animal movement control and surveillance; 2) slaughter of infected, recovered and FMD-susceptible contact animals; 3) disinfection of premises and all infected material, including implements, cars, clothes, etc.; 4) destruction of cadavers, litter and susceptible animal products in the infected area; and 5) quarantine measures. While mass vaccinations of animals would provide immunity to the disease, this method of control results in the loss of FMD-free status for at least two years.[4]

A disruption in the primary stage of meat and dairy production, caused by an outbreak of foot-and-mouth disease, would have a substantial negative impact on farm sales, food

processing output levels and shipments, and on the livelihood of a large part of the rural population in the affected countries. Beef and pork production dominate the Canadian and U.S. meat sectors. Given this dominance, one might expect the beef and pork subsectors to be particularly vulnerable to economic harm arising from a bioterrorist attack. The Canadian meat sector is about one-fifth the size of the U.S. meat sector. Differences in relative size suggest that the welfare losses from an FMD outbreak will be much larger for the United States than for Canada, but given Canada's trade exposure to the U.S. market the relative welfare losses in Canada could be larger than in the United States.

Farm cash receipts in Canada and the United States underscore the potential economic consequences of FMD. Cattle and calf sales, sales of hogs, and dairy product sales represented 19.9, 6.2, and 12.2 percent of *total* farm cash receipts, respectively, in the U.S. for 2001, and 21.1, 9.2, and 11.4 percent, respectively, in Canada for 2002 .

The farm level would not be the only sector affected by FMD. Distribution channels for the different agri-food products affected by FMD would also bear a portion of the total burden of an outbreak of FMD. Indeed, such economic consequences could be larger than the farm-level effects. For instance, meat products represented 22.4 percent of the value of food industry shipments in Canada and 15.7 percent of the value of shipments of food and kindred products in the United States in 1999, while dairy products accounted for 17.4 and 12.6 percent of the value of shipments in Canada and the United States, respectively.[5]

Prior to the completion of the Uruguay Round of multilateral trade negotiations, foot-and-mouth disease–free countries banned all imports of restricted commodities from countries that were not free from the disease. Under the newly created World Trade Organization some important changes occurred in the regulatory framework affecting trade between FMD-free and FMD-endemic regions (Ekboir, 1999). These changes include the principle of regionalization, risk assessment and assessment of the scientific grounds for the imposition of non-tariff barriers to trade, and prohibition of the use of sanitary and phyto-sanitary regulations as barriers to trade.

The principle of regionalization allows imports of restricted commodities originating from FMD-free zones within FMD-endemic countries into FMD-free countries, provided the disease is contained within designated quarantined areas. Furthermore, should a country formerly free of FMD experience an outbreak, it can continue to export restricted commodities as long as the outbreak is successfully contained within a quarantined area. In the case of a naturally occurring outbreak of FMD in a NAFTA country, quick geographical containment of the disease could mean little long-run disruption in its export trade. However, a large-scale outbreak of FMD that is the result of terrorist actions would be more difficult to contain quickly, and would cause widespread panic and uncertainty over the safety of trade-restricted commodities originating from a NAFTA country. At least in the short term, a ban on imports by FMD-free countries is a certainty.

Table 1 Value of exports of livestock, meat, and dairy by NAFTA country in 2002 (thousands of U.S. dollars)

Destination	Live bovine	Live swine	Meat of bovine	Meat of swine	Dairy	Total	Percent of total
			Exports from Canada[a]				
United States	1,161,706	308,907	1,055,730	578,042	74,470	3,178,855	81.57
Mexico	203	528	110,454	15,504	37,564	164,253	4.21
Non-NAFTA, FMD-free	3,986	536	807	47,163	26,224	78,716	2.02
Non-NAFTA, FMD	457	0	13373	433924	27328	475,082	12.19
Total	1,166,352	309,971	1,180,364	1,074,633	165,586	3,896,906	
			Exports from the United States[a]				
Mexico	74,830	30,347	582,563	128,209	162,127	978,076	31.42
Canada	50,111	1,513	199,789	112,260	66,838	430,511	13.83
Non-NAFTA, FMD-free	825	757	530,994	814,966	56,132	1,403,674	45.09
Non-NAFTA, FMD	1,772	4,052	91,333	81,217	122,394	300,768	9.66
Total	127,538	36,669	1,404,679	1,136,652	407,491	3,113,029	
			Exports from Mexico[b,c]				
United States	242,561		1,894	137,172	11,718	393,345	91.58
Canada				134	6	140	0.03
Non-NAFTA, FMD-free	218	24	0	8716	18422	27,380	6.37
Non-NAFTA, FMD	298	0	0	200	8154	8,652	2.01
Total	243,077	24	1,894	146,222	38,300	429,517	

a. Source: Industry Canada trade data online (http://strategis.ic.gc.ca/sc_mrkti/tdst/tdo/tdo.php)
b. Source: La Secreteria de Economia de Mexico (http://www.economia-snci.gob.mx/sic_sistemas/siavi/entrada.php)
c. Covers the period April 2002 to February 2003.

Table 1 shows the value of intra-NAFTA and non-NAFTA exports of meat, dairy and livestock originating from Canada, the United States and Mexico. The value of intra-NAFTA exports accounts for a sizable proportion of the total value of exports of all three NAFTA members. This is particularly true for Canada and Mexico, whose exports to the United States account for more than 80 percent of the total value of their livestock product exports. U.S. exports to Canada (13.8%), Mexico (31.4%) and non-NAFTA countries deemed free of FMD (45.1%) account for more than 90 percent of the total value of U.S. meat, dairy and livestock exports. Clearly, FMD-free countries (which include the NAFTA partners) represent a very important component of the export markets for Canadian, U.S. and Mexican meat, dairy and livestock. Moreover, given the volume of intra-NAFTA trade and the potential for FMD to spread quickly via this trade, an outbreak in one NAFTA country could jeopardize other members' disease-free status and cause importers to look for other sources of product.

The indirect effects of such an outbreak are equally vexing. For instance, an outbreak in the United States may force adjustments in the pattern of exports such that Canadian and Mexican exports to FMD-endemic regions face increased competition from U.S. exports that otherwise would be destined to FMD-free countries. The precise nature of such a realignment is difficult to predict without a formal trade model. Moreover, capturing the economy-wide impacts of such adjustments requires a modeling technique that enables measurement of international trade flows and welfare in many different regions.

The Model and Data

In order to examine the economy-wide effects of the intentional introduction of foot-and-mouth disease to the agri-food sectors of the NAFTA countries, this study employs a multiregion, multicommodity, general equilibrium framework. In this case, a standard closure of the Global Trade Analysis Project (GTAP) model (Hertel, 1997) of the global economy is used in conjunction with an aggregation of Version 5 of the GTAP database (Dimaranan and McDougall, 2002). This analysis focuses primarily on the impact of a terrorist attack on agriculture, so the commodity aggregation features a fairly disaggregate agri-food industry with the following twelve sectors: 1) wheat, 2) other grains, 3) oilseeds, 4) fruits and vegetables, 5) other crops, 6) livestock, 7) other animal products, 8) raw milk, 9) red meat (excluding pork),[6] 10) other meat, 11) dairy products and 12) other processed foods. The remaining sectors in the model include 1) other primary production, 2) manufactures and 3) services. The regional aggregation employed includes the following: 1) the United States, 2) Canada, 3) Mexico, 4) Argentina, 5) Brazil, 6) an aggregate of the rest of Latin America and the Caribbean, 7) a Western Europe aggregate, 8) China and Hong Kong, 9) Taiwan, 10) South Korea, 11) Japan, 12) Australia and New Zealand and 13) a rest-of-the-world aggregate.

In the standard GTAP model, each region features perfectly competitive firms operating under constant-returns-to-scale technology using five primary factors of production: land, skilled labour, unskilled labour, capital and natural resources. Labour and capital are treated as perfectly mobile factors of production within a region, while land is specific to agricultural production and the natural resources factor is specific to industries such as coal, oil, natural gas, minerals, fisheries and forestry. In this analysis land and natural resources are treated as less than fully mobile among alternative activities in agricultural production (land) and natural resource–based industries (natural resources). Land, in particular, is treated as nearly immobile based on the assumption that it is either physically impossible or undesirable to switch land used for livestock production to crop production in the short term. Given the magnitude of the output shifts considered in the various scenarios, this is a reasonable assumption. The primary factor mix is determined using constant elasticity of substitution (CES) technology, with the domestic and imported

intermediate mix being likewise determined. Imported intermediates are differentiated by country of origin according to the Armington assumption. Intermediate inputs and value added are then combined under a fixed-proportions technology.

The GTAP model features a representative regional household whose behaviour is governed by an aggregate utility function specified over per capita private household consumption, per capita government spending and per capita savings. Private preferences are defined according to the constant difference elasticity (CDE) expenditure function. Demands for savings and international transportation services are met by the global banking and transportation sectors.

In the standard model solution, all markets must be in equilibrium, all firms earn zero profits and households are on their budget constraints. This forces global savings to equal global investment via Walras' Law. A neoclassical macroeconomic closure allows regional investment to adjust according to any changes in regional savings. Additional details on the GTAP model can be found in Hertel (1997).

The tariffs in the GTAP Version 5 database do not accurately reflect the current internal and external tariff structures of Canada, the United States and Mexico. Given the focus here on the impact of a bioterrorist attack in one or all of the NAFTA countries, and the potential changes to their international trade activities, the GTAP tariffs for the three NAFTA countries were updated to reflect their current values.

The GTAP model does not explicitly model the complicated issue of agricultural tariff-rate quotas, and instead they are approximated by a single *ad valorem* tariff equivalent.[7] As well, the GTAP model and data do not specifically reflect the supply-managed nature of the Canadian dairy industry, so for the purposes of this study it is assumed that production quotas remain in place at the farm level in the scenario that models an outbreak of FMD in the United States alone. As such, Canadian output of raw milk is fixed under this scenario in order to realistically model the lack of an output response in this sector. In all of the other scenarios this assumption is relaxed, as the nature of the shocks implies that raw milk output in Canada will fall in the short run as a result of FMD.

Model Scenarios

Although any number of potential terrorist attacks against the agri-food systems of Canada, the United States or Mexico can be imagined, this study focuses on what would be one of the easiest to execute, namely the deliberate introduction of foot-and-mouth disease into the livestock sector of one or all of the NAFTA countries. Scenario 1 considers the impact of the output effects resulting from a deliberate introduction of FMD in Canada. In addition to the obvious impact on output in the affected sectors, the occurrence of a deliberately staged outbreak of FMD in Canada will have an impact on Canadian trade relations with the rest of the world. Currently, Canada enjoys a strong

reputation for its FMD-free status, but a large-scale outbreak of FMD resulting from terrorist activity would have serious implications for Canadian exports of not only livestock, but meat and dairy products as well. In addition to considering the economic impact of FMD-induced supply shifts, scenario 1 also models the impact of a ban on imports of livestock, meat, and dairy products from Canada by the FMD-free regions of the world in response to the outbreak. Scenario 2 examines the impact of a deliberately introduced outbreak of FMD in the United States.[8] Again, both the output effects of the disease and the impact of the resulting trade ban faced by the United States are modeled.

The final two scenarios consider the impact of an outbreak of FMD in all three NAFTA countries simultaneously. Such a widespread outbreak could be the result of deliberate terrorist actions in each country, or FMD introduced by terrorists in one country could spread rapidly to the others given the large trade in live animals that takes place on a daily basis within the NAFTA region. Both scenarios model the impact of FMD on output of livestock, raw milk and other animal products in Canada, the United States and Mexico. Scenario 3A assumes that regions outside the NAFTA that are free from FMD ban imports of affected goods from NAFTA countries, but that trade within the NAFTA region in these goods continues. In scenario 3B, the NAFTA countries face an import ban imposed by FMD-free regions outside the area, as well as a ban imposed by each of the NAFTA trading partners. Each of the scenarios is now discussed in more detail.

Scenarios 1 and 2 model the effects of an outbreak of FMD on output and the resulting trade ban for Canada and for the United States, respectively. It is assumed that outputs of livestock, raw milk and other animal products are affected negatively by an outbreak of FMD.[9] For a naturally occurring outbreak, a decline in production of 5 percent for affected meat and dairy animals is not unrealistic. However, if a terrorist group deliberately infected Canadian or U.S. livestock with FMD, the impact on production could be much greater than that of a natural outbreak. Scenarios 1 and 2 assume a more severe outbreak than would occur naturally, with a reduction in output of 10 percent for livestock and raw milk, and 5 percent for other animal products. These supply shifts are achieved via negative productivity shocks whose levels are determined in an unreported run of the model that does not include an import ban. When these shocks are applied at the same time as an import ban, as in scenarios 1 and 2, the actual changes in output for the livestock, raw milk and "other animal products" sectors will differ from the 10 percent reductions in production of livestock and raw milk and the 5 percent for other animal products, due to the additional impact of the ban.

The regions considered initially FMD-free in the model include Canada, Mexico, the United States, Western Europe, Japan, and Australia and New Zealand. In scenario 1 it is assumed that the FMD-free regions implement a ban on imports of Canadian livestock, other animal products, red meat, other meat, and dairy products,[10] while in scenario 2, it is the United States that experiences the FMD outbreak and faces the trade ban. The trade

ban is modeled by increasing the tariffs on imports of the affected commodities to prohibitive levels in the FMD-free regions. Imports from Canada (in the case of scenario 1) and then from the United States (in the case of scenario 2) to the remaining regions in the model, namely Argentina, Brazil, rest of Latin America, China, Taiwan, South Korea and the rest-of-world aggregate, are not restricted given the presence of FMD in those areas.

In scenarios 3A and 3B, it is assumed that the outbreak of FMD extends to all three NAFTA countries. In both cases, the negative productivity shocks applied in the livestock, raw milk and "other animal products" sectors in scenario 1 for Canada and scenario 2 for the United States are applied along with additional negative productivity shocks to the Mexican livestock, raw milk and "other animal product" sectors. In both scenarios 3A and 3B, it is assumed once again that the FMD-free regions outside of the NAFTA ban imports of the restricted commodities from all three NAFTA countries. The two scenarios differ in how Canada, the United States and Mexico treat intra-NAFTA trade in the restricted commodities. Scenario 3A assumes that the simultaneous presence of FMD in each of the three countries does not stop intra-NAFTA trade in the affected commodities. More realistically, scenario 3B assumes that each NAFTA partner will attribute responsibility for the outbreak to the "poor" security and sanitary practices of the other two partners, which allowed the disease to cross the border undetected, resulting in the spread of the "initial" outbreak. Under this atmosphere of blaming the practices of others for the outbreak, it is realistic to assume that the NAFTA partners would close their borders to trade in the affected commodities within the region. So in scenario 3B, the import ban each NAFTA member faces is extended to its NAFTA trading partners. The following section discusses the results of each scenario in detail.

Model Results

Scenario 1 examines the international trade implications that might result from a deliberately staged outbreak of foot-and-mouth disease in Canada. The United States, Mexico, Western Europe, Japan, and Australia and New Zealand – the FMD-free regions in the model – all ban imports of livestock, other animal products, red meat, other meat, and dairy products from Canada. Additionally, Canadian production of livestock, raw milk, and other animal products experiences negative productivity shocks designed to model the impact of a deliberate introduction of FMD. Table 2 shows the percentage changes in output, market prices, exports and imports resulting from the combined import ban and output reductions. In Canada, outputs of livestock (- 40.1%), raw milk (-10.3%), other animal products (-28.1%), red meat (-17.3%), other meat (-16.8%) and dairy products (-12.3%) decline considerably under the export ban. The output of "other grains" (-6.6%) also falls in response to the fall in price (-2.3%) generated by lower demand for this input in the livestock, milk and "other animal products" sectors. In the absence of the

Table 2 Canadian outputs of livestock, raw milk, and other animal products decline as a result of foot-and-mouth disease; exports of these products face a ban in FMD-free regions (scenario 1)

	USA	Canada	Mexico
Production		*% change*	
Wheat	0	-0.9	-0.1
Other grains	0.7	-6.6	0.3
Oilseeds	-0.2	-4.1	-0.2
Fruits & veg.	-0.1	-7.3	0
Other crops	0	-0.2	0
Livestock	2.5	-40.1	3.9
Raw milk	0.2	-10.3	0.1
Animal prod.	1.6	-28.1	0.3
Red meat	0.5	-17.3	-0.4
Other meat	0.5	-16.8	0.1
Dairy	0.2	-12.3	0.5
Other food	0	-2.0	0
Market prices			
Wheat	0	-0.4	-0.1
Other grains	0.6	-2.3	0.4
Oilseeds	-0.2	-2.1	-0.3
Fruits & veg.	-0.1	-1.9	0
Other crops	0	-0.2	0
Livestock	1.3	-3.3	5.2
Raw milk	0.3	85.3	0.2
Animal prod.	0.6	-1.9	0.4
Red meat	1.4	-1.6	2.5
Other meat	0.9	-1.2	0.3
Dairy	0.1	38.6	0.2
Other food	0	-0.3	0
Exports			
Wheat	-0.2	1.4	0.3
Other grains	-1.2	9.4	-1.0
Oilseeds	-0.4	6.9	-1.2
Fruits & veg.	-0.7	7.6	-0.5
Other crops	0	0.9	0
Livestock	0.5	-98.9	87.3
Animal prod.	-0.9	-76.1	22.6
Red meat	-1.0	-90.7	4.7
Other meat	-1.1	-79.5	10.2
Dairy	7.2	-85.3	1.2
Other food	-0.3	1.3	0
Imports			
Wheat	0.9	-4.8	0.2
Other grains	5.9	-15.3	-0.3
Oilseeds	2.5	-6.5	0
Fruits & veg.	0.1	-2.9	0.2
Other crops	0	-0.7	0
Livestock	-36.7	-16.5	9.4
Animal prod.	-19.4	-0.9	-0.3
Red meat	-13.1	-9.3	1.1
Other meat	-18.0	-7.7	-1.3
Dairy	-1.8	85.7	-1.3
Other food	0.3	-1.9	0

trade ban, one would expect the prices of livestock and other animal products to rise as a result of the negative supply shift caused by FMD. However, their prices actually fall by 3.3 (livestock) and 1.9 percent (other animal products) as a result of the sizable drop in foreign demand. The Canadian livestock export market is decimated by the loss of the U.S. market in particular, and experiences a decline of 98.9 percent, while exports of other animal products also fall considerably by 76.1 percent. The non-traded commodity, raw milk, experiences a price increase of 85.3 percent in response to the decline in its output. Exports of red meat (-90.7%), other meat (-79.5%) and dairy products (-85.3%) fall in the face of the export ban. For red meat and other meat, the decline in foreign demand drives prices down by 1.6 and 1.2 percent, respectively. The price of dairy products rises by 38.6 percent, driven by the increase in raw milk prices. Canada decreases its imports of livestock, other animal products, red meat and other meat by 16.5, 0.9, 9.3 and 7.7 percent, respectively, in response to lower domestic prices. Dairy product imports, on the other hand, increase by 85.7 percent given the large increase in the domestic price.

The United States and Mexico both increase their outputs of livestock, raw milk, other animal products, other meat, and dairy products in response to higher prices created by the output declines in Canada. The United States also increases its output of red meat, while Mexico reduces its output marginally. The United States increases exports of livestock marginally, but Mexican exports increase significantly, by 87.3 percent, as the United States turns to sources other than Canada. U.S. exports of other animal products (-0.9%), red meat (-1.0%) and other meat (-1.1%) fall slightly while Mexican exports rise for these products by 22.6, 4.7, and 10.2 percent, respectively, again replacing Canadian supplies. Both the United States and Mexico increase dairy products exports, by 7.2 and 1.2 percent, respectively. U.S. imports of all the banned goods fall whereas Mexican imports fall for other animal products, other meat, and dairy products only.

Scenario 2 examines the international trade implications that might result if the deliberately staged outbreak of foot-and-mouth disease occurred in the United States rather than Canada. In this case, Canada, Mexico, Western Europe, Japan, and Australia and New Zealand ban imports of livestock, other animal products, red meat, other meat, and dairy products from the United States. U.S. production of livestock, raw milk, and other animal products also experiences negative productivity shocks to model the impact of the FMD outbreak. Table 3 reports the percentage changes in output, market prices, exports and imports resulting from the combined import ban and output reductions. U.S. outputs of livestock (-12.3%), raw milk (-10.1%), other animal products (-8.1%), red meat (-10.5%), other meat (-6.3%) and dairy products (-10.5%) decline under the export ban. The output of "other grains" falls by 5.1 percent in response to the price drop of 4 percent that results from lower demand for this input in the livestock, milk, and "other animal products" sectors. The prices of livestock, raw milk, and other animal products rise by 24.4, 92.3, and 0.9 percent, respectively, in the United States as a result of the negative

Table 3 U. S. outputs of livestock, raw milk, and other animal products decline as a result of foot-and-mouth disease; exports of these products face a ban in FMD-free regions (scenario 2)

	USA	Canada	Mexico
Production		*% change*	
Wheat	0	0.1	0
Other grains	-5.1	-0.4	0.5
Oilseeds	0	0.9	-0.1
Fruits & veg.	0	1.9	0.1
Other crops	0.1	-0.1	-0.1
Livestock	-12.3	15.5	12.0
Raw milk	-10.1	0	0.6
Animal prod.	-8.1	9.2	6.1
Red meat	-10.5	9.7	9.3
Other meat	-6.3	12.6	5.0
Dairy	-10.5	0.1	1.2
Other food	-1.0	0	0.1
Market prices			
Wheat	-0.4	0.1	0
Other grains	-4.0	-0.1	0.7
Oilseeds	-0.3	0.6	-0.1
Fruits & veg.	-0.3	0.7	0.2
Other crops	-0.2	0	-0.1
Livestock	24.4	9.5	20.2
Raw milk	92.3	13.8	0.7
Animal prod.	0.9	2.8	6.4
Red meat	17.2	6.2	11.9
Other meat	5.2	3.9	5.3
Dairy	39.8	6.4	3.2
Other food	0.3	0.4	0.1
Exports			
Wheat	1.7	-0.5	0.8
Other grains	10.1	-9.6	-9.0
Oilseeds	1.2	-2.6	-0.1
Fruits & veg.	1.3	-2.8	-1.5
Other crops	1.2	-0.3	0.1
Livestock	-96.9	25.8	-24.6
Animal prod.	-43.6	-7.9	-22.2
Red meat	-84.4	28.3	-17.7
Other meat	-54.1	3.0	8.6
Dairy	-79.9	-2.9	6.8
Other food	-0.9	-1.8	-0.3
Imports			
Wheat	-2.5	1.8	0.3
Other grains	-15.5	10.6	7.8
Oilseeds	-2.4	2.1	0.1
Fruits & veg.	-1.3	0.9	0.8
Other crops	-0.8	-0.1	0.2
Livestock	27.8	-18.3	-40.2
Animal prod.	7.0	13.0	-25.2
Red meat	23.4	-21.8	-45.2
Other meat	4.7	-32.2	-71.5
Dairy	86.0	1.0	-3.0
Other food	-0.6	0.4	-0.5

supply shift caused by FMD. Prices of red meat (17.2%), other meat (5.2%) and dairy products (39.8%) also increase in response to lower output. U.S. exports of livestock (-96.9%), other animal products (-43.6%), red meat (-84.4%), other meat (-54.1%) and dairy (-79.9%) all decline. Due to higher domestic prices, imports of livestock (27.8%), other animal products (7%), red meat (23.4%), other meat (4.7%) and dairy products (86%) all increase.

Canada and Mexico both increase their outputs of livestock, other animal products, red meat, other meat, and dairy products in response to higher prices created by the output declines in the United States. Mexico also increases its output of raw milk while Canadian output is treated as fixed owing to the presence of supply management. Canada increases exports of livestock, red meat, and other meat by 25.8, 28.3 and 3 percent, respectively, while Mexican exports of other meat (8.6%) and dairy products (6.8%) increase. Mexican imports of all the banned goods fall whereas Canadian imports fall for other livestock, red meat, and other meat only.

It is interesting to note the differences in the way FMD affects Canada versus the United States. In scenario 1, only Canada experiences an outbreak of FMD. The output effects are greater in Canada under this scenario than they are in the United States under scenario 2 where the United States alone is targeted with a bioterrorist attack. When Canada is attacked, livestock, outputs of other animal products, red meat, other meat, and dairy products fall by 40.1, 28.1, 17.3, 16.8, and 12.3 percent versus declines of 12.3, 8.1, 10.5, 6.3, and 10.5 percent in the same sectors in the United States when the FMD outbreak occurs there. This reflects the greater dependence Canadian producers have on export sales than have their counterparts in the United States, who benefit from a much larger domestic market for their goods. Changes in Canadian prices are driven more by the loss of export sales than they are in the United States, where the price changes are driven more by the original declines in output caused by FMD. Prices of livestock, other animal products, red meat and other meat all fall slightly in Canada under scenario 1, while prices for the same products rise significantly in the United States under scenario 2. When the FMD outbreak occurs in Canada, the prices in the other NAFTA countries change very little, while such an occurrence in the United States has a much larger impact on prices throughout the region. The location of the FMD outbreak matters a great deal to the other NAFTA partners. If Canada is the unlucky host, most of the adjustment takes place internally at the cost of domestic producers and food processors. Should an outbreak occur in the United States, Canada and Mexico are affected as well via greater changes in prices.

Scenarios 3A and 3B both consider the implications of a widespread outbreak of FMD in all three of the NAFTA partners. In both scenarios, identical negative technology shocks are applied to the livestock, raw milk and "other animal products" sectors to model the impact of FMD on output. The two scenarios differ in the extent of trade limitations

Table 4 Outputs of livestock, raw milk and "other animal products" decline in all NAFTA countries as a result of foot-and-mouth disease; NAFTA exports face a ban in FMD-free regions but trade within NAFTA is not halted (scenario 3A)

	USA	Canada	Mexico
Production		*% change*	
Wheat	-0.1	-0.8	-0.2
Other grains	-4.7	-4.1	-2.4
Oilseeds	-0.2	-1.5	-0.3
Fruits & veg.	-0.2	-2.2	-0.6
Other crops	0	-0.7	-0.1
Livestock	-10.5	1.1	-5.1
Raw milk	-10.0	-9.3	-9.5
Animal prod.	-5.3	-7.5	-5.0
Red meat	-9.4	-3.3	-2.4
Other meat	-4.8	-5.4	-3.7
Dairy	-10.4	-11.1	-15.2
Other food	-0.9	-1.2	-0.7
Market prices			
Wheat	-0.4	0.1	-0.5
Other grains	-3.7	-1.1	-3.2
Oilseeds	-0.5	-0.4	-0.7
Fruits & veg.	-0.4	-0.3	-1.1
Other crops	-0.3	0	-0.4
Livestock	28.9	16.8	29.6
Raw milk	94.2	94.1	56.9
Animal prod.	2.0	2.5	14.3
Red meat	20.6	9.4	16.2
Other meat	6.5	2.0	10.6
Dairy	40.6	42.8	34.4
Other food	0.4	0.3	-0.4
Exports			
Wheat	1.5	-0.3	2.8
Other grains	8.3	-5.7	6.6
Oilseeds	0.9	0.4	1.2
Fruits & veg.	0.9	0	2.7
Other crops	1.1	-0.3	1.2
Livestock	-57.1	11.6	-35.9
Animal prod.	-21.1	-17.1	-74.4
Red meat	-62.1	-13.8	-61.4
Other meat	-33.0	-25.8	-88.3
Dairy	-70.4	-74.8	-73.2
Other food	-1.5	-1.2	2.1
Imports			
Wheat	-2.1	-0.6	-1.1
Other grains	-12.8	2.0	-0.3
Oilseeds	-1.2	-1.3	-0.7
Fruits & veg.	-0.5	-0.6	-1.9
Other crops	-0.8	-0.5	-1.0
Livestock	24.6	-11.6	4.7
Animal prod.	-3.3	-0.3	17.2
Red meat	28.0	-8.0	-5.8
Other meat	9.3	-7.6	5.8
Dairy	84.4	73.9	31.5
Other food	-0.2	-0.8	-2.1

faced by Canada, the United States and Mexico. In scenario 3A, it is assumed that the three NAFTA partners continue to trade sensitive goods with each other, and together face a ban on their exports by the FMD-free regions outside the trading bloc. In scenario 3B, in addition to a ban on exports to FMD-free regions outside of the NAFTA, each of the NAFTA partners also ceases trade within the region on all sensitive products. The results for scenarios 3A and 3B are reported in tables 4 and 5 and are discussed together to highlight the impact of the NAFTA trading partners' behaviour towards one another.

When the NAFTA partners continue to trade, the United States experiences somewhat smaller declines in output for raw milk (-10 versus -10.1%), other animal products (-5.3 versus -6.8%), red meat (-9.4 versus -10.7%) and other meat (-4.8 versus -6.3%) than is the case when intra-NAFTA trade halts. U.S. output of livestock falls marginally more under continued NAFTA trade (-10.5 versus -10.2%) and its dairy output declines are identical (-10.4%) for both scenarios. For Canada, the differences in output under the two scenarios are often more dramatic. Canadian livestock output increases slightly, by 1.1 percent, when NAFTA trade continues, but falls by 35.1 percent when shipments to the United States and Mexico are halted under scenario 3B. Canadian production of other animal products falls by nearly two and a half times more (-18.3%) when intra-NAFTA trade ceases compared to the situation when NAFTA trade in sensitive products continues (-7.5%). Canadian output of red meat falls considerably more when there is no intra-NAFTA trade in sensitive products (-12.1%) than under the scenario of continued NAFTA trade (-3.3%). The differences in output changes between the two scenarios for Canadian raw milk, other meat, and dairy products are marginal.

When intra-NAFTA trade in sensitive products continues under scenario 3A, Mexican outputs of livestock (-5.1%), other animal products (-5%), red meat (-2.4%) and other meat (-3.7%) fall as a result of the FMD outbreak. When NAFTA trade is halted under scenario 3B, Mexican outputs in these sectors increase by 1.6, 0.4, 5.8 and 0.4 percent, respectively, in order to supply the domestic market. Mexican outputs of raw milk and dairy products fall under both scenarios by similar amounts.

For the United States, the price changes resulting from scenarios 3A and 3B are similar. The impact of the FMD-induced supply shift results in higher prices for all of the sensitive commodities. In Canada, the prices of the sensitive commodities increase under the continued intra-NAFTA trade scenario, but when trade in sensitive commodities is banned within the region, Canadian prices for livestock, other animal products, and red meat fall in response to the loss of NAFTA markets, in particular that of the United States. Mexican prices for sensitive commodities increase under both scenarios and are higher when imports from Canada and the United States cease under scenario 3B.

Table 5 Outputs of livestock, raw milk and "other animal products" decline in all NAFTA countries as a result of foot-and-mouth disease; NAFTA exports face a ban in FMD-free regions and trade within NAFTA is halted (scenario 3B)

	USA	Canada	Mexico
Production		*% change*	
Wheat	-0.1	-0.8	-0.3
Other grains	-4.6	-7.9	-1.7
Oilseeds	-0.3	-3.5	-0.4
Fruits & veg.	-0.2	-6.1	-0.5
Other crops	0.1	-0.2	-0.1
Livestock	-10.2	-35.1	1.6
Raw milk	-10.1	-9.2	-9.4
Animal prod.	-6.8	-18.3	0.4
Red meat	-10.7	-12.1	5.8
Other meat	-6.3	-5.5	0.4
Dairy	-10.4	-10.9	-15.5
Other food	-1.0	-1.8	-0.8
Market prices			
Wheat	-0.5	-0.4	-0.6
Other grains	-3.7	-2.8	-2.3
Oilseeds	-0.6	-1.9	-0.9
Fruits & veg.	-0.5	-1.7	-1.0
Other crops	-0.3	-0.2	-0.4
Livestock	30.2	-2.5	54.5
Raw milk	93.3	93.8	57.6
Animal prod.	1.4	-0.7	25.1
Red meat	22.1	-0.1	30.3
Other meat	7.1	1.6	19.1
Dairy	40.2	42.5	37.7
Other food	0.3	0	-0.2
Exports			
Wheat	1.5	1.1	3.6
Other grains	8.4	-0.4	2.6
Oilseeds	0.7	5.2	0.6
Fruits & veg.	0.6	5.7	1.9
Other crops	1.3	0.8	1.6
Livestock	-97.2	-98.7	-100.0
Animal prod.	-44.2	-78.6	-98.0
Red meat	-86.1	-88.8	-95.7
Other meat	-56.5	-80.5	-95.6
Dairy	-79.9	-86.2	-84.1
Other food	-1.3	0.2	1.1
Imports			
Wheat	-1.5	-3.6	-1.1
Other grains	-10.6	-7.3	1.2
Oilseeds	0.3	-5.1	-0.8
Fruits & veg.	-0.6	-2.4	-1.7
Other crops	-0.8	-0.7	-1.2
Livestock	-12.9	-38.6	-0.8
Animal prod.	-25.1	12.4	-16.2
Red meat	14.5	-36.1	-44.5
Other meat	-10.7	-37.9	-67.1
Dairy	83.7	76.3	39.5
Other food	-0.3	-1.8	-2.0

For the United States and Mexico, exports of all sensitive goods fall under both scenarios. When intra-NAFTA trade in sensitive goods is banned, both countries experience larger declines in their levels of exports. Canadian exports of other animal products, red meat, other meat, and dairy products fall when exports to FMD-free destinations outside of the NAFTA are banned. Livestock exports, however, increase by 11.6 percent when the U.S. and Mexican borders remain open to Canadian animals. Under the scenario extending the export ban on sensitive products to the NAFTA region, Canadian exports of livestock tumble dramatically by 98.7 percent. Similarly, Canadian exports of the other sensitive products fall by significantly higher amounts when NAFTA markets are closed.

When intra-NAFTA trade is allowed, the United States increases its imports of livestock (24.6%), red meat (28%), other meat (9.3%) and dairy products (84.4%) to make up for the loss in domestic output due to the FMD outbreak. Under the scenario featuring an intra-NAFTA ban on trade of sensitive products, U.S. imports of livestock (-12.9%) and other meat (-10.7%) fall, while imports of red meat (14.5%) and dairy products (83.7%) rise by smaller amounts than under the scenario of continued free trade in NAFTA. Canadian imports of livestock (-11.6%), other animal products (-0.3%), red meat (-8%) and other meat (-7.6%) fall when the FMD-free regions outside the NAFTA ban exports of sensitive products. When trade within the NAFTA is halted for these products, imports of livestock (-38.6%), red meat (-36.1%) and other meat (-37.9%) fall even more than under scenario 3A, while imports of other animal products increase by 12.4 percent. Canadian dairy imports increase under both scenarios, slightly more in the case of no intra-NAFTA trade. This is due to the dramatic increase in the cost of raw milk. When intra-NAFTA trade is allowed for sensitive products, Mexico increases its imports of livestock (4.7%), other animal products (17.2%), other meat (5.8%) and dairy products (31.5%). With the exception of dairy products, imports of which increase even more (39.5%), Mexico reduces its imports of livestock (-0.8%), other animal products (-16.2%) and other meat (-67.1%) when trade within the NAFTA is banned for sensitive products. Under both scenarios Mexican imports of red meat decline, but the size of the decrease is significantly higher under the scenario of no intra-NAFTA trade.

Table 6 reports the global welfare effects of the Canada-only FMD scenario (1), the United States–only FMD scenario (2), the FMD-in-NAFTA scenario with continued intra-NAFTA trade on sensitive goods (3A), and the FMD-in-NAFTA scenario with an intra-NAFTA ban on trade in sensitive commodities (3B).

Under scenario 1, Canada is subjected to a ban on its exports of livestock, other animal products, red meat, other meat, and dairy products to FMD-free regions, and a deliberate outbreak of FMD affects outputs of livestock, raw milk, and other animal products. Canada experiences a welfare loss of $1,859 million (all figures are in U.S. dollars). Canada's NAFTA trading partners the United States and Mexico also experience

Table 6 Global welfare results for various NAFTA foot-and-mouth disease scenarios (millions of U.S. dollars)

Region	Scenario 1	Scenario 2	Scenario 3A	Scenario 3B
United States	-333	-10,166	-9,403	-10,805
Canada	-1,859	-243	-1,059	-2,551
Mexico	-51	-764	-2,387	-3,220
Argentina	34	45	45	89
Brazil	19	127	119	163
Rest of Latin America	-3	109	33	127
Western Europe	-354	-632	-953	-1,085
Australia & New Zealand	106	661	654	926
China	-21	-80	-113	-114
Taiwan	-7	51	45	48
South Korea	-28	26	0	2
Japan	-330	-2,183	-2,613	-2,678
Rest of the world	-125	-221	-370	-423
Total	-2,952	-13,270	-16,002	-19,521

welfare losses of $333 million and $51 million, respectively. Other regions, including rest-of-Latin America, Western Europe, China, Taiwan, South Korea, Japan and the rest-of-world aggregate also lose under this scenario. Argentina, Brazil, and Australia and New Zealand enjoy welfare gains when Canada experiences an outbreak of FMD and a ban on exports of sensitive goods.

Scenario 2 considers the impact of an outbreak of FMD in the United States and the resulting ban on U.S. exports of sensitive goods. The global welfare loss is much higher than it is under scenario 1, the Canada-only FMD scenario – $13.3 billion versus $3 billion. When terrorists hit the United States only with FMD, again all three NAFTA countries experience welfare losses. As expected, the United States is hardest hit, with a loss of $10.2 billion, while Canada and Mexico experience welfare losses of $243 million and $764 million, respectively. The other losers under this scenario include Western Europe, China, Japan and the rest-of-world aggregate. The remaining regions in the model experience welfare gains.

When all three NAFTA countries are targeted by a bioterrorist attack introducing FMD, the welfare results are qualitatively similar regardless of whether Canada, Mexico and the United States continue to trade sensitive goods among themselves or not. When intra-NAFTA trade in these commodities is halted, the size of the welfare gains or losses is larger for all regions. The three NAFTA countries experience sizable declines in their welfare under both scenarios. U.S. welfare losses range from $9.4 billion to $10.8 billion,

Mexican losses range from $2.4 billion to $3.2 billion, and Canadian losses more than double between the two scenarios from $1.1 billion when NAFTA trade continues to $2.6 billion when the ban extends to the NAFTA region. Western Europe, China, Japan and the rest-of-world aggregate region also experience welfare losses under scenarios 3A and 3B, while Argentina, Brazil, rest-of-Latin America, Australia and New Zealand, Taiwan and South Korea all experience welfare gains.

In considering the welfare effects of various FMD scenarios it is important to note that the global welfare losses are larger than those in Canada, the United States or all of the NAFTA alone. Although some countries benefit from a terrorist-led FMD attack on one or all of the NAFTA countries, aggregate welfare losses outside the infected area(s) range from $1.1 billion in scenario 1 (Canada only) to $2.9 billion in scenario 3B where all three NAFTA countries experience an outbreak of FMD and face internal and external bans on exports of sensitive goods. Clearly, from an economic standpoint terrorist activity in the NAFTA is not just a NAFTA problem.

Conclusions

There is little doubt that the NAFTA partners are vulnerable to a terrorist attack on their food supplies. Such an attack could focus directly on the loss of human life, or its aims could be indirect, with the primary objective of causing substantial economic damage and mass uncertainty about the safety of the food supply. A terrorist attack with economic damage as its major goal could focus on infrastructure (e.g., ports, bridges and rail crossings) or on crops and livestock. The attack could originate in any NAFTA country, or off-shore. The type of model required to calculate the potential economic costs depends on the type and source of the terrorist action. However, to simulate a broadly based attack, an applied general equilibrium model, such as the GTAP model, that takes into account the economy-wide effects – on consumers, processors and primary producers – of economic disruptions seems a logical choice.

The potential welfare costs of the intentional introduction of foot-and-mouth disease into Canada, the United States or the entire NAFTA region are scary, especially so for Canada given how dependent it is on the U.S. market for live animals and red meat sales. Foot-and-mouth disease was chosen as an illustration because of how easily it could be introduced and because of its highly contagious nature. A foot-and-mouth disease attack that reduces Canadian output of FMD-susceptible animals by 10 percent, coupled with an import ban in FMD-free countries, is shown to impose welfare costs of $1.9 billion in Canada and another $1.2 billion outside Canada. When the FMD outbreak takes place in the United States, the resulting reduction in output, together with trade sanctions, lowers welfare in the United States by $10.2 billion and outside the United States by $3.1 billion. An attack on all three NAFTA countries pushes welfare losses in the three NAFTA countries to $16.6 billion, if they close their borders to trade with each other, and global

welfare losses to $19.5 billion. These estimates do not include the costs of eradication and compensation, which would total several billion additional dollars. The U.S. welfare costs alone equal 5 percent of U.S farm cash receipts.

In the case of a widespread terrorist attack on all three NAFTA countries, the way in which NAFTA partners manage their borders has a significant influence on the size, and more importantly the distribution, of welfare losses. If the NAFTA members close their borders to trade with each other the welfare costs of the FMD outbreak are $3.7 billion, or 29 percent higher than if the borders remain open. Welfare costs outside of the NAFTA are nearly identical in the two scenarios. Canada and Mexico are particularly hard hit if the NAFTA borders are closed, with welfare losses 2.4 times larger in Canada and 1.3 times larger in Mexico than with open NAFTA borders.

The work of Turvey et al. (2003) suggests that the commodities at most risk from a terrorist attack are those with the most inelastic supply and demand schedules. This finding has to be tempered by the ease with which an attack could be mounted in the various commodity sectors. The results presented here are a first step in conducting a comprehensive cost/benefit analysis of potential terrorist activity in the food chain. It is hoped that results like these will help the authorities to best determine where to allocate scarce security resources.

References

Dimaranan, Betina V. and Robert A. McDougall (eds.). 2002. *Global trade, assistance, and production – the GTAP 5 data base*. West Lafayette, IN: Center for Global Trade Analysis, Purdue University.

Ekboir, Javier M. 1999. *Potential impact of foot-and-mouth disease in California – the role of animal health surveillance and monitoring services*. Unpublished Ph.D. dissertation, University of California at Davis.

Hertel, Thomas W. (ed.). 1997. *Global trade analysis – modeling and applications*. Cambridge University Press.

Huff, K. M., K. D. Meilke and C. G. Turvey. 2003. *Issues in modeling bioterrorism in the agri-food sector*. Paper presented at WCC-72, Western Coordinating Committee on Agribusiness, Las Vegas, Nevada.

National Research Council (U.S.). 2002. *Making the nation safer*. Washington, D.C.: The Council.

Turvey, Calum, Eduoard Mafoua, Brian Schilling and Benjamin Onyango. 2003. *Economics, hysteresis and agroterrorism.*. Food Policy Institute, Rutgers University.

Endnotes

[1] Financial support for this project was provided by the Ontario Ministry of Agriculture and Food and the Food Policy Institute, Rutgers University. The views expressed in this paper are those of the authors and should not be attributed to the funding agencies.

[2] The most recent manifestation of increased security concerns in the United States is the Bioterrorism Act (Turvey et al., 2003).

[3] The model used for this research, the GTAP model, is a full employment model; when output is reduced through negative productivity shocks, resources (land, labour and capital) are trapped in animal agriculture, i.e., the same level of inputs gives less output. The negative productivity shock is not applied to the intermediate inputs category that includes animal feed.

[4] See http://www.oie.int/eng/maladies/fiches/A_A010.HTM for further scientific information on FMD.

[5] Data on production, farm cash receipts and food processing shipments are from Agriculture and Agri-Food Canada, Statistics Canada, Industry Canada and ERS/USDA sources.

[6] The GTAP database includes swine in the "other animal products" sector and pork in the "other meat" sector.

[7] All tariff lines comprising a single GTAP sector are aggregated, resulting in a sector-wide tariff rate. This is a challenge since each tariff line may have its own TRQ, as is frequently the case for the aggregate dairy sector. The situations of the several tariff lines may differ: in some cases, imported quantity may exceed the minimum access quantity and consequently the over-quota tariff is used, while other tariff lines are below their minimum access quantity and the in-quota tariff is applicable.

[8] Huff, Meilke and Turvey (2003) analyze the impact of output shocks in the United States ranging in size from minus 5 percent to minus 20 percent.

[9] The "other animal products" sector consists mainly of swine and poultry. Given that poultry is unaffected by FMD, the shifts in output assumed for this sector are one-half of those assumed for livestock and raw milk.

[10] Poultry would not be affected by an FMD-related ban while swine would. For the purposes of this exercise, the entire "other animal products" sector is included in the FMD ban given that it is not possible to ban some fraction of the exports in this commodity aggregation.