An Economic Assessment of the BSE Crisis in Canada: Impacts of Border Closure and BSE Recovery Programs

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Abstract

Using a static, multi-market, partial equilibrium model this paper assesses the economic consequences three alternative government responses to the BSE crisis in Canada: 1) expansion in slaughter capacity, 2) partial destruction of the cattle herd, and 3) deficiency payments. Each of these policies is evaluated under four different border situations 1) free trade in young beef only, the 2004 baseline situation; 2) autarky; 3) free trade in young beef and cattle; and 4) complete free trade. The results of the policy analysis are quite sensitive to the border assumptions employed making it impossible to select a "best" policy without perfect foresight with respect to the timing and the degree of border opening.

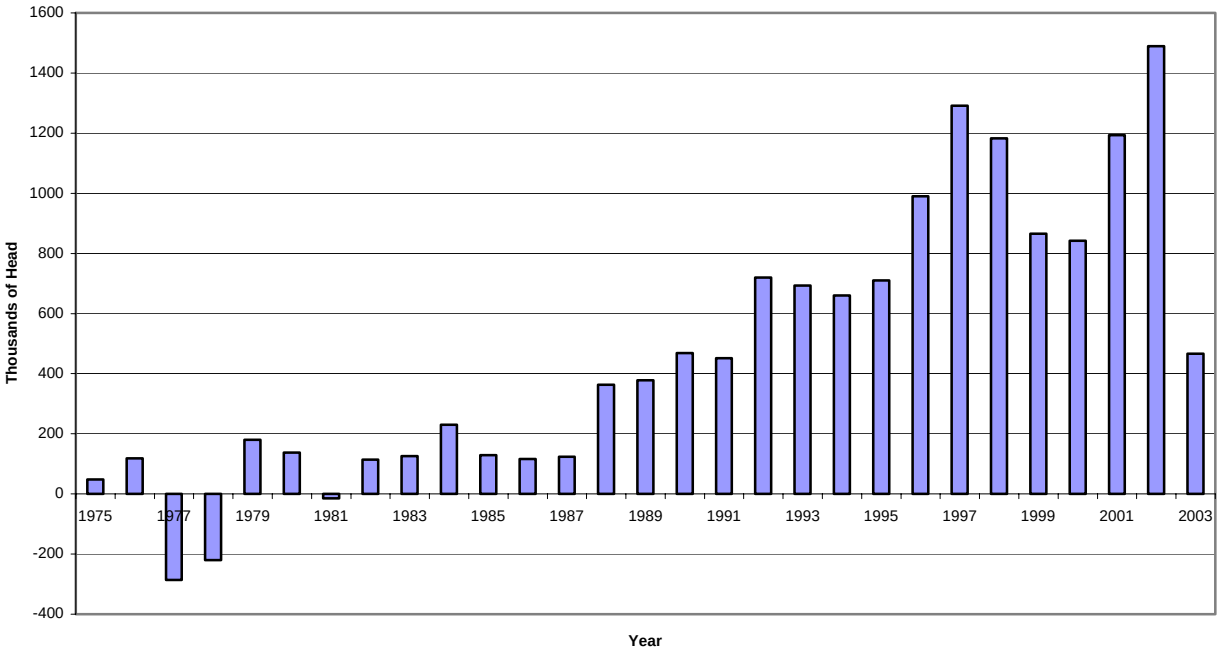
INTRODUCTION

Cattle and beef producers in Canada became increasingly dependent on export markets as a result of major policy changes in the 1980s and 1990s. The elimination of the Crow Rate transportation subsidy in 1995 enabled cattle producers to more easily exploit naturally occurring comparative advantages in sourcing feed grains, especially in Southern Alberta. Prior to the termination of the transportation subsidy, the expansion of cattle feeding activities had been promoted by federal and provincial governments through: 1) a national tripartite margin support program for beef cattle; 2) subsidies on feed grains; 3) subsidies for slaughter plant construction; and 4) programs for beef export promotion. The pursuit of these export oriented policy objectives in the cattle and beef sector coincided with the negotiation of the Canada – United States Free Trade Agreement (and later NAFTA) which granted preferential market access to goods produced within the member countries while maintaining tariffs on cattle and tariff-rate-quotas on beef imports from outside. The combination of export oriented domestic policies plus preferential and more secure access to the United States and Mexican markets resulted in rapid expansion in cattle and beef production in Canada, and the seamless flow of increasing quantities of cattle and beef among the three NAFTA members.

Unfortunately, the discovery of BSE in Alberta abruptly illustrated the problems that an export dependent sector can face. On May 20, 2003, the governments of 34 countries, including the United States and Mexico, banned imports of ruminant and ruminant products originating in Canada. As a result, nearly all export markets for live animals and red meat produced in Canada were lost. The resulting dislocation in the Canadian cattle industry was unprecedented with catastrophic implications for the entire domestic supply chain.

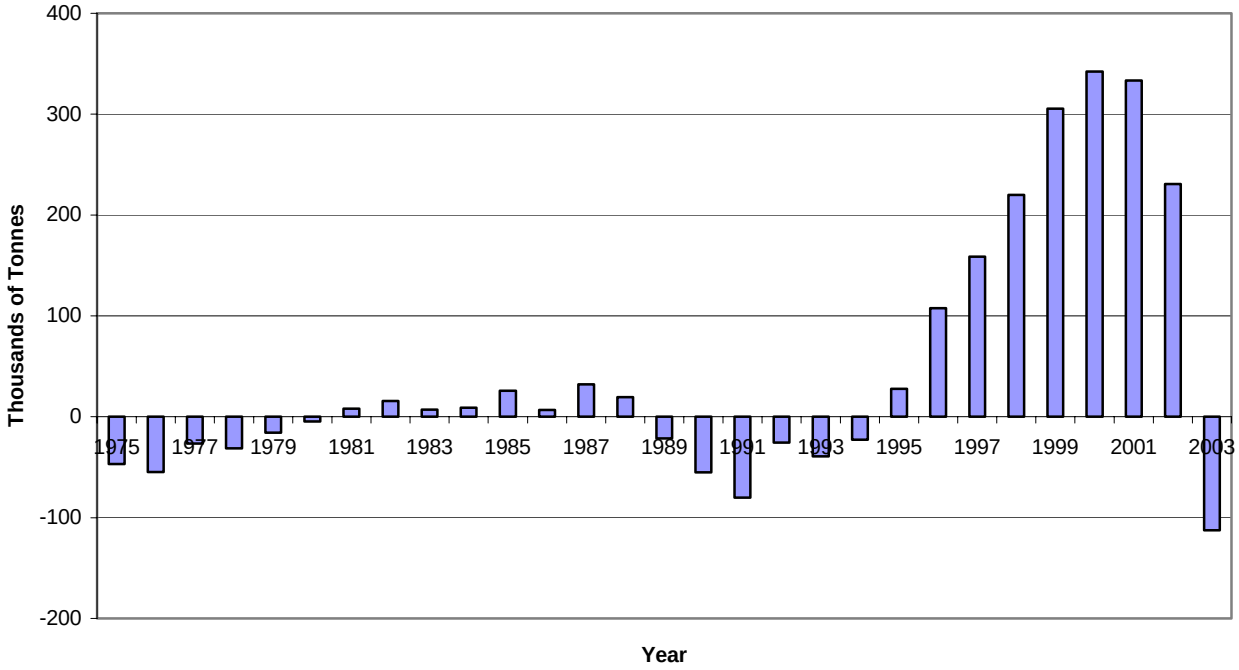
Before May 20, 2003, cattle raised in Canada were slaughtered in processing plants in the United States and in Canada. With few barriers to trade, net exports of cattle from Canada to the United States, which had been small or negative before 1987, grew to 1.5 million head per year by 2002 (Figure 1). Annual net exports of beef, again of minor magnitude until 1995, grew to 350,000 tonnes by 2002 (Figure 2), the equivalent of nearly one-half of the total amount of beef produced in Canada (Agriculture and Agri-Food Canada). When BSE was confirmed in Canada, lucrative lines of production aimed at satisfying foreign consumers became unprofitable. Cattle prices at one Alberta auction dropped from $1.20/lb to $0.32/lb before most cattle were taken off the market. Slaughter plants in Canada stopped accepting new cattle because of limited capacity

Figure 1: Canadian Net Export of Cattle to the United States, 1975-2003



Source: Agriculture and Agri-Food Canada (extracted from LeRoy and Klein).

Figure 2: Canadian Net Export of Dressed Beef, 1975-2003



Source: Agriculture and Agri-Food Canada (extracted from LeRoy and Klein).

and lost foreign sales. The Canadian government stopped all beef shipments not already in transit. Some live animals already in the United States were returned to Canada.

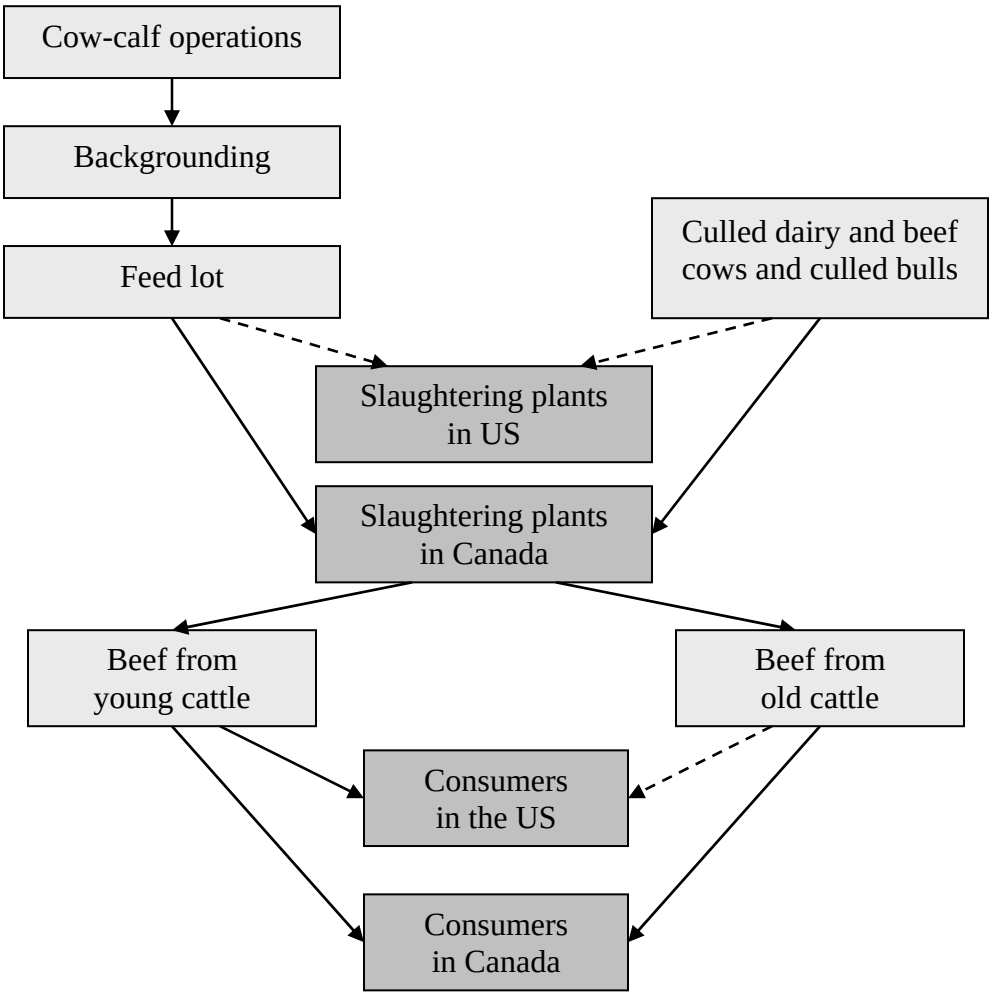
The extraordinary financial collapse of the beef sector could have been much worse had the United States Department of Agriculture not re-admitted imports of beef muscle cuts from ruminants under 30 months of age, on September 10, 2003. The quantity and value of beef exports soon returned to levels that approached pre-BSE volumes. Access to the United States market improved further on July 18, 2005 when imports of live ruminants under 30 months of age were re-permitted, and exports of young animals to the United States also returned to levels comparable to those prior to BSE. While exports of cattle under 30 months of age have risen to levels similar to 2002 (average 8,803 head/week in 2006 vs. 8,802/head week in 2002), the border remains closed for older ruminants.

One consequence of the restrictions, in the United States on imported Canadian cattle and beef, is that the cattle market in Canada is now segregated by age: young cattle, less than 30 months old (calves, steers and heifers) and old cattle, more than 30 months old (bulls and cows). Currently, older cattle cannot be processed in slaughter plants which also process young cattle for export markets. Figure 3 illustrates the resulting distinct age specific marketing channels for cattle and beef.

The financial fallout from the discovery of BSE in Canada has motivated a debate about the policies and programs that governments ought to have taken to restore and ensure the long run viability of Canada's cattle-beef sector. The purpose of this paper is to provide an assessment of three proposed policy and program alternatives on the basis of their economic consequences.[1] This assessment involves four alternative assumptions about border policy: 1) free trade in young beef only, the baseline situation; 2) autarky; 3) free trade in young beef and cattle; and 4) free trade. To this end, a static, multi-market, partial equilibrium model of the Canadian cattle and beef markets is used to quantify the economic impacts of the discovery of BSE and the impacts of three possible BSE recovery programs. The proposed programs include: 1) government subsidization of improvements in slaughtering capacity; 2) a coordinated mass cull of part of the Canadian beef cow herd; and 3) the provision of deficiency payments to ranchers based on the slaughter of old cattle. The analysis uses market conditions in

[1] The analysis in this paper was used in LeRoy, Weerahewa and Anderson (LWA). However, following publication of LWA small changes in the empirical model were made so the numbers in LWA and this paper are slightly different.

Figure 3: Marketing Channel of Cattle and Beef in Canada



2004 to construct a baseline scenario and then discusses the effects of different trade/policy combinations.

The paper is organized in six sections. The next section provides a conceptual analysis of different trade regimes and policy options that guides the structure of the empirical model developed in the third section. The fourth section describes the data used in the empirical model to develop the baseline scenario and to implement the alternative policy scenarios. The fifth section presents the simulation results. The last section summarizes and concludes the paper.

CONCEPTUAL FRAMEWORK

The marketing channel for Canadian cattle and beef is characterized using a partial equilibrium framework. The conceptual framework contains two vertically related markets (cattle and beef) and two horizontally related markets (young and old). Figures 4, 5 and 6 illustrate the equilibrium in the four markets under different trade scenarios. In all three figures, panel A depicts the vertically related markets for old cattle/beef and panel B depicts the vertically related markets for young cattle/beef. The upper level diagrams illustrate the cattle markets and the lower level diagrams show the beef markets.

In the old cattle market (top half of figure 4, panel A) the supply and demand curves for old cattle are denoted by S_{oc} and D_{oc}. Similarly, in the top half of panel B, the supply and demand curves for young cattle are denoted by S_{yc} and D_{yc}. The slaughter demand curves for both old and young cattle are kinked and become perfectly price inelastic at the point of maximum slaughter capacity. Since the figures illustrate static equilibrium solutions, the cattle supply curves show how the supply of old and young cattle change as the breeding herd expands, or contracts, with changes in profitability. Profitability is in turn driven by changes in the prices of old and young cattle. The demand curves for old and young beef are denoted by D_{ob} and D_{yb}. To simplify the graphical presentation it is assumed that old beef and young beef are independent goods (i.e., the cross price elasticity of demand between young and old beef is zero).[2] The quantity supplied of old and young beef is determined by the quantity demanded (slaughtered) of old and young cattle by processors, given the assumption of a fixed proportions technology.

Equilibrium under free trade

Figure 4 depicts the equilibrium under free trade (i.e., before May 20, 2003). The equilibria in the cattle (young and old) and beef markets (young and old) are the result of the free interplay of supply and demand for both cattle and beef. Cattle and beef producers in Canada are assumed to be price takers. P^{w}_{oc} shows the world market price of old cattle and S^{b}_{oc} and D^{b}_{oc} show the corresponding quantity of old cattle supplied and demanded. Similarly, P^{w}_{yc} is the world market price of young cattle and S^{b}_{yc} and D^{b}_{yc} are the corresponding quantities supplied and demanded of young cattle. With the small country assumption changes in the Canadian market do not influence the world market prices for beef or cattle.

[2] This assumption is relaxed in the empirical model.

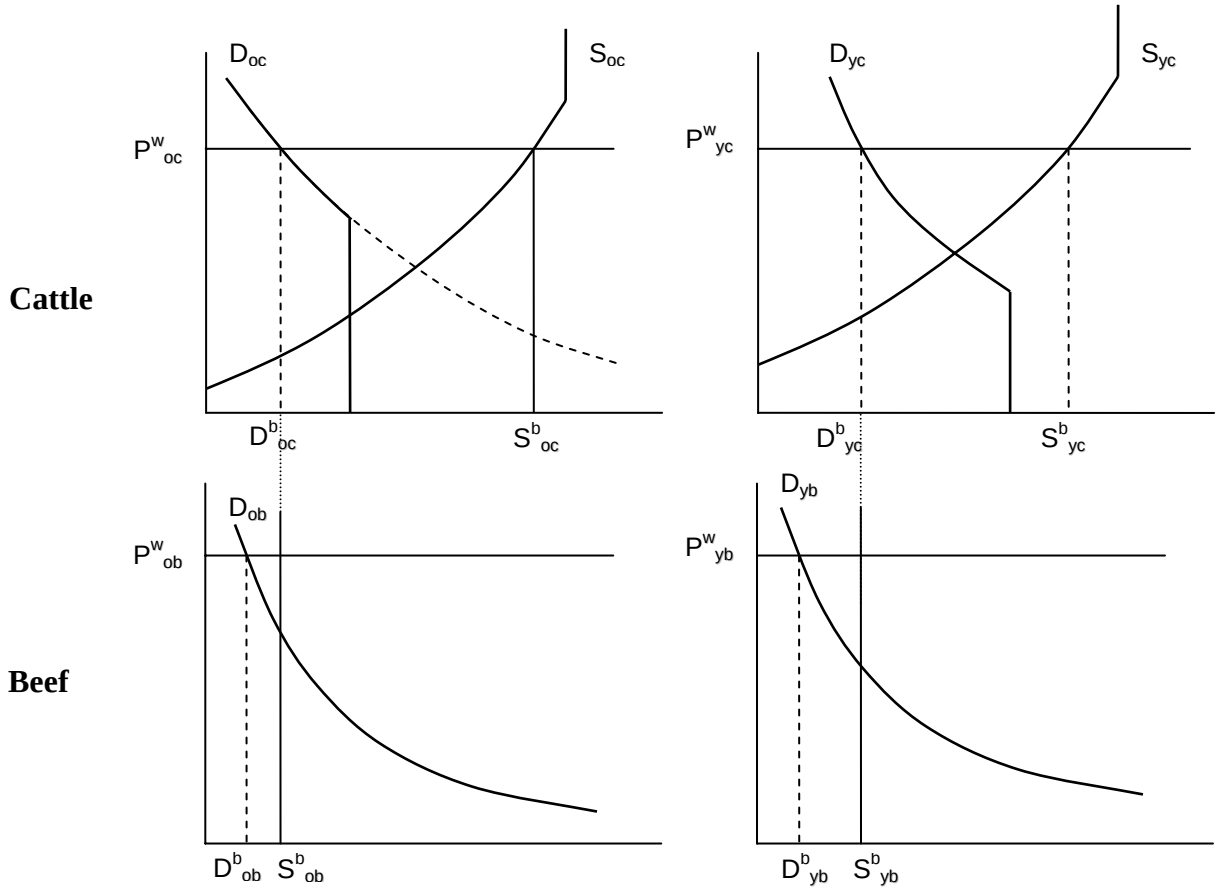


Figure 4: Equilibrium in Cattle and Beef Markets: Free Trade

In the beef markets (bottom half of Figure 4) P^w_{ob} shows the world market price of old beef and D^b_{ob} shows the quantity demanded at that price. Similarly, P^w_{yb} shows the world market price of young beef and D^b_{yb} is the quantity of young beef demanded at P^w_{yb}. The quantity of old and young beef supplied is S^b_{ob} and S^b_{yb}. In all four markets, the quantity supplied exceeds the quantity demanded. Excess supplies are exported at the prevailing world market price. In this trade scenario, the processing margin (the revenues from beef minus the cost of cattle) is determined exogenously by world market prices. The role of the domestic demand curve is to determine how many cattle are slaughtered domestically and how many are exported at the exogenously determined processing margin. Given the domestic supply of beef, determined as a fixed proportion of the number of cattle slaughtered, domestic beef demand again determines the quantity of beef exported.

Equilibrium under autarky

When BSE was confirmed in Canada on May 20, 2003 cattle and beef export opportunities vanished. As a consequence, prices were determined through buying and selling on the domestic market only. Figure 5 illustrates this situation. The price of old cattle, P^a_{oc}, is the result of the interaction between the domestic demand for old cattle (D_{oc}), which is kinked at the maximum processing capacity, and the supply of old cattle (S_{oc}). At P^a_{oc}, the quantity of old cattle demanded is D^a_{oc}. Through the slaughtering process this quantity of old cattle generates a quantity of old beef supplied equal to S^a_{ob}. P^a_{ob} is the market clearing price for old beef.

The effects of the border closures operate in a similar fashion in the markets for young cattle and beef. The price for young cattle (P^a_{yc}) is the outcome of the interaction between the domestic demand for young cattle (D_{yc}) and the supply of young cattle (S_{yc}). At P^a_{yc}, the quantity of young cattle demanded is D^a_{yc}. When processed, this quantity of young cattle generates a quantity supplied of young beef equal to S^a_{yb}. P^a_{yb} is the market clearing price for quantity S^a_{yb} of young beef.

Prices without trade in all four markets are lower than before the border closures but cattle prices must fall more than beef prices to generate the higher processing margins necessary to entice domestic processors to slaughter more animals.[3] The quantities demanded

[3] In this description and in the empirical model it is assumed that beef supply is an upward sloping function of the processing margin (Moschini and Meilke). Given this assumption and a fixed technical relationship between the number of cattle slaughtered and beef supply, the demand curve for cattle slopes downward. For a fixed beef price, lower cattle prices (i.e., a higher processing margin) are required to get processors to slaughter more animals.

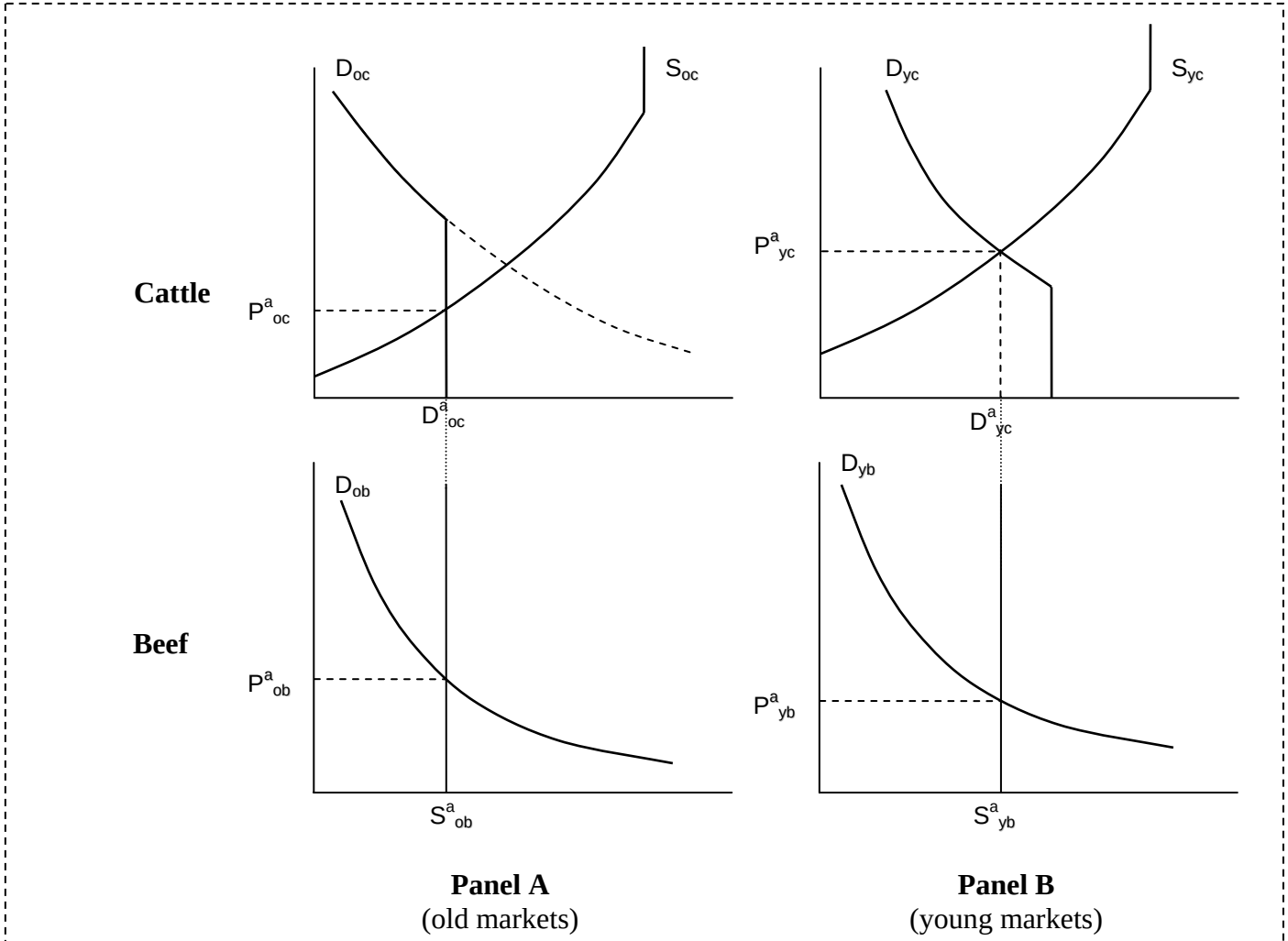


Figure 5: Equilibrium in Cattle and Beef Markets: Autarky

are higher and quantities supplied are lower than those depicted in the free trade equilibrium in Figure 4.

Equilibrium with a partial trade ban (free trade for young beef only)

Figure 6 shows the effects of a partial opening of the market for young beef compared with autarky. As before, the price for old cattle (P^a_{oc}) is the outcome of the interaction between domestic demand for old cattle ($D_{oc,}$) which is kinked at the maximum processing capacity, and the domestic supply of old cattle (S_{oc}). At P^a_{oc}, the quantity demanded of old cattle is D^a_{oc}. The slaughter of old cattle creates a quantity supplied of old beef equal to S^a_{ob}. The market clearing price of this quantity of old beef is P^a_{ob}.

With the border open for young beef the price of young beef increases from P^a_{yb} to P^w_{yb}. At P^w_{yb}, the quantity demanded of young beef on the domestic market falls to D'_{yb}. In response to the higher prices received for young beef, processors' demand for young cattle shifts to the right to D'_{yc} and the equilibrium quantity slaughtered is D'_{yc}. As drawn, the maximum processing capacity (D'_{yc}) limits the quantity of young cattle slaughtered domestically and corresponds to a quantity supplied of young beef equivalent to S'_{yb}. With the higher young beef price the quantity exported changes from zero under autarky to $S'_{yb} - D'_{yb}$.

There is also a small impact in the market for old cattle. The higher young cattle price causes the old cattle supply curve to shift to the right to S'_{oc} as the breeding herd expands. This expansion plus the processing constraint results in the price of old cattle falling to P'_{oc}. The old beef market is unaffected because of the processing constraint.

Welfare effects

The conceptual framework developed above can be used to compare the welfare effects of different trade policy environments. The standard measures of consumer and producer surplus are used to provide the welfare comparisons. Consider a move from free trade to autarky as occurred when the borders were closed to all cattle and beef exports. Canadian consumer surplus (measured as the area below the demand curve and above the prevailing market price) in both the old and young beef markets increases as prices fall and consumption increases.[4]

[4] With the assumption of zero cross price effects the path dependency problem in measuring consumer surplus does not exist (Just, Hueth and Schmitz).

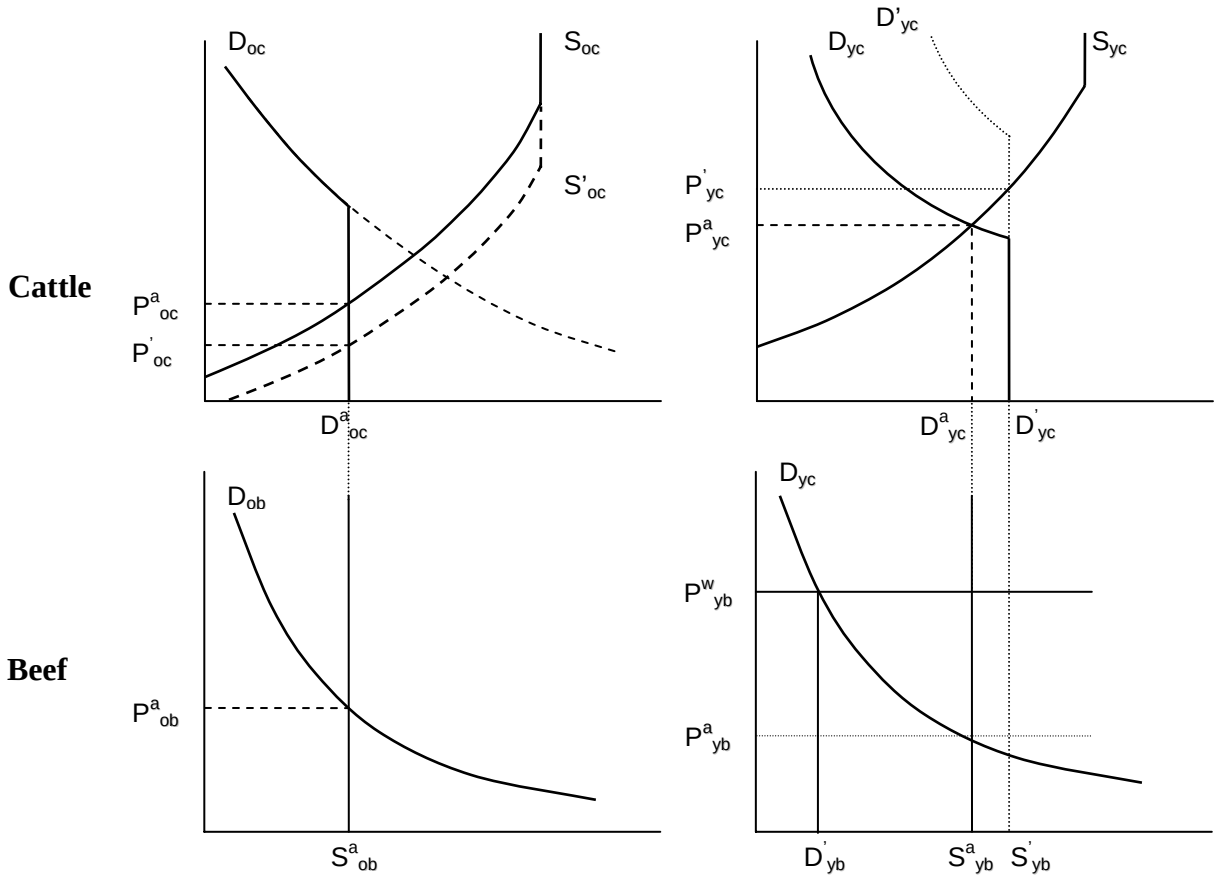


Figure 6: Equilibrium in Cattle and Beef Markets: Trade in Young Beef Only

Cattle producers lose as market prices fall and the quantity supplied declines. Cattle producer surplus is measured as the area above the supply curve and below the market price. The binding processing constraint has the effect of depressing old cattle prices more than if this constraint did not exist. Ignoring the effects outside of the beef market it is clear that a move from free trade to autarky leads to losses among cattle producers while beef consumers enjoy welfare gains.

Canadian cattle processors are also affected by the border closing. The more beef prices fall in the domestic market, the less processors are willing to pay for cattle. Given the relatively price inelastic nature of cattle supply, in the medium-run, processors almost certainly end up processing more cattle at higher processing margins than in the free trade scenario. In this situation, Canadian cattle processors unambiguously gain from the border closing. The welfare of processors is measured as the area under the cattle demand functions (young and old) and above the market price.

Impact of slaughter capacity expansion with a partial trade ban

One of the policy responses to the unfolding BSE crisis, considered (and later implemented) by the Canadian government, was to subsidize the expansion of domestic slaughtering capacity, particularly for old cattle. The impacts of such a policy in the partially opened beef market (trade in young beef only) are shown in Figure 7. A binding processing constraint implies that on the margin, old cattle receive a price lower than their marginal value product. Enhanced slaughter capacity shifts the kink in the demand curve for old cattle to the right, from D_{oc} to D'_{oc}. As capacity expands, processors increase the quantity of cattle purchased from D^a_{oc} *to* D^c_{oc} and the price is bid upward from P^a_{oc} to P^c_{oc}. Figure 7 illustrates that as the price of old cattle increases to P^c_{oc}, the quantity of old cattle supplied increases and the quantity of old beef supplied increases to S^c_{ob} and the price of old beef falls to P^c_{ob}. In other words, the increase in slaughtering capacity can help to mitigate the losses incurred by old cattle producers as it simultaneously increases old cattle prices and the quantity of old cattle supplied. In addition, consumers of old beef will enjoy the lower prices which are necessary to clear the market of the larger quantity of old beef. Although it is not illustrated in Figure 7 the higher price for old cattle would cause the supply curve for young cattle to shift slightly to the right as a result of a slight expansion in the breeding herd.

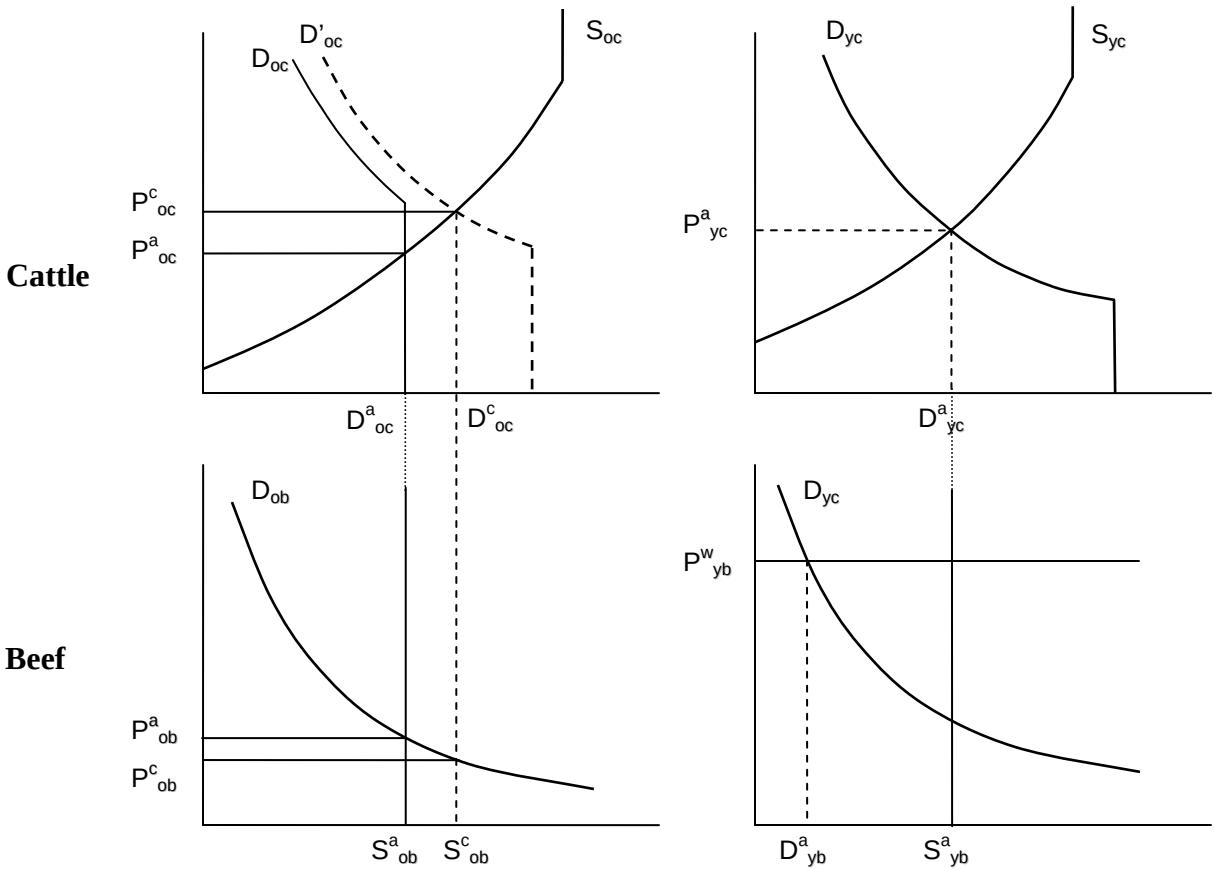


Figure 7: Equilibrium in Cattle and Beef Markets with an Increase in Slaughter Capacity For Old Cattle

Impact of a mass cull with a partial trade ban

A second policy alternative (which was not implemented) is the mandatory destruction of some of the beef cow herd. Figure 8 shows that a mass culling policy would have the effect of shifting the supply curves for both young and old cattle to the left. As a result, prices of young and old cattle increase and the availability of cattle to manufacture beef decreases. These changes in the cattle market lead to a decrease in the supply of old beef from S^a_{ob} to S^c_{ob} and to an increase in the price of old beef from P^a_{ob} to P^c_{ob}. Since the demand curve for young beef is perfectly price elastic at the world market price P^w_{yb}, a decrease in the quantity supplied of young beef implies that exports decrease from $S^a_{yb} - D^b_{yb}$ to $S^c_{yb} - D^b_{yb}$.

Impacts of a slaughter subsidy in a partially open market

A third policy alternative considered is a per head subsidy for old slaughter cattle. This policy was implemented because of its anticipated direct and beneficial impacts on cattle producers income. Figure 9 illustrates that if the subsidy, denoted by s, was delivered as a deficiency payment, in the old cattle market only, it shifts the old cattle supply curve to the right from S_{oc} to S'_{oc}. This drops the market price for old cattle from P^a_{oc} to $P^a_{oc} - s$, the exact amount of the subsidy payment. This "odd" outcome follows from the assumption that the old cattle supply curve intersects the perfectly inelastic section of the old cattle demand curve. In this situation, the entire amount of the deficiency payment is captured by the processing sector. In a more "normal" situation where the old cattle supply curve intersects the downward sloping portion of the cattle demand curve, processors and ranchers would share the value of the subsidy. The more price inelastic the supply of cattle relative to the demand for cattle the more of the subsidy captured by ranchers. This diagram illustrates that a deficiency payment program makes little sense if there is a processing constraint and the goal is to help ranchers.

With the processing capacity constraint in place a deficiency payment program for old cattle has no market effects other than to lower the price of old cattle.

Summary

The conceptual analysis in this section reveals how border closures can lead to significant losses to Canadian cattlemen. It also describes the likely effects of three proposed policies to mitigate some of the losses within the Canadian cattle and beef marketing channel. Using the conceptual framework, the next section develops an empirical model to quantify the impacts of the three different trade regimes and the three policies described above.

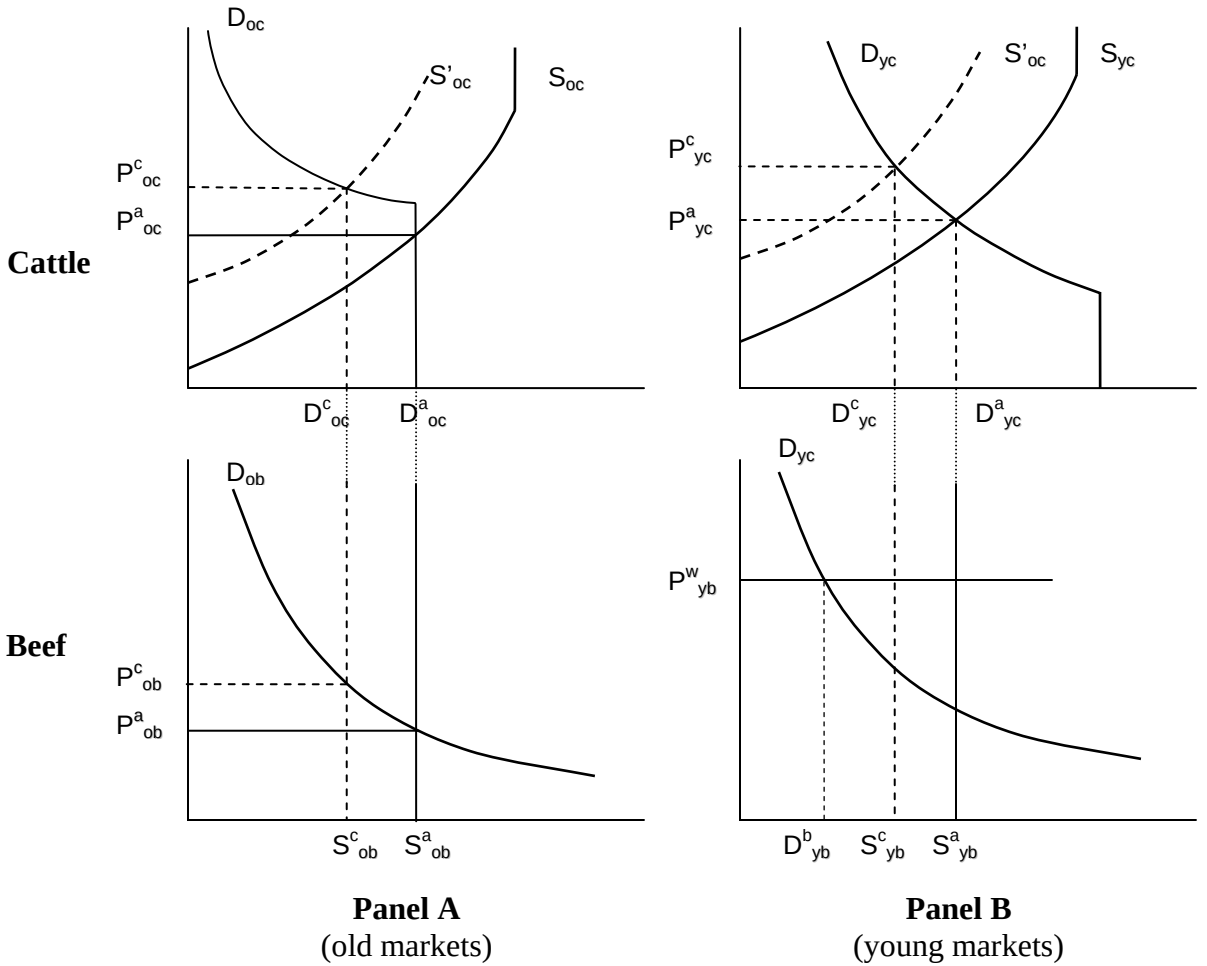
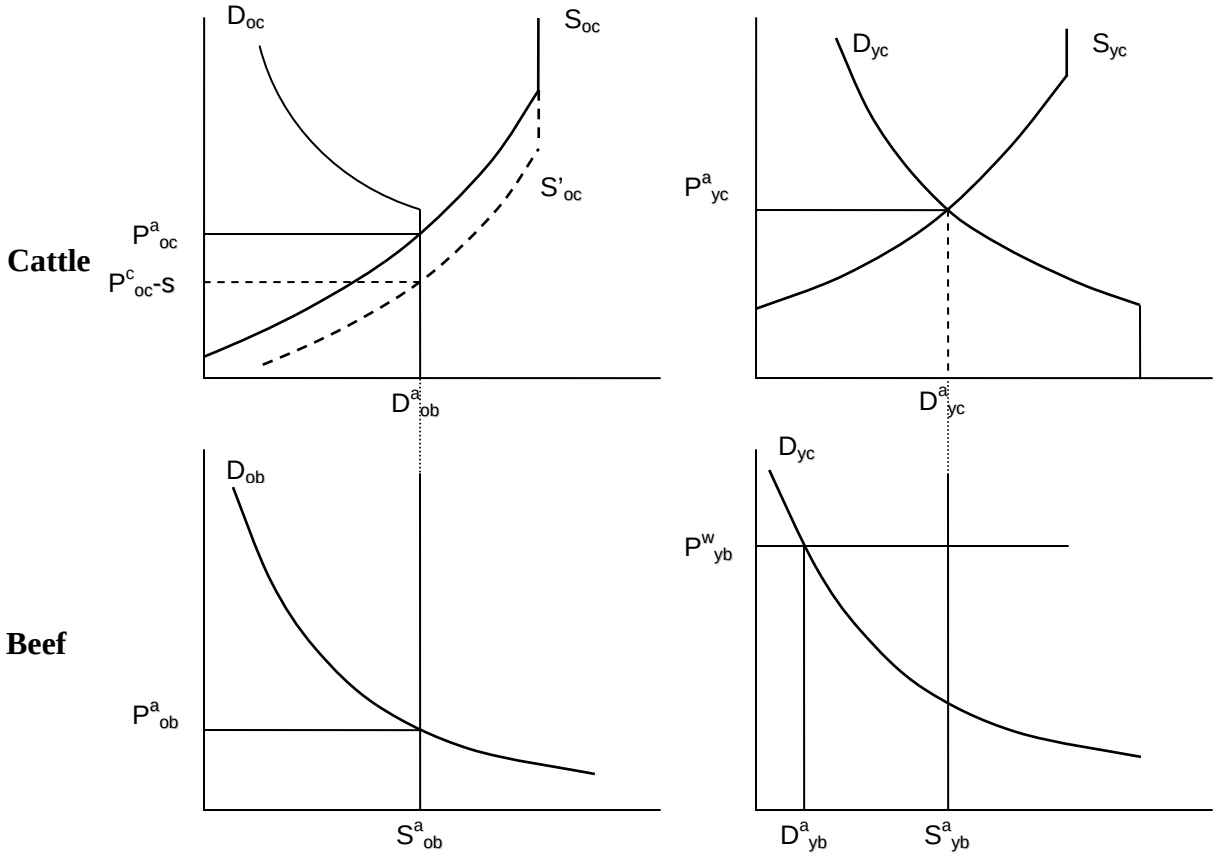


Figure 8: Equilibrium in Cattle and Beef Markets with a Mass Cattle Cull



Panel A
(old markets)

Panel B
(young markets)

Figure 9: Equilibrium in Cattle and Beef Markets with a Slaughter Subsidy

EMPIRICAL MODEL

The goal of this modeling exercise is to construct a cattle/beef model that captures the essence of the sector while abstracting from the cattle cycle. We take this approach because we want to focus attention on the medium-run consequences of policy actions. It is quite possible that there are "good" short-run policies that have "bad" longer-run consequences. In addition, we want a model that is simple and transparent enough to be easily understood and explained. To explain the short-run effects of policies in the cattle/beef sector, complex dynamic models are required. Not only are these models difficult to construct and to explain, they make the calculation of producer welfare almost impossible. In addition, regardless of the short-run dynamics - the cattle/beef sector will eventually reflect the fact that the breeding herd will adjust to the profitability in the sector and a breeding herd of a given size will generate a relatively fixed group of animals that must either be slaughtered or exported. Border measures will largely determine the amount of domestic production (cattle and beef) that is processed or consumed at home and how much is exported. It is the medium-run outcome we want to capture and that also makes the calculation of producer surplus relatively straightforward.

(1) $I = a_1 + a_2 P_o + a_3 P_i; where \;\; P_o = w_y (P_{yc} + sub_{yc}) + w_o (P_{oc} + sub_{oc})$

In equation (1), I is the breeding inventory of cattle, P_o is the average output price and P_i represents all other input prices. The parameter (a_2) in equation (1) shows the medium-run change in the breeding inventory resulting from a unit change in the returns from selling both young and old cattle. The weights w_y and w_o show the average proportion of the total number of animals slaughtered that are young and old. P denotes price and it is expressed in dollars per head and *sub* denotes the per head subsidy, if any. Subscripts denote the type of product, *yc* is young cattle and *oc* is old cattle. Production costs, other than the cost of live animals, are treated as constant across all scenarios and are captured in the inventory equations intercept term ($a_0 = a_1 + a_3 P_i$).[5] A constant proportion of the breeding inventory (off-spring and cull animals) are slaughtered as young and old cattle. As a result, the supply functions for young and old cattle are (equations 2 and 3).

(2) $S_{yc} = \lambda_{yc} * I$ Supply of young cattle for slaughter

[5] An unfortunate and inescapable consequence of using a price inelastic linear supply curve is that it cuts the price axis at a negative value.

(3) $S_{oc} = \lambda_{oc} * I$ Supply of old cattle for slaughter

Where λ_{yc} and λ_{oc} are the average proportions of the breeding inventory that are slaughtered as young and old animals. The demand for young cattle by processors is a function of the packer's gross margin - the difference between the price of a unit of beef minus the cost of the cattle required to produce the beef. The constant Φ shows the quantity of cattle required to produce one unit of beef (Moschini and Meilke).

(4) $D_{yc} = c_{yc} + d_{yc}(P_{yb} - \Phi_{yc} \cdot P_{yc})$ Slaughter demand for young cattle

The demand for old cattle by packers uses the same specification as for young cattle except a capacity constraint in processing old beef is incorporated into equation (5) by kinking the demand curve and making it completely price inelastic at the capacity constraint.

(5) $D_{oc} = Min\{(c_{oc} + d_{oc}(P_{ob} - \Phi_{oc} \cdot P_{oc})), \quad \overline{D}_{oc}\}$ Slaughter demand for old cattle

Where $\overline{D}_{oc}$ is the maximum slaughtering capacity.

The supply of beef is a constant proportion of the cattle slaughtered.

(6) $S_{yb} = cf_{yc} * D_{yc}$ Supply of young beef

(7) $S_{ob} = cf_{oc} * D_{oc}$ Supply of old beef

Where *cf* is the cold carcass weight and subscript *yb* denotes young beef and *ob* denotes old beef.

Unlike the earlier graphical representations in the empirical model consumers treat young and old beef as substitutes and the final demand for both products are functions of both prices (equations 8 and 9).

(8) $D_{yb} = f_{yb} - g_{yb}P_{yb} + h_{yb}P_{ob}$ Demand for young beef

(9) $D_{ob} = f_{ob} + g_{ob}P_{yb} - h_{ob}P_{ob}$ Demand for old beef

Direct government expenditures on subsidy programs are calculated as:

(10) $GE = sub_{yc} * S_{yc} + sub_{oc} * S_{oc}$

The market clearing conditions incorporated in the model differ depending border conditions.

For free trade equations (11), (12) (13) and (14) impose the small country assumption, i.e., Canadian prices equal those in the United States adjusted for currency (x) and transfer costs (T), assuming Canada is an exporter of all four products.

(11) $P_{yc} = P_{yc}^{us} \cdot x - T_{yc}$; (12) $P_{oc} = P_{oc}^{us} \cdot x - T_{oc}$; (13) $P_{yb} = P_{yb}^{us} \cdot x - T_{yb}$;

(14) $P_{ob} = P_{ob}^{us} \cdot x - T_{ob}$

For autarky Canadian supply is equated to Canadian demand to generate market clearing prices.

(11') $S_{yc} = D_{yc}$; (12') $S_{oc} = D_{oc}$; (13') $S_{yb} = D_{yb}$; (14') $S_{ob} = D_{ob}$

For trade in young beef only (baseline) the market clearing conditions are:

(11'') $S_{yc} = D_{yc}$; (12'') $S_{oc} = D_{oc}$; (13'') $P_{yb} = P_{yb}^{us} \cdot x - T_{yb}$; (14'') $S_{ob} = D_{ob}$

For trade in *young beef and young cattle only* the market clearing conditions are:

(11''') $P_{yc} = P_{yc}^{us} \cdot x - T_{yc}$; (12''') $S_{oc} = D_{oc}$; (13''') $P_{yb} = P_{yb}^{us} \cdot x - T_{yb}$; (14''') $S_{ob} = D_{ob}$

Where x is the C$/US$ exchange rate and T represents the basis between the relevant U.S. cash market and the Canadian cash market when free trade prevails.

In all of the models, Canada's net exports (E) of cattle and beef are calculated from the following identities.[6]

(15) $E_{oc} = S_{oc} - D_{oc}$

(16) $E_{yc} = S_{yc} - D_{yc}$

(17) $E_{ob} = S_{ob} - D_{ob}$

(18) $E_{yb} = S_{yb} - D_{yb}$

Producer total revenue is calculated using equation (19).

(19) $TR = S_{oc} \cdot (P_{oc} + sub_{oc}) + S_{yc} \cdot (P_{yc} + sub_{yc})$: Gross revenue of cattle producers

This static medium-run model contains 20 endogenous variables (D_{yc}, D_{oc}, D_{yb}, D_{ob}, S_{yc}, S_{oc}, S_{yb}, S_{ob}, E_{yc}, E_{oc}, E_{yb}, E_{ob}, GE, I, P_{yc}, P_{oc}, P_{yb}, P_{ob}, P_o, TR); thirteen exogenous variables ($\overline{D}_{oc}, P_{yc}^{us}, P_{oc}^{us}, P_{ob}^{us}, P_{yb}^{us}, sub_{oc}, sub_{yc}, x, T_{yc}, T_{oc}, T_{yb}, T_{oc}, T_{yb}, T_{ob}, P_i$; eight technical coefficients (cf_{yc}, cf_{oc}, Φ_{yc}, Φ_{oc}, λ_{yc}, λ_{oc}, w_y, w_o); and 12 parameters (a_0, a_2, c_{yc}, d_{yc}, c_{oc}, d_{oc}, f_{yb}, g_{yb}, h_{yb}, f_{ob}, g_{ob}, and h_{ob}).

When the policy shocks are introduced they are handled in the following ways:

(i) Slaughter capacity expansion: increase the intercept of the old cattle demand function and capacity limit by ten percent.

[6] Under the assumption of autarky exports are obviously zero.

(ii) Destroying a part of cattle herd: shift the inventory function to the left by ten percent.

(iii) Subsidy on old cattle slaughter: create a wedge between the price that producers receive and the price that packers pay (sub_{oc}) by an amount equivalent to the per head payment.

DATA AND PARAMETERS

The model is calibrated to 2004 data. Hence, the baseline data represents the situation where the border is open to trade in young beef but not to trade in live animals or old beef. The data maintained by Agriculture and Agri Food Canada (AAFC) and utilized in its Food and Agriculture Regional Model (FARM) is the main data source. Where FARM data is insufficient it is augmented with data from CANSIM and other AAFC sources. Steers, heifers and calves are considered young animals while bulls and cows are considered old animals.

Cattle market

The number of animals slaughtered and the breeding inventory are measured in thousands of head. Cattle slaughter is delineated by the type of animal; steers (2,001.46), heifers (1,383.73), bulls (52.67) and cows (465.73). The number of calves slaughtered (353) is from CANSIM. The total number of old and young animals slaughtered is 518.67 and 3,738.44 thousand head, respectively. The total number of animals slaughtered in 2004 is 4,256.64 thousand head. Therefore, 12.18 percent and 87.82 percent of total slaughter consisted of old and young animals and these percentages are the weights used for the old (w_o) animal price and young (w_y) animal price in the inventory equation (equation 1).

These animals originated from a breeding inventory that contained 239.7, 1,065.3 and 4,752.1 thousand head of bulls, dairy cows and beef cows respectively.[7] The total breeding inventory is 6,057.10 thousand head from which 8.56 percent were slaughtered as old cattle (culls) and 61.72 percent were slaughtered as young cattle (off spring). Therefore, 8.56 percent and 61.72 percent are used as the technical coefficients (λoc and λyc) in the old and young cattle supply equations (equations 3 and 2).

[7] The static nature of the model forced a difficult decision. Most of the young animals slaughtered in 2004 are the offspring of cows on farms in 2003 while most of the culls would have been taken from the 2004 herd. We made the decision to assume that both young and old slaughter animals in 2004 could be related to the size of the 2003 herd.

Beef market

Beef production, exports, imports, inventory and consumption are measured in thousands of metric tonnes. The number of animals slaughtered is multiplied by the respective cold carcass weights to obtain old and young beef production of 162.84 and 1,280.31 thousand tonnes respectively (Table 1). All exports of beef in 2004 are young beef and net exports total 466.37 thousand tonnes.[8] Beef consumption levels are obtained by adjusting beef production for net exports. Accordingly, young beef consumption is 813.94 thousand tonnes[9]. Old beef consumption in 2004 is 162.84 thousand tones.

Prices

The Canadian cow price (C$23.36 per 100 pounds (cwt) in live weight) and steer price (C$77.89 per cwt live weight) are indicative of the domestic prices of old and young cattle in 2004. The price per head is obtained by multiplying the prices by cold carcass weights and dividing by the respective dressing percentages (Table 1). The dressing percentages for bulls, dairy cows and beef cows are in the range of 48 to 58, 40 to 50, and 50 to 60 respectively. For steers, heifers and calves the dressing percentages are 58.5 percent, 57 percent and 50 percent respectively. The weighted average dressing percentages for old and young cattle are 50.30 percent and 57.14 percent, respectively. The average cold carcass weight of an old animal is 692.53 pounds (the weighted average of bulls and cows obtained as 0.11*1014.87+0.89*656.07 where 0.11 and 0.89 are the shares of bulls and cows in old cattle and 1,014.87 and 656.07 are their cold carcass weights respectively). The average cold carcass weight of a young animal is 805.42 lbs (the weighted average of steers and heifers obtained as 0.59*827.59+0.41*773.35 where 0.59 and 0.41 are the shares of steers and heifers in young cattle and 827.59 and 773.35 are their cold carcass weights respectively). The resulting old and young cattle live weights are 1,376.63 and 1,409.51 pounds respectively and the prices per head are C$321.45 and C$1097.87 per head respectively.

Cattle prices in the U.S. for boning utility cows and choice steers are treated as old and young cattle prices. However, the closed border in 2004 distorted these prices. When we model partial or complete border opening we want to capture the normal relationship among Canadian and US prices. To do this we calculate the cash market basis (US cash market price minus the

[8] Old beef could not be exported in 2004.

[9] In 2004 Canada was a small net exporter (16 thousand tones) of beef to countries other than the United States. This trade is ignored in our analysis.

Table 1: Data for Carcass Weights, Cattle Slaughter and Beef Production

Type of animal	Number slaughtered ('000 head)	Dressing percentage (percent)	Cold carcass weight (kg)	Beef production ('000 tones)
Steers	2001.46	58.5	375.39	751.33
Heifers	1383.73	57.0	350.79	485.40
Bulls	52.67	48-58	460.34	24.25
Cows	465.73	50.0	297.59	138.60
Calves	353.05	50.0	123.46	43.59

Source: Calculated by authors using secondary data.

Canadian cash market price) between Canada and the United States in 2002 (the year prior to the discovery of BSE). The price of old cattle in 2002 in Canada was C$58.51/cwt live weight, and the U.S. price after adjusting for the exchange rate (1.57 in 2002) was C$61.64/cwt live weight. Prices per head of old cattle in Canada and in the US in 2002 were C$805.49 and C$848.55 respectively. Hence, the old cattle basis in 2002 was $43.06/head. The 2002 price of young cattle, in Canada, was C$98.74/cwt live weight and the US price after adjusting for the exchange rate was C$105.25/cwt live weight, hence the 2002 basis for young cattle was C$91.80/head.

According to AAFC, the price of beef sides in Canada, which is used as the young beef price, was C$4.96/kg (C$4,960/tonne) in 2004. The US equivalent price for young beef is assumed to equal the Canadian price, adjusted for exchange rates, since young beef was freely traded in 2004.[10]

The price of low quality beef in Canada in 2004 and 2002 was C$113 and C$129.3/cwt (C$2,506.66 and C$2,851.24/tonne) respectively. The U.S. price of low quality beef reported in the FARM database is taken to represent the old beef price in the US. It was US$64.17/cwt

[10] We were unable to find comparable beef price data for the US and as a result we ignored the basis between the two markets.

(C$100.74/cwt or C$2,221.09/tonne) in 2002. Hence, the basis in 2002 was negative C$630.10 per tonne.[11]

The cold carcass weight of cattle is used in determining the production of beef. The cold carcass weight of a young animal is 805.42 lbs (0.365 tonnes). This number implies that one young animal is used to produce 0.365 tonnes of beef or 2.737 young animals are required to produce one tonne of young beef. Therefore, the constant term (Φ_{yc}) in the young cattle demand function (equation 4) is 2.737. For old animals, the cold carcass weight is 0.314 tonnes implying 3.183 old animals are required to produce one tonne of old beef. The constant term (Φ_{oc}) in the young cattle demand function (equation 5) is 3.183.

ELASTICITY ESTIMATES

Elasticity of the breeding inventory with respect to price:

This medium-run inventory elasticity is assumed to equal 0.33 and it determines the own and cross price elasticities of the young and old and cattle supply functions in the following manner.

Combining equations (1), (2) and (3) the cattle supply functions can be written as:

$$(2') \quad S_{yc} = \lambda_{yc} \cdot (a_1 + a_2 (w_y (P_{yc} + sub_{yc}) + w_o (P_{oc} + sub_{oc})))$$

$$(3') \quad S_{oc} = \lambda_{oc} \cdot (a_1 + a_2 (w_y (P_{yc} + sub_{yc}) + w_o (P_{oc} + sub_{oc})))$$

Simplifying the above equations gives:

$$(2'') \quad S_{yc} = a_{yc} + b_{yc} (P_{yc} + sub_{yc}) + c_{yc} (P_{oc} + sub_{oc})$$

$$(3'') \quad S_{oc} = a_{oc} + b_{oc} (P_{yc} + sub_{yc}) + c_{oc} (P_{oc} + sub_{oc})$$

The relationships among different parameters are:

$b_{yc} = \lambda_{yc} a_2 w_y$

$c_{yc} = \lambda_{yc} a_2 w_o$

$b_{oc} = \lambda_{oc} a_2 w_y$

$c_{oc} = \lambda_{oc} a_2 w_o$

As the inventory elasticity with respect to price is 0.33, the values obtained for the above parameters are: b_{yc} = 1.090; c_{yc}=b_{oc}=0.151; c_{oc}=0.021 implying that the own price effect is higher

[11] Since Canada was a net exporter of low quality beef to the US the fact measured US prices are lower than those in Canada is troubling. We feel this is a problem of not being able to compare comparable products and using the traditional basis in our analysis does not create any serious problems in the policy analysis.

than the cross effect in the young cattle supply function but the own effect is smaller than the cross effect in the old cattle supply function.

Elasticity of cattle demand with respect to beef price:

The elasticity of cattle demand (processors demand) with respect to the beef price is 0.66 and taken from FARM. Using this elasticity the young cattle demand function can be calibrated (demand is expressed as a function of the gross margin). The old and young capacity constraints were considered as 110 percent and 200 percent (effectively non-binding) of the 2004 actual slaughter level.

Own and cross price elasticities of the young and old beef demand functions:

Both the own and the cross price elasticities of demand are required to calibrate the consumer demand functions and they were obtained from FARM (Table 2). The direct price elasticity in both the young and the old demand functions is assumed to be -0.69 following FARM, the old beef cross price elasticity is assumed to be 1.00 and the young beef cross price elasticity is set at 0.043. The implication of these elasticities is that young beef price changes have a relatively large impact on old beef consumption, while old beef price changes have a relatively small impact on young beef demand.

Table 2: Elasticity Assumptions for Baseline Model[a]

Elasticity	Estimate
Inventory elasticity	0.33
Young Cattle demand with respect to young cattle price	-0.40
Old Cattle demand with respect to old cattle price	-0.27
Cattle demand with respect to beef price	0.66
Young beef demand with respect to own price	-0.69
Old beef demand with respect to own price	-0.69
Old beef demand with respect to young beef price	1.00
Young beef demand with respect to old beef price	0.04

[a] The elasticities are based on estimates in FARM, a search of the literature and the authors judgment (AAFC).

RESULTS AND DISCUSSION

A series of simulations were performed to: (i) to assess the impacts of closing the border on the markets for — young beef, young cattle, old beef and old cattle, and (ii) to assess the impacts of potential BSE recovery programs under different trade regimes.

Baseline equilibrium

The baseline scenario replicates market conditions in 2004 when the United States border was open only for young Canadian beef (Table 3). In 2004, 518 thousand head of old cattle and 3,738 thousand head of young cattle were slaughtered in Canada. Since the border was closed to live animal trade, all of these animals were processed in Canadian slaughtering plants. As a consequence, the domestic demand for cattle equaled the domestic supply. Average prices for old and young cattle were C$321 and C$1098 per head respectively. The production of beef from old cattle was 162.8 thousand tonnes all of which was consumed in Canada. The production of beef from young cattle was 1,280.3 thousand tonnes and net exports totaled 466.37 thousand tonnes, the rest was consumed in Canada. Suppliers of young beef in Canada received U.S. equivalent prices, which were C$4,960 per tonne. The domestically determined price of old beef was C$2,507 per tonne. In 2004, the total revenue of the cattle industry was C$4,271 million. Cattle producers' surplus totaled C$3,613 million which was distributed between producers of old cattle (C$165.6 million) and producers of young cattle (C$3,448 million).[12]

OUTCOMES WITH ALTERNATIVE TRADE REGIMES

During 2004, beef produced from young cattle could be exported from Canada but beef from old cattle and live cattle could not. By changing the restrictions on beef and cattle trade, the model can be used to quantify the effects of three alternative trade regimes: autarky (no trade in cattle or beef), partial free trade (trade in young beef and cattle only) and free trade (trade in all cattle and beef).

Trade Regime 1: Autarky Suppose the United States border had been closed to young Canadian beef in 2004 (Table 3, regime 1). With this export marketing opportunity unavailable to Canadian suppliers, all young beef would have had to be consumed domestically. The results

[12] The old cattle producers surplus applies only to cull cows and bulls; the return on feeder animals by cow-calf operators is captured in the young cattle producers surplus calculation.

Table 3: Cattle and Beef Demand, Supply, Prices and Surplus Measures Under Different Trade Regimes

Variable		Baseline: trade in young beef only	Regime 1: Autarky	Regime 2: Partial trade liberalization – trade in young beef and cattle	Regime 3: Free trade
Cattle supply ('000 head)	Old	518.48	424.55 (-18.12)	569.58 (9.85)	585.48 (12.92)
	Young	3,738.42	3,061.10 (-18.12)	4,106.83 (9.85)	4,221.51 (12.92)
Cattle demand ('000 head)	Old	518.48	424.55 (-18.18)	569.58 (9.85)	185.16 (-64.29)
	Young	3,738.42	3,061.11 (-18.11)	2,483.69 (-33.56)	2,483.69 (-33.56)
Cattle prices ($ per head)	Old	321.45	156.84 (-51.21)	139.88 (-56.48)	898.65 (179.56)
	Young	1,097.87	499.10 (-54.54)	1,461.13 (33.08)	1461.13 (33.08)
Beef supply ('000 tones)	Old	162.84	133.34 (-18.12)	178.89 (9.85)	58.15 (-64.29)
	Young	1,280.31	1,048.34 (-18.12)	850.88 (-33.56)	850.59 (-33.56)
Beef demand ('000 tones)	Old	162.84	133.43 (-18.12)	178.89 (9.85)	145.18 (-10.84)
	Young	813.94	1,048.34 (28.80)	808.96 (-0.61)	819.42 (0.67)
Beef prices ($ per tone)	Old	2,506.66	1,575.48 (-37.14)	2,150.22 (-14.22)	2,898.88 (15.64)
	Young	4,960.00	2,784.46 (-43.86)	4,960.00 (0.00)	4,960.00 (0.00)
Gross revenue ($ million)		4,270.99	1,594.93 (-62.67)	6,080.31 (42.36)	6,694.33 (56.74)
Producer surplus ($ million)	Old	165.58	66.33 (-59.94)	79.47 (-52.01)	517.68 (212.63)
	Young	3,447.63	1,392.09 (-59.62)	4,837.48 (40.31)	5,005.02 (45.17)
	Total	3,613.22	1,458.42 (-59.64)	4,916.94 (36.08)	5,522.71 (52.84)

suggest that in this situation young beef prices would have fallen from C$4,960 to C$2,784 per tonne (44 percent). The reduction in the young beef price causes a downward shift in the slaughter demand for young cattle lowering the price of young cattle from C$1098 to C$499 per head (54 percent). As a result, the equilibrium young cattle quantity supplied and demanded would have declined from 3,738 to 3,061 thousand head (18 percent) and the old cattle price would have dropped from C$321 to C$157 per head (51 percent). This decrease in price and quantity results from shifts in both the old cattle demand and supply functions. The old cattle demand function shifts to the left because of the drop in the old beef price from C$2,507 to C$1,575 per ton (37 percent) and because young beef is a good substitute for old beef. Due to changes in cattle prices and supply levels, total producer surplus drops from C$3,613 to C$1,458 million, a 59 percent reduction from the base level. The gross revenue of cattlemen falls from C$4,271 to C$1,595 million, a 62 percent reduction from the base level where trade in young beef is allowed. This simulation shows that the opening of the US border for young beef was a crucial response – things were bad in 2004 but they could have been much worse!

Trade Regime 2: Partial Free Trade (trade in young beef and cattle) If the United States border had been reopened for young Canadian cattle in 2004, our results suggest that cattlemen would have received higher prices for young cattle and young cattle supply would have increased 9.8 percent from 3,738 to 4,106 thousand head (Table 3, regime 2). The increase in the quantity of young cattle supplied results from an increase the breeding inventory. However, the larger supply of old cattle, that have to be slaughtered and consumed in Canada would have depressed their price from C$321 to C$140 per head (56 percent). The large price decrease results from a rightward shift in the old cattle supply curve along a very inelastic domestic demand curve, given the constraints on slaughter capacity. Net exports of young cattle and young beef would have been 1,623 thousand head and 41.9 thousand tones, compared to zero young cattle exports and 466 thousand tones of young beef in the baseline. Clearly, when the border is closed to young cattle trade, beef instead of cattle move south. The gross revenue of the industry would have increased from C$4,271 to C$6,080 million, an increase of 42.3 percent from the base level with trade only in young beef. Total producer surplus increases from C$3,613 to C$4,917 million, a 36 percent increase from the base level. For cattlemen, prosperity requires, at least, an open border for young cattle and beef.

Trade Regime 3: Free Trade If there were no trade impediments in 2004 (Table 3, regime 3) – the pre-BSE situation, our results show that producers in Canada would have received higher prices for all types of cattle and beef. It would have generated larger supplies of cattle and beef and greater net exports of cattle and young beef. The supply of old and young cattle would have both gone up 12.9 percent equaling 585 and 4,211 thousand head respectively, while the net exports of old and young cattle would have been 400 and 1,737 thousand head compared to none in the BSE environment of 2004. Domestic demand for cattle and the production of beef would have been lower. Old beef production would have been 58 thousand tonnes instead of 163 thousand tones, a reduction of 64 percent, resulting in net imports of 87 thousand tonnes of old beef. Young beef production would have been 851 thousand tonnes, of which 31 thousand tonnes would have been net exports. Again, open borders result in Canada trading more cattle and less beef. Total producer surplus, would have been higher at C$5,523 million, an increase of 53 percent from the base level and $605 million (12 percentage points) more than when the border was open only to young cattle and beef. Gross revenue in the cattle industry would have increased from C$4,271 to C$6,694 million, a 57 percent increase from the base level.

IMPACTS OF DIFFERENT POLICY PROPOSALS

The simulations described above provide a prediction of the equilibrium outcomes under different trade regimes. The results of three different BSE mitigation policies are now evaluated under each of the four possible trade regimes (Table 4 and Table 5): baseline (free trade in young beef only) autarky, partial free trade (free trade in young beef and cattle) and free trade. The specific mitigation policies include: 1) increasing old cattle slaughter capacity, 2) a mass cull, and 3) an old cattle slaughter subsidy.

Scenario 1: Impact of an increase in slaughter capacity The first policy simulation quantifies the economic consequences if Canadian domestic slaughter plant capacity was ten percent higher for old cattle. Table 4 shows the impacts of expanding the slaughter capacity on the supply, demand, prices, revenue and producer surplus of cattlemen assuming no change in the 2004 trade regime (trade in young beef only). The higher slaughter capacity shifts the demand curve for old cattle to the right and hence, increases the price of old cattle from C$321 to C$481 per head

Table 4: Cattle and Beef Demand, Supply, Prices and Surplus Measures Under Different Policy Scenarios with Trade in Young Beef Only (baseline)

Variable		Baseline: trade in young beef only	Policy 1: Increased slaughter capacity	Policy 2: Mass cull	Policy 3: Slaughter subsidy
Cattle supply ('000 head)	Old	518.48	520.03	480.11	520.06
			(0.30)	(-7.40)	(0.30)
	Young	3,738.42	3,749.58	3,461.72	3,749.75
			(0.30)	(-7.40)	(0.30)
Cattle demand ('000 head)	Old	518.48	520.03	480.11	520.06
			(0.30)	(-7.40)	(0.30)
	Young	3,738.42	3,749.58	3,461.71	3,749.75
			(0.30)	(-7.40)	(0.30)
Cattle prices ($ per head)	Old	321.45	481.38	457.83	315.88
			(30.15)	(42.43)	(-1.73)
	Young	1,097.87	1,094.65	1,177.98	1,094.60
			(-0.29)	(7.30)	(-0.29)
Beef supply ('000 tones)	Old	162.84	163.32	150.79	163.33
			(0.30)	(-7.40)	(0.30)
	Young	1,280.31	1,284.50	1,185.54	1,284.18
			(0.30)	(-7.40)	(0.30)
Beef demand ('000 tones)	Old	162.84	163.32	150.79	163.33
			(0.30)	(-7.40)	(0.30)
	Young	813.94	813.79	817.68	813.79
			(-0.02)	(0.46)	(-0.02)
Beef prices ($ per tone)	Old	2,506.66	2,495.88	2,774.40	2,495.72
			(-0.43)	(10.68)	(-0.44)
	Young	4,960.00	4,960.00	4,960.00	4,960.00
			(0.00)	(0.00)	(0.00)
Gross revenue ($ million)		4,270.99	4,322.03	4,297.66	4,322.82
			(1.19)	(0.62)	(1.21)
Producer surplus ($ million)	Old	165.58	215.74	217.84	216.51
			(30.29)	(31.55)	(30.76)
	Young	3,447.63	3,451.62	3,397.42	3,451.68
			(0.12)	(-1.46)	(0.12)
	Total	3,613.22	3,667.36	3,615.26	3,668.19
			(1.50)	(0.06)	(1.52)

Table 5: Cattle Supply, Prices and Surplus Measures Under Different Policy Scenarios and Three Different Trade Regimes

Variable		Trade Regime	Equilibrium values	Policy 1: Increased slaughter capacity	Policy 2: Mass cull	Policy 3: Slaughter subsidy
Cattle supply ('000 head)	Old	Autarky	424.55	425.08	408.77	425.31
		Partial lib.	569.58	571.35	516.20	570.33
		Free trade	585.48	585.48	526.94	587.66
	Young	Autarky	3,061.11	3,064.95	2,947.32	3,066.57
		Partial lib.	4,106.83	4,119.65	3,721.95	4,112.28
		Free trade	4,221.51	4,221.51	3,799.35	4,237.23
Cattle prices ($ per head)	Old	Autarky	156.84	225.01	302.57	149.85
		Partial lib.	139.88	224.73	329.58	71.95
		Free trade	898.65	898.65	898.65	898.65
	Young	Autarky	499.10	493.17	674.99	490.66
		Partial lib.	1,461.13	1,461.13	1,461.13	1,461.13
		Free trade	1,461.13	1,461.34	1,461.13	1,461.13
Gross revenue ($million)		Autarky	1,594.40	1,607.19	2,113.10	1,612.61
		Partial	6,080.33	6,147.78	5,608.40	6,108.95
		Free trade	6,694.33	6,694.33	6,024.90	6,780.37
Producer surplus ($ million)	Old	Autarky	66.33	95.12	122.82	107.29
		Partial lib.	79.47	127.87	169.10	100.03
		Free trade	517.68	517.68	465.91	578.69
	Young	Autarky	1,392.09	1,379.03	1,766.01	1,373.48
		Partial lib	4,837.48	4,856.21	4,391.43	4,845.44
		Free trade	5,005.02	5,005.02	4,504.52	5,027.99
	Total	Autarky	1,458.42	1,474.15	1,888.83	1,480.77
		Partial	4,916.94	4,984.09	4,560.53	4,945.46
		Free trade	5,522.70	5,522.07	4,970.44	5,606.68
Government expenditure ($ million)		Autarky	0.00	0.00	0.00	44.23
		Partial lib.	0.00	0.00	0.00	59.31
		Free trade	0.00	0.00	0.00	61.12

The partial trade liberalization regime allows trade in young cattle and beef.

(30 percent).[13] Under this scenario the price of young cattle would drop slightly from C$1,098 to C$1,094 per head. The price changes and the extra capacity would have resulted in only slightly higher levels of slaughter for old and young cattle because of the inelastic nature of supply response. The increased supply of cattle would have been processed in Canadian slaughter plants and hence the production of old (0.3 percent) and young beef (0.3 percent) would have also been slightly higher. However, the increase in the supply of old beef would have depressed the old beef price by 0.4 percent and the young beef price is unchanged with the open border. The increased slaughter capacity would have increased cattlemen's gross revenue from C$4,271 to C$4,322 million, a 1.2 percent increase from the base level.

Table 5 summarizes the impacts of a ten percent expansion in old cattle slaughter capacity under the three other trade regimes: autarky, partial trade liberalization with trade in young beef and cattle, and free trade. Table 5 shows the equilibrium values with higher slaughter capacities, however in evaluating these results recall that the base case situation is different in each simulation. For example, the autarky results show what the impact of an increase in slaughter capacity would be – if in 2004 the border had been closed to all cattle and beef trade. The results indicate that the adverse impacts of the border closure would have been smaller if Canada had more old cattle slaughter capacity. Old cattle prices under autarky would have been 43.5 percent higher (C$225/head) with more slaughter capacity and young cattle prices only 1.2 percent lower. Producer surplus would have increased from C$1,458 million to C$1,474 million and gross revenues would have risen from C$1,594 million to C$1,607 million. If all borders had been closed to Canadian exports in 2004 the economic situation would have been a disaster for cattlemen and beef processors, but the disaster would have been slightly smaller with more old cattle slaughter capacity.

In regime two (partial trade liberalization, trade in young cattle and beef), if the border was open for young cattle and young beef then more old cattle slaughter capacity would increase old cattle supply from 569 to 571 thousand head, the price of old cattle by 61 percent from C$140 to C$225 per head, young cattle supply from 4,107 to 4,120 thousand head, total producer surplus from C$4,917 to C$4,984 million dollars and gross revenue from C$6,080 million to C$6,148 million. While most of the changes are small the extra slaughter capacity of old cattle is important for cow-calf producers when old cattle can't be exported.

[13] It is assumed that with increased capacity processors are willing to purchase more old cattle at all prices.

If the border was open for all types of beef and cattle (regime three - free trade) an increase in slaughter capacity in Canada would not have changed cattle producer surplus through prices or supply levels. An increase in slaughter capacity would not have helped cattlemen because it is assumed that old cattle in Canada receive the United States price adjusted for transfer costs.

Scenario 2: Impact of mass cull The second policy simulation evaluates the impact of a deliberate culling of beef cows. Table 4 shows the impact on the supply, demand, prices, revenue and producer surplus of cattlemen when ten percent of the breeding herd is destroyed under the 2004 trade regime. The loss of ten percent of the breeding herd would lower the supply of old and young cattle by ten percent, *ceteris paribus*. However, because of the feedback effects in the medium run model a ten percent cow cull only reduced the output of old and young cattle by 7.4 percent. This shift in the supply curves increases the price of both old and young cattle by 42.4 percent and 7.3 percent respectively. Total producer surplus increases from C$3,613 to C$3,615 million, a 0.06 percent increase from the baseline. Gross revenue increases from C$4,271 to C$4,298 million, a 0.6 percent increase from the baseline suggesting that in the medium term, under the 2004 trade regime, cattlemen benefit slightly from a mass cull. It is important to note that this analysis does not account for the costs of the cow cull and disposal – costs that would be substantial.

Table 5 shows the impacts of culling the cattle herd under different trade regimes. Under autarky, mass culling of the cattle herd would have increased the surplus and gross revenue of cattlemen through an increase in cattle prices. The old cattle price would have increased from C$156 to C$302 per head while the young cattle price would have increased from C$499 to C$675 per head. It would have increased the total producers surplus from C$1,458 to C$1,889 million and gross revenue from C$1,594 to C$2,113 million. However, if the border were open for young cattle and/or beef (trade regimes two and three), the mass cull would have lead to reductions in gross revenue for the industry as it reduces the capacity to export. Old cattle supply would have decreased from 569 to 516 (9.3 percent) thousand head under partial opening (trade in young cattle and beef) and from 585 to 527 (10 percent) thousand head under free trade. Young cattle supply would have decreased from 4,107 to 3,722 (9.3 percent) thousand head under partial opening and from 4,212 to 3,799 (9.9 percent) under free trade. Reductions in producer surplus and gross revenue would have been observed under both the partial trade and

free trade regime. As a consequence, a mass cow cull would not be a wise policy if trade resumes for young cattle, or all type of cattle and beef.

Scenario 3: Impact of introducing a slaughter subsidy The final policy scenario assesses the impacts of introducing a slaughter subsidy for old cattle. Table 4 shows the detailed impacts of an imposition of a slaughter subsidy equal to C$104 per head for old cattle assuming the baseline trade regime does not change. Table 5 shows the impacts under the other trade regimes. A slaughter subsidy would have lowered the price paid by packers for old cattle and increased the price received by cow-calf producers (market price plus subsidy). An imposition of a slaughter subsidy equivalent to C$104 per head would have lead to a drop in the packer's price of old cattle from C$321 to C$316 per head and for young cattle from C$1,098 to C$1,095 per head in the 2004 trade regime (Table 4). Since producers receive a subsidy of C$104 per head on top of the prices paid by the packers, the old and young cattle supply levels would have been about 0.3 percent higher. As there is no trade in live cattle in the 2004 trade regime, cattle have to be slaughtered in Canadian plants and hence local old and young beef supply would also increase. Exports of young beef would have increased by 4 thousand tones (1 percent). The gross revenue and producer surplus of the industry would have increased by 1.2 percent and 1.5 percent from the baseline respectively.

The results suggest that the adverse impacts of the border closure, on cattlemen, would have been slightly smaller if a slaughter subsidy were present. With slaughter subsidies, gross revenue for cattlemen increases from C$1,594 to C$1,613 million under autarky. Total producers surplus rises from C$1,458 to C$1,481 million. If the border were open for young cattle, a slaughter subsidy would have increased the gross revenue from C$6,080 to C$6,109 million and the under free trade scenario it would have increased from C$6,694 to C$6,780 million. Total producer surplus would have increased from C$4,917 to C$4,945 million under partial trade (free trade in young cattle and young beef) and from C$5,523 to C$5,607 million under free trade. The government expenditures on the subsidy program would have been C$54, C$43, C$59 and C$61 million if it existed under 2004, autarky, partial opening and free trade regimes respectively. It is clear from these results that an old cattle slaughter subsidy program expands output under all trade regimes, in all of these cases additional output is either not wanted or not necessary.

LESSONS LEARNED FROM POLICY EVALUATIONS

The results of the policy simulations help to understand the impacts of various BSE recovery programs in Canada under different trade regimes. The results show it is difficult to design a program to mitigate the adverse effects of a border closure when exports are a large portion of sales. In addition, the usefulness of various policy measures depends crucially on the long run border situation. Encouraging the expansion of slaughter capacity, mass culling of cows and provision of old cattle slaughter subsidies involves sizable taxpayer transfers and other significant costs not captured in this analysis, especially as regards the cow cull program (and the slaughter capacity expansion).

Among the policies proposed, the expansion of old cattle slaughter capacity seems sensible if the border remains closed for old cattle and the costs are not to high. However, if the border is open for all cattle and beef, this program will provide few benefits to producers. The imposition of an old cattle slaughter subsidy could also increase the welfare of cattlemen but it seems unwise to expand the size of the cattle herd if the border is going to remain closed. The destruction of part of the cow herd might be a viable policy under autarky but foolish under other trade regimes given its undoubtedly high cost.

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