US AND CANADIAN CATTLE MARKETS: INTEGRATION, THE LAW OF ONE PRICE AND IMPACTS FROM INCREASED CANADIAN SLAUGHTER CAPACITY

by

Brenna Beth Grant

A thesis submitted in partial fulfillment
of the requirements for the degree

of

Masters of Science

in

Applied Economics

MONTANA STATE UNIVERSITY
Bozeman, Montana

April 2007

APPROVAL

of a thesis submitted by

Brenna Beth Grant

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style and consistency, and is ready for submission to the Division of Graduate Education.

Dr. Gary W. Brester

Approval for the Department of Agricultural Economics and Economics

Dr. Myles Watts or Dr. Wendy Stock
Co-department Heads

Approval for the Division of Graduate Education

Dr. Carl A. Fox

STATEMENT OF PERMISSION TO USE

Brenna Beth Grant

April, 2007

ACKNOWLEDGEMENTS

I would like to express my sincere thanks to the chairman of my graduate committee, Dr. Gary W. Brester, for his patience, and assistance during the writing of this thesis. This thesis would not be readable without the hours he put into proof reading and editing my work. My deepest thanks Gary; for improving my writing, presentation, and proof reading skills.

I would like to thank Dr. John M. Marsh for his patience in answering all my questions; his assistance and guidance while working on the econometrics portion of this thesis. I would also like to thank Dr. Vince Smith for his criticism, focus, and suggestions.

Finally I would like to thank my parents, for all their encouragement and support of me taking my masters in Bozeman.

TABLE OF CONTENTS

TABLE OF CONTENTS – CONTINUED

LIST OF FIGURES

Figure Page

LIST OF FIGURES CONTINUED

Figure Page

LIST OF TABLES

LIST OF TABLES CONTINUED

Table Page

ABSTRACT

The objectives of this study are to econometrically determine if the US and Canadian fed steer, feeder steer, and slaughter cow markets were integrated from 1985 to 2006. The law of one price was tested for individually defined policy regimes. Price transmission and exchange rate pass-through are tested in each regime to determine the degree of market integration for each cattle market. Regimes are tested for changes in market structure to determine if the policy change had been significant. The increase in Canadian slaughter capacity is then quantified on cattle prices in Canada and the US.

All cattle markets were integrated from 1985 to 2006. However, while the markets were found to be integrated they are not perfectly integrated because of imperfect price transmission and incomplete exchange rate pass-through. The LOP held pre-CUSTA for all markets, and post-1995 for the fed steer and feeder steer markets. The LOP is rejected in the post-CUSTA regime for all markets. LOP results are indeterminate for post-2003 and are rejected for the post-2005 period, as expected because of limited trade. The Wald test indicated that all policy changes were significant. The fed steer market was the most responsive to policy changes and have the most animals traded.

Expansion of Canadian slaughter capacity resulted in a small increase in Canadian prices for all cattle markets. The largest increase was in the fed steer market and the smallest in the feeder steer market. These increases are very small economically even though they are statistically significant. There was no initial impact on US cattle prices from increasing Canadian slaughter capacity and this may be because of the Canadian packing plants operating at less than full capacity. In the long-run the US slaughter cow market saw a very small increase in price, but the fed and feeder steer markets remained unaffected. And that is probably because they are much larger then the Canadian market.

CHAPTER 1

INTRODUCTION

The beef and cattle industries in the United States (US) and Canada have been shown to be integrated and interdependent (Young and Marsh 1998). Integration is a measure of the degree in which two markets act as one, while interdependence refers to the degree in which two countries rely on each other for trade. In general, exogenous shocks or changes in national trade policies in one country may be transferred to another country through prices. However, recent international trade events may have altered this relationship for beef and cattle prices between the US and Canada.

Figures 1.1, 1.2, and 1.3 illustrates that the nominal US and Canadian prices of fed steers (1100-1200lb.), feeder steers (500-600lb.), and slaughter (cull) cows were similar (exclusive of transportation costs), between 1985 and 2002.

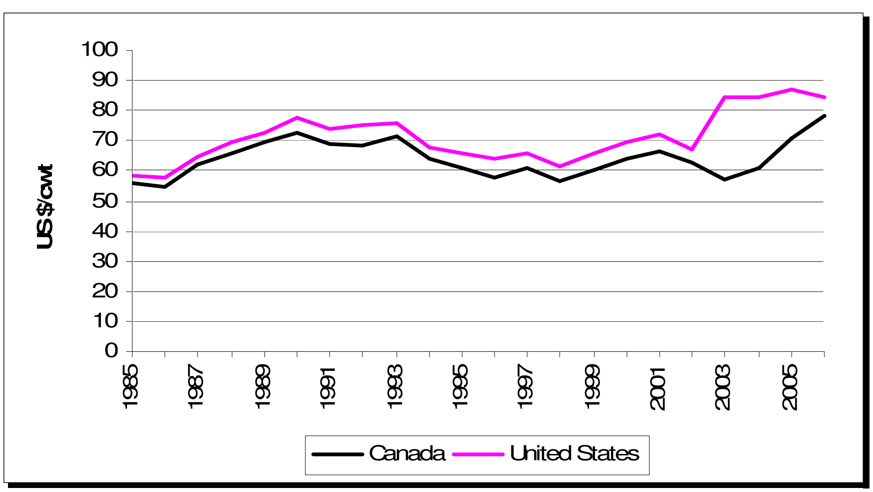

Figure 1.1. Prices of Fed Steers in the US and Canada, 1985-2006.
Source: CanFax and LMIC.

US fed steer prices increased in 2003 relative to Canadian cattle prices after the closure of the border because of the May 2003 discovery of Bovine Spongiform Encephalopathy (BSE) in Canada.

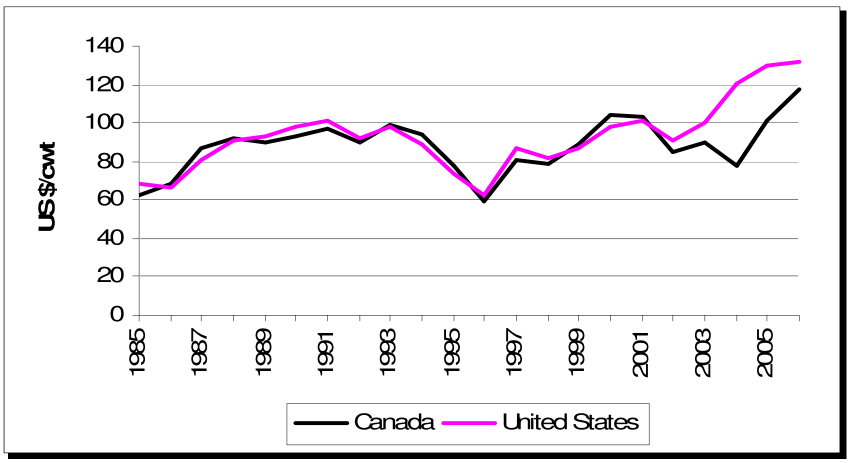

Figure 1.2. Prices of 500-600lb. Feeder Steers in Canada and the US, 1985-2006.
Source: CanFax and LMIC.

US and Canadian feeder cattle prices have shown more variation than fed steer prices because of regional fluctuations in feedlot demand and the local availability of feedstuffs. Canadian and Northern US calves weighing 700 pounds can go straight into a feedlot from weaning; while Southern US 500 pound calves tend to be backgrounded after weaning until they are ready for a feedlot; prices for 500 to 600 pound calves were used in this study in order to distinguish from the 700 pound animals that are demanded by feedlots.

Prior to the discovery of BSE in North America, the majority of Canadian slaughter cows were slaughtered in the United States (Feuz 2006). The inability to export slaughter cows because of BSE decreased slaughter cow prices in Canada and raised them in the US.

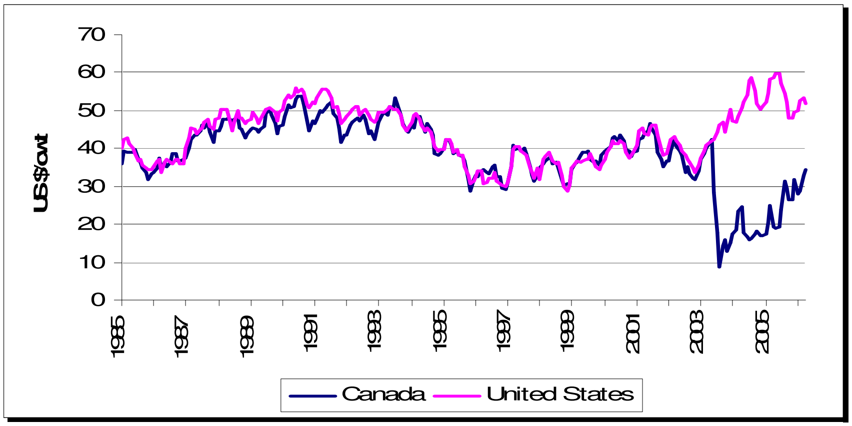

Figure 1.3. Prices of Slaughter Cows in Canada and the US, 1985-2006.
Source: CanFax and Cattle-Fax.

The US represents the largest market for Canadian cattle exports. In 2001 and 2002, Canada exported about 35 percent of its slaughter cattle to the US (LMIC). Total live cattle exports from Canada to the US grew throughout the 1999 to 2002 period (Figure 1.4). From 1999 to 2002, Canadian live cattle exports to the US consisted on average of a mix with 13 percent feeder cattle, 64 percent fed cattle and 14 percent slaughter cows. The final 9 percent of Canadian live cattle exports to the US is made up of slaughter bulls and breeding animals. In 2002, Canada exported 34 percent of its slaughter cow production to the US.

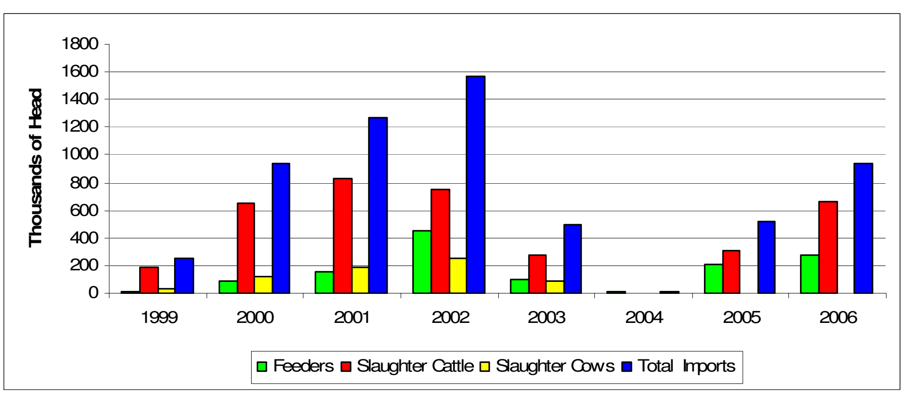

Figure 1.4. Canadian Live Cattle Exports by Class to the US, 1999-2006.
Source: Livestock Marketing Information Center (LMIC).

Small numbers of live Canadian cattle are shipped to other international markets; however, these exports are generally limited to breeding stock. Most US slaughter cattle imports originate in Canada, while the majority of its imported feeder cattle are from Mexico. In 2005, the US imported 0.559 million head of Canadian slaughter cattle and 1.256 million head of Mexican feeder cattle (LMIC). Low trade barriers have facilitated the integration of the North American cattle markets, causing US and Canadian slaughter prices to be closely related (Young and Marsh 1998).

Integration in the US and Canadian beef and cattle industries has been accompanied by corresponding interdependence. However, because of the difference in size between the US and Canadian markets, the interdependence between them is not symmetric. Canada's breeding inventory was only 16 percent of US breeding inventories in 2005 (LMIC). The Canadian industry has a higher degree of dependence on the US market for its exports and, therefore, is vulnerable to US market shocks (Young and Marsh 1998). While 80 percent of Canada's beef exports were destined for the US in 2005, only 10 percent of US beef exports went to Canada (CanFax; LMIC). Canada is also more dependent on world trade. In 2003, 22.7 percent of Canada's beef production was exported, compared to only 8.7 percent of US beef production (CanFax; LMIC).

If the two markets were not integrated, a reduction in US beef and cattle imports from Canada would increase US cattle prices. However, if the markets are nearly integrated, a reduction in US imports of Canadian cattle would have minimal effects on US cattle prices. Such an action would be the equivalent of preventing trade between two states like Kansas and Nebraska in that it would not affect aggregate US slaughter price.

The US and Canadian cattle markets are considered to be integrated because: (1) prices in the two countries move together and shocks are transmitted between markets through prices; (2) trade occurs between the two countries; and (3) cattle production input markets are similar (Young and Marsh 1998; USITC 1997; Marsh 1999; Young 2000). Therefore, total North American cattle and beef supplies are more important for determining cattle prices in both markets than Canadian-US cattle trade (Marsh 1999).

Canada responded to the US border closure in 2003 by increasing slaughter capacity and boxed beef exports to the US. Canadian cattle slaughtering firms have increased capital investments in plant capacity with Canadian government assistance. However, these assets may not be completely utilized in the long-run if the US has a comparative advantage in slaughtering and trade relations return to normal.

Objectives

Previous research indicates that the US and Canadian beef and cattle markets have been highly integrated since the 1989 Canada–United States Free Trade Agreement (CUSTA). The objective of this thesis is to determine whether the degree of integration of the fed steer, feeder steer, and slaughter cow markets in the US and Canada has been altered by trade disruptions caused by BSE, the temporary closure of the US/Canadian border to live cattle trade, and increases in Canadian slaughter capacity.

CHAPTER 2

HISTORY

The following is an overview of the US and Canadian beef and cattle trade between 1985 and 2006. Trends are presented for production, trade, and prices. In addition, a discussion of the beef packing industry is given with emphasis on labor costs and recent expansions.

Trends in the Canadian and US Cattle Industries

Production

Canadian and US cow inventories followed each other closely from 1976 to 1996. This suggests that both markets responded to similar economic signals. The two markets were increasingly integrated and few trade disputes arose between the countries over this period.

The US beef cow inventory peaked in the mid-1970s, and has been declining since (Figure 2.1). The decline left the US packing industry with excess packing capacity (Boswell 1973). The combination of excess slaughter capacity in the US and insufficient slaughter capacity in Canada resulted in live cattle being exported from Western Canada to underutilized feedlots and packing plants in the western United States (Brester and Marsh 1999; Young and Marsh 1998).

Although the US cattle herd continued to decline after 1996, the Canadian herd increased. In 1980, the Canadian breeding herd was nine percent as large as the US breeding herd; by 2005 it was 16 percent.

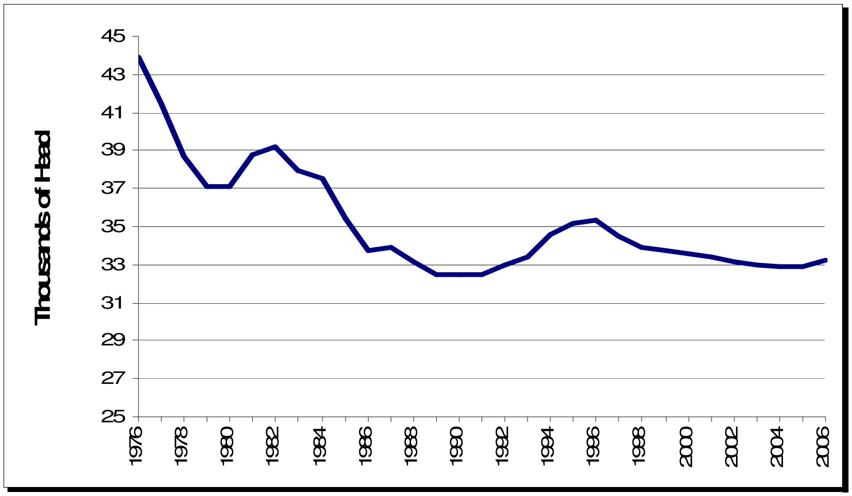

Figure 2.1. United States Beef Cow Inventory, January 1.
Source: Livestock Marketing Information Center, 1976-2006.

Canadian beef cow numbers increased approximately 50 percent between 1987 and 2006 largely because of increased demand for feeder cattle by Canadian feedlots (Figure 2.2).

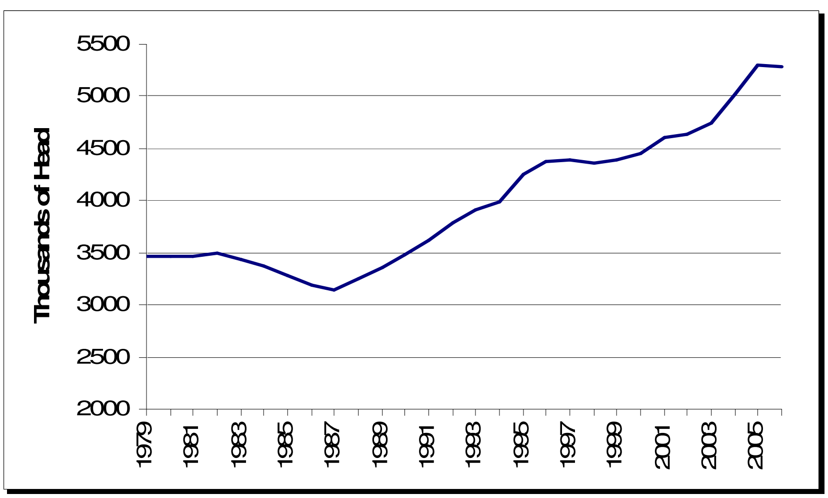

Figure 2.2. Canadian Beef Cow Numbers.
Source: Statistics Canada, January 1, 1979-2006.

The expansion of the Canadian cattle industry was partially caused by the removal of the Canadian Crow Rate Subsidy in 1995. The Crow Rate subsidized grain transportation to the Canadian coast. After its removal, grain prices in the Prairie Provinces decreased. Lower feed prices encouraged feedlot expansion in Alberta and Saskatchewan. Thus, Canadian cattle feeding became more competitive because of lower feed costs. However, Canadian cattle slaughter remained relatively constant at three million head per year between 1998 and 2003 (Figure 2.3). Because of limited slaughtering capacity, exports of Canadian fed cattle to the US increased.

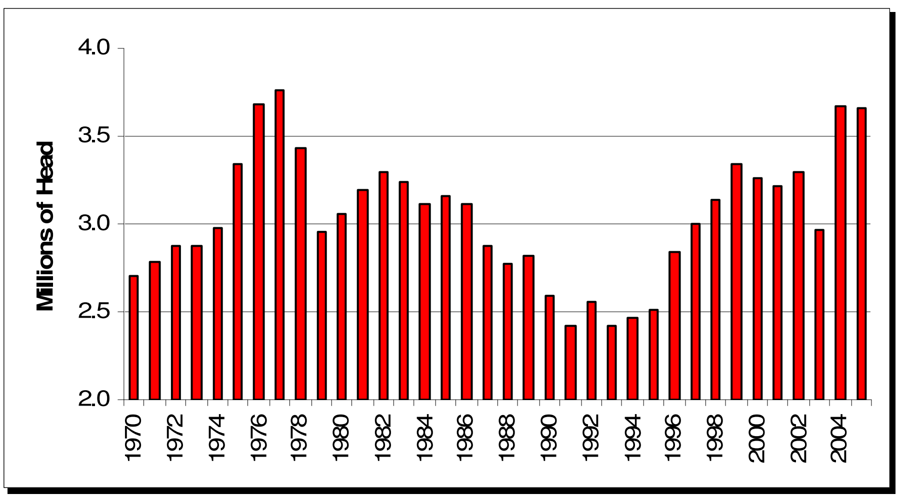

Figure 2.3. Canadian Federally Inspected Slaughter Numbers.
Source: CanFax.

Canada's increased dependence on the US slaughter market was caused by a lag in the expansion of Canadian slaughter capacity with respect to Western Canadian feedlot production and the prevalence of excess US slaughter capacity. From the late 1980s to the early 1990s, slaughter capacity in Canada declined as older, less efficient plants closed. However, there was gradual growth of capacity in the late-1990s.

<u>Trade</u>

As noted above, Canadian cattle exports expanded after 1989 (Figure 2.4). Increased Canadian cattle production led to increased dependence on exports. Canadian cattle and beef prices have been affected by export markets, particularly since the late 1980s. Canada exports 22.7 percent of its beef and cattle production and depends upon the US for approximately 80 percent of its exports (CanFax). Before 2003, slaughter cattle represented 85-95 percent of Canadian live cattle exports (Wachenheim et al. 2004). However, live cattle exports from Canada have leveled off since 1996 because of increased Canadian slaughter capacity.

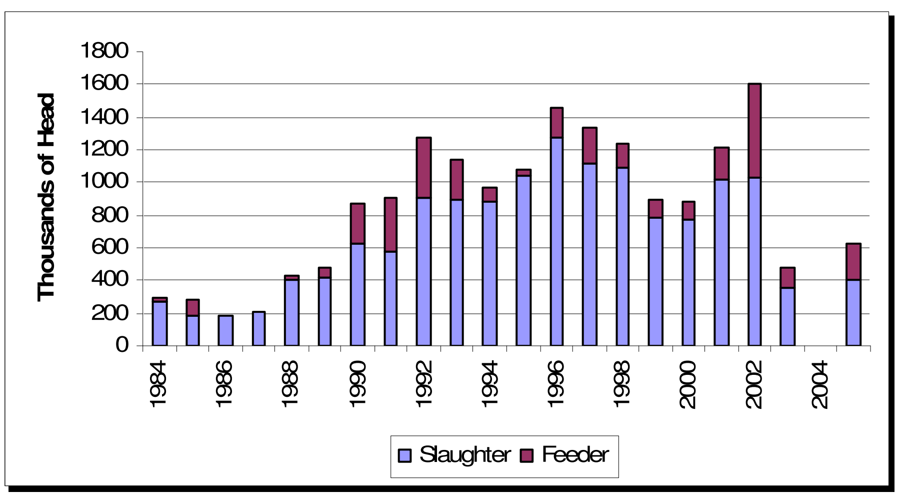

Figure 2.4. Canadian Slaughter and Feeder Exports to the United States.
Source: Statistics Canada, CanFax 1984-2004.

Marsh (1999) discussed five reasons for increased exports of Canadian live cattle to the US: (1) the removal of the Western Grain Transportation Act in 1995 lowered feed grain prices and increased feedlot capacity in Western Canada; (2) Canadian meat packing capacity lagged Canadian feedlot expansion; (3) a strong US dollar combined with high US slaughter prices more than compensated for transportation costs between

Canada and the US; (4) excess capacity in US beef packing plants and feedlots; and (5) the ability to apply USDA grades to Canadian live cattle and carcasses.

Canada responded to the US border closure in 2003 by increasing domestic slaughter capacity an estimated 27 percent over pre-BSE levels (Figure 2.5; Canfax Dec 2, 2005). In addition, processing plant expansions have been planned with the goal of ensuring that Canada never exports more than 50 percent of its beef and cattle to any one country by 2010 (CCA 2004). This goal will require Canada to further develop international trade relationships with countries other than the US. "However, building new plants must be done with caution,' [Dennis Laycraft] said, noting that any plan must take into account the US border opening. 'Or else we'll be left with facilities that have to be shut down again (Dudley 2004, Pg. 2)". This caution was realized when the US opened the border to Canadian cattle of less than thirty months of age in July 2005. Canadian packing plant utilization fell from 90 percent in 2003 to 70 percent in December 2005 (Canfax 2005).

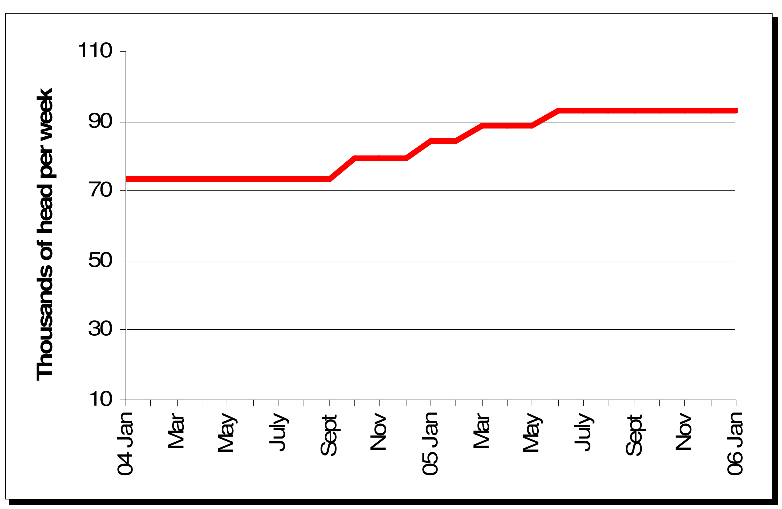

Figure 2.5. Canada's Federal Slaughter Capacity, 2004-2005.
Source: Canfax 2005.

In 2004, total pounds of Canadian beef exported to the US were approximately equal to pre-BSE levels. The United States imported 1.7 million head of Canadian cattle in 2002 and 500,000 head in 2003 before the border closed in May. However, US imports of Canadian beef increased relative to previous years after the border opened to boneless boxed beef obtained from animals of less than thirty months of age in August 2003 (Figure 2.6; Rosson and Adcock 2006). Therefore, the US replaced Canadian cattle imports with Canadian beef imports.

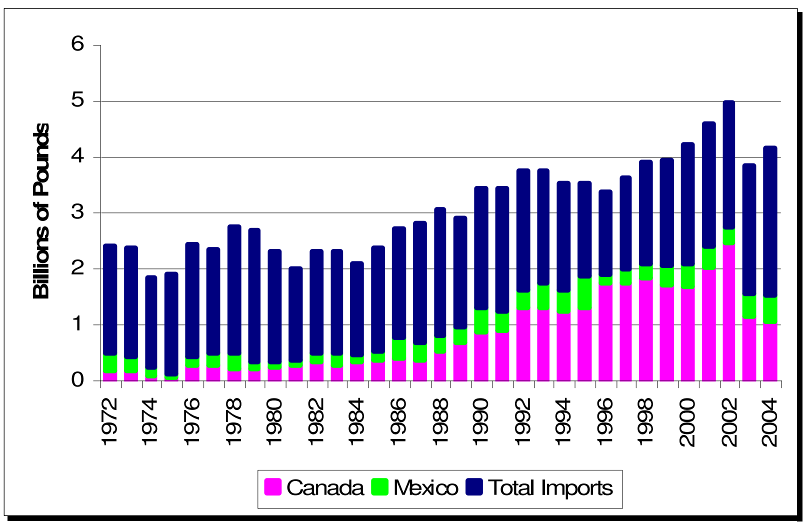

Figure 2.6. US Beef and Live Cattle Imports in Beef Equivalents,[1] 1972-2004.
Source: Brester 2006.

Since CUSTA, US beef producers have been concerned with the steady increase in US imports of cattle and beef from Canada. As a proportion of US beef supplies, Canadian beef imports increased from 1.4 percent in 1985 to 8.0 percent in 2002, but then

[1] Live cattle imports from Mexico were converted into beef equivalents by multiplying the number of cattle with the average live weight (525lb.) for feeder cattle and the Canadian imports were found by multiplying the number of cattle with the average dressed weight of steers for slaughter cattle and an average dressed yield of 65 percent. This gave billions of pounds in carcass weight equivalents from live cattle imports (Marsh 2006a).

declined. Canadian imports as a percentage of total US beef imports have also increased from 15 percent to 50 percent in the same period, but decreased to 30 percent in 2003.

Since 1970, US beef exports have increased substantially and are increasingly important to domestic producers (Figure 2.7). In 2002, approximately 44 percent of US exports went to Japan (LMIC). Brester, Mintert and Hayes (1997) give four reasons for increased beef exports since the mid-1980s: (1) depreciation of the US dollar relative to other currencies before 1997; (2) adoption of technologies to transport chilled rather than frozen meat; (3) relaxation of trade restrictions; and (4) increased per capita incomes and changes in dietary preferences in developing countries.

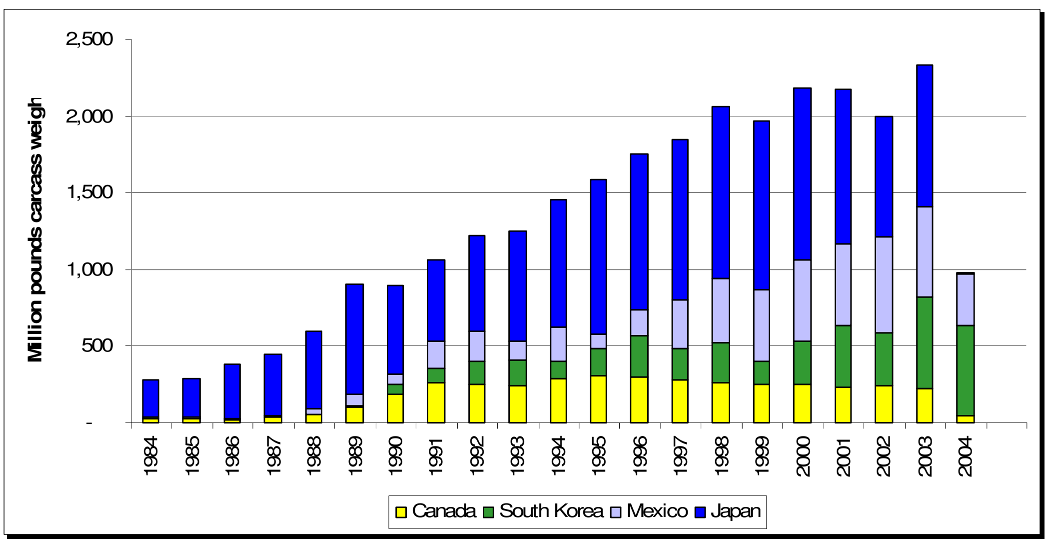

Figure 2.7. US Beef Exports.
Source: Cattle-Fax 1984-2004.

US beef exports represented 9.6 percent of US beef production before the December 2003 BSE case. However, US beef exports have been limited since 2003 because of BSE. Although US beef exports have resumed, they are currently only 17 percent of 2003 levels, and will not increase further without access to Japanese and South Korean markets.

Prices

Canadian and U.S. fed steer, feeder steer, and slaughter cow prices were highly correlated until 2003. However, Canada's dependence on cattle exports to the US resulted in fed steer, feeder steer, and slaughter cow prices declining dramatically after the 2003 US border closure. Canadian fed steer prices initially fell 65 percent, but recovered most of their value by 2004 (Figure 2.8). The recovery of Canadian prices can be attributed to strong Canadian consumer beef demand and the re-opening of the US market to boneless beef obtained from cattle less than thirty months of age in August 2003.

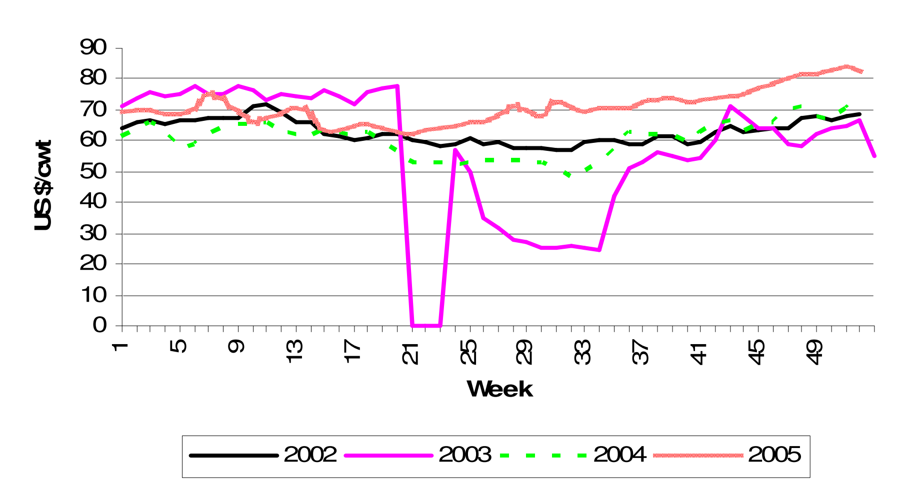

Figure 2.8. Alberta Fed Steer Prices, 2002-2005.
Source: CanFax.

The feeder steer market in Canada was generally unaffected by the border closure. However, the value of Canadian slaughter cows initially declined 75 percent, and recovered only after cow slaughter increased in August 2005 when the US border re-opened to animals less than thirty months of age (Figure 2.9; Rosson and Adcock 2006). Cow slaughter had declined 70 percent after the discovery of BSE in Canada (Figure 2.10). Before the border re-opened, Canadian packing plants were slaughtering animals less than thirty months of age and exporting boxed beef. However, after the border opened, animals less than thirty months of age were exported to US packing plants and Canadian plants increased cow slaughter.

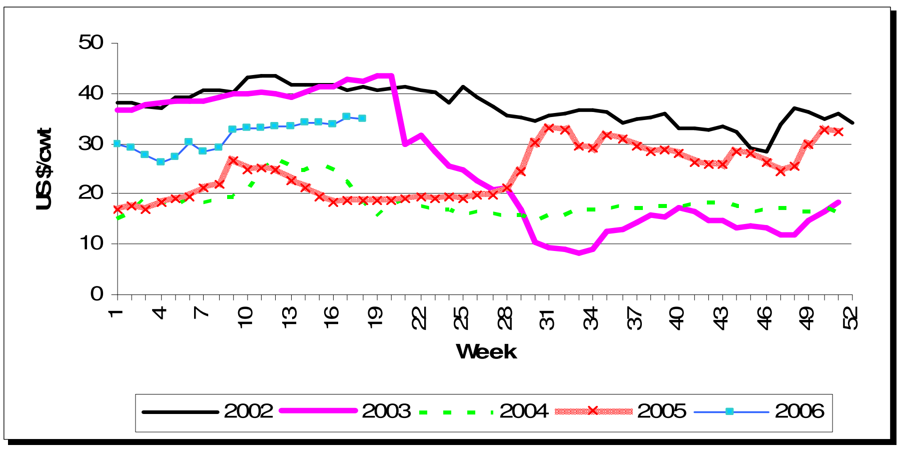

Figure 2.9. Alberta D1, D2 Cow Prices, 2002-2005.
Source: CanFax.

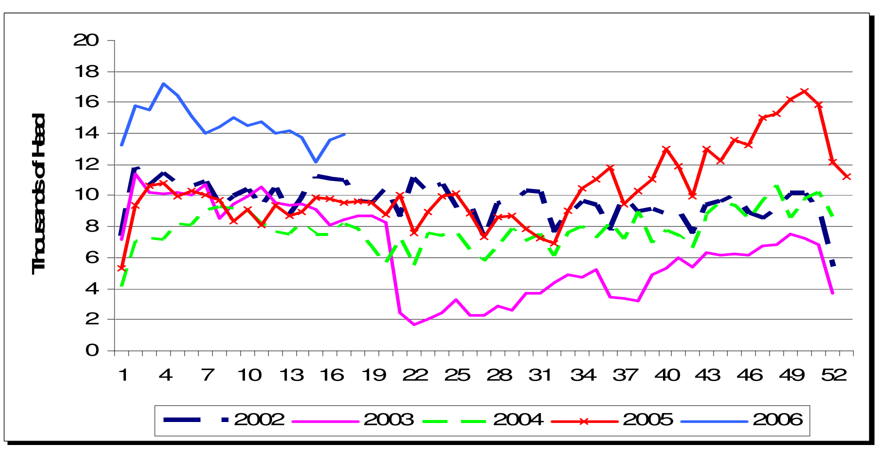

Figure 2.10. Canadian F.I. Cow Slaughter, 2003-2006.
Source: CanFax.

For three weeks following the announcement of the US BSE case on December 23, 2003, US fed cattle prices declined by about 20 percent and feeder cattle prices declined by 17 percent over the following three weeks. However, prices recovered reaching record highs in the summer of 2004 because of low beef supplies, US import restrictions on Canadian cattle, an increase in domestic consumer demand for beef driven by high protein diets, and quick action by the USDA to reassure consumers regarding food safety issues (Rosson and Adcock 2006).

Policy

Beef Trade Policies, 1989-1994

Prior to 1989, various restrictions on beef and cattle trade between the United States and Canada existed. Canadian and US beef import restrictions were similar prior to CUSTA. Both countries charged a tariff of 2.2 cents per kilogram on cattle imports. Purebred breeding cattle could be traded duty-free. These tariffs are relatively small compared to the value of the animals. Pre-CUSTA, the largest barriers to trade were the Canadian and US Meat Import Laws, although those were not always binding. The Canadian Meat Import Law had not been invoked since 1985, but tariff rate quotas have been imposed since on other countries with over-quota tariffs of 25 to 30.3 percent. The US share of Canadian beef imports total 10 to 15 percent annually before CUSTA and 40 to 50 percent after. Canada's quota under the US Meat Import Law would have been 130 to 135 million pounds of beef in 1994. Actual imports were 393 million pound in 1994 which were approximately four times the calculated quota from 1995 to 2000 (ERS; USDA).

The 1989 Canada-United States Free Trade Agreement (CUSTA) gradually phased out tariffs on live cattle and beef products and eliminated meat import quotas. This increased market access for both countries. The elimination of tariffs was completed in 1993 and cattle and most beef products have traded duty-free since (Foreign Agricultural Service 1999). Although pre-1989 tariffs were relatively small (1.4 percent of value), the elimination of import quotas had a large impact on trade in slaughter cattle, feeder cattle, carcass, and boxed beef (Young and Marsh 1998). However, CUSTA did not completely integrate the Canadian-US markets. Differences in meat grading standards create non-tariff barriers (Young and Marsh 1997). CUSTA did not remove non-tariff barriers such as Canadian testing of anaplasmosis, tuberculosis, brucellosis, and bluetongue in feeder cattle imported from the US.

The 1994 North American Free Trade Agreement (NAFTA) had little impact on US-Canadian beef trade because tariffs and quotas had previously been eliminated by CUSTA (Marsh 1997). However, the agreement reduced cattle and beef trade restrictions with Mexico, particularly in term of US exports of beef and by-products.

The third and most recent international trade agreement to influence the beef industry was the 1994 Uruguay Round Agricultural Agreement (URAA). Although the URAA did not directly impact beef trade between the US and Canada, it had indirect effects because of increased access to other international markets. The URAA replaced import quotas with tariff-rate quotas and reduced European Union export subsidies. This increased US beef exports and US demand for Canadian slaughter cattle (Brester and Marsh 1998).

Grain Policies

Feed grains (corn and barley) are the primary protein inputs used to fatten cattle in the US and Canada. Thus, changes in feed grain policies influence the beef industry. The Western Grain Transportation Act (WGTA) or Crow Rate subsidized producer grain transportation from the Prairie Provinces to the Canadian coast. In 1995, the Crow Rate subsidy was removed, reducing grain prices in the Prairie Provinces. Lower feed prices encouraged expansion of feedlots in Alberta and Saskatchewan. Subsequently, two multinational corporations (IBP and Cargill) purchased packing plants in Alberta (near feedlots) and increased slaughter capacity over the 1995 to 1997 period. This growth in the feedlot industry increased feed barley use by more than 35 percent from about 7.0 mt in the early 1990s to 9.3 mt in 2004-2005. Domestic feed use as a percentage of total production grew from 60 percent to 78 percent. Exports of barley, specifically feed barley as a percent of Canadian grain exports decreased from 35 percent to approximately 20 percent in the same period. While Canadian exports of feed barley have steadily declined since 1992 and reached record lows in 2003 and 2003, domestic feed use has been steadily increased (AAFC, 2005). Since 1995, most of Canada's feed barley has been used domestically (Doan et al. 2002). In addition, Canadian livestock producers have increased corn imports from the US in recent years (Figure 2.11).

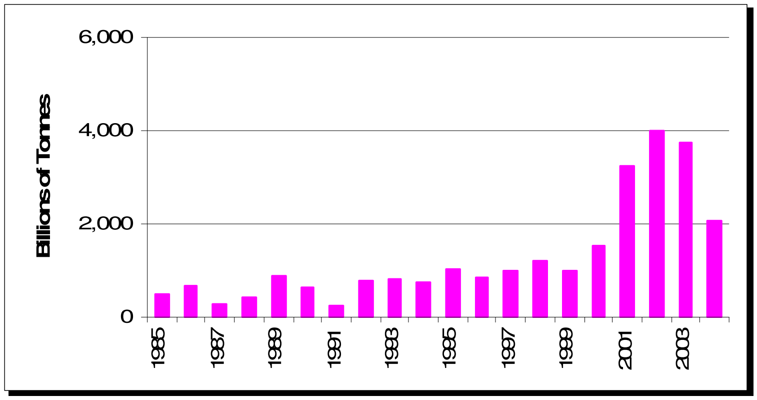

Figure 2.11. Canadian Corn Imports, 1985-2004.
Source: FAOSTAT 2006.

On December 15, 2005, a provisional corn tariff of $1.65 per bushel was placed on Canadian imports of unprocessed US corn. On April 18, 2006, the Canadian International Trade Tribunal (CITT) made their final ruling that dumping and subsidized corn exports from the US were not causing or threatening injury to the Canadian corn industry. The ruling immediately removed the provisional duty on corn imports.

Trade Intervention Since 1995

The US and Canadian beef industries benefit from a variety of government support such as inspection services, research and advisory programs, and marketing and promotion programs. Young and Marsh (1998) used producer subsidy equivalents to ascertain the level of government intervention for cattle and beef sectors in the US and Canada. They found government support has been similar between the countries since 1995 when grain transportation subsidies were removed in Canada. In general, subsidies in both countries are quite modest compared to grain production.

US exports of feeder cattle to Canada increased as a result of the Northwest Pilot Project which started in October 1997. The project eliminated tests for anaplasmosis, brucellosis, and tuberculosis among feeder cattle originating in Montana and Washington and exported to Canada between October 1 and March 31 (Young and Marsh 1998). The program was later renamed the Restricted Feeder Cattle Program and currently includes thirty-nine states. The program has had positive impacts on US feeder cattle prices and net feeder cattle exports. It is estimated that the project more than tripled live cattle exports to Canada from an average of 3,393 head per month in 1996 to 11,185 head per month in 2002 (LMIC). Northern-tier US feeder cattle producers benefit from lower transportation costs to Canadian feedlots relative to Southern Plains US feedlots, partly because Canadian truckers bringing fed cattle into the US were able to secure backhauls of US feeder cattle. Therefore, transportation costs to Alberta feedlots from Montana are generally lower than to Kansas feedlots. However, US feeder cattle exports to Canada declined from 140,542 in 2002 to 11,950 in 2005 because of reduced demand by Canadian feedlots caused by the border closure (Figure 2.12).

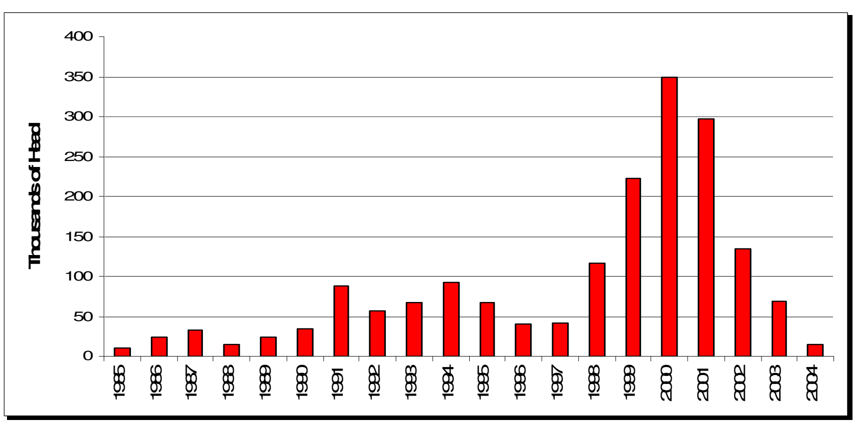

Figure 2.12. US Live Cattle Exports to Canada.
Source: LMIC, 1985-2004.

In 1998, the Ranchers-Cattlemen Action Legal Fund (R-CALF) filed an antidumping and countervailing petition against the Canadian cattle industry. R-CALF claimed that fed and feeder cattle prices declined approximately 27 percent in real dollars between 1993 and 1998 because of increased US imports of Canadian fed cattle. In January 1999, the US International Trade Commission (ITC) ruled that US producers may have been materially injured by US imports of Canadian fed cattle. On June 30, 1999 the US Department of Commerce Import Administration issued a preliminary ruling instructing the US Custom Service to require a cash deposit, or bond of 4.73 percent (later increased to 5.57 percent) of the value of imported Canadian fed cattle. This ruling was based on the presumption that Canadian feedlot managers sold live cattle to US purchasers below the "normal value" of the same cattle in Canada (Brester, Marsh, and Smith 1999). In November 1999, the ITC issued a final ruling that rescinded the preliminary tariff. R-CALF initially appealed this ruling under Chapter 19 provisions in NAFTA, but later retracted the appeal (Brester, Smith, and Marsh 2003).

BSE in North America

On May 20, 2003 the first North American case of BSE was reported in Alberta, Canada, and resulted in the closure of the US/Canadian border to cattle trade. Approximately seven months later, on December 23, 2003, the US reported its first BSE case in a Washington dairy cow that had been imported from Alberta. Since these initial cases, both Canada and the US have reported additional cases of BSE (three and nine cases, respectively). To date, rigorous surveillance measures (rapid testing and traceback) in both countries have prevented contaminated materials from entering the food chain. These cases have had little impact on US and Canadian consumer demand. Both countries have the same minimal risk status (Canadian Food Inspection Agency), and have banned feeding ruminant meat or bone meal to ruminants since 1997. Such feeding practices are thought to be a primary cause of the spread of BSE.

On August 8, 2003 the US re-opened the border to imports of Canadian boneless boxed beef. The USDA published a rule to end the ban on Canadian cattle less than thirty months of age on October 31, 2003. This initiated a dialogue to create a minimum risk region status for countries that were taking measures to prevent BSE infected meat from entering the food chain. On December 30, 2004, the USDA acknowledged that Canada had met the minimal risk standard and announced a plan to reopen the border on March 7, 2005 to US imports of Canadian live cattle less than thirty months of age if they were destined for immediate slaughter. However, on March 2, 2005, the Ninth US District Court granted a preliminary injunction preventing the reopening of the border. On March 29, 2005, Canada removed import regulations resulting from the Washington BSE case in December 2003. The preliminary injunction was lifted on July 14, 2005, and the border between the US and Canada opened to livestock less than thirty months of age for feeding and slaughter on July 18, 2005. On December 11, 2005, Japan opened its border to North American beef. However, Japan closed its border to US beef, but not to Canadian beef, in January 2006 because of the discovery of BSE risk materials in a shipment of US beef.

Evolution of the Canadian/US Packing Industry

The beef packing industry has influenced cattle movements between the US and Canada. Industry structure and policy changes have shaped the industry in recent years. Improved information, technology, genetics, and nutrition have reduced cattle feeding periods and produced heavier beef carcasses. Increased feedlot efficiency has decreased unit costs of feeding cattle, resulting in smaller margins in a highly competitive industry. Small margins are also prevalent in the meat packing sector; plants must operate at full capacity to take advantage of scale economies. Consolidation of US meat packing plants has been influenced by geographic changes in feedlot locations.

Historically, Canadians have exported slaughter cattle to Northern US packing plants. However, cost differences between the two countries have changed recently. Jim Laws, executive director of the Canadian Meat Council, claims that labor rates are higher in Canada as a result of recent increases in the value of the Canadian dollar. Labor agreements signed during the profitable post-BSE meat packing era in Canada increased labor costs.

The Canadian government provided approximately $2 billion federal and provincial aid for cattle producers starting in March 2004 (Commonwealth 2006). Government subsidization, after 2003, for slaughter capacity expansions in Western Canada created incentives for expansion.

The US Bureau of Labor Statistics found that Canadian employers paid more in direct pay but less for insurance relative to US employers. The lower cost of hourly compensation may have influenced private investment in the Canadian meat packing after 1995, as the Canadian cattle feeding industry expanded. Although hourly compensation was lower in Canada from 1994-2004, it was higher in previous years (Figure 2.13).

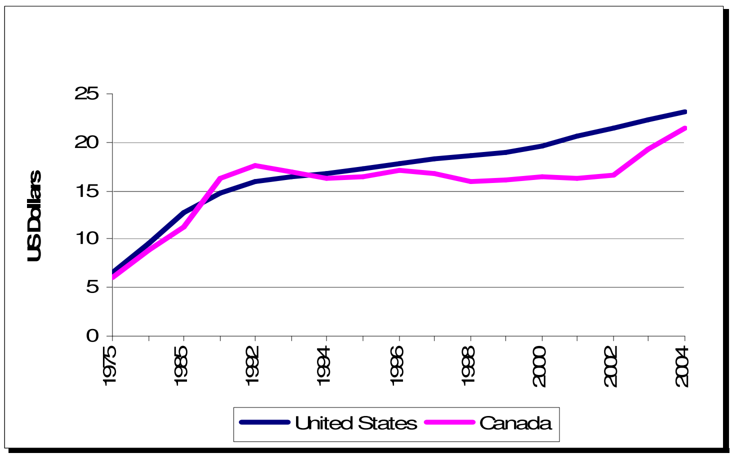

Figure 2.13. Hourly Employer Compensation Costs for manufacturing production workers.
Source: Bureau of Labor Statistics, 2004

Overall unit labor costs were greater in Canada from 1973 to 2000 (Canada and US Labor Statistics). Thus, it may be that the US has a comparative advantage in cattle slaughtering.

Summary

US and Canadian fed and feeder cattle prices were highly correlated before CUSTA, even though tariff and non-tariff barriers existed. After CUSTA, tariff barriers were largely eliminated; however, non-tariff barriers in grading and health restrictions still exist. The elimination of the Canadian Crow Rate in 1995 encouraged Western Canadian feedlot expansion, and the slaughter industry followed. In 1997, health restrictions on feeder cattle exported to Canada were reduced under the Restricted Feeder Cattle Program. From 1997 through 2003, these markets were able to operate largely as one North American market. After the May 2003 BSE case in Canada, US and Canadian prices diverged for fed steers and slaughter cows, but not for feeder steers. In addition, the Canadian government subsidized Canadian slaughter capacity expansions after 2003.

Currently, the US beef cow herd is near the bottom of the most recent cattle cycle and is projected to increase. The Canadian beef cattle industry has increased feedlot and meat packing capacity. However, the US has increased imports of beef from other countries. The US has experienced reductions in beef sales to Japan and South Korea. These factors may decrease dependence and perhaps market integration in the future.

The integration and interdependence of the US and Canadian cattle industry will be considered over five distinct time periods: (1) 1985-1989, pre-CUSTA; (2) 1989-1995, trade before the removal of the Crow Rate or post-CUSTA; (3) 1995-2003, essentially free-trade between Canada and the US or post-1995; (4) May 2003-July 2005, no trade of live cattle because of the closed US/Canadian border because of BSE or post-2003; and (5) August 2005-2006 gradual reopening and reestablishment of trade across the US/Canadian border or post-2005.

The overall level of integration of the North American market will be assessed by examining how the relationship of US and Canadian fed steer, feeder steer, and slaughter cow prices changed during these periods. The interdependence for each country is then examined by how much each country responds to a shock in the other country.

CHAPTER 3

THEORETICAL FRAMEWORK

Market integration between countries affects economic growth, causes structural change, alters the location of economic activity, and influences the viability of small and large agricultural enterprises (Vollrath and Hallahan 2006). In the case of cattle markets, this chapter provides an overview of international trade theory, the literature on market integration, the law of one price, and the influence of exchange rates on trade.

International Trade Theory

Trade occurs when one country wants more of a product at current prices than it can produce, and another country produces more than it wants to consume at current prices, and transaction costs are sufficiently low to make trade practical. When these conditions exist, a country has a comparative advantage in production and, in autarky, produces a product at a lower price than another.

Figure 3.1 indicates that in a world with zero transportation costs, in the absence of trade, Country A has a domestic "no trade" price of P^A, and Country B has a lower domestic "no trade" price of P^B. However, when trade is possible, the equilibrium price moves to P_T in both countries. Country B produces Q_s^B but consumes only Q_d^B, and Q_s^B - Q_d^B = Q_T is exported. Country A produces Q_s^A consumes Q_d^A, and imports Q_T. This implies complete exchange rate pass-through and perfect price transmission between countries when there are no trade barriers. However, tariff and non-tariff trade barriers affect the amount of product traded and influences the excess demand in country A and/or excess supply in country B. Tariffs, transportation, or transaction costs create prices wedges in each country. However, the law of one price can still hold if price shocks are fully transmitted from one country to another.

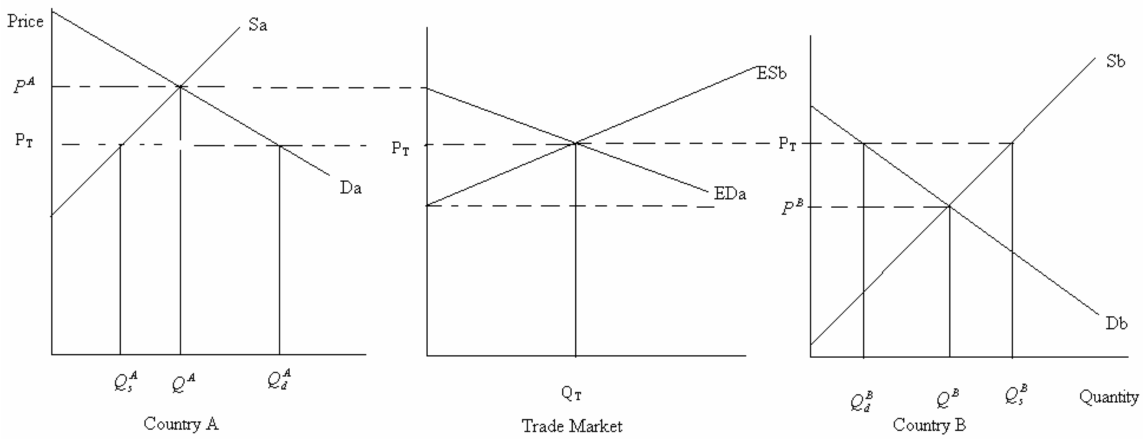

Figure 3.1. International Trade.

Figure 3.2 illustrates a shock to country B's excess supply. This upward shift in excess supply may be caused by a tariff or an increase in transaction costs for trading, either of which equal to $P_1^A - P_1^B = \text{t}$.

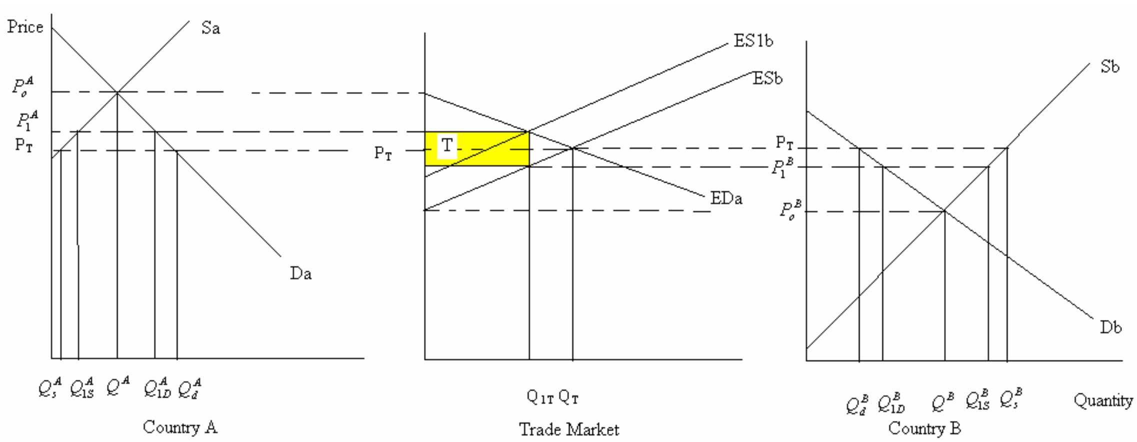

Figure 3.2. Supply Shock in International Trade.

For example, when the US border re-opened to Canadian live cattle in July 2005, additional export costs (age identification, pregnancy tests on heifers and additional paperwork) increased the marginal costs of exporting. When excess supply decreases from ES_b to ES_{1b}, the amount of product traded decreases from Q_T to Q_{1T}. In response, equilibrium prices spread creating incomplete pass-through, where country A's price is P_1^A and country B's price is P_1^B. In this situation if country A was imposing a tariff (t), the tariff rents would equal the shaded area T and would go to country A.[2]

If a non-tariff barrier (e.g., health testing requirements removed with the Restricted Cattle Feeders Program) is removed or the cost of producing the product decreases (e.g., removal of the Canadian Crow Rate subsidy which decreased feed costs) then domestic supply would increase. This causes excess supply to increase from ES_{1b} to ES_b decrease equilibrium trade price, and increase trade volume.

A supply shock in the rest of the world creates a one-to-one change in domestic prices for both countries. This is shown in Figure 3.2 as $P^B = P^A + t$, then $\frac{dP^B}{dP^A} = 1$. However, proportional changes in prices in the two countries are different, with country A's change being smaller. However, an ad valorem tariff creates a greater change in country A in absolute terms since $P^B = (1+t)P^A$, and therefore $\frac{dP^B}{dP^A} = (1+t)$. However,

[2] Note that a tariff or increase in transportation costs can result in zero trade if the cost is large enough.

complete pass-through occurs with an ad valorem tariff because $\frac{dP^B}{P^B} = \frac{(1+t)dP^A}{(1+t)P^A} = \frac{dP^A}{P^A}$ (Alston and Martin 1995).[3]

Integration

Spatial market integration as defined by Fackler and Goodwin (2001) is a measure of the degree to which demand and supply shocks in one region are transmitted to another region. Perfect market integration occurs when two markets act as one. This occurs if the expected price transmission ratio, the amount a price shock in one market that is transferred to the price in another market, is not significantly different from one. However, even if two markets are perfectly integrated, one market may be more dependent upon another; that is exogenous shocks to one of the markets may have larger effect on prices in both countries than an exogenous shock in the other market. As previously noted, this is the case with the Canadian and US beef markets. The Canadian beef market is more dependent on the US market than *vice-versa*.

Cointegration is a measure of market connectedness (Vollrath and Hallahan 2006). Using cointegration testing Goodwin and Schroeder (1991) reported that, from 1980 to 1987, regional cattle markets separated by long distances had lower degrees of cointegration than markets in close proximity to one another. They hypothesized that high costs and risks associated with transporting fed cattle over long distances caused

[3] It should be noted that an import quota can also lead to incomplete or zero pass-through because when a tariff is introduced or transaction/transportation costs of trade increases it may not influence the domestic price at all because of the quota being the greater restriction. A domestic price support that is effective can similarly create incomplete or zero pass-through, as long as the support price is not sufficient to increase the world price to the same level (Carter et. al. 1990, Alston et. al. 1993).

market prices in different regions to diverge for extended periods. Integration also increased with time, coinciding with increased concentration in the cattle slaughtering industry. Increased concentration may have forced packers to compete for fed cattle in the same markets and reduced trade and information costs across regions, contributing to spatial integration.

The degree of integration between two markets is influenced by numerous factors including barriers to trade (tariff and non-tariff barriers), market power (non-competitive price behavior), and exchange rate risk (Klovland 2005; Miljkovic 1998). Studies of market integration must account for: (1) transaction costs which, if ignored, can generate misleading statistical results; and (2) transportation costs because "agricultural products are typically produced over an extensive spatial area and are costly to transport relative to their total value" (Fackler and Goodwin 2001).

Furthermore, "[T]he nature, speed, and extent of adjustments to market shocks may have important implications for marketing margins, spreads, and mark-up pricing practices" (Goodwin and Holt 1999). Goodwin and Holt (1999) showed that farm, wholesale, and retail beef prices have become more responsive to exogenous shocks. This may be because markets have become more efficient in transmitting information through vertical marketing channels.

Pre-tests for Integration: Stationarity and Cointegration

A common strategy when testing market integration is to apply standard unit root tests and cointegration tests among variables in time-series data. Variables that contain unit roots have time varying means and variances (nonstationary) (Wooldridge 2006). A regression equation in which a dependent and independent variable both have unit roots can lead to spurious results that may indicate significant statistical relationships where none exists. However, if all variables have unit roots, they may be cointegrated and be related. An Augmented Dickey-Fuller (ADF) unit root test for the variable X_t compares an unrestricted model (that allows for serial correlation in the error term) represented in equation (3.1), to a restricted model (equation (3.2)).

$$(3.1) \quad X_t - X_{t-1} = \alpha + \beta T + (\rho\text{-}1)\, X_{t-1} + \sum_{j=1}^{N} \lambda_j \, \Delta X_{t-j} + \varepsilon_t$$

$$(3.2) \quad X_t - X_{t-1} = \alpha + \sum_{j=1}^{N} \lambda_j \, \Delta X_{t-j} + \varepsilon_t$$

The null hypothesis of unit roots being present is tested with an F-test of $\beta=0$ for Trend (T) and $\rho=1$. The alternative hypothesis of no unit roots is that $\beta\neq0$, $\rho<1$. This test is not powerful for samples of less than 100 observations (Marsh 2006b).

A cointegration test is used to determine whether variables are cointegrated. If that is the case, a regression analysis or error correction model (ECM) may proceed with data in level form (Greene 2000). For example, suppose X_t and Y_t contain unit roots in the following relationship:

$$(3.3) \quad Y_t = \alpha + \beta X_t + \mu_t$$

If equation (3.3) is stationary, then ordinary least squares (OLS) provide consistent estimates of β (Pindyck and Rubinfeld p.465). An ADF cointegration test is performed on the OLS residuals (μ_t) of (3.3). If the null hypothesis of unit roots is rejected at some level of significance (usually $\alpha=0.10$ or $\alpha=0.05$), then the residuals are stationary and the equation is cointegrated. The OLS residuals of equation (3.4), the cointegrating equation, are tested in equation (3.5). The null hypothesis that unit roots are present implies $\theta=0$.

(3.4) $\hat{\mu}_t = Y_t - \alpha - \beta X_t$

(3.5) $\hat{\mu}_t - \hat{\mu}_{t-1} = \alpha - \theta \hat{\mu}_{t-1} + \lambda (\hat{\mu}_{t-1} - \hat{\mu}_{t-2})$,

The ADF statistic is then compared to the critical values using the Davidson-McKinnon (DM) statistic. The null hypothesis is rejected if ADF≥DM, but cannot be rejected if ADF<DM. Equation (3.4) is the cointegrating equation and the t-statistic of θ in equation (3.5) is the ADF statistic. If the variables Y_t and X_t are not cointegrated then the data needs to be differenced until each variable is integrated of order zero/I(0).

Goodwin and Schreoder (1991) used seven cointegration tests developed by Engle and Granger to determine spatial price relationships in regional cattle markets in the US. These tests consider two nonstationary variables X_t and Y_t that required a single differencing transformation to produce a stationary series. However, a linear combination of the two series (estimated with OLS) produced stationary errors. Therefore, the two series are cointegrated.

The first of Engle and Granger's seven tests for cointegration uses the standard Durbin-Watson test statistic from the first stage OLS estimation of the cointegrating regression.

(3.6) $\hat{e}_t = Y_t - \hat{\alpha} - \hat{\beta} X_t$

The residuals ($\hat{e}_t$) can be calculated as in Equation (3.6) to be used in the following test statistics.

(3.7) First Test Statistic = $\left(\sum_{t=2}^{T} (\hat{e} - \hat{e}_{t-1})^2 \right) / (\sum_{t=1}^{T} \hat{e}_t^2)$

The null hypothesis of no cointegration is rejected for values from the first test statistic, which are significantly different from zero. This test statistic is approximately equal to 2-$2\hat{\rho}$, where $\hat{\rho}$ is the estimated autoregressive parameter for the residual errors. Therefore, this test is the same as ρ is significantly different from one.

The second cointegration test utilizes Dickey-Fuller type regressions to determine whether the autoregressive parameter for the estimated residuals is significantly different from one. If a unit root is present, then the two series are not cointegrated. Equation (3.8) is estimated and the test statistic is constructed from the ratio of the estimated ϕ to its standard error (a t-ratio).

(3.8) $\Delta \hat{e}_t = -\phi \hat{e}_{t-1} + \varepsilon_t$

The null hypothesis of no cointegration is rejected for values of ϕ which are significantly different from zero.

The third test also uses Dickey-Fuller type regressions but contains p lagged values of the differenced residual errors, equation (3.9).

(3.9) $\Delta \hat{e}_t = -\phi \hat{e}_{t-1} + \theta_1 \Delta \hat{e}_{t-1} + ... + \theta_p \Delta \hat{e}_{t-p} + \varepsilon_t$

These lagged differences ensure that the second stage residuals of the augmented Dickey-Fuller regression, ε_t, are serially uncorrelated. The ADF test statistic is the t-ratio for the estimate of ϕ, in equation (3.9).

The fourth cointegration test involves the estimation of a vector error correction mechanism for the cointegrating regression:

(3.10) $\Delta X_t = \beta_1 \hat{e}_{t-1} + \eta_{1t}$, and

$$\Delta Y_t = \beta_2 \hat{e}_{t-1} + \gamma \Delta X_t + \eta_{2t}$$

A test of no cointegration is based on the joint significance of the error correction coefficients β_1 and β_2. A test statistic is calculated from the sum of the squared t-ratios of β_1 and β_2. If β_1 and β_2 are jointly different from zero, the null hypothesis of no cointegration is rejected.

The fifth test statistic is constructed similarly to the fourth with lagged values of the differences of the economic variables (ΔX_t and ΔY_t) to ensure the white noise in the error terms of the vector autoregressive system.

(3.11) $\Delta X_t = \beta_1 \hat{e}_{t-1} + \sum_{k=1}^{K} \psi_1 \Delta X_{t-k} + \sum_{k=1}^{K} \psi_2 \Delta Y_{t-k} + \eta_{1t}$, and

$$\Delta Y_t = \beta_2 \hat{e}_{t-1} + \gamma \Delta X_t + \sum_{k=1}^{K} \psi_3 \Delta X_{t-k} + \sum_{k=1}^{K} \psi_4 \Delta Y_{t-k} + \eta_{2t}$$

The fourth and fifth tests are conditional on the estimates from the cointegrating regression. However, the final two tests relax this restriction by estimating a vector autoregression (VAR) which is not constrained to satisfy the cointegration constraints.

(3.12) $\Delta Y_t = \theta_1 Y_{t-1} + \theta_2 X_{t-1} + c_1 + \nu_{1t}$, and

$$\Delta X_t = \theta_3 Y_{t-1} + \theta_4 X_{t-1} + \lambda \Delta Y_t + c_2 + \nu_{2t}.$$

The null hypothesis of no cointegration is rejected if parameters θ_1 and θ_2 of the first equation and θ_3 and θ_4 of the second equation are jointly significantly different from zero. Failure to reject the null hypothesis indicates there is not statistically significant relationship between current and past values, and that the variables are not cointegrated. The final test statistic is similar to the sixth test, but with lags of ΔX_t and ΔY_t used to ensure serially uncorrelated residuals.

(3.13) $$\Delta Y_t = \theta_1 Y_{t-1} + \theta_2 X_{t-1} + \sum_{k=2}^{K} \psi_1 \Delta Y_{t-k} + \sum_{k=2}^{K} \psi_2 \Delta X_{t-k} + c_1 + \nu_{1t}, \text{ and}$$

$$\Delta X_t = \theta_3 Y_{t-1} + \theta_4 X_{t-1} + \lambda \Delta Y_t + \sum_{k=2}^{K} \psi_3 \Delta Y_{t-k} + \sum_{k=2}^{K} \psi_4 \Delta X_{t-k} + c_2 + \nu_{2t}.$$

In summary, cointegration tests provide evidence of linkages between prices series in different markets. Therefore, cointegration is not an absolute test of market integration, but does provide some evidence that it might exist.

Tests of Integration

Fackler and Goodwin (2001) discuss empirical tests for integration and their limitations. These tests include simple regression and correlation analyses as well as methods based on vector autoregressions (e.g., Granger-causality).

Shortcomings of simple regression and correlation analyses are that empirical tests of market integration are confounded by common components such as inflation, population growth, or climate patterns that affect all markets. Correlation in such cases may be spurious and may not reflect what one commonly assumes to be the implications of spatially integrated markets. The extent to which individual price series are aggregated over time affects the extent to which these systematic effects are problematic. The use of data level prices series in such situations, although statistically inefficient, can provide consistent estimates of the correlation coefficients that are not subject to spurious correlation effects. However, one must be able to accurately measure the systematic factors which may be impossible for daily or weekly data. Another limitation is that the instrument for measuring integration between two markets involves the potential for independent variation of prices created by transaction costs.

Granger causality tests are typically conducted within the framework of a vector autoregression model where regional prices for one market are regressed upon lagged values of prices from another market. This is a limited notion of causality in that it implies that past values of one series (X_t) are useful for predicting future values of another series (Y_t), after controlling for past values of Y_t (Wooldrigde 2006). Granger causality tests indicate only whether a relationship between variables is statistically significant. A statistically significant relationship that is inconsistent with market integration could exist and be mistaken as support for spatial integration. Therefore, it is important that any results from a Granger causality test be supplemented by other procedures. From the reduced form in equation (3.14), the hypothesis is that X_1 fails to Granger-cause X_2 or no causality is accepted if equation (3.15) is zero, for all k (Fackler and Goodwin 2001).

$$(3.14)\quad X_t = \frac{1}{b_1+b_2}\sum_{k=1}^{m}\begin{bmatrix}1 & -b1\\ 1 & b1\end{bmatrix} * \begin{bmatrix}B_{11k} & B_{12k}\\ B_{21k} & B_{22k}\end{bmatrix} * \begin{bmatrix}b_1 & b_2\\ -1 & 1\end{bmatrix} * X_{t-k} + \varepsilon_t = \frac{1}{b_1+b_2} * \sum_{k=1}^{m}$$

$$\begin{bmatrix}B_{11k}b_1 - B_{12k} - B_{21k}b_1b_2 + B_{22k}b_2 & (B_{11k} - B_{22k} - B_{21k}b_2)\,b_2 + B_{12k}\\ (B_{11k} - B_{22k} + B_{21k}b_1)\,b_1 + B_{12k} & B_{11k}b_2 + B_{12k} + B_{21k}b_1b_2 + B_{22k}b_1\end{bmatrix} * X_{t-k} + \varepsilon_t$$

$$(3.15)\quad (B_{11k} - B_{22k} + B_{21k}b_1)\,b_1 - B_{12k} = 0$$

Vollrath and Hallahan (2006) test market integration using a VAR framework. Adjustment lags account for feedback and prevent simultaneity bias of parameter estimates. A two-equation model is used to examine market connectedness, as represented in equation (3.16).

$$(3.16)\quad P_{1t} = \sum_{j=1}^{m} \Phi_{i-j1} P_{1,t-j} + \sum_{j=1}^{m} \Phi_{i-j2} P_{2,t-j} + \sum_{j=1}^{m} \Phi_{i-j3} SD_j + \Phi_{i4} A_t + \Phi_{i5} G_t + \varepsilon_{it}$$

$$P_{2t} = \sum_{j=1}^{m} \Phi_{i-j1} P_{1,t-j} + \sum_{j=1}^{m} \Phi_{i-j2} P_{2,t-j} + \sum_{j=1}^{m} \Phi_{i-j3} SD_j + \Phi_{i4} A_t + \Phi_{i5} G_t + \varepsilon_{it}$$

where P_1 is the US price, and P_2 is the Canadian price in US dollars. A seasonal dummy (SD), CUSTA dummy (A_t) and government policies (G_t) are controls. Inspection of the residual correlogram and Wald test is recommended to ensure that M is of sufficient length to generate white noise residuals. Granger-causality, impulse response functions and impact multipliers are then examined. Granger-causality tests indicate lead-lag relationships between the two markets; while impulse response functions describe how quickly and the extent to which one country's price responds to shocks in another country. A larger, faster transmission indicates greater integration between markets, while a full and instant transmission implies perfect integration. Impact multipliers then provide information on market dynamics.

VAR Versus Structural Models

A VAR model uses the data to determine the dynamic structure of a model used for forecasting. A VAR model uses time series data and is not based on an economic structure as a means of model identification. In contrast, a structural model is based on economic theory in the industry being examined. Both models are systems for which errors may be contemporaneously correlated, e.g., a non-diagonal covariance matrix of errors, resulting in a system of equations that are estimated as a group. Generalized Least Squares is the preferred estimator although little efficiency is gained for VAR with identical regressors. A VAR model provides impulse response functions from shocked innovation error terms indicating the time path of a dependant variable (Y_t) to an equilibrium. This is useful in testing for market integration because in examining convergence patterns of time paths. A market that takes a shorter time to reach a stable equilibrium may also imply a more integrated market. However, a structural model which provides dynamic multipliers indicates the length of time required for a market to move to a new equilibrium. This is useful in quantifying differences between old and new equilibriums, giving an indication of the change caused by a shock to the market through policy or market structure. It should be noted that when the reduced form of a dynamic structural model is used to find such length-of-run multipliers, market stability is assumed. Therefore, a structural model does not necessarily provide information with regards to the degree of market integration and interdependence.

The Law of One Price

The law of one price (LOP) states that, after accounting for transaction costs and exchange rates, regional markets that are linked by trade should experience equivalent prices. This law is "strong" if $p_j - p_i = r_{ij}$ holds, where p is the price in markets i and j, and r_{ij} is the cost of moving the good between markets (given that trade is continuous). The law is "weak" if $p_j - p_i < r_{ij}$ (Fackler and Goodwin 2001). The LOP is expected to hold because of profit-seeking actions of international commodity traders and arbitragers. However, international commodity arbitrage and trade occur over time as well as across spatially separated markets. Because traders respond to expected prices, one would expect the LOP to hold in terms of expected prices after allowing for delivery lags (Goodwin et al. 2002).

Vollrath and Hallahan (2006) note that most LOP studies ignore important spatial and temporal factors that affect commodity prices such as adjustment lags, changes in the value of national currencies, and policy-induced trade barriers. The law of one price can be used to formally test market integration. For example, Klovland (2005) uses deviations from the LOP to test market integration between Britain and Germany for 39 agricultural and manufacturing commodities.

Chambers and Just (1979) note that most analyses of exchange rates and international trade explicitly assume adherence to the LOP in absolute terms. Officer (1982) finds that support for the LOP is limited, specifically for short run data. Williamson (1986) noted that the law of one price has probably been more thoroughly discredited by empirical evidence than any other proposition in the history of economics. However, supportive evidence is present for modified versions. The LOP is more strongly supported for traded versus non-traded goods (Officer 1986) and in the long-run versus the short-run (Protopapadakis and Stoll 1986). Accounting for transaction costs and delivery lags tends to help provide support for the law of one price (Crouhy-Veyrac et al. 1982; Goodwin 1992a; Michael et al. 1994).

If markets become more integrated, deviations from LOP decrease. A test of this hypothesis requires information on local currency prices of nearly identical commodities. Cointegration and other time series methods can be employed to examine how prices move over time and how rapidly price differences vanish when shocks to relative prices occur. A systematic convergence toward one price can be expected to occur but only in the very long run (Klovland 2005). Sarno et al. (2003) suggest that deviations from the law of one price may be somewhat sticky, but are not persistent.

Although many tests have rejected the LOP, Goodwin, Grennes, and Craig (2002) note that many failed to adequately consider spatial price linkages and transactions costs associated with international commodity exchange. In response, several spatial market integration analyses have considered transaction costs and show that arbitrage activities take place only when price differences exceed a certain amount (Serra and Goodwin 2004). Engel and Rogers (1996) suggest that crossing national boarders increases the volatility of price differentials by the same order of magnitude that would be generated by the additional distance between cities. Moreover, even if countries have reduced tariffs over time, nontariff barriers are often significant. This is the case for beef and cattle trade between the US and Canada. Even after the removal of trade barriers under CUSTA, nontariff barriers such as health factors and the absence of national grade equivalencies continued to persist. Commodity analysts believe that nontariff barriers drive a wedge between the two national markets in the beef industry (Hayes and Kerr, 1997).

Testing the LOP

Cointegration tests developed by Engle and Granger (1987) and Johansen and Juselius (1990) are popular methods for testing the LOP (Ardeni 1989; Goodwin 1992a and 1992b). Conventional regression tests of the LOP may misrepresent or ignore the time-series properties of individual price data series (Ardeni 1989; Goodwin 1992a). In particular, ignoring serial correlation in an empirical test may result in biased and inconsistent conclusions. Techniques such as differencing transformations and filters to control for serial correlation are *ad hoc* in nature and may be inappropriate for a given price series (Ardeni 1989).

A general two-step approach prepared by Engle and Granger using OLS and lagged variables to define error correction terms is an alternative. However, significant lags normally occur in the adjustment of prices and are generally attributed to adjustment costs which delay or inhibit market price adjustments (Goodwin and Holt 1999).

Delivery lags are created when a product is sold, but not delivered and paid for until a future date. If prices are determined at the time of sale, agents must formulate expectations of what prices will be at the time of delivery. Goodwin, Grennes and Wohlgenant (1990) warn that the use of expected prices causes future prices to be correlated with the contemporaneous disturbance term leading to biased and inconsistent OLS estimates. A generalized method of moments (GMM) estimator purges the price variable of correlation with the disturbance term and creates consistent and asymptotically efficient parameter estimates.

Other tests for the LOP include bivariate two-step cointegration testing techniques of Engle and Granger. However, cointegration considerations are confined to pair-wise comparisons in the models because such tests require one of the two prices to be designated as exogenous. The test procedures do not have well defined limiting distributions and do not offer straight forward testing procedures.

Multivariate cointegration tests use maximum likelihood estimate procedures in case of multiple cointegrating vectors. This procedure estimates the limiting distribution as a function of a single test statistic and provides advantages over the bivariate Engle and Granger procedure (Miljkovic 1998). Confirmation that each series is I(1) is needed before using multivariate cointegration tests. Goodwin (1992a) used the Johansen multivariate cointegration testing procedure to evaluate the LOP for prices in five international wheat markets.

Vollrath and Hallahan (2006) used an LOP model to test for market integration and price transmission included an autoregressive-moving-average (ARMA) error term (μ_t) to account for seasonality:

(3.17) $P_1 = \beta_o + \beta_1 P_{2t} + \beta_2 e_t + \beta_3 A_t + \beta_4 A_t P_{2t} + \beta_5 A_t e_t + \beta_6 G_t + \mu_t$

where P_1 is the Canadian prices, P_2 is the US price, e_t is the exchange rate, A_t is the CUSTA dummy and G_t the government policy dummies. Prices are enumerated in own currencies to examine the extent of exchange rate pass-through. The exchange rate is expected to have a positive sign on the coefficient for an exporting home country. Appreciation of the exchange rate lowers e_t and reduces foreign sales. If the home country is an importer of a product, an exchange rate depreciation (or a higher number e_t) makes imports more expensive, permitting local producers to increase their prices. The disadvantage of the VAR approach is that results may depend upon which price is used on the left-hand side. This can be addressed by using a Granger-causality test to determine the lead-lag relationship between two prices. The advantage is a straight forward testing procedure for integration, price transmission and exchange rate pass-through.

In the pre-CUSTA period, perfect (zero) price transmission from the foreign to the domestic market occurs when β_1=1(0); complete (zero) exchange rate pass through is implied by β_2=1(0); and perfect (zero) market integration occurs when $\beta_1=\beta_2$=1(0). Conversely, in the post-CUSTA period perfect (zero) price transmission countries occurs if $\beta_1+\beta_4$=1(0); complete (zero) exchange rate pass through occurs if $\beta_2+\beta_5$=1(0); and perfect (zero) market integration if $\beta_1+\beta_4=\beta_2+\beta_5$=1(0).

The Relationship of Cointegration to LOP

McNew and Fackler (1997) noted that caution should be exercised when applying and interpreting cointegration models with regard to spatial price behavior. They define the LOP as a situation where arbitrage opportunities are quickly eliminated and, therefore, are generally unobservable. This is distinguished from market integration which is the extent to which shocks in one market are passed to another. They argue that if demand and supply forces are cointegrated across regions, one may conclude that prices are cointegrated regardless of whether inter-regional flows of commodities and associated binding arbitrage conditions exist. Therefore, the degree of cointegration among prices is not a useful measure of the strength of inter-regional market integration.

Cointegration between prices does not imply that LOP holds even after accounting for transaction costs. Barrett (1996) states that cointegration is neither necessary, nor sufficient for LOP. For example, if transaction costs are nonstationary, failure to find cointegration between two market price series may be perfectly consistent with LOP (Miljkovic 1998). The practical importance of cointegration is not as a test for LOP, but as a pretest for other issues (Miljkovic 1998).

The Influence of Exchange Rates on Trade

In competitive markets, commodity arbitrage tends to equalize prices for identical internationally traded products after allowing for transportation costs (Baldwin and Yan 2004). So, exchange rate variation should not influence trade patterns or volumes. If each country can convert prices to their domestic currency, exchange rates should be irrelevant. However, floating currencies allow for fluctuations in exchange rates and have increased risk in international transactions (Hooper and Kohlahagen 1978). Therefore, both exchange rates and exchange rate risk may cause incomplete price pass-through. Hooper and Kohlhagen (1978) found that exchange rate risk negatively impacted trade, but had a positive impact on prices when exporters bear exchange risk. Guzel and Kulshreshtha (1995) found that a 5 percent appreciation of the Canadian dollar decreased Canadian livestock exports by 10 percent. Because Canadian agriculture is dependent upon export markets, it is vulnerable to fluctuations in exchange rates (Guzel and Kulshreshtha 1995).

The influence of relative exchange rates on meat export prices has been increasingly questioned. However, correlation between exchange rate and cattle exports does not imply causation. For example, Canadian cattle exports increased substantially between 1987 and 1993; meanwhile, the Canadian exchange rate was appreciating over this period (Klein, McGivens, and Grier 2006). Miljkovic, Brester, and Marsh (2003) note US beef exports to Japan, South Korea, Canada, and Mexico are characterized by imperfect exchange rate pass-through. Incomplete exchange rate pass-through occurs if an importing country's local product price does not respond proportionally to changes in exchange rates. In general, currency devaluations in major US export markets negatively influence meat export prices.

While exchange rate effects are generally negligible on trade, their "surprises" do create fluctuations in export demand and instability for exporting producers when arbitragers do not accurately predict exchange rate movements (Miljkovic 1998).

Research

Vollrath and Hallahan (2006) tested the Canadian and US slaughter steer market for LOP and degree of integration from 1988 to 2000 using an LOP framework and vector autoregression model. Chow tests for the hypothesis of no structural change could not be rejected for the Canadian/US steer markets. Evidence was found of greater interdependence in Canada to the US market than in the US to the Canadian market.

A significant barrier to cross-border integration may be caused by exchange rates. Vollrath and Hallahan found that low exchange rate pass-through transmission along with a decline in the value of the Canadian dollar (compared to the US dollar) indicated Canadian suppliers had a profit advantage in the late 1990s and early 2000s. However, the decline of the US dollar since 2002 suggests this advantage is disappearing (Vollrath and Hallahan 2006). Baldwin and Yan (2004) found that Canadian cattle prices lagged US prices and responded to changes in exchange rates.

Summary

While the Canadian and US cattle markets may be integrated and act as one market, the law of one price may not hold because of incomplete pass through of price shocks. Therefore, market integration and the law of one price will be tested in the fed steer, feeder steer, and slaughter cow markets to determine market connectedness between the two countries. The modeling strategy will generally indicate unit root tests for US and Canadian cattle prices, and cointegration tests as detailed by Goodwin and Schroeder (1991), using Engle and Granger's technique to determine if the price data needs to be differenced or can be used in level form. Market integration will be modeled with a VAR as outlined by Vollrath and Hallahan (2006) to determine market integration and interdependence. Because cointegration does not imply that the LOP holds, both concepts will be tested. Adherence to the LOP over individual regime periods will be tested using the LOP model developed by Vollrath and Hallahan (2006). The Granger-Causality and VAR will determine lead-lag relationships for which price should be the dependant variable. This modeling procedure allows for testing of structural change (on price transmission and exchange rate pass-through) between regimes. Adjustment lags and exchange rate risk will be considered along with other market controls.

CHAPTER 4

DATA

The sample period for testing market integration and the LOP between the US and Canada for the fed steer, feeder steer, and slaughter cow markets consists of weekly data, from January 1985 to June 2006, for a total of 1,117 observations. A description of the data and their sources is listed in Table 4.1.

Table 4.1. Weekly Data for Canadian and US cattle markets, 1985-2006.

Variable	Units	Source
Alberta Fed Steer Prices	US $/cwt	CanFax
Alberta Feeder Steer (500-550lb.)	US $/cwt	CanFax
Alberta D1,D2 Cow Prices	US $/cwt	CanFax
Exchange Rate	US cents/Can$	Statistics Canada
Exchange Rate Risk		Created
Omaha Fed Steer Prices	US $/cwt	LMIC
Oklahoma Feeder Steer (500-600lb.)	US $/cwt	LMIC
Billings Slaughter Cow Prices	US $/cwt	LMIC
Canadian Beef Production	Billion of lbs.	CanFax
US Beef Production	Billion of lbs.	LMIC
US Corn Price	US $/bushel	NASS/USDA
Canadian Beef Cow Inventory	Million of head	CanFax
US Beef Cow Inventory	Million of head	LMIC
Transportation Index		BLS
Net Trade	Million of head	LMIC
Dummy Jan 1985-Jan 1989		Created
Dummy Jan 1989-Aug 1995		Created
Dummy Aug 1995-May 2003		Created
Dummy May 2003-August 2005		Created
Seasonal Dummy(1) January – March		Created
Seasonal Dummy(1) April – June		Created
Seasonal Dummy(1) July – September		Created

All Canadian prices were multiplied by the US-Canadian exchange rate to obtain US dollar equivalents. Alberta prices for fed steers (1100-1200lb.), feeder steers (500-

550lb.), and slaughter cows (D1, D2) were used for the Canadian cattle prices. Omaha fed steer (1150-1250lb.), and Oklahoma City feeder steer (500-600lb.) were used for the US cattle prices. US slaughter cow prices are based on Billings, Montana for 1986-2006; only monthly prices for 1985 Utility Cows were available. Hence, the monthly price was assigned to each week of the month.

Beef cow inventories were only available biannually (January 1 and July 1). Therefore, linear interpolation was used to obtain monthly observations. Each week within a month was assigned the same observation.

It is assumed that fuel and trucking costs are similar in the US and Canada. The US transportation index for trucks over 14,000 pounds is used as a proxy for transportation costs in both countries. The transportation index from the Bureau of Labor Statistics is reported only on a monthly basis. Thus, each week of a month is assigned the same index value.

The net trade variable is calculated by subtracting Canadian cattle exports to the US from US cattle exports to Canada. It was uncertain how to define exchange rate risk to measure the volatility in the market at the time (hindsight approach) or to measure exchange rate risk how producers would perceive the current market volatility. Therefore, two proxies for exchange rate risk were created. The first was defined as:

(4.1) $Risk_t(1) = (Exchange_t - E[Exchange]_n)^2/n$

where E[Exchange] is the mean for each individual period (e.g., pre-CUSTA, post-CUSTA) and n is the number of observations for that period. The second proxy was calculated as:

(4.2) $Risk_t(2) = [(Exchange_t - E[Exchange]_n)^2/n]^{1/2}$

where n is the number of past observations used to create the mean. N was varied to find out how many weeks a buyers would consider when examining market stability. Two, four, six, eight and ten past weeks were considered to create a moving average in standard deviation form. T-values of the variables were compared to determine which definition explained exchange rate variation the best. Table 4.2 shows the descriptive statistics of the variables used; excluding binary variables.

Table 4.2. Summary Statistics of Weekly Data, 1985-2006.

Variable	Observations	Mean	Standard Deviation
Alberta Fed Steer Prices	1116	63.0	8.2
Alberta Feeder Steer (500-550lb.)	1113	87.0	14.3
Alberta D1,D2 Cow Prices	1111	39.0	9.7
Exchange Rate	1117	0.8	0.1
Exchange Rate Risk (1)	1117	6.86E-6	7.66E-6
Exchange Rate Risk (2) - 4 lags	1117	0.21	0.03
Exchange Rate Risk (2) - 6 lags	1117	0.17	0.02
Omaha Fed Steer Prices	1116	70.0	9.2
Oklahoma Feeder Steer (500-600lb.)	1088	91.0	17.5
Billings Slaughter Cow Prices	1090	42.0	7.0
Canadian Beef Production	1117	0.041	0.008
US Beef Production	1117	0.462	0.042
US Corn Price	1117	2.3	0.5
US Hay Price	1113	72.0	14.0
Canadian Beef Cow Inventory	1117	4.2	0.7
US Beef Cow Inventory	1117	38.7	3.2
Transportation Index	1117	136.0	16.7
Net Trade	1117	15.4	10.3

The Alberta Grain Commission noted that Alberta feedlots import feed corn from the US rather than from Ontario. Therefore, US corn prices were used for both US and Canadian feed costs. Canadian hay prices were unavailable. Therefore, US hay prices were used for both countries as a proxy for winter cow maintenance costs. Because of limited observations in the US weekly hay prices, a monthly price was assigned to each week of the month.

CHAPTER 5

EMPIRICAL MODEL AND RESULTS

This chapter describes the models used for testing market integration and the Law of One Price (LOP) for US and Canadian fed steer, feeder steer, and slaughter cow markets. Unit root and cointegration tests are conducted; and market integration and LOP models are estimated.

Market Integration Model

A VAR model is developed following Vollrath and Hallahan (2006). Two equations (5.1) and (5.2) are estimated for fed steer, feeder steer, and slaughter cow markets; and then used to check for integration.

$$(5.1)\quad P^{i}_{US,t} = \sum_{j=1}^{k} \Phi_{ij1} P^{i}_{US,\, t-j} + \sum_{j=1}^{k} \Phi_{ij2} P^{i}_{can,t-j} + \Phi_{i3} Controls_t + \varepsilon_{it}$$

$$(5.2)\quad P^{i}_{can,t} = \sum_{j=1}^{k} \Phi_{ij4} P^{i}_{US,\, t-j} + \sum_{j=1}^{k} \Phi_{ij5} P^{i}_{can,t-j} + \Phi_{i6} Controls_t + \mu_{it} \ ,$$

where i = market class (fed steer, feeder steer, or slaughter cow) and t = 1,2, … ,n The error terms are assumed to be white noise and contemporaneously correlated. The exogenous variables (controls) are selected for each model based upon economic relevance. The fed steer market control variables include Canadian and US beef production, net live cattle trade, and a trucking cost index. The feeder steer model includes US corn price, Canadian and US beef cow inventories, net live cattle trade, and the trucking cost index as exogenous variables. The slaughter cow model uses US hay price, Canadian and US beef cow inventories, net live cattle trade, and the trucking cost index as exogenous variables.

Decision makers (buyers) have information available from past (lagged) cattle prices from each country to determine the current period cattle prices (their bids). Therefore, prices observed in the current period price are determined from knowledge on past price behavior in both countries (equations (5.1) and (5.2)). The j^{th} lag structure for each market price equation is determined empirically by inspecting the adjusted R-squared, standard error of the regression, and the Akaike Information Criterion (AIC). Stability conditions, Granger-causality tests, and impulse responses will be examined to determine if each market is integrated.

The Law of One Price Model

The Law of One Price (LOP) is tested for each market that is determined to be integrated. The Vollrath and Hallahan (2006) LOP model is specified as:

(5.3) $P^i_{can,t} = \beta_o + \beta_1 P^i_{us,t} + \beta_2 Exchange_t + \beta_3 ExchangeRisk_t + \beta_4 Controls_t + \mu_t$,

where i = market class (fed steer, feeder steer, or slaughter cow) and t = 1,2, … ,n and μ_t is an ARMA error term. However, the presence of several missing price observations prohibit the generation of a moving average (MA) component. Therefore, only an AR process of the error term is considered. A separate regression model was estimated for each time period to be considered.

The control variables for equation (5.3) are the same as those presented in equations (5.1) and (5.2). The lags on the control variables are determined based on t-values and the Wald test (joint significance). The stability of each regression's AR error term will be examined. To test for cattle price transmission and exchange rate pass-through in each period, the Wald test will be used. This test indicates the degree of market integration in each period. The null hypothesis of perfect (zero) price transmission from the US to the Canadian market occurs when β_1=1(0). The null hypothesis of complete (zero) exchange rate pass-through transmission is implied by β_2=0(1). The null hypothesis of perfect (zero) market integration occurs when $\beta_1+\beta_2$=1(0). Structural change between each period of the LOP model will be tested using the Wald coefficient restriction test. β_1 and β_2 of equation (5.3) are individually and jointly tested for significant changes across time periods. This will indicate if individual policy changes resulted in structural change in specific markets.

Results: Stationarity and Cointegration

Equations (3.1) and (3.2) are estimated to determine the presence of stationarity. The statistical results (Table 5.1) indicate that all prices series are nonstationary (unit roots) at the α=0.01 significance level.

Table 5.1. Augmented Dickey-Fuller Unit Root Test Results.

Variable	**ADF Test Statistic***
Canadian Fed Steer	-1.716
Canadian Feeder Steer	-2.572
Canadian Slaughter Cow	-2.302
US Fed Steer	-1.58
US Feeder Steer	-3.1
US Slaughter Cow	-3.45

*Two lags was used in the Dickey-Fuller test.
Critical t-value at α=0.01 is -3.50

The ADF test (Table 5.2) shows that all prices were stationary (e.g., reject the null hypothesis of unit roots) at the α=0.05 significance level when differenced once [e.g., I(1)].

Table 5.2. ADF Unit Root Results on Prices differenced once.

Variable	ADF Test Statistic*
Canadian Fed Steer	-6.32
Canadian Feeder Steer	-5.89
Canadian Slaughter Cow	-5.39
US Fed Steer	-7.24
US Feeder Steer	-4.42
US Slaughter Cow	-5.05

*Two lags was used in the Dickey-Fuller test.
Critical t-values at α=0.01 is -3.50 and α=0.05 is -2.89

Engle and Granger tests for cointegration equations (3.7-3.13) are also estimated. The null hypothesis of no cointegration in equation (3.7) was rejected for slaughter cows and fed steers at the α=0.10 significance level. However, the test statistic for the feeder steer market failed to reject the null hypothesis of no cointegration at the α=0.10 significance level. T-statistics for the first test are given in Table 5.3.

Table 5.3. Test One Results.

	T-statistic	Probability
Fed Steers	1.787	0.0742
Feeder Steers	1.1116	0.2666
Slaughter Cows	1.9592	0.0503

The second and third tests (equations (3.8) and (3.9)) indicate that ϕ was significantly different from zero for all markets at the α=0.01 significance level. Therefore, the null hypothesis of no cointegration was rejected.

Tests four through seven from equations (3.10) to (3.13) include controls for each market as described in the market integration model. The joint test of the β_j's in equations (3.10) and (3.11) were found to be different from zero for all cattle price markets at the α=0.01 significance level. Therefore, the null hypothesis of no cointegration was rejected.

Finally, the joint tests on ϕ_1, ϕ_2, ϕ_3, and ϕ_4 from equations (3.12) and (3.13) were found to be significantly different from zero for all cattle price markets. Therefore the null hypothesis of no cointegration was rejected at the α=0.01 significance level.

In summary, these tests conclude that the weekly prices series for the fed steer, feeder steer, and slaughter cow markets between the US and Canada have unit roots and are cointegrated. Therefore, the data will be used in level form in the market integration and LOP models.

Market Integration Results

Given that prices contained unit roots and were cointegrated, cattle prices in the VAR models were not deflated or differenced. Granger-causality tests were conducted on the price variables following equations (3.14) and (3.15). Lag lengths of the control variables differed for each sector. The Granger-causality results for fed and feeder steer prices indicated the US cattle market Granger-causes the Canadian cattle market. This is as expected because the US cattle market is significantly larger than the Canadian cattle market. Canadian exports of cattle and beef are also primarily sent to the US. However, Canada's market appears to Granger-cause the US slaughter cow market; even though Canada's slaughter cow exports only made up 7.8 percent of the US slaughter cow supply in 2002. This represented 34 percent of Canada's 2002 slaughter cow supply. This may indicate the importance of access to Canadian slaughter cows for US cow slaughter plants.

The VAR models were tested for stability, where stability implies that an exogenous shock to the VAR (e.g., through the error terms) result in the dependent variables asymptotically approaching an equilibrium. Results revealed stable VAR's for all cattle price markets. The moduli of the roots, both real and conjugate complex, are shown in Table 5.4.

Table 5.4. Modulus of the Roots of the VAR Models.

Fed	Feeder	Cow
0.65	0.91	0.69
0.65	0.91	0.48
0.28	0.39	0.48
0.13	0.42	0.83
0.92	0.42	0.83
0.92	0.17	0.54
0.39	0.53	0.54
0.98	0.53	0.72
	0.79	0.72
	0.99	0.30
		0.85
		0.85
		0.89
		0.89
		0.85
		0.96

An eigenvalue near the boundary of the unit root circle (close to one) implies that the model is close to being unstable; as is the case with the feeder steer market. The correlogram of residuals failed to reject the null hypothesis of no unit roots for all markets, implying stationary errors. The VAR models (estimated by OLS) for the three markets, are given in Table 5.5.

Table 5.5. VAR Models for Fed Steer, Feeder Steer, and Slaughter Cow Markets.

VAR's	Fed		Feeder		Cow	
	CanFed	USFed	CanFeeder	USFeeder	CanCow	USCow
CanP(-1)	0.87	0.02	0.80	0.02	0.89	0.12
	(28.67)	(1.10)	(24.92)	(0.51)	(26.21)	(4.52)
CanP(-2)	-0.05	0.01	0.13	-0.01	-0.05	0.05
	(-1.41)	(0.31)	(3.27)	(-0.12)	(-1.19)	(1.42)
CanP(-3)	-0.32	0.02	0.00	0.04	-0.03	-0.04
	(-8.35)	(1.06)	(-0.04)	(0.77)	(-0.76)	(-1.19)
CanP(-4)	0.32	-0.01	-0.01	-0.02	0.09	-0.03
	(10.80)	(-0.80)	(-0.18)	(-0.49)	(2.05)	(-0.81)
CanP(-5)			0.00	0.00	0.05	0.00
			(-0.08)	(0.11)	(1.10)	(0.12)
CanP(-6)					-0.03	0.00
					(-0.81)	(0.03)
CanP(-7)					-0.08	-0.01
					(-1.79)	(-0.39)
CanP(-8)					0.03	-0.01
					(1.10)	(-0.36)
US(-1)	0.25	1.00	0.05	0.74	0.07	0.80
	(4.66)	(32.21)	(1.98)	(22.97)	(1.75)	(23.82)
US(-2)	-0.22	-0.23	0.02	0.05	-0.02	-0.08
	(-2.89)	(-5.47)	(0.66)	(1.36)	(-0.32)	(-1.89)
US(-3)	0.17	0.26	-0.06	0.03	0.01	0.39
	(2.24)	(5.98)	(-1.83)	(0.89)	(0.16)	(0.89)
US(-4)	-0.04	-0.09	0.03	0.12	0.04	0.19
	(-0.68)	(-2.83)	(1.03)	(3.05)	(0.88)	(4.42)
US(-5)			0.01	-0.02	-0.01	-0.01
			(0.39)	(-0.60)	(-0.21)	(-0.28)
US(-6)					-0.03	-0.04
					(-0.65)	(-1.12)
US(-7)					0.09	0.05
					(1.83)	(1.31)
US(-8)					-0.07	-0.06
					(-1.82)	(-1.99)
C	-1.54	3.78	0.41	13.07	-0.22	6.75
	(-0.45)	(1.95)	(0.14)	(4.03)	(-0.10)	(3.85)
PreCusta	1.46	-1.34	0.58	-2.31	2.47	-1.92
	(1.29)	(-2.08)	(0.63)	(-2.15)	(3.29)	(-3.11)
PostCusta	1.31	-0.93	0.66	-1.92	2.82	-1.72
	(1.52)	(-1.91)	(0.95)	(-2.36)	(4.56)	(-3.39)
Post95	0.89	-0.94	0.46	-1.74	2.49	-1.69
	(1.28)	(-2.40)	(0.81)	(-2.66)	(4.72)	(-3.89)
Post03	-4.40	0.68	-1.67	-0.26	-2.04	1.74
	(-5.69)	(1.55)	(-2.87)	(-0.39)	(-4.40)	(4.57)
US Corn Price			-0.33	0.10		
			(-1.95)	(0.51)		

Table 5.5. VAR Models for Fed, Feeder Steer, and Slaughter Cow Markets Continued.

Canadian Beef Prod	0.02	0.00	0.00	0.00		
	(0.91)	(-0.45)	(-1.11)	(1.75)		
US Beef Production	0.00	0.00	0.00	0.00		
	(-1.65)	(0.95)	(-0.44)	(-4.61)		
Can Beef Cow Inv					0.00	0.00
					(0.31)	(1.67)
US Beef Cow Inv					0.00	0.00
					(-1.07)	(-1.33)
Truck Index	0.03	-0.01	0.04	-0.07	0.00	-0.05
	(1.63)	(-0.81)	(1.56)	(-2.12)	(0.03)	(-2.68)
Trade	0.00	0.00	0.00	0.00	0.00	0.00
	(-2.42)	(0.52)	(-1.29)	(-0.88)	(-1.60)	(0.11)
Hay Price					0.00	0.00
					(-0.88)	(-1.07)
Observations	1103		992		871	
Adjusted R-squared	0.87	0.96	0.97	0.97	0.97	0.96
St. Error of Eq.	2.95	1.68	2.18	2.53	1.55	1.27
AIC	5.02	3.89	4.42	4.71	3.74	3.35

The VAR models include the 1985 to 2006 period, rather than the five separate time regimes previously noted. The individual time regimes were not of sufficient length to obtain proper lag structures. Seasonality dummies that were specified in the theoretical model were omitted because they created multicollinearity problems.

Coefficients on the lagged price variables are summed to provide the marginal impact of prices on each dependent variable. Results are given in Table 5.6.

Table 5.6. Marginal Price Impacts from the VAR Models.

Sum of Lagged Price Variables	Dependant Variables					
	CanFed	USFed	CanFeeder	USFeeder	CanCow	USCow
Canadian Price	0.82	0.04	0.92	0.03	0.87	0.08
US Price	0.16	0.94	0.05	0.92	0.08	1.24

Although a change in each individual country's price has a larger impact on its own market, the US price has a larger influence on the Canadian market compared to the effect of the Canadian price on the US market. Although these markets do influence each other, the Canadian market is more vulnerable to changes in the US market prices than *vice-versa*. This difference in dependence is expected, and the results support the earlier tests indicating that all three cattle markets are integrated to some degree. Control variables in the VAR models had generally small coefficients and only a few were statistically significant.

The policy dummies are all in comparison to post-2005 prices. Pre-CUSTA, post-CUSTA, and post-1995 all have negative dummies for Canadian cattle prices, and positive dummy coefficients for US cattle prices. As trade barriers were removed, Canadian cattle supplies increased; as did Canadian excess supply (Figure 3.2). This reduced prices and increased trade quantities. The post-2003 period includes the border closure to live cattle. US cattle prices and Canadian slaughter cow prices decreased. US cattle prices actually increased after 2003. However, this period had lower prices than the post-2005 period and, therefore, the dummy coefficient is negative. Excess supply in the Canadian market and lost demand decreased Canadian slaughter cow prices.

Figures 5.1-5.3 show the VAR impulse response functions for the three cattle markets. The impulse responses or time paths of the dependent variables are developed by shocking each error terms (or innovation terms) by one standard deviation.

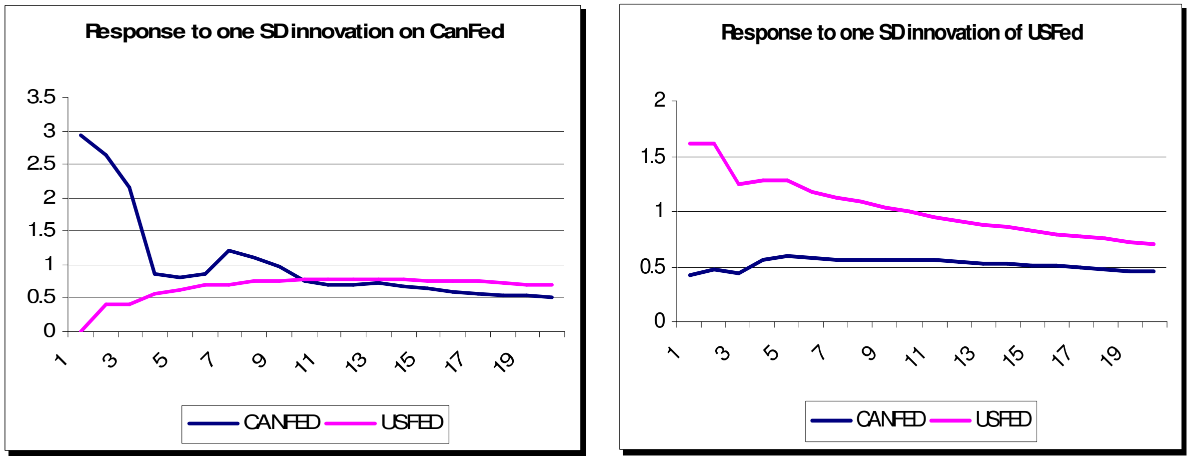

Figure 5.1. Fed Steer Impulse Response Functions.

In the fed steer market (Figure 5.1), each country (Canada, US) had relatively small responses when the other country (US, Canada) was shocked. The majority of the endogenous impacts occur with respect to exogenous shocks in the home country. The Canadian fed cattle market exhibited a larger change (left panel of Figure 5.1), compared to the US fed cattle market (right panel of Figure 5.1). Thus, the larger US cattle market absorbs changes more readily than the Canadian market; the US beef market is also less reliant on trade than Canada.

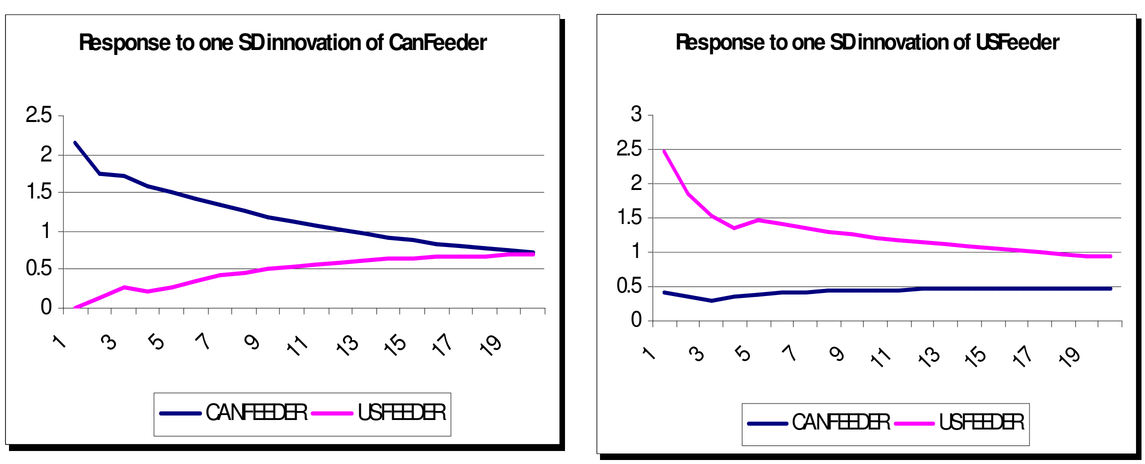

Figure 5.2. Feeder Steer Impulse Response Functions.

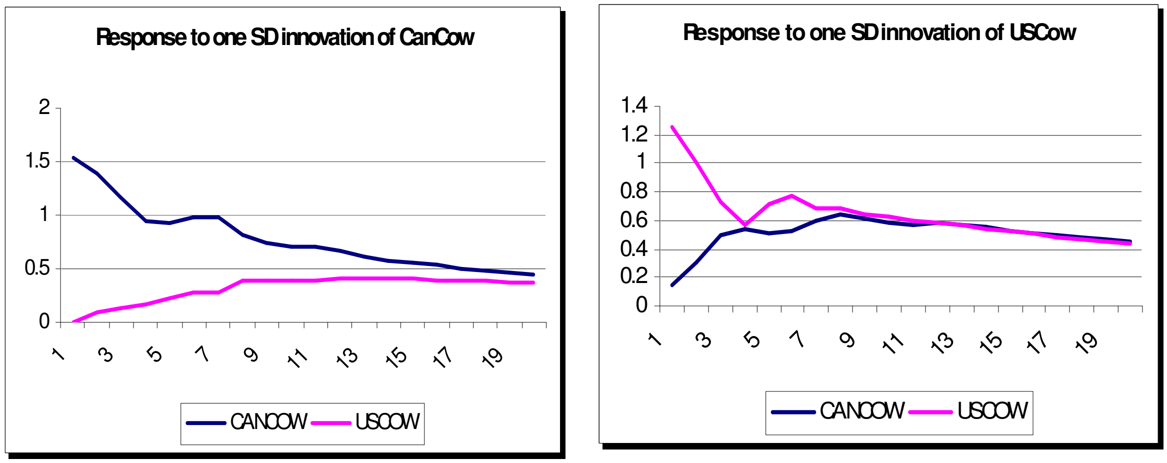

Figure 5.3. Slaughter Cow Impulse Response Functions.

In the feeder steer and slaughter cow markets, a change in the Canadian feeder steer or slaughter cow prices (left panels of Figure 5.2 and Figure 5.3) created near symmetrical responses for each country. This may be caused by increased feeder cattle trade since the initiation of the Restricted Feeder Cattle Program. Slaughter cow trade also increased from 1999 to 2002. However, when the US feeder market is shocked, the Canadian market response is almost flat (right panel Figure 5.2). This is probably because US feeder cattle exports to Canada account for a small percentage of total Canadian feeder cattle supplies (implying that this market may not be as integrated as the others). Canadian slaughter cows, however, are a small percentage of the North American slaughter cow supply. Figures 5.2 and 5.3 suggest that the Canadian feeder steer and slaughter cow markets have a greater dependence on the US cattle market than *vice-versa*.

Overall, the VAR impulse responses for fed steer, feeder steer, and slaughter cow prices support the hypothesis of integration between the US and Canadian cattle markets. This integration occurs even if economic dependence is unequal between the countries.

Although it was not possible to test, it is assumed that the cointegration and integration tests noted above also hold for all cattle markets in the separate time regimes. Therefore, the LOP will be tested within each individual regime.

LOP Results

Nominal prices were used to test for the law of one price (LOP) because US and Canadian cattle prices were cointegrated.[4] Economic theory suggests that exchange rate risk may affect the LOP. However, this variable was not statistically significant in initial estimates of equation (5.3) at the α=0.10 level and, therefore, was omitted in subsequent models.

The LOP models for each period were initially specified with Autoregressive Distributed Lags (ARDL). However, the lagged dependent variable was unstable and, therefore, omitted. Distributed lags were included on all the independent variables. Because theory is unable to determine appropriate lag lengths, the final lag structures are based on Wald tests. These lags are unique to each regime period because of differing market dynamics.

Dynamic lag structures are used because of weekly market rigidities including price expectations, delivery lags because of physical movement of cattle, and contracts. In addition to distributed lags on the independent variables, dynamics were also specified in the error terms. An autoregressive error structure was included because of a high probability of systematic errors in weekly data. Seasonality could also be present across the weekly data. However, because of limitations in degrees of freedom, quarterly

[4] Real prices were also used and did not result in any significant changes in coefficients or t-values.

seasonal dummies were included. The LOP was estimated by nonlinear least squares for each cattle market.

Fed Steer Market

Table 5.7. Fed Steer LOP Results.[5]

Fed	Pre-CUSTA	Post-CUSTA	Post-95	Post-03	Post-05
C	87.52	80.60	270.33	69.65	-272.45
	4.13	3.68	3.50	1.31	-5.23
USFED	0.87	0.57	0.68	0.15	0.40
	11.18	12.80	4.68	1.79	10.24
USFED(-1)	0.07	0.02	-0.17	0.46	0.35
	0.83	0.45	-1.11	5.63	7.56
USFED(-2)	-0.25	0.01	-0.14	-0.07	0.26
	-3.18	0.27	-0.96	-0.83	5.32
USFED(-3)	0.09	0.00	-0.08		0.09
	1.19	-0.04	-0.56		2.09
USFED(-4)	-0.04	-0.05			
	-0.52	-1.23			
USFED(-5)	-0.06				
	-0.77				
USFED(-6)	0.02				
	0.27				
EXCH	-28.04	54.06	45.25	115.38	90.12
	-1.50	5.57	1.25	4.48	11.21
EXCH(-1)	-39.21	-44.01	-65.38	65.54	33.17
	-2.12	-4.37	-1.76	2.42	3.27
EXCH(-2)	-8.11	-2.47	-86.59	34.79	14.99
	-0.43	-0.24	-2.34	1.37	1.46
EXCH(-3)	6.57	-0.40	-112.88		31.02
	0.35	-0.04	-3.01		3.54
EXCH(-4)	10.73	-20.48			
	0.56	-2.09			
EXCH(-5)	35.49				
	1.80				
EXCH(-6)	-22.56				
	-1.12				

[5] In Tables 5.7, 5.9, and 5.11 the inverted AR's include both real and complex roots.

Table 5.7. Fed Steer LOP Results Continued.

CANBFPROD	-14.57	-13.46	-17.66	66.34	22.33
	-0.52	-0.84	-0.42	1.39	0.97
CANBFPROD(-1)	-52.30	-29.09			-27.42
	-1.73	-1.58			-1.33
CANBFPROD(-2)	-49.73	-73.45			-68.44
	-1.52	-3.65			-3.82
CANBFPROD(-3)	-76.40	-46.00			-58.54
	-2.27	-2.22			-3.41
CANBFPROD(-4)	-35.12	-48.74			-61.90
	-1.11	-2.40			-7.99
CANBFPROD(-5)	-58.26	-27.27			
	-1.92	-1.61			
CANBFPROD(-6)	-72.45	-28.94			
	-2.72	-1.80			
USBFPROD	-1.91	-1.48	-6.62	4.45	18.62
	-0.58	-0.73	-1.13	0.48	6.46
USBFPROD(-1)		1.27		-10.89	14.71
		0.58		-0.99	5.02
USBFPROD(-2)		-0.51		-24.91	4.63
		-0.23		-2.45	1.67
USBFPROD(-3)		4.33		-29.59	
		2.12		-3.12	
USBFPROD(-4)				-14.98	
				-1.62	
USBFPROD(-5)				-36.06	
				-3.50	
USBFPROD(-6)				-10.46	
				-1.12	
TRUCKINDEX	-0.03	0.02	-0.54	-1.08	0.59
	-0.25	0.31	-1.41	-2.42	2.88
TRUCKINDEX(-1)		0.07			
		1.02			
TRUCKINDEX(-2)		-0.09			
		-1.57			
TRUCKINDEX(-3)		-0.16			
		-2.65			
TRUCKINDEX(-4)		-0.09			
		-1.64			
TRADE	-0.10	0.00	-0.01	0.05	0.08
	-1.33	-0.12	-0.28	0.23	3.06
TRADE(-1)			-0.03	0.52	
			-0.52	2.53	
TRADE(-2)			-0.03	0.17	
			-0.52	0.93	
TRADE(-3)			0.22	2.29	
			4.51	5.34	
TRADE(-4)				0.53	
				1.47	

Table 5.7. Fed Steer LOP Results Continued.

TRADE(-5)				0.14	
				0.48	
TRADE(-6)				-2.19	
				-7.82	
S1	0.01	0.08	0.37	-1.54	-2.08
	0.02	0.21	0.33	-0.92	-3.41
S2	0.83	-0.67	-0.30	1.55	-1.45
	1.07	-1.72	-0.24	0.85	-2.91
S3	-0.61	-0.18	-1.18	-1.20	-2.17
	-0.80	-0.51	-1.05	-0.62	-4.36
AR(1)	0.83	0.81	0.95	1.04	1.58
	10.32	12.35	17.93	9.19	13.99
AR(2)	0.05	0.11	-0.02	-0.19	-0.66
	0.63	1.69	-0.35	-1.16	-6.85
AR(3)				-0.39	
				-3.13	
AR(4)				0.36	
				3.06	
AR(5)				-0.25	
				-3.11	
Observations	201	343	401	115	40
Degrees of Freedom	171	311	380	85	16
Adjusted R-squared	0.97	0.97	0.75	0.93	0.99
St.Error of Eq.	0.95	0.85	3.82	2.96	0.34
AIC	2.86	2.59	5.56	5.23	0.94
Inverted AR	0.88	0.93	0.93	0.81	0.81
	-0.06	-0.12	0.02	0.81	0.81
				0.66	
				0.66	
				-0.78	

Note: T-values are provided below the coefficients and critical T-values are 1.66 for α=0.05 and 1.29 for α=0.10; except for Post-2005 where they are 1.746 for α=0.05 and 1.337 for α=0.10.

Results show the lag structures are significantly different for each regime period. Pre-CUSTA had the most lags for the US fed steer price, exchange rate, and Canadian beef production. However, the post-2003 period had the most lags for the trade and US beef production variables.

Each variable's contemporaneous and lagged coefficients were summed, and mean elasticities are calculated to obtain aggregate impacts. Results are provided in Table 5.8.

Table 5.8. Elasticities from exogenous variables on Canadian Fed Steer Price.

	1% change in the exogenous variable creates a % change in Can Price					
Regime	USPrice	Exchange	Canbfprod	USbfprod	truckindex	trade
PreCUSTA	0.58	0.53	-0.24	-0.01	-0.06	-0.02
PostCUSTA	0.63	-0.15	-0.18	0.03	-0.54	0.00
Post95	0.33	-2.58	-0.01	-0.05	-1.16	0.04
Post03	0.59	2.53	0.04	-0.89	-2.31	0.37
Post05	1.23	1.99	-0.13	0.28	1.26	0.02

In the post-2003 period, a one percent change in the US fed steer price results in a 0.59 percent change in the Canadian fed steer price. In the post-2005 period, the US fed steer price elasticity changed from being inelastic to relatively elastic at 1.23. It is interesting to note that the post-1995 period was the most inelastic period and had the fewest trade barriers. Therefore, it would be assumed the post-1995 period would adhere to LOP the closest because of the absence of wedges in the trade market (e.g., tariffs, Figure 3.2).

Since the US and Canadian cattle prices are both in US dollars, it would be expected that the exchange rate coefficient would be zero if complete exchange rate pass-through exists. A shock in the US exchange rate that changes Canadian cattle price (while the US cattle price is held constant) would indicate a divergence from the law of one price. All of the exchange rate coefficients were jointly significant in the fed steer market.[6] These coefficients are relatively inelastic from 1985 to 1995, but elastic post-1995. This change between Pre-1995 and Post-1995 indicates that the removal of the Crow Rate Subsidy in Canada, which increased Canadian supply of cattle for trade (Figure 3.2), changed fed market responses.

Canadian and US beef production and trade were all relatively inelastic. US beef production was close to unit elastic in the Post-2003 period at -0.89. The trucking cost index became increasingly elastic with time and was the most elastic in the Post-2003 period.

In general, the seasonal dummies are not statistically significant, with the exception of the post-2005 period. This could be a result of smoothing that that occurs when quarterly dummies are used as proxies for seasonality in weekly data.

Feeder Steer Market

Table 5.9. Feeder Steer LOP Results.

Feeder	Pre-CUSTA	Post-CUSTA	Post-95	Post-03	Post-05
C	-28.23	80.02	48.17	-83.33	1471.53
	-0.33	1.82	1.07	-0.90	5.95
USFEEDER	0.36	0.11	0.16	0.02	-0.24
	3.28	2.78	4.29	0.27	-2.56
USFEEDER(-1)	-0.02	0.02	0.09		-0.03
	-0.16	0.48	2.48		-0.30
USFEEDER(-2)		0.16	0.07		0.05
		3.89	1.94		0.68
USFEEDER(-3)		0.01			0.13
		0.26			1.87
USFEEDER(-4)		0.00			
		0.11			
EXCH	97.65	110.31	109.33	96.74	12.50
	2.72	5.48	5.52	2.81	0.36

[6] Post-CUSTA and Post-1995 have negative signs that are significant. However, since any movement away from zero indicates a divergence from complete exchange rate pass-through this shows a change in the direction of the divergence.

Table 5.9. Feeder Steer LOP Results Continued.

EXCH(-1)	-2.44	-45.09	-2.31	12.91	123.87
	-0.07	-2.20	-0.12	0.37	3.07
EXCH(-2)		-38.12	-26.30	125.96	-179.36
		-1.83	-1.37	3.47	-4.80
EXCH(-3)		7.80		32.98	60.11
		0.39		0.99	2.23
EXCH(-4)		-42.44		8.00	
		-2.26		0.24	
EXCH(-5)				-34.97	
				-1.04	
EXCH(-6)				-57.69	
				-1.78	
CANBFCOWINV	15.39	-1.61	2.03	-14.64	-123.17
	0.51	-0.22	0.30	-0.72	-4.98
USBFCOWINV	0.08	-0.12	0.10	0.24	-0.26
	0.20	-0.67	0.54	0.52	-1.03
USBFCOWINV(-1)	-0.48				
	-2.42				
TRUCKINDEX	-0.23	-0.02	-0.42	0.55	0.18
	-1.07	-0.14	-1.84	0.75	0.23
TRUCKINDEX(-1)					-4.46
					-5.94
TRUCKINDEX(-2)					-1.10
					-1.22
TRUCKINDEX(-3)					1.57
					2.29
TRADE	0.01	-0.03	-0.05	0.13	-0.23
	0.11	-0.85	-1.86	0.59	-2.58
TRADE(-1)					-0.52
					-5.94
TRADE(-2)					0.07
					0.76
TRADE(-3)					-0.23
					-2.95
USCORN	-0.13	-2.05	-0.54	0.93	-31.28
	-0.07	-1.33	-0.62	0.28	-4.69
USCORN(-1)		3.57			-11.46
		2.29			-1.78
USCORN(-2)					13.43
					1.89
USCORN(-3)					20.50
					3.25
USCORN(-4)					-14.97
					-2.88

Table 5.9. Feeder Steer LOP Results Continued.

S1	2.03	0.31	0.22	0.11	4.58
	1.84	0.33	0.31	0.07	3.43
S2	2.33	1.01	0.76	1.66	-3.89
	1.87	1.24	1.29	0.91	-2.32
S3	1.25	1.10	0.13	-0.11	-1.96
	0.94	1.74	0.25	-0.06	-1.59
AR(1)	0.48	0.74	0.86	1.14	-0.87
	6.36	11.98	15.53	11.09	-6.42
AR(2)	0.27	0.14	0.20	-0.26	-0.97
	3.51	1.72	2.75	-2.50	-6.82
AR(3)	0.20	0.08	-0.07		
	2.71	1.13	-1.24		
Observations	204	295	347	107	36
Degrees of Freedom	187	274	329	88	7
Adjusted R-squared	0.9626	0.9191	0.985	0.9132	0.9248
St.Error of Eq.	2.4993	1.5478	1.801	3.0481	0.7273
AIC	4.7496	3.7863	4.0651	5.2265	2.1746
Inverted AR	0.97	0.96	0.99	0.82	0.91
	0.45	0.01	0.40	0.32	0.91
	0.45	0.01	0.40		

Note: T-values are provided below the coefficients and critical T-values are 1.66 for α=0.05 and 1.29 for α=0.10; except for Post-2005 where they are 1.895 for α=0.05 and 1.415 for α=0.10.

In general, lagged exogenous variables were not statistically significant except during the post-2005 period, where the trucking cost index, trade, and US corn price are lagged three to four periods. This may have been because of greater volatility in the market because of uncertainty in trade policy. Table 5.10 provides the mean elasticities for the exogenous variables.

Table 5.10. Elasticities from exogenous variables on Canadian Feeder Steer price.

	1% change in the exogenous variable creates a % change in Can Price					
Regime	USPrice	Exchange	Canbfprod	truckindex	trade	UScorn
PreCUSTA	0.36	0.82	0.01	-0.36	0.00	0.00
PostCUSTA	0.32	-0.06	0.00	-0.03	-0.01	0.04
Post95	0.34	0.70	0.00	-0.66	-0.01	-0.01
Post03	0.02	1.59	-0.01	0.86	0.02	0.02
Post05	-0.09	0.15	-0.06	-5.95	-0.16	-0.62

Feeder steer price transmissions are more inelastic than the fed steer price transmission elasticities. A one percent change in US feeder steer price causes a 0.32 to 0.36 percent change in the Canadian feeder steer price from pre-CUSTA to post-1995. In post-2003 and post-2005 this effect becomes even more inelastic at 0.02 and -0.09. However, the post-2003 coefficient is insignificant (Table 5.9). This decrease in price transmission elasticity may be because of the reduction in feeder steer trade between Canada and the US while the border was closed to live cattle trade. Even though the Canadian border was not closed to US feeder cattle, imports of US feeders decreased after 2003. Increased supplies of Canadian feeder cattle decreased demand for US feeder cattle imports. The negative sign in the post-2005 period while statistically significant, results in an economically insignificant change in the Canadian feeder steer price (discussed in Table 5.14 below).

The exchange rate elasticities in the feeder steer LOP model are generally inelastic, except for the post-03 period (1.59). The increase in response from the exchange rate variable implies a greater divergence between the two markets, by creating a wedge between domestic and import demand (e.g., Figure 3.2). Post-CUSTA is very inelastic at -0.06, and therefore the closest to complete exchange rate pass-through.

Canadian beef production, trade, and US corn prices are all generally inelastic. However, all become increasingly elastic in the post-2005 period with US corn price changing the most from 0.02 to -0.62. The trucking cost index is perfectly inelastic pre-CUSTA and elastic post-2005 (-0.16). Seasonal dummies are generally inconclusive.

Slaughter Cow Market

Table 5.11. Slaughter Cow LOP Results.

Cow	Pre-CUSTA	Post-CUSTA	Post-95	Post-03	Post-05
C	-78.00	66.83	71.88	-67.39	11306.66
	-3.47	2.90	1.98	-1.26	2.00
USCOW	0.43	0.25	-0.02	-0.07	-0.97
	5.40	3.75	-0.25	-0.81	-5.33
USCOW(-1)	0.14	0.07			2.15
	1.85	0.98			4.96
USCOW(-2)		0.07			0.44
		1.09			2.68
USCOW(-3)					0.59
					5.26
USCOW(-4)					-0.59
					-5.79
EXCH	21.21	61.94	25.97	16.45	525.69
	1.58	4.05	1.49	1.02	4.63
EXCH(-1)		-59.44	-14.64		459.20
		-3.88	-0.85		8.74
EXCH(-2)		-25.63	-15.08		252.47
		-1.67	-0.87		4.12
EXCH(-3)			-29.26		-76.73
			-1.68		-2.00
EXCH(-4)			-30.65		9.18
			-1.78		0.84
CANBFCOWINV	16.35	-8.19	-3.18	5.38	1031.05
	1.18	-1.40	-0.55	0.35	8.23
CANBFCOWINV(-1)	4.21	-2.73		16.01	-32.54
	0.40	-0.68		1.77	-0.74
CANBFCOWINV(-2)	-15.43	-2.83		16.38	-15.72
	-1.42	-0.79		1.94	-0.81
CANBFCOWINV(-3)	-2.07			-3.65	69.59
	-0.23			-0.41	2.26
CANBFCOWINV(-4)	7.05			-26.74	-2622.08
	0.56			-1.97	-3.77
CANBFCOWINV(-5)	-21.59				
	-1.92				
CANBFCOWINV(-6)	27.80				
	2.58				
USBFCOWINV	-0.08	0.26	0.55	0.15	1.96
	-0.66	1.82	3.06	0.77	0.34
USBFCOWINV(-1)					-1.36
					-4.16

Table 5.11. Slaughter Cow LOP Results Continued.

USBFCOWINV(-2)					3.05
					(11.55)
USBFCOWINV(-3)					2.29
					(3.28)
USBFCOWINV(-4)					39.28
					(3.65)
TRUCKINDEX	0.06	-0.01	0.00	-0.60	-31.60
	(0.48)	(-0.13)	(-0.01)	(-1.88)	(-1.85)
TRUCKINDEX(-1)	-0.04	0.22		0.03	
	(-0.32)	(2.17)		(0.12)	
TRUCKINDEX(-2)	0.12			0.15	
	(1.08)			(0.50)	
TRUCKINDEX(-3)	-0.10			1.06	
	(-1.05)			(3.08)	
TRUCKINDEX(-4)	0.01				
	(0.08)				
TRUCKINDEX(-5)	0.18				
	(1.91)				
TRUCKINDEX(-6)	0.07				
	(0.78)				
TRADE	-0.08	0.04	-0.01	0.04	4.60
	(-1.24)	(1.68)	(-0.22)	(0.43)	(3.97)
TRADE(-1)					0.22
					(2.55)
TRADE(-2)					0.04
					(1.05)
TRADE(-3)					0.30
					(2.05)
TRADE(-4)					1.15
					(0.93)
HAY	0.10	-0.07	0.04	-0.18	-7.78
	(2.51)	(-2.49)	(1.15)	(-1.01)	(-2.59)
HAY(-1)	-0.03	-0.03		-0.48	
	(-0.77)	(-0.98)		(-2.67)	
HAY(-2)	-0.08			-0.41	
	(-1.98)			(-2.22)	
HAY(-3)	0.00			-0.14	
	(-0.03)			(-0.74)	
HAY(-4)	-0.01			0.30	
	(-0.19)			(1.57)	
HAY(-5)	0.01				
	(0.25)				
HAY(-6)	-0.06				
	(-1.62)				
S1	0.99	2.90	0.70	0.94	-94.53
	(1.78)	(3.13)	(1.11)	(0.79)	(-3.14)
S2	0.99	2.59	0.98	-0.96	-89.60
	(1.66)	(3.36)	(1.76)	(-1.09)	(-14.37)
S3	0.98	2.27	0.13	0.37	-2.10
	(1.41)	(3.62)	(0.25)	(0.42)	(-1.12)
AR(1)	0.49	0.83	0.90	1.19	
	(7.00)	(21.94)	(36.22)	(11.06)	

Table 5.11. Slaughter Cow LOP Results Continued.

AR(2)				-0.25	
				(-1.79)	
AR(3)				-0.10	
				(-1.19)	
Observations	198	304	377	102	33
Degrees of Freedom	167	284	361	77	2
Adjusted R-squared	0.94	0.91	0.85	0.91	0.99
St.Error of Eq.	1.16	1.25	1.74	1.44	0.17
AIC	3.28	3.35	3.98	3.78	-1.58
Inverted AR	0.49	0.83	0.9	0.72	
				0.72	
				-0.19	

Note: T-values are provided below the coefficients and critical T-values are 1.66 for α=0.05 and 1.29 for α=0.10; except for Post-2005 where they are 2.92 for α=0.05 and 1.886 for α=0.10.

The pre-CUSTA period had the most significant lags on hay price, trucking cost index, and Canadian beef production. Post-2005 has the most lags on trade, US beef production, exchange rate and US slaughter cow price. This change may indicate a structural change in the market because of policy and packing plant capacity. Table 5.15 provides the mean elasticities for the exogenous variables.

Table 5.12. Elasticities from exogenous variables on Canadian Slaughter Cow price.

	1% change in the exogenous variable create % change in Canadian Price						
Regime	USPrice	Exchange	Canbfprod	usbfprod	truckindex	trade	Hay
PreCUSTA	0.61	0.40	0.02	0.00	1.03	-0.03	-0.13
PostCUSTA	0.42	-0.44	-0.01	0.00	0.72	0.02	-0.18
Post95	-0.02	-1.20	0.00	0.01	0.00	0.00	0.07
Post03	-0.08	0.31	0.01	0.00	2.19	0.02	-1.67
Post05	1.74	22.14	-1.65	0.53	-108.35	2.45	-14.26

The slaughter cow market is similar to the fed steer market in that the price transmissions are relatively inelastic, except for the Post-2005 period (1.74). After the border opened to animals less than thirty months of age in 2005, Canadian fed cattle exports increased. The removal of trade barriers allows Canada's excess supply to move on the trade market (e.g., Figure 3.2). This allowed Canadian slaughter capacity to be redirected to cow slaughter. In the pre-CUSTA and post-CUSTA periods, a one percent change in US cow price creates a 0.61 and 0.42 percent change in the Canadian cow price. The post-1995 and post-2003 elasticities are very small (-0.02 and -0.08) and are not significantly different from zero.[7]

Exchange rate pass-through (which is expected to be zero for complete pass-through) averages 0.38 for the pre-CUSTA, post-CUSTA and post-2003 periods. For the post-1995 and post-2005 periods, pass-through is more elastic with the post-1995 period at -1.20. Thus, exchange rates have had greater impact on Canadian slaughter cow prices in recent years. Because exchange rate risk acts like a wedge between two trading countries (e.g., Figure 3.2), a greater impact implies a larger wedge as the exchange rate becomes more important.

The price of slaughter cows with respect to a change in Canadian beef production and trade are inelastic with the exception of the post-2005 period. Slaughter cow prices with respect to a change in hay prices have become increasingly elastic in the post-2003 and post-2005 periods. Post-1995 slaughter cow prices were inelastic to changes in hay prices. Slaughter cow prices vary from elastic to perfectly inelastic in the post-1995 period from changes in the trucking cost index.

Large changes in elasticity for all exogenous variables in the post-2005 period may be because of the small sample size (40) that could be biasing coefficient estimates. Seasonal dummies are significant for the post-CUSTA and post-2005 periods.

---

[7] It should be noted here that the 1985 monthly observations that were interpolated to weekly did not cause a problem in the VAR or LOP models for the Pre-CUSTA period and therefore were included.

Trends

Trends for individual cattle markets price transmission and exchange rate pass-through elasticities are given in Figure 5.4, and based on results from Tables 5.7, 5.9, and 5.11.

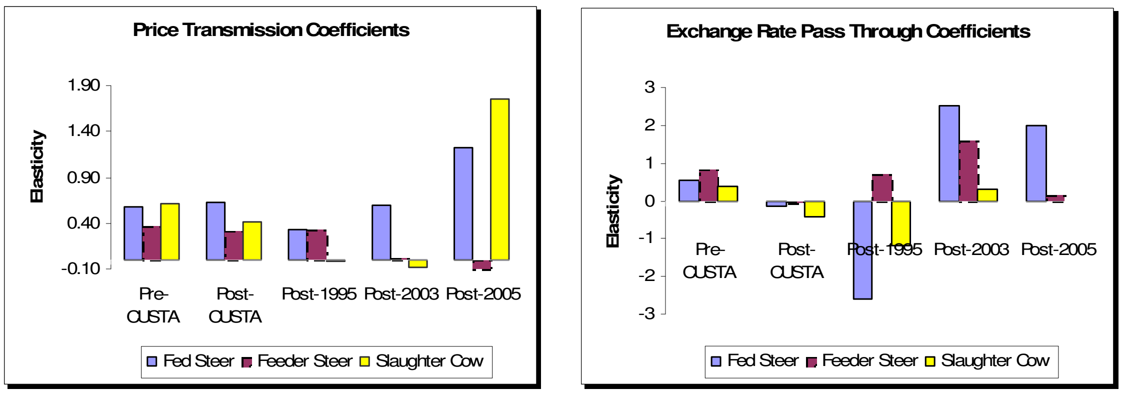

Figure 5.4. Price and Exchange Rate Elasticities.

Price transmission elasticity is expected to equal one if perfect transmission occurs. The estimated price transmission elasticities are all less than 0.90, implying barriers to trade are significant throughout the study. Fed steer price and exchange rate coefficients generally have the highest elasticity; this is probably because they are highly traded. Exchange rate pass-through is close to zero implying complete pass-through. Fed steer prices have the most variance in the elasticity coefficients between periods; indicating they are the most responsive to policy changes. Between 1985 and 1995 the fed steer market price transmission and exchange rate pass-through became more inelastic, as trade barriers were removed. However, they became more elastic after 1995.

The feeder steer market price transmission and exchange rate pass-through coefficients have generally not been affected by policy changes. However, in the post-

1995 period, increased feed grain supplies created a movement away from market integration with an increasingly inelastic price transmission and exchange rate pass-through. This may have been caused by a change in competitive advantage for finishing cattle from the US to Canada.

The slaughter cow market price transmission and exchange rate pass-through coefficients were relatively unchanged between 1985 and 2003. Since 2003, price transmission and exchange rate pass-through coefficients have become significantly elastic as capacity became available in Canada for slaughtering cows. Thus, the two market's nominal prices converged. The opening of the border in 2005 had a greater impact than the closing in 2003, implying slaughter capacity is more important for this market than trade. Post-2005 the slaughter cow market gives highly elastic price transmission and exchange rate pass-through. These results are significantly different from the other periods; indicating that bias may be present in its coefficients that may have been caused by slaughter cows not being traded in that period.

Coefficient Testing

To test for perfect price transmission, complete exchange rate pass-through, and perfect market integration for each period in individual markets, equation (5.3) was estimated in double log form to obtain elasticities. Perfect price transmission is implied by unit elasticity and complete exchange rate pass-through by an elasticity of zero.[8] Perfect market integration is then implied by unit elasticity when the US price and

[8] Since prices are both in US dollars the exchange rate theoretically would have zero impact

exchange rate coefficients are summed together. If the elasticities are significantly different from both zero and one, the results are indeterminate.

The contemporaneous and lagged US cattle prices and exchange rate variables were summed to get a total elasticity. An F-test was then used to see if total elasticities were statistically different from zero or one. The Post-2003 regime was not tested because of collinearity problems.

Table 5.13. LOP Coefficient Test Results.

F-statistics	Fed Steers		Feeder Steers		Slaughter Cows	
Pre-CUSTA	0	1	0	1	0	1
US Price	31	14	7.75	27	46.00	20
	(0)	(0)	(0)	(0)	(0)	(0)
Exchange Rate	7	4.3	4.8	0.07	1.59	6
	(0)	(0.03)	(0.02)	(0.78)	(0.20)	(0.01)
US Price+Exch	47	0.86	9	0.32	11	0.04
	(0)	(0.35)	(0)	(0.56)	(0)	(0.83)
Post-CUSTA						
US Price	45	17	11	5.3	9.9	32
	(0)	(0)	(0)	(0)	(0)	(0)
Exchange Rate	1.28	56	0.02	16	1.4	23
	(0.25)	(0)	(0.87)	(0)	(0.23)	(0)
US Price+Exch	7.05	11	1	6.7	0.01	13
	(0)	(0)	(0.31)	(0)	(0.89)	(0)
Post-1995						
US Price	159	4.9	21	72	-0.11	232
	(0)	(0.02)	(0)	(0)	(0.91)	(0)
Exchange Rate	0.01	81	3.7	3.4	6.9	23
	(0.89)	(0)	(0.05)	(0.06)	(0)	(0)
US Price+Exch	39	1.5	10	0.24	6.8	22
	(0)	(0.21)	(0)	(0.61)	(0)	(0)
Post-2005						
US Price	94	3.6	12	198	32	9.1
	(0)	(0.07)	(0.01)	(0)	(0.02)	(0.09)
Exchange Rate	14	14	4.6	32	30	27
	(0)	(0)	(0.08)	(0)	(0.03)	(0.03)
US Price+Exch	72	36	6.6	27	36	32
	(0)	(0)	(0.04)	(0)	(0.02)	(0.02)

Note: P-value are provide in brackets below F-statistic

Table 5.13 provides the F-statistic and p-values for these tests. A large F-statistic or a p-value less than 0.10 indicate that the null hypothesis of the sum of the variables being equal to zero or one was rejected.[9] For the pre-CUSTA period, the tests fail to reject perfect market integration for all cattle markets. This implies that pre-CUSTA trade barriers were not particularly restrictive probably because the tariffs per head were small. This implies that Canadian cattle feeding expansions were more the result of reductions in grain prices rather than a product of access to the US market.

The fed steer market results were indeterminate in the post-CUSTA regime in that the tests rejected the null hypotheses of equaling one or zero. However, the feeder steer and slaughter cow markets fail to reject zero market integration (0.31 and 0.89) in the post-CUSTA period. Thus, the LOP does not hold. The movement away from market integration in the pre-CUSTA period, to the post-CUSTA period for the feeder steers and slaughter cow markets may have been caused by several policy events in the post-CUSTA period. These events include: (1) the complete removal of tariffs in 1993; (2) policy changes from NAFTA and URAA may have had a more significant impact than originally assumed; and (3) feed prices. These events may have offset each other to some degree or may have amplified each other.

From 1989 to 1991 US feeder steer prices were higher than Canadian prices (Figure 5.5). However, barley prices were generally trended downward, and the feeder steer price gap closed from 1991 to 1993 (Figure 5.6).

[9] A small F-statistic or a p-value greater than 0.10 indicate that the null hypothesis of the sum of the coefficients being statistically different from zero or one failed to be rejected.

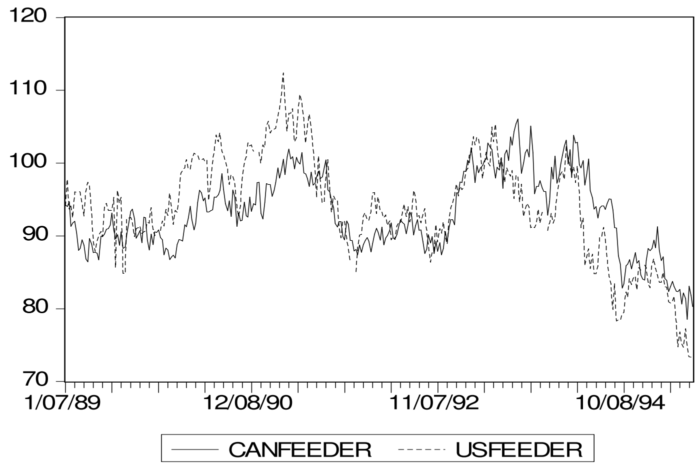

Figure 5.5. Canadian and US Feeder Steer Prices 1989-1995.

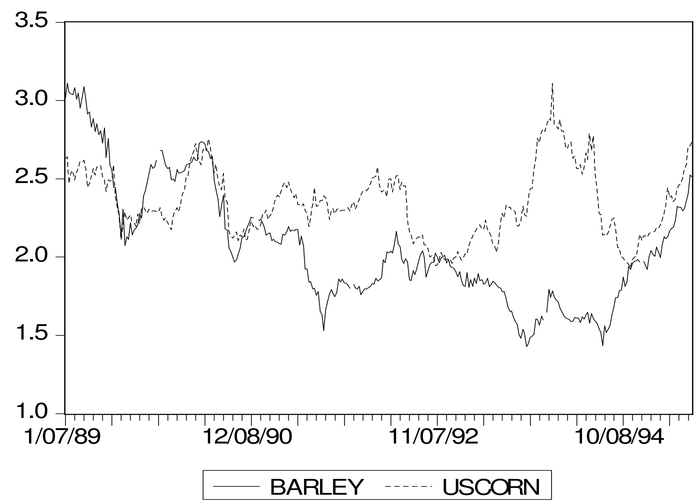

Figure 5.6. Canadian Barley and US Corn Prices 1989-1995.

Canada had an open barley market in continental North America (apart from the Canadian Wheat Board) from August 1 to September 10 that may have impacted Western Canadian barley prices throughout this period, possibly changing price expectations. Figure 5.5 implies three separate policy periods may be more appropriate for the 1989 to 1995 time period.

Zero market integration in the slaughter cow market from 1989 to 1995 may have been influenced by low Canadian slaughter numbers as the industry rebuilt the cow herd. Increased live cattle exports to the US were caused by a lack of Canadian slaughter capacity. Figure 5.7 shows that slaughter cow prices, like feeder steer prices may have more than one policy regime within the post-CUSTA period defined. Slaughter cow prices had a smaller basis than fed steer prices from 1989 to 1995 (Figure 5.7 and 5.8).

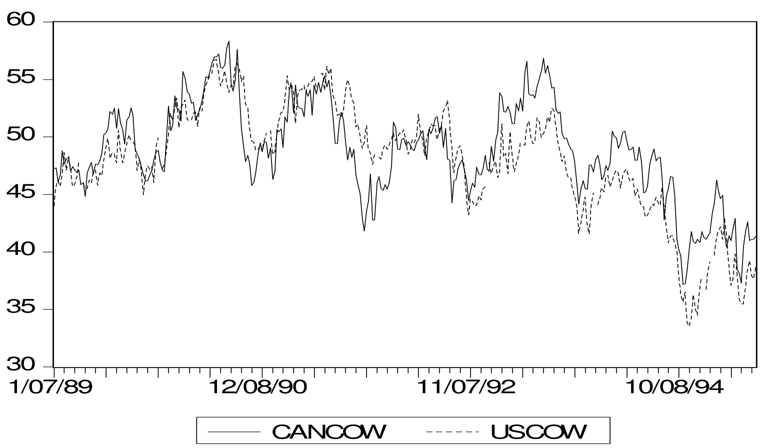

Figure 5.7. Canadian and US Slaughter Cow Prices, 1989-1995.

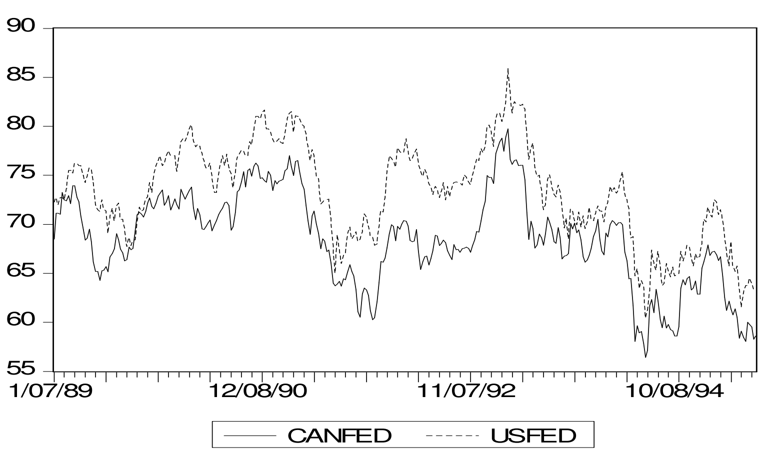

Figure 5.8. Canadian and US Fed Steer Price, 1989-1995.

However, when transportation and transaction costs are included, slaughter cow prices diverge, while fed steer prices converge. Therefore, the LOP does not hold for the slaughter cow market, but holds for the fed steer market.

Results were indeterminate for the fed steer market post-CUSTA; the most definitive result was a 0.25 p-value for complete exchange rate pass-through. Increasing US exports kept US fed steer prices above Canadian fed steer prices throughout the period (Figure 5.8).

The fed steer and feeder steer markets support integration and the LOP in the post-1995 regime (0.21 and 0.61). However, the slaughter cow market fails to reject zero price transmission (0.91); and market integration results are indeterminate (zero for both hypotheses).

Although there are no results for the post-2003 period because of collinearity problems, it is expected that the LOP would not hold because of a lack of trade. The post-2005 period results were indeterminate for all markets (p-values less than 0.10 for all hypotheses). This may be because of insufficient observations or uncertainty regarding trade between the two countries.

In summary, the LOP held pre-CUSTA indicating trade barriers were minimal and post-1995 for the fed and feeder steer markets when trade barriers were the lowest. It was not expected that the LOP would hold post-2003 because of limited trade between the two countries. The LOP held for the pre-CUSTA period only in the slaughter cow market; indicating that since 1989 the slaughter cow markets have diverged. The slaughter cow market has less trade movement and appears to be the least integrated.

Policy changes that removed trade barriers for fed and feeder cattle would have little impact on the slaughter cow market that is mostly influenced by weather conditions (e.g., drought) and cattle cycles. Therefore, since the Canadian and US cow inventories have trended in opposite directions since 1995 it would be expected for them to not be integrated and the LOP to not hold.

Impact on Canadian Cattle Prices

Price transmission and exchange rate pass-through were also examined by considering the impact of US cattle prices on the Canadian cattle prices. Table 5.14 shows the change in Canadian cattle prices per hundred weight given a one percent change to the US cattle price or the exchange rate. The impact on Canadian price was found by multiplying the mean elasticities from Tables 5.8, 5.10, and 5.12 by the mean of the cattle price variable.

Table 5.14. Impact on Canadian cattle prices.

Impact Canadian price /cwt	Fed		Feeder		Cow	
	US Price	Exchange Rate	US Price	Exchange Rate	US Price	Exchange Rate
Pre-CUSTA	0.37	0.34	0.31	0.72	0.24	0.16
Post-CUSTA	0.40	-0.10	0.29	-0.06	0.18	-0.17
Post-1995	0.21	-1.64	0.13	0.61	0.00	-0.48
Post-2003	0.38	1.61	0.01	1.38	0.00	0.12
Post-2005	0.78	1.26	0.00	0.13	0.00	8.80

These changes are relatively small and generally less than one dollar (US) per hundred weight. The largest change in the fed steer market is $-1.64/cwt from a one percent increase in the exchange rate. This was not expected as theory would suggest that exchange rates are irrelevant, if the LOP held. Therefore the largest impact would be expected to come from a change in the US price. The exchange rates smallest impact was $-0.10/cwt in the post-CUSTA period. A one percent change in US price had its smallest influence in the post-1995 period for fed steers and highest in the post-2005 period.

The feeder steer market had the largest response to exchange rates with $1.36/cwt in the post-2003 period. A change in US price had a zero price transmission in the post-2003 and post-2005 periods when trade was restricted.

In the slaughter cow market, the exchange rate had the largest impact in the post-2005 period. A one percent increase in the exchange rate caused $8.80/cwt increase in price. This result is questionable because of its size and because Canadian slaughter cow trade was halted in 2003. Canadian slaughter cow prices do not respond to US slaughter cow prices in the post-1995, post-2003 and post-2005 periods. This may have been because of variables not controlled for in this model, specifically changes in trade movement of slaughter cows. However, this is consistent with LOP results, where the slaughter cow market is not integrated over these periods.

Structural Changes

The slope coefficients in equation (5.3) for the fed steer, feeder steer, and slaughter cow markets were tested for structural change between the five regimes. The condition for the structural change tests was that slope coefficients of the equations in Tables 5.7, 5.9, and 5.11 must be statistically significant. Therefore, only the regime periods with significant coefficients on US cattle prices and exchange rates were tested. Regime periods were then tested chronologically. The Wald statistics for structural change of US cattle price and exchange rate are given both separately and jointly.[10] The changes in price transmission were significant for all cattle markets from Pre-CUSTA to Post-CUSTA (Table 5.15).

Table 5.15. Price Transmission change results.

US Price	Fed	Feeder	Cow
Pre-CUSTA to Post-CUSTA	10.79 (2.83)	20 (1.61)	5.6 (0.584)
Post-CUSTA to Post-1995	-44.3 (1.61)	5.2 (1.61)	
Post-1995 to Post-2003	23.1 (1.064)		
Post-2003 to Post-2005	16.1 (1.064)		

Note: Wald statistics are numbers without parentheses; Chi-squared critical values for α=0.10 are in parenthesis

These changes were caused by removal of trade barriers (tariffs and beef import quotas) between the US and Canada. The change in 1995 is also significant for the fed steer and feeder steer markets because of increased feed grain availability in western Canada because of the removal of the Crow Rate. This increased feedlot capacity and demand for calves in Western Canada and resulted in changes in trade patterns. The slaughter cow market had an insignificant US cow price coefficient in the post-1995 period. This implies that the US price was not significant in determining slaughter cow price in Western Canada post-1995.

The closure of the border in 2003 is a significant structural change in the fed steer market and for exchange rate pass-through in the feeder steer market. It should be noted that this regime change includes policy changes from the Restricted Feeder Cattle Program started in 1997 and antidumping and countervailing duties imposed in 1998. Similarly, the re-opening of the border to animals less than thirty months in 2005 also

[10] Since the number of lags varied between regimes, periods with less lags than the period it was being compared to, were given zeros for the coefficients and relevant covariance cells.

implied a strong structural change for fed steers and feeder steer exchange rate pass-through. Many changes in trade policy have influenced beef trade between Canada and the US between 2003 and 2005, as discussed in Chapter Two. Exchange rate pass-through was structurally different between all regimes for the fed steer and feeder steer markets (Table 5.16).

Table 5.16. Exchange Rate Pass-Through change results.

Exchange Rate	Fed	Feeder	Cow
Pre-CUSTA to Post-CUSTA	13.4 (2.83)	12 (1.61)	25.9 (0.584)
Post-CUSTA to Post-1995	18.6 (1.61)	8.8 (1.61)	12 (1.61)
Post-1995 to Post-2003	33.8 (1.064)	16.0 (2.83)	
Post-2003 to Post-2005	20.2 (1.064)	50.6 (2.83)	

Although the price change was not significantly different for feeder steers in the post-2003 and post-2005 periods, the change in exchange rate pass-through was significant.[11]

The slaughter cow market shows structural change in the post-1995 period indicating increased feed grain supply impacted this market through changes in trade and the exchange rate. The post-2003 and post-2005 periods have insignificant exchange rate pass-through and this may be because of a lack of slaughter cow trade in these regime periods.

Table 5.17. Structural Change Test Results.

Joint Test	Fed	Feeder	Cow
Pre-CUSTA to Post-CUSTA	26.6 (7.79)	32.7 (4.87)	32.4 (2.20)
Post-CUSTA to Post-1995	13.6 (4.87)	14.4 (4.87)	
Post-1995 to Post-2003	58.3 (1.064)		
Post-2003 to Post-2005	33.3 (1.064)		

[11] These periods were not tested for structural change in price transmission because US price coefficients were not significant.

Combined price transmission and exchange rate pass-through results for structural change are the same as those for price transmission, implying the change in exchange rate pass-through was not strong enough to structurally change the entire market (Table 5.17). Based on the estimated dynamic LOP models (Tables 5.7, 5.9 and 5.11), the null hypothesis of no structural change was rejected separately and jointly for the US cattle price and exchange rate in all periods tested.[12]

It should be noted that the power of a test is the probability that it will correctly lead to rejection of a false null hypothesis (Greene 2000, pg.148). The Wald test is known to have a low power; therefore, the results here that indicate structural change for all policy changes may not be as strong as implied.

Summary

Pre-tests indicate that weekly US and Canadian prices for fed steers, feeder steers, and slaughter cows possess unit roots, but were cointegrated. The VAR model supported US-Canadian market integration in all three cattle sectors. The VAR models for feeder steer and slaughter cow markets indicate that Canada has a greater dependence on the US for cattle trade than the US has on Canada. Granger-causality tests showed that the US fed steer and feeder steer prices Granger-caused Canadian fed steer and feeder steer prices. While Canada's slaughter cow price Granger-caused the US slaughter cow price.

[12] Static models of the LOP that had the same variables were also tested. These models had the same periods tested because of insignificant coefficients, and again all periods rejected the null hypothesis of no structural change.

VAR models indicate that the larger US cattle market set the price for the Canadian cattle market.

Lag structures were different between regimes in all cattle markets indicating a change in the market structure. US price elasticities are generally inelastic, with the exception of post-2005 in the fed steer and slaughter cow markets. The feeder steer market is more inelastic than the fed steer market because of less trade. Post-2003 is the most inelastic period for the feeder steer and slaughter cow markets. The exchange rate elasticity variance is greater than the US price elasticity variance. Generally, the exchange rate elasticity becomes increasingly elastic post-1995. Canadian and US beef production, US corn price, and trade are generally inelastic; with post-2003 being the most elastic period. The trucking cost index becomes increasingly elastic overtime.

Trends in US price and exchange rate elasticities show that the fed steer market is the most responsive to policy changes than the feeder steer or slaughter cow markets. The feeder steer market elasticities were relatively stable overtime. Slaughter cow price elasticities became increasingly inelastic, implying a divergence from market integration since 1985; while, exchange rate elasticities were relatively stable.

The LOP holds in the pre-CUSTA period for all markets. This implies that the cattle feeding expansion after 1995 in Canada was more important than increased access to the US market created by CUSTA. The LOP held for the fed steer and feeder steer markets in the post-1995 period. The possibility of more than one regime during the post-CUSTA period, feed price fluctuations and lower transaction costs from use of contracting may have influenced LOP results for the fed steer and feeder steer markets.

Policy changes appear to separate the slaughter cow markets post-CUSTA. Mutual increases in cow herds and transaction/transportation costs may have prevented the slaughter cow markets from reintegrating.

The LOP models indicate that the fed steer market displayed structural changes in prices and exchange rates in all regime periods. The feeder steer market displayed structural price changes in 1989 and 1995, and was structurally different in all regimes for exchange rate pass-through. The slaughter cow market was structurally different for prices in 1989; and was structurally different in 1989 and 1995 for the exchange rate pass-through. However, the Wald test is known to have a low power and therefore these results are unreliable.

CHAPTER 6

STRUCTURAL MODEL

A structural model was developed to quantify the effects of increased Canadian slaughter capacity since 2003 on fed steer, feeder steer, and slaughter cow prices in the US and Canada. The unit root and cointegration results from chapter five for all cattle prices were used to develop the model. An inverse derived demand was specified for each market so that the impact of increased slaughter capacity on the demand for fed steers and slaughter cows could be quantified. Although not directly impacted by slaughter capacity, feeder steer prices are also indirectly affected through changing demand for fed cattle.

A Structural Model of the Canadian and US Cattle Markets

The US and Canadian fed cattle inverse demands are the derived (input) demands for slaughter cattle by beef packers. Because of excess capacity in the US beef packing industry, US slaughter demand is specific to domestically produced slaughter cattle and Canadian slaughter cattle imports (Brester and Marsh 1985). This demand influences the fed steer and slaughter cow prices directly; it also indirectly influences feeder steer prices. Therefore, a system of equations is used to quantify dynamic effects among cattle markets. In principle, a system is appropriate because of potential simultaneity between prices and quantities and the presence of correlated errors between equations (Marsh 2003).

Beef packer's willingness to pay for live cattle is derived from the prices they receive for by-products and boxed beef (Blake and Clevenger 1980). Boxed beef prices are influenced by beef supplies, retail beef demand, and processing and distribution costs. Therefore, boxed beef prices minus processing and marketing costs establishes live slaughter cattle prices (Marsh and Brester 1985). The derived wholesale supply of beef is calculated by multiplying the number of animals slaughtered by their carcass weight.[13] These supplies are also affected by beginning period stocks of fresh or frozen beef and veal on hand and imports. Supplies are assumed to be fixed on a monthly basis (Wohlgenant 1989).

Brester and Marsh (1983) argue that dynamic structures in the beef and cattle sector should be specified because of consumer and producer expectations, biological production lags, technology, and institutional rigidities. However, theory is not clear as to the proper specification of the lag structure. According to Marsh (1983) the use of a rational distributed lags in nonlinear estimation of seasonal cattle prices provided better results than static-serial correlation and purely autoregressive specifications. A rational distributed lag also minimizes statistical problems of incomplete dynamic model specification and lack of proper error structure identification. Using Jorgenson's rational lag structure or an autoregressive distributed lag (ARDL) as defined by Greene (2000, p.724):

(6.1) $$y_t = P(L)x_t = \frac{A(L)}{B(L)} x_t + e_t$$

[13] Slaughter animals were separated into fed steers and slaughter cows.

where P(L) is a rational generating function represented by the ratio of two polynomials A(L) and B(L), L is a lag operator where $L^k x_t = x_{t-k}$ and A(L) and B(L) have no common characteristic roots. The error term e_t is a white noise series, e.g., mean zero, constant variance, and no serial correlation. Multiplying both sides by B(L) gives the autoregressive form:

(6.2) $B(L)y_t = A(L)x_t + B(L)e_t$

or,

(6.3) $(1 - b_1L - \ldots - b_nL^n)y_t = (a_o + a_1L + \ldots + a_mL^m)x_t + e^*_t,$

and $e^*_t = B(L)e_t = \left(\sum_{i=o}^{n} b_i e_{t-i}\right)$ where $b_o = 1$. Therefore, e^*_t is autocorrelated; and the rational distributed lag function after some rearranging can then be written as:

(6.4) $y_t = a_0x_t + a_1x_{t-1} + \ldots + a_mx_{t-m} + b_1y_{t-1} + \ldots + b_ny_{t-m} + b_1e_{t-1} + \ldots + b_ne_{t-n} + e_t$

This provides an *n*th order difference equation with an *n*th order moving-average disturbance term. Therefore, dynamics are incorporated into the model through autoregressive distributed lags and a systematic error structure. The empirical lag structure rarely exceeds order two or three. Therefore, lag lengths are determined using a combination of statistical measurements such as adjusted R-squared, t- and F-values, and the Akaike Information Criterion.

The following monthly structural model is used to quantify the impact of increased Canadian slaughter capacity on fed steer, feeder steer, and slaughter cow prices in the US and Canada. Because of contemporaneously correlated error terms (non-diagonal error covariance matrix) and endogenous right-hand-side variables, three stage least squares (3SLS) will be used to estimate the system. This estimation technique conceptually provides estimators that are asymptotically efficient, consistent, and asymptotically normal. Equations (6.5) to (6.19) provide the system of equations estimated.

(6.5) $P_{us}^{df} = f_1 (Q_{us}^{df}, CW_{us}^{df}, P_{us}^{box}, P_{us}^{BPV}, MC_{us}, P_{ca}^{df}) + U_1$ (US fed inverse demand)

(6.6) $P_{ca}^{df} = f_2 (Q_{ca}^{df}, CW_{ca}^{df}, P_{ca}^{box}, P_{ca}^{BPV}, MC_{ca}, P_{us}^{df}, CAP_{ca}) + U_2$ (Can fed inverse demand)

(6.7) $(Q_{us}^{df} * CW_{us}^{df})$ = fixed supply

(6.8) $(Q_{ca}^{df} * CW_{ca}^{df})$ = fixed supply

(6.9) $Q_D^{df}=Q_S^{df}=Q^{df}, \quad P_D^{df}=P_S^{df}=P^{df}$ (Market Clearing for quantity and prices)

(6.10) $P_{us}^{dc} = f_3 (Q_{us}^{dc}, CW_{us}^{dc}, P_{us}^{boxc}, P_{us}^{BPV}, MC_{us}, P_{ca}^{dc}) +U_3$ (US cow inverse demand)

(6.11) $P_{ca}^{dc} = f_4 (Q_{ca}^{dc}, CW_{ca}^{dc}, P_{ca}^{boxc}, P_{ca}^{BPV}, MC_{ca}, P_{us}^{dc}, CAP_{ca}) + U_4$ (Can cow inverse demand)

(6.12) $(Q_{us}^{dc} * CW_{us}^{dc})$ = fixed supply

(6.13) $(Q_{ca}^{dc} * CW_{ca}^{dc})$ = fixed supply

(6.14) $Q_D^{dc}=Q_S^{dc}=Q^{dc}, \quad P_D^{dc}=P_S^{dc}=P^{dc}$ (Market Clearing for quantity and prices)

(6.15) $P_{us}^{dr} = f_5 (Q_{us}^{dr}, P_{us}^{df}, P_{us}^{corn}) + U_5$ (US feeder steer inverse demand)

(6.16) $P_{ca}^{dr} = f_6 (Q_{ca}^{dr}, P_{ca}^{df}, P_{ca}^{bar}) +U6$ (Can feeder steer inverse demand)

(6.17) Q_{us}^{dr} = fixed supply

(6.18) Q_{ca}^{dr} = fixed supply

(6.19) $Q_D^{dr}=Q_S^{dr}=Q^{dr}, \quad P_D^{dr}=P_S^{dr}=P^{dr}$ (Market Clearing for quantity and prices)[14]

The variables $P^{df,}$ $P^{dc,}$ and P^{dr} are the prices for fed steers, slaughter cows, and feeder steers in the US and Canada; Q^{df} and Q^{dc} are the number of fed steer and cows slaughtered in the US and Canada; CW is the carcass weight of fed steers and cows in each country; P^{box} is the boxed beef price and P^{BPV} is by-product value for fed steers and cows in each country; MC is the food marketing cost index in each country; and CAP is

[14] Inverse demand is estimated by shifting quantity supplied, which is fixed. This plots out a demand curve versus a supply curve.

the annual slaughter capacity in Western Canadian beef packing plants. The quantity of feeder steers (Q^{dr}) is given by the calf crop in each country. The feeder steer inverse demand equations use US corn price (P_{us}^{corn}) and Canadian barley price (P_{ca}^{bar}) as proxies for finishing costs.

Policy and seasonality dummies will also be included for each market, as defined in chapter four. The price of boxed beef in each country is assumed to incorporate beef imports and stocks of beef available at the beginning of each period. Therefore, these latter two variables were excluded from specification. Live animal trade is imbedded in the model through the quantity of fed steers and cows that are slaughtered in each period; this measurement includes imported slaughter animals.

The Hausman specification test is used to determine if the right-hand-side variables are simultaneously determined with the dependent variable. The Hausman test creates an instrument of the variable of interest (e.g., by-product value) by regressing it on all exogenous variables as follows:

(6.20) $BPV = f(\text{income, all exogenous variables}^{15}) + V_t$

The estimated residuals ($\hat{V}_t$) from equation (6.20) are then added to the structural model (e.g. equation (6.5)), and estimated by OLS. For example, equation (6.21) shows the by-product value residuals in the US fed steer market.

(6.21) $P_{us}^{df} = f_1 (Q_{us}^{df}, CW_{us}^{df}, P_{us}^{box}, P_{us}^{BPV}, MC_{us}, P_{ca}^{df}, S_{us}^{ba}) + \beta_o V_t + U_1$

[15] All exogenous variables and income are also the instruments used in the 3SLS regression

If the coefficient (β_o) on the residual is statistically significant from zero, then the variable is assumed to be endogenous. If the coefficient is not statistically significant, then it is assumed to be exogenous.

Canadian slaughter capacity (CAP) was defined as the number of animals the Canadian beef packing industry could slaughter annually.[16] This value changes when new plants open or expansions to existing plants occur.

Testing

Stability of the system depends upon the estimates of the lagged dependent variable coefficients. All moduli of the eigenvalues are required to be less than unity for stability of the system. Eigenvalues of B(L) in equation (6.2) will be obtained to examine the complementary function which gives the stability of market impacts. Assuming dynamic stability, the particular solution is obtained from the reduced form and provides the long-run multipliers. Therefore, a shock in Canadian slaughter capacity will create a multiplier effect on Canadian and US cattle prices. These shocks are converted to elasticities, and changes in mean prices for each cattle market are estimated.[17]

Data

Cattle prices as defined in Chapter Four are based on monthly observations and deflated by the US Gross Domestic Product (GDP) implicit price deflator. Monthly observations from January 1999 to April 2006 were used because of limitations in

---

[16] Individual packing plant's capacity was collected and the total summed to get an industry aggregate
[17] Math derivations are provided by Chaing Chapter 16

Canadian capacity information; this gave a total of 88 observations. Table 6.1 displays the variables used and their sources.

Table 6.1. Structural Model Variables.

Variable	Unit	Source
Canadian Steer Carcass Weight	lb.	CanFax
Canadian Fed Slaughter	1000 hd	CanFax
Canadian Cow Slaughter	1000 hd	CanFax
Canadian Calf Crop	1000 hd	Statistics Canada
Canadian Boxed Beef Value	$/cwt	CanFax
Canadian By-Product Value, Fed	$/cwt	CanFax
Canadian Food Cost Index	(1992=100)	Statistics Canada
Canadian Barley Price	US $/bushel	Alberta Grain Commission
Canadian Slaughter Capacity	Head per year	CanFax
US Steer Carcass Weight	lb.	LMIC
US Fed Slaughter	1000 hd	Cattle-Fax
US Cow Slaughter	1000 hd	Cattle-Fax
US Calf Crop	1000 hd	LMIC
US Boxed Beef Value	$/cwt	LMIC
US By-Product Value Fed	$/cwt	LMIC
US By-Product Value Cow	$/cwt	LMIC
US Food Marketing Cost Index	(1987=100)	Agricultural Outlook (USDA)
US Corn Price	$/bu	NASS

All Canadian prices were converted to US dollars using a monthly exchange rate. Intercept dummies were included for May 2003 (Canada's first BSE discovery) and August 2005 (the opening of the US border to Canadian live cattle less than thirty months of age).

Seasonality of live cattle prices is expected because of production cycles and differences in desired carcass weights between the two countries. Canada discounts carcass weights greater than 600-750 lbs. Conversely, US packers generally prefer carcass weights ranging from 600-900 lbs. This creates an incentive for heavier Canadian cattle to be shipped to the US if transportation costs are less than the domestic weight discounts (Young and Marsh 1997). Therefore, intercept dummies for quarterly seasonality on the monthly observations were included.

Calf crops were biannual observations and interpolated to monthly periods by averaging two observations to generate quarterly data. Each of three months within any given quarter was assigned the same monthly value.

The US Food Marketing Index is reported on a quarterly basis. Thus, the same value was assigned for each of the three months occurring within each quarter.

Canadian boxed beef values were only available from 2004 to 2006. Therefore, US boxed beef values were used as proxies for Canadian boxed beef between 1999 and 2004.[18]

US by-product values for cows were unavailable for January to July of 1999. Therefore, US fed cattle by-product values are used as proxies. Canadian cow by-product values and slaughter weights were unavailable. Therefore, Canadian fed steer slaughter weights and fed cattle by-product values are used as proxies.

Table 6.2 provides the summary statistics for these variables based on the measurement units of Table 6.1.

Table 6.2. Summary Statistics.

Variable	Mean	Standard Deviation
Canadian Fed Steer Price	67.55	10.98
Canadian Slaughter Cow Price	33.23	9.58
Canadian Feeder Steer Price	98.2	15.32
US Fed Steer Price	80.92	13.98
US Slaughter Cow Price	47.04	9.55
US Feeder Steer Price	114.81	31.9
Canadian Steer Carcass Weight	825.89	25.53

[18] The correlation between US and Canadian boxed beef values from 2004 to 2006 was 0.66

Table 6.2 Summary Statistics Continued.

Canadian Fed Slaughter	238580.5	39574.76
Canadian Cow Slaughter	39725.23	10320.13
Canadian Calf Crop	2782.08	1871.69
Canadian Boxed Beef Value	154.14	11.64
Canadian By-Product Value, Fed	76.18	9.75
Canadian Food Cost Index	120.48	6.64
Canadian Barley Price	2	0.3
Canadian Slaughter Capacity	69248.66	11633.28
US Steer Carcass Weight	745.29	15.46
US Fed Slaughter	4249.18	6821.95
US Cow Slaughter	829.6	1335.74
US Calf Crop	19054.15	6362.35
US Boxed Beef Value	132.52	21.23
US By-Product Value, Fed	8.01	0.75
US By-Product Value, Cow[19]	7.57	0.72
US Food Marketing Cost Index	515.49	28.13
US Corn Price	2.15	0.33

Structural Model Results

Monthly observations of fed steer, feeder steer, and slaughter cow prices and other variables for the US and Canada contained unit roots at the 0.05 significance level (nonstationary). However, the inverse demands were cointegrated. Therefore, the model was estimated with data in level form.

Lags on control variables were insignificant in initial regressions, thus they were excluded in the final specification.[20] A Koyck variable (lagged dependent variable) was significant in all markets.

By product price and boxed beef prices were tested for endogeneity using the Hausman test as described in equations (6.20) and (6.21). The Hausman Test failed to

[19] January to July of 1999 not included
[20] Lags of t -1 and t -2 were tested.

reject the null hypothesis of exogeneity for by-products. However, boxed beef prices rejected the null hypothesis of exogeneity.

Lags of the number of animals slaughtered multiplied by carcass weights were included and variables that were not significantly different from zero (p-values greater than 0.15) were omitted from the regression. Table 6.3 provides the regression results using 3SLS with all data (except binary variables) transformed by natural logarithms. Consequently, the estimated coefficients represent elasticities. All exogenous variables in the system as well as real US per capita disposable income were used as instruments.

Table 6.3. Structural Model Results.

Variables	**USFedP**	**CaFedP**	**USCowP**	**CaCowP**	**USFeedP**	**CaFeedP**
C	0.12	-1.71	-0.58	0.42	-0.21	-1.83
	(0.62)	(-1.79)	(-2.61)	(0.27)	(-1.54)	(-2.53)
Q*	-1.12	-3.43	1.39	-0.28	-0.01	0.26
	(-2.73)	(-5.31)	(6.67)	(-0.24)	(-1.18)	(2.48)
Q* -1	1.12	3.38	-1.38	0.10	0.04	0.02
	(2.73)	(5.25)	(-3.66)	(0.09)	(3.07)	(1.77)
Boxed Beef Price	0.50	1.95	0.25			
	(5.31)	(9.19)	(4.55)			
By-Product Value		0.33	-0.06	0.44		
		(4.70)	(-1.29)	(3.97)		
USFedP		-1.22			0.17	
		(-9.09)			(4.40)	
CaFedP	-0.01					0.19
	(-0.29)					(5.03)
CaCowP			0.01			
			(0.60)			
USCowP				0.25		
				(1.50)		
S2	-0.03	-0.12				0.02
	(-4.84)	(-6.55)				(1.70)
S3	-0.02	-0.07		-0.10		-0.40
	(-1.97)	(-2.83)		(1.29)		(-2.36)
S4			-0.04	-0.06		-0.42
			(-4.29)	(-2.63)		(-2.48)
Capacity		0.10		0.20		
		(1.18)		(-2.16)		
BSE	0.03			-0.64		
	(1.94)			(-7.94)		

Table 6.3. Structural Model Results Continued.

Post05	0.03 (1.74)	0.07 (1.66)	-0.04 (-1.82)	-0.31 (-3.31)		
USFedP -1	0.42 (4.42)					
CaFedP -1		0.05 (0.73)				
USCowP -1			0.85 (25.32)			
CaCowP -1				0.37 (6.12)		
USFeedP -1					0.84 (23.20)	
CaFeedP -1						0.83 (19.44)
Barley						-0.10 (-3.36)
Adjusted R-squared	0.97	0.82	0.97	0.92	0.97	0.82

*Quantity is equal to the number of head slaughtered in the appropriate animal class multiplied by the carcass weight. Quantity for Feeders is the calfcrop for the quarter.

Note: t-statistics are in brackets below coefficient

All coefficients on the first-order lagged dependent variables have a modulus of less than unity indicating a stable geometric distributed lag model. The lagged dependent variables consistently had a larger influence in the US market than the Canadian market. This may be because of US price leadership in the North American beef market.

Lags of quantity (e.g., supply) were included and, in some cases, made the marginal impact positive (the wrong sign). For example, the US slaughter cow and feeder steer prices have summed (t and t-1) elasticities from a one percent increase in quantity of 0.01 and 0.03. Canadian feeder steer prices had a marginal positive elasticity of 0.28. However, the US fed steer market implies there was zero marginal impact on price from quantity. All lagged quantity variables were jointly significant with their contemporaneous counterparts at the α=0.10 significance level.

These sign problems for price response to increased quantity slaughtered may have been caused by the small sample, or errors in identifying the quantity variable. Quantity was defined as the number of head slaughtered multiplied by the carcass weight of that class of animal for the time period. Stocks of beef available at the beginning of the period and imports for that period were not included. However, when included these variables were insignificant. The small sample size of 88 observations, 473 degrees of freedom for the system may have influenced the coefficients. It should be noted that these quantity estimates are not included in A_o which is inverted to find the initial and long-run multipliers. Therefore, the estimates from the impact of increased Canadian slaughter capacity remain unaffected from these sign problems.

The boxed beef price had the expected positive impacts on cattle prices, with elasticities ranging from 0.25 on the US slaughter cow price to 1.95 on the Canadian fed steer price. By-product value had the expected positive impact on Canadian fed steer and slaughter cow markets of 0.33 and 0.44, respectively. However, US by-product value had a negative impact (-0.06) on US slaughter cow price.

The cross price elasticities show that Canadian fed steer and slaughter cow prices have little influence on US cattle prices. However, US cattle prices do influence Canadian slaughter cow prices positively (0.25) and fed steer prices negatively (-1.22). Each country's feeder steer price had a positive impact on the other country. The US and Canadian feeder steer prices had an average impact on each other of 0.18.

Barley prices had a negative impact on Canadian feeder cattle prices. A one percent increase in barley prices decreased Canadian feeder price by 0.10 percent. Seasonality dummies had indeterminate results.

The capacity variable (CAP) is significant on the Canadian fed steer and slaughter cow prices. A one percent increase in capacity increased Canadian fed steer and slaughter cow prices 0.10 and 0.20 percent respectively. Packing plants initially focused on slaughtering animals less than thirty months of age to be boxed and exported to the US when the border was closed to live animal trade. Therefore, any increased capacity would initially benefit the fed cattle market, but not the slaughter cow market. This is seen by the significant BSE dummy on slaughter cow prices (-0.64); but BSE had no impact on fed steer prices. However, once the border opened to fed steers and the increased capacity became available to slaughter cows post-2005, slaughter cow prices would then benefit. The post-2005 dummy positively impacts Canadian fed steers (0.03), but slaughter cows are again negatively impacted -0.31 percent, leaving Canadian slaughter cow prices negatively impacted overall.

The BSE dummy was significant in the US fed steer demand equation (0.03). US fed steer and slaughter cow demand equations do not have significant post-2005 dummies. While BSE positively influenced US fed steer prices the reopening of the border did not significantly impact US cattle prices.

Initial Impacts

Reduced form equations in general provide the framework to estimate the initial, intermediate, and long-run impacts of each exogenous variable on a dependent variable.

Solved reduced form equations are derived from structural models in which each endogenous variable is a function of all of the system's exogenous variables and unobserved errors. Equations (6.21 and 6.22) present the matrix operations used to get the reduced form from the dynamic structural model.

(6.21) $A_oP_t = A_1P_{t-1} + A_2Q_t + BZ_t$

where P_t is the price vector, P_{t-1} is the lagged price vector, Q_t is the quantity vector and Z_t is the control variable vector (including the capacity variables). The terms A_o, A_1, A_2, and B are relevant coefficient matrices specific to the vectors of variables. Solving equation (6.21) for P_t results in:

(6.22) $P_t = (A_o^{-1}A_1)P_{t-1} + (A_o^{-1}A_2)Q_t + (A_o^{-1}B)Z_t$

The matrix $(A_o^{-1}A_1)$ provides the complementary function that is used to test model stability and initial impacts. All matrices in parentheses of equation (6.22) represent initial or short run impacts on the dependent variables; elasticities of these initial impacts are presented in Table 6.4.

Table 6.4. Initial Impact from Exogenous Variables.

Initial Impact	USFed	CAFed	USCow	CACow	USFeed	CAFeed
usfedp-1	0.42	-0.51	0.00	0.00	0.07	-0.10
cafedp-1	0.00	0.05	0.00	0.00	0.00	0.01
uscowp-1	0.00	0.00	0.85	0.21	0.00	0.00
cacowp-1	0.00	0.00	0.00	0.37	0.00	0.00
usfeedp-1	0.00	0.00	0.00	0.00	0.84	0.00
cafeedp-1	0.00	0.00	0.00	0.00	0.00	0.83
Q*CW USFed	-1.12	1.37	0.00	0.00	-0.19	0.26
Q*CW-1 USFed	1.12	-1.37	0.00	0.00	0.19	-0.26
Q*CW CaFed	0.00	-3.43	0.00	0.00	0.00	-0.65
Q*CW-1 CaFed	0.00	3.38	0.00	0.00	0.00	0.64
Q*CW USCow	0.00	0.00	1.39	0.35	0.00	0.00
Q*CW-1 USCow	0.00	0.00	-1.38	-0.35	0.00	0.00
Q*CW CaCow	0.00	0.00	0.00	-0.28	0.00	0.00
Q*CW-1 CaCow	0.00	0.00	0.00	0.10	0.00	0.00
Q USFeeder	0.00	0.00	0.00	0.00	-0.01	0.00

Table 6.4. Initial Impact from Exogenous Variables Continued.

Q-1 USFeeder	0.00	0.00	0.00	0.00	0.04	0.00
Q CaFeeder	0.00	0.00	0.00	0.00	0.00	0.26
Q-1 CaFeeder	0.00	0.00	0.00	0.00	0.00	0.02
C	0.12	-1.86	-0.58	0.28	-0.19	-2.18
USBB	0.50	-0.61	0.25	0.06	0.09	-0.12
CABB	0.00	1.95	0.00	0.00	0.00	0.37
USBPV	0.00	0.00	-0.06	-0.02	0.00	0.00
CABPV	0.00	0.33	0.00	0.44	0.00	0.06
CAP	0.00	0.10	0.00	0.20	0.00	0.02
Barley	0.00	0.00	0.00	0.00	0.00	-0.10
s2	-0.03	-0.08	0.00	0.00	-0.01	0.00
s3	-0.02	-0.05	0.00	-0.10	0.00	-0.41
s4	0.00	0.00	-0.04	-0.07	0.00	-0.42
bse	0.03	-0.04	-0.01	-0.64	0.01	-0.01
post05	0.03	0.03	-0.04	-0.32	0.01	0.01

Lagged price variables in each equation indicate that Canadian prices do not affect US cattle prices. However, a one percent increase in US fed steer and slaughter cow prices affect the Canadian fed steer and slaughter cow prices by -0.51 and 0.21 percent. The US cattle supply has no impact on cattle prices, except the US feeder steer price which increases 0.03 percent from a one percent increase in the US calf crop and US slaughter cow price increased 0.01 percent from a one percent increase in slaughter cows. A one percent increase in Canadian cattle supply (Q*CW) negatively impacts Canadian fed steer and slaughter cow prices by -0.05 and -0.18 percent. Canadian feeder steer prices increase 0.28 percent from a one percent increase in the Canadian calf crop. Feeder steer prices had positive marginal impacts from increased calf crops in both countries. Theory would suggest that increased supplies decrease prices, unless demand is increasing at a faster rate. These sign problems may have been caused by incorrectly identifying Q and the small sample of data.

US boxed beef prices influenced all cattle prices to some degree with the greatest impact on the US and Canadian fed steer prices (0.50 and -0.61). The negative impact was not expected since increased boxed beef prices are expected to reflect increased demand, and therefore higher prices for cattle. However, the Canadian boxed beef prices had large positive impacts on the Canadian fed steer and feeder steer prices (1.95 and 0.37). The marginal impact on Canadian fed steer and feeder steer prices from US and Canadian boxed beef prices was 1.34 and 0.25, respectively.

Canadian by-product values had the expected positive impacts on all Canadian cattle prices. Since Canada is not the price setting market, it is assumed that these positive impacts do not influence US cattle prices. The US by-product value impact is small and negative for slaughter cow prices in both countries (-0.06 in the US and -0.02 in Canada).

The BSE dummy shows the largest negative impact to be on Canadian slaughter cow price (-0.64), while fed steer prices only marginally declined (-0.04). This is because of the quick opening of the US border to beef less than thirty months of age which provided a market for beef obtained from fed steers. The opening of the border in 2005 to live animals less than thirty months of age depressed slaughter cow prices in both countries. However, Canadian packing plant capacity was used to slaughter cows post-2005. The increased demand for slaughter cows would be expected to increase slaughter cow price; however, it did not. The post-2005 dummy a small positive impact on Canadian fed steer price of 0.03 percent with the renewed demand of US feedlots and packing plants. Both policy dummies had a positive impact on US fed steer prices (0.03 for each).

Capacity does have a positive impact on Canadian prices with elasticities of 0.10, 0.20 and 0.02 for fed steer, slaughter cow, and feeder steer prices, respectively. A one percent increase in Canadian slaughter capacity results in a real increases of $0.075/cwt, $0.05/cwt, and $0.02/cwt.[21] The increase in Canadian capacity did not have an initial impact on US cattle prices. This may be because of trade restrictions between the two countries during this period. One would expect US feeder steers to benefit from increased Canadian slaughter capacity if normal trade patterns resume. However, from 2003 to 2006 US feeder steers were not exported to Canada because of large supplies in Canada. Therefore, these capacity impacts do not accurately reflect impacts on market prices under normal trade patterns.

Canadian packing plants chose to operate at less than full capacity since the fall of 2005 (CanFax, Dec 2005). This implies that they are not competitive with American plants that are demanding Canadian fed cattle. This can be for a variety of reasons including not being cost competitive in processing. Therefore, when the border opens one could expect to trade to return to pre-BSE levels. The greatest short-run impact is in the fed steer market which benefited from increased capacity while the border was closed and more efficient US slaughter plants were unavailable.

---

[21] Based on the mean prices from 1999-2006 in US 2000 real dollars

Long-run Multipliers

Long-run or equilibrium multipliers are calculated using equations (6.23) and (6.24).

(6.23) Let $P_t = P_{t-1} = P^*$ (vector of dependent variables)

$Z_t = Z_t^*$ (vector of independent variables)

and $V_t = V^* = 0$ (vector of disturbances)

where * variables are the mean or long-run values. Based on equation (6.21) and appropriately solving, we get:

(6.24) $P^* = (I - A_o^{-1}A_1)^{-1} (A_o^{-1}B) Z_t^*$

The long-run multipliers or particular solution from equation (6.24) are presented in Table 6.5.

Table 6.5. Particular Solution or Long-Run Multipliers.

Long-Run Multipliers	USFed	CAFed	USCow	CACow	USFeed	CAFeed
Q*CW USFed	-1.93	2.48	0.00	0.00	-2.05	2.77
Q*CW-1 USFed	1.93	-2.48	0.00	0.00	2.05	-2.77
Q*CW CaFed	0.00	-3.61	0.00	0.00	0.00	-4.04
Q*CW-1 CaFed	0.00	3.56	0.00	0.00	0.00	3.98
Q*CW USCow	0.00	0.00	9.52	3.78	0.00	0.00
Q*CW-1 USCow	0.00	0.00	-9.45	-3.75	0.00	0.00
Q*CW CaCow	0.00	0.00	-0.03	-0.46	0.00	0.00
Q*CW-1 CaCow	0.00	0.00	0.01	0.16	0.00	0.00
Q USFeeder	0.00	0.00	0.00	0.00	-0.06	0.00
Q-1 USFeeder	0.00	0.00	0.00	0.00	0.25	0.00
Q CaFeeder	0.00	0.00	0.00	0.00	0.00	1.53
Q-1 CaFeeder	0.00	0.00	0.00	0.00	0.00	0.12
C	0.21	-2.07	-3.93	-0.89	-1.09	-13.07
USBB	0.86	-1.11	1.71	0.68	0.92	-1.24
CABB	0.00	2.05	0.00	0.00	0.00	2.29
USBPV	0.00	0.00	-0.41	-0.16	0.00	0.00
CABPV	0.00	0.35	0.05	0.72	0.00	0.39
CAP	0.00	0.11	0.02	0.33	0.00	0.12
Barley	0.00	0.00	0.00	0.00	0.00	-0.59

Table 6.5. Particular Solution or Long-Run Multipliers Continued.						
s2	-0.05	-0.06	0.00	0.00	-0.05	0.05
s3	-0.03	-0.03	-0.01	-0.16	-0.04	-2.39
s4	0.00	0.00	-0.28	-0.21	0.00	-2.47
BSE	0.05	-0.07	-0.07	-1.04	0.05	-0.07
post05	0.05	0.01	-0.31	-0.61	0.05	0.01

In the long-run, Canadian cattle supply has a very small impact on US cattle prices. US slaughter cow prices decline -0.02 percent for a one percent increase in Canadian slaughter cow supply. US fed steer and feeder steer supply does not impact Canadian fed and feeder steer prices. Overall, supply negatively impacts fed steer and slaughter cow prices, while they continue to be positive for feeder steers.

Boxed beef prices positively impact cattle prices on the margin; and by-product values positively impact cattle prices, for all markets except US slaughter cows (-0.36). Barley prices have a greater influence in the long-run at -0.59, compared to the short-run influence of -0.10.

The influence of the policy dummies increase in the long-run but move in the same direction as the initial impacts. Slaughter cow prices are negatively impacted by each policy change, while the feeder steer prices increase over time. Canadian fed steer prices had a larger negative impact from BSE in the long-run at -0.07 compared to -0.04 in the short-run. The fed steer prices were positive influenced from the post-2005 policy change.

In the long-run there is a positive impact on the US slaughter cow price of 0.02 percent when Canadian annual slaughter capacity increases one percent. This results in a very small change of $0.009/cwt, using the mean real US slaughter cow price. Canadian slaughter capacity shows no impact on US fed steer prices. The impact in the Canadian market increases for all markets at \$0.08/cwt, \$0.12/cwt and \$0.08/cwt for fed steer, slaughter cow, and the feeder steers. The greatest impact in the long-run with the border open to live cattle under thirty months of age is in the slaughter cow market. Implying that cattle prices in Canada benefit from increased slaughter capacity only while the border to the US is closed. If the border is open for trade, animals will be exported and Canadian slaughter capacity would not be utilized since animals would be exported to more efficient plants in the US.

Canadian annual slaughter capacity increased approximately 27 percent from 2003 to 2005. Consequently, the estimated long-run impacts from the increase are \$2.16/cwt, \$3.24/cwt, and \$2.16/cwt for Canadian fed steers, feeder steers, and slaughter cows. The US slaughter cow price would be expected to increase \$0.24/cwt. Therefore, increased capacity does show to be a benefit to Canadian fed steer and feeder steer producers. However, these increases are all less than the standard deviation for these markets, making them relatively small. Overall, there is no positive or negative price impact on US producers from the change in Canadian packing plant capacity.

Summary

Sign problems with respect to supply may have been caused by incorrectly defining supply, and/or the small sample size used. However, these sign problems are not included in the A_o matrix and therefore do not influence capacity estimates.

The increase in Canadian slaughter capacity initially increased Canadian cattle prices. However, little impact occurred on the US cattle prices. The BSE dummy positively impacted US fed steer prices while negatively impacting Canadian slaughter cow prices. The post-2005 dummy was not significant in the US demand equations, but positively impacted Canadian fed steer prices and negatively impacted Canadian slaughter cow prices. Fed steer prices benefited from increased slaughter capacity only while the border is closed. Once the border opened, fed steer prices benefited from US slaughter plant demand, as live cattle exports resumed.

In the long-run, Canadian slaughter capacity expansion increases Canadian cattle prices and US slaughter cow prices. US fed steer and feeder steer prices are not affected by the expansion. Policy dummies had a positive impact on US and Canadian fed and feeder steer demand equations, and US and Canadian slaughter cow prices were negatively impacted. Canadian slaughter cow prices benefit from increased slaughter capacity in the long-run while the border is closed to live cattle exports over thirty months of age. That is, as more fed cattle are exported to the US, slaughter capacity is being used to slaughter cows. However, one would expect the same situation with slaughter cows as with fed steers when the border re-opens to animals over thirty months of age. When the border opened to fed steers, capacity in Canada became irrelevant and live cattle moved to where slaughtering was the most efficient.

CHAPTER 7

SUMMARY AND CONCLUSIONS

The fed steer, feeder steer, and slaughter cow markets in the United States (US) and Canada have been shown to be integrated and interdependent. However, recent international trade events may have altered this relationship. The objective of this thesis was to determine whether the degree of integration for the fed steer, feeder steer, and slaughter cow markets in the US and Canada had been altered by trade disruptions caused by BSE, the temporary closure of the US/Canadian border to cattle trade, and increases in Canadian slaughter capacity.

Pre-tests indicate that weekly US and Canadian prices for fed steers, feeder steers, and slaughter cows possess unit roots, but were cointegrated. Market integration was then modeled with a VAR outlined by Vollrath and Hallahan (2006); which also allows for the degree of market interdependence to be quantified. The VAR model supported US-Canadian market integration in all three cattle sectors from 1985 to 2006. The VAR models indicate that Canada has a greater dependence on the US for cattle trade than *vice-versa*.

Because cointegration does not imply that the LOP holds, the LOP was also tested. Adherence to the LOP over each regime period was tested using Vollrath and Hallahan's (2006) LOP model. The policy regimes tested included: (1) 1985-1989, pre-CUSTA; (2) 1989-1995, trade before the removal of the Crow Rate or post-CUSTA; (3) 1995-2003, essentially free-trade between Canada and the US or post-1995; (4) May

2003-July 2005, no trade of live cattle because of the closed US/Canadian border because of BSE or post-2003; and (5) August 2005-2006 gradual reopening and reestablishment of trade across the US/Canadian border or post-2005. Structural changes in price transmission and exchange rate pass-through between regimes were tested. Adjustment lags and exchange rate risk were considered along with other market controls. Exchange rate risk was found to be insignificant and removed from further regressions.

Lag structures were different between regimes in all cattle markets indicating a change in market structure. US price elasticities were generally inelastic. The feeder steer market was more inelastic than the fed steer market because of less trade. Post-2003 was the most inelastic period for the feeder steer and slaughter cow markets. The exchange rate elasticity fluctuated more than the US price elasticities, but generally become increasingly elastic after 1995.

Trends in US price and exchange rate elasticities show that the fed steer market was the most responsive to policy changes. The feeder steer market elasticities were relatively stable overtime. Slaughter cow price elasticities became increasingly inelastic, implying a divergence from market integration since 1985. Exchange rate elasticities were relatively stable over time.

Previous research has indicated that the US and Canadian beef and cattle markets have been highly integrated since CUSTA in 1989. However, while the LOP held for all pre-CUSTA markets, and post-1995 for the fed steer and feeder steer markets; it did not hold in the post-CUSTA period. The possibility of more than one regime, feed price fluctuations and lower transaction costs from use of contracting may have influenced LOP results for the fed steer and feeder steer markets in the post-CUSTA period. This implies that increased US market access was not as important to the Canadian cattle market as other market signals which restricted cattle feeding capacity until 1995. Policy changes separated the slaughter cow markets post-CUSTA. Cow herds in the US and Canada were increasing after 1989; along with transaction/transportation costs these may have prevented the slaughter cow markets from reintegrating even with the removal of trade barriers after CUSTA. However, non-tariff trade barriers remain in the form of disease testing and meat grading standards.

The LOP models show that the fed steer market displayed structural changes in prices and exchange rates in all regime periods. The feeder steer market displayed structural price changes in 1989 and 1995, and was structurally different in all regimes for exchange rate pass-through. The slaughter cow market was structurally different for prices in 1989; and was structurally different in 1989 and 1995 for exchange rate pass-through.

A structural model quantified the impact of increased Canadian slaughter capacity. Sign problems with quantity indicated an error in identifying that variable and the small sample used. A small initial increase in Canadian cattle prices was indicated and no impact on US cattle prices. The largest dollar impact was in the fed steer market while the border was closed. However, once the border opened to live cattle trade less than thirty months of age slaughter cows benefited the most. Therefore, it would be expected that once trade resumed for all live cattle, Canadian slaughter capacity would not influence price because animals would move to where slaughtering was the most efficient.

In the long-run, Canadian slaughter capacity expansion increased Canadian cattle prices and US slaughter cow prices. US fed steer and feeder steer prices were not affected by the expansion. An increase in Canadian annual slaughter capacity of 27 percent was estimated to increase Canadian fed steers, feeder steers, and slaughter cows \$2.16/cwt, \$3.24/cwt, and \$2.16/cwt and US slaughter cow price by \$0.24/cwt. Overall, policy dummies had a positive impact on US and Canadian fed and feeder steer demand equations. While, US and Canadian slaughter cow demand equations were negatively impacted by the policy changes.

Limitations and Implications

The LOP results for the post-2005 period were significantly different from the other regime periods. There is potential that the coefficients are biased because of large sample assumptions used on this small sample of observations. In simplifying the LOP model, the use of five policy regimes may have caused inconsistent results in the post-CUSTA period.

The annual data for Canadian slaughter capacity provided less precise information with regards to changes in the industry and may not accurately reflect the industry situation. The small sample also may have created sign problems with quantity.

Results imply the fed steer market is reintegrating as trade barriers are removed and trade resumed. The feeder steer market showed little response to policy changes and this may prevent large shocks from influencing prices. The slaughter cow market appears to be the most influenced from recent policy changes; but has not been integrated since CUSTA and appears to be diverging more. Increased Canadian slaughter capacity shows positive returns to Canadian producers, while US producers will be unaffected. However, increased Canadian capacity would only benefit prices while the border is closed. After that animals would be expected to trade as before, where slaughtering is the most cost efficient.

BIBLIOGRAPHY

Agriculture and Agri-Food Canada (AAFC). November 25, 2005. Bi-weekly Bulletin. Feed Barley: Situation and Outlook. Vol. 18. No. 19.

Alberta Grain Commission, 2006. Personal Communication.

Alston, Julian M., Colin A. Carter, and Vincent H. Smith. 1993. Rationalizing Agricultural Export Subsidies. American Journal of Agricultural Economics 75(4):1000-1009.

Alston, Julian M. and Will Martin. 1995. A Comment on Border Price Changes and Domestic Welfare in the Presence of Distortions. Oxford Economic Papers 47(1):79-82.

Ardeni P.G. 1989. Does the law of one price really hold for commodity prices? American Journal of Agricultural Economics 71:661-669.

Baldwin John R. and Beiling Yan. 2004. The Law of One Price: A Canada/U.S. Exploration. Review of Income and Wealth Series 50(1):1-10

Barrett C.B. 1996. Market Analysis Methods: Are Our Enriched Toolkits Well Suited to Enlivened Markets? American Journal of Agricultural Economics 78(3):477-87.

Blake Martin and Tom Clevenger. 1980. The Impacts of Beef By-Product Exports on Live Cattle Prices. American Journal of Agricultural Economics 62(1):103-106

Boswell. A.M. 1973. Determinants of Change in Canadian Beef Cattle Slaughter. Canadian Farm Economics V. 8 (1):1-7

Brester Gary W., James Mintert, and Dermot J. Hayes. 1997. US Meat Exports Increasing Rapidly. Choices Fourth Quarter: 22-23.

Brester, Gary W. and John M. Marsh 1983. A Statistical Model of the Primary and Derived Market levels in the US Beef Industry. Western Journal of Agricultural Economics 8(1):34-49

Brester, Gary W. and John M. Marsh. 1995.

Brester, Gary W. and John M. Marsh. 1998. Impacts of the Uruguay Round Trade Agreement on US Beef and Cattle Prices. Policy Issues Paper No.6 Trade Research Center. Montana State University, Bozeman.

Brester, Gary W. and John M. Marsh. April 1999. US Beef and Cattle Imports and Exports: Data Issues and Impacts on Cattle Prices. Policy Issues Paper No.9. Trade Research Center. Montana State University, Bozeman.

Brester, Gary W. John M. Marsh, and Vincent H. Smith. August 1999. Evaluating the Impacts of the US Department of Commerce's Preliminary Imposition of Tariffs on US Imports of Canadian Live Cattle. Research Discussion Paper No.34

Brester, Gary W. John M. Marsh, and Vincent H. Smith. 2002. The Impacts of US and Canadian Slaughter and Feeder Cattle Prices of a US Import Tariff on Canadian Slaughter Cattle. Canadian Journal of Agricultural Economics 50:51-60.

Brester, Gary W., Vincent H. Smith, and John M. Marsh. August 2003. Do Protectionist Trade Policies Protect? The Unintended Consequences of an Antidumping Tariff. http://www.choicemagazine.org/current/2003-3-09.htm

Brester, Gary. 2006. Personal Communication - Email

Bureau of Labor Statistics (BLS) 2004. http://www.bls.gov/

Canadian Cattlemen's Association (CCA) August 2004. Annual Report.

Canadian Cattlemen's Association (CCA), 2006.www.cattle.ca/newsroom/Archive/news%release%20-%20june%2024%2005.pdf

Canadian Food Inspection Agency (CFIA), 2006.www.inspection.gc.ca/english/animal/heasan/disemala/bseesb/newscome/shtml

CanFax, 2006. www.canfax.ca/ Members only – Spreadsheets.

CanFax, Weekly Report Dec 2, 2005.

CanFax, 2004. Annual Report

Cattle-Fax. 2006. http://www.cattle-fax.com/ USDA Livestock Data

Carter Colin A., Richard S. Gray, and W.H. Furtan. 1990. Exchange Rate Effects on Inputs and Outputs in Canadian Agriculture. American Journal of Agricultural Economics 72(3):738-743.

Chambers R.G. and R.E. Just. 1979. A critique of exchange rate treatment in agricultural trade models. American Journal of Agricultural Economics 61:249-257.

Coleman J.R. and Karl D. Meilke. 1988. The Influence of Exchange Rate3s on Red Meat Trade Between Canada and the United States. Canadian Journal of Agricultural Economics. 36:401-424.

Commonwealth 2006 Aid to Cattle Farmers. HTTP://WWW.CBC-TV.ORG/CANADA.PHP?ID=32 accessed September 6, 2006 at: http://www.cbc-tv.org/canada.php?id=36

Crouhy-Veyrac, L., M. Crouhy and J. Melitz. 1982. More about the law of one price. European Economic Review 18(3):325-344.

Doan Darcie, Brain Paddock, Jan Dyer. 2002. Grain Transportation Policy and Transformation in Western Canadian Agriculture. Agriculture and Agri-Food Canada.

Dudley Wendy. Aug 4, 2004. Business Edge. Cattle industry launches revitalization strategy: Market Diversity key for Industry. Western Producer. Contact at: wendy@businessedge.ca

Economic Research Services (ERS) USDA. 2006. http://www.ers.usda.gov/

Engel, C. and J.H. Rogers. 1996. How wide is the border? American Economic Review 85(5):1112-25.

Engle R.F., and C.W.J. Granger. 1987. Co-integration and error correction: Representation, estimation, and testing. Econometrica 55:251-276.

Fackler Paul L. and Barry K. Goodwin. 2001. Spatial Price Analysis. Handbook of Agricultural Economics. Vol.1B Marketing, Distribution and Consumers. Eds. Bruce L. Gardner and Gordon C. Rausser. North-Holland. Pg.971-1023.

FAOSTAT, 2006. Agricultural Data. http://faostat.fao.org/default.aspx

Feuz Dillon M. July 2006. BSE and Cattle Trade. Utah State University. http://www.panhandle.unl.edu/feuz/current.html

Foreign Agricultural Services. 1999. http://www.fas.usda.gov/

Greene William H. 2000. Economic Analysis. Fourth Edition. Prentice-Hall Inc. Upper Saddle River, New Jersey 07458 USA. New York University.

Goodwin B.K. 1992a. Multivariate cointegration tests and the law of one price in international wheat markets. Review of Agricultural Economics 14(1):117-124.

Goodwin B.K. 1992b. Multivariate Cointegration Tests and the Law of One Price: A Clarification and Correction. Review of Agricultural Economics 14(2):337-38.

Goodwin Barry K., Thomas J. Grennes, and Lee A. Craig. 2002. Mechanical Refrigeration and the Integration of Perishable Commodity Markets. Explorations in Economic History 39:154-182.

Goodwin Barry K. Thomas J. Grennes and Michael K. Wohlenant. 1990. A Revised Test of the Law of One Price using Rational Price Expectations. American Journal of Agricultural Economics :682-693

Goodwin Barry K., and Matthew T. Holt. 1999. Price Transmission and Asymmetric Adjustment in the US Beef Sector. American Journal of Agricultural Economics 81(3):630-637.

Goodwin Barry K. and Ted C. Schroeder. 1991. Cointegration Tests and Spatial Price Linkages in Regional Cattle Markets. American Journal of Agricultural Economics. 73:452-464.

Guzel, H. Alper and Surendra N. Klshreshtha. 1995. Effects of Real Exchange Rate Changes on Canadian Agriculture: A General Equilibrium Evaluation. Journal of Policy Modeling 17(6): 639-657.

Hayes, D.J. and W.A. Kerr. 1997. Progress toward a single market: The new Institutional economics of the NAFTA livestock sectors. In Harmonization/Convergence/ Compatibility in Agriculture and Agri-Food Policy; Canada, United States and Mexico, edited by R.M.A. Loyns et al, pp.163-180. University of Guelph.

Hooper Peter and Steven W. Kohlhagen. 1978. The effects of exchange rate uncertainty on the prices and volume of international trade. Journal of International Economics 8(4):483-511.

Johansen S. and K. Juselius. 1990. The full information maximum liklihood procedure for inference on cointegration – with application to the demand for money. Oxford Bulletin of Economics and Statistics 52:169-210.

Klein Kurt, Dennis McGivern and Kevin Grier. 2006. Exchange Rate Impacts on the Canadian Beef Industry. For the National Beef Industry Development Fund. George Morris Centre, informa economics: an AGRA informa company.

Klovland, Jan Tore. 2005. Commodity market integration 1850-1913: Evidence from Britain and Germany. European Review of Economic History 9:163-197

Livestock Marketing Information Center (LMIC). 2006. http://www.lmic.info/

Marsh, John M. December 1999. US Beef Trade and Price Relationships with Japan, Canada, and Mexico. Policy Issues Paper No.12 Trade Research Center, Montana State University, Bozeman.

Marsh John. October 1997. US Live Cattle and Beef Trade with Canada and Mexico: Effects of Feeder Cattle Price. Research Discussion Paper No.6. Trade Research Center Montana State University, Bozeman.

Marsh, John M. November 13, 2000. US Beef Trade Effects and the Restricted Feeder Cattle Program. Briefing No.13 Trade Research Center. Montana State University, Bozeman.

Marsh, John M. 1983. A Rational Distributed Lag Model of Quarterly Live Cattle Prices. American Journal of Agricultural Economics 65(3):539-547

Marsh, John M. 2003. Impacts of Declining US Retail Beef Demand on Farm-Level Beef Prices and Production. American Journal of Agricultural Economics 85(4):902-913

Marsh, John M. 2006. Econ 514 Class Notes.

McNew Kevin and Paul L. Fackler. 1997. Testing Market Equilibrium Is Cointegration Informative? Journal of Agricultural and Resource Economics 22(2):191-207.

Michael, P., A.R. Nobay and D. Peel. 1994. Purchasing Power Parity yet again: Evidence from spatially separated commodity markets. Journal of International Money and Finance 13:637-657.

Miljkovic, Dragon. Brester, Gary W. and Marsh, John M. 2003. Exchange rate pass-through, price discrimination, and US meat export prices. Applied Economics 35:641-650.

Miljkovic, Dragan. June 1998. The Law of One Price in International Trade: A Critical Review. Research Discussion Paper No.10. Trade Research Center. Montana State University, Bozeman.

National Agricultural Statistics Services. NASS/USDA 2006. http://www.nass.usda.gov/index.asp

Officer, L. 1982. Purchasing Power Parity and Exchange Rates: Theory, Evidence, and Relavence (JAI Press, Greenwich, CT).

Officer, L. 1986. The law of one price cannot be rejected: Two tests based on the tradable/nontradable goods dichotomy. Journal of Macroeconomics 8:159-182.

Pindyck Robert S. and Daniel L. Rubinfeld. 1998. Econometric Models and Economic Forecasts. Fourth Edition. Irwin/McGraw-Hill.

Protopapadakis, A.A., and H.R. Stoll. 1986. The law of one price in international commodity markets: A reformulation and some formal tests. Journal of International Money and Finance 5(3):335-360.

Rosson C. Parr III and Flynn J. Adcock. 2006. Food Chain Disruptions and Trade: The Important North American Market Integration. Choices Magazine accessed: June 15, 2006. www.choicesmagazine.org/

Sarno Lucio, Mark P. Taylor, and Ibrahim Chowdhury. 2003. Nonlinear dynamics from the law of one price: a broad-based empirical study. Journal of International Money and Finance 23:1-25.

Serra, Teresa and Barry K. Goodwin. 2004. Regional Integration of Nineteenth Century U.S. Egg Markets. Journal of Agricultural Economics 55(1):59-74

Statistics Canada, Data. CANSIM search engine 2006. http://cansim2.statcan.ca/cgi-win/cnsmcgi.exe?CANSIMFile=CII/CII_1_E.HTM&RootDir=CII/
January 1, 1979-2006 (Beef Cow Numbers)

U.S. International Trade Commission (USITC) 1997. "Cattle and Beef: Impact of the NAFTA and Uruguay Round Agreements on U.S. Trade" Publication No.3048, Washington D.C. (July)

Vollrath, Thomas and Charles Hallahan. 2006. Testing the Integration of US – Canadian Meat and Livestock Markets. Canadian Journal of Agricultural Economics 54:55-79.

Wachenheim, Cheryl J., Jeremy W. Mattson, and Won W. Koo. 2004. Canadian Exports of Livestock and Meat to the United States. Canadian Journal of Agricultural Economics 52: 55-71.

Williamson, J. 1986. Target zones and the movement of the dollar. Brookings Papers on Economic Activity 17:165-174.

Wohlgenant M.K. 1989. Demand for Farm Output in a Complete System of Demand Functions. American Journal of Agricultural Economics 71:241-252.

Wooldridge Jeffery M. 2006. Introductory Economics: A Modern Approach. Third Edition. Thomson South-Western. Michigan State University.

Young Linda. 2000. US – Canadian Agricultural Trade Conflicts: Time for a new paradigm. The Estey Centre Journal of International Law and Trade Policy. V.1(1):22-35.

Young, Linda M. and John M. Marsh. July 1998. Integration and Interdependence in the US and Canadian Live Cattle and Beef Sectors. Policy Issues Paper No.5 Trade Research Center. Montana State University, Bozeman.

Young, Linda M. and John M. Marsh. December 1997. Live Cattle Trade Between the United States and Canada: Effects of Canadian Slaughter Capacity and Health Regulations. Research Discussion Paper No.7 Trade Research Center.