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PROJECT REPORT

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A Study of Optimal Location: Competitiveness of the Alberta Cattle Feeding Industry with U.S. Regions[1]

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1 This report is based on Duncan McKinnon. 1991. *A Study of Optimal Locations: Competitiveness of the Alberta Cattle Feeding Industry With U.S. Regions*. Unpublished Masters thesis, Department of Rural Economy, University of Alberta.

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ABSTRACT

This study examines optimal location of cattle feeding among Alberta and the north-western U.S. states. Optimal location is based on comparative advantage (reflected in lower cost) in the production of resources such as feeds and feeders, and final product of boxed beef. Transportation costs of resources and final product also influence optimal location.

A spatial equilibrium model is developed to determine optimal location among seven regions. It is a linear programming cost minimization model that applies to 1988. A production function for transforming intermediate resources into final product (boxed beef) is used and regional demand for boxed beef is specified.

Alberta beef supply and disposition for 1988 is simulated, and various policy alternatives are then applied to this base model. Results indicate Alberta can be competitive with U.S. regions in feeding and processing cattle. Comparison of actual 1988 cattle feeding patterns to "optimal" feeding patterns indicated by the model leads to several inferences. Significant impacts on numbers of cattle fed in Alberta arise from removal of (or alterations to) the current method of paying the Crow Benefit. The Alberta cattle sector shows considerable sensitivity to this policy through its impact on barley price. Study models indicate the Alberta cattle feeding and processing industry would expand with Crow rate removal.

Had Pacific Rim demand for high quality beef been greater, both northern and southern Alberta would have increased exports by shipping beef through Vancouver. Exports to the Pacific Rim would have displaced beef shipments from Alberta to eastern Canada.

Depreciation of the value of the Canadian dollar would also have led to increased activity in the Alberta cattle sector. Alberta imported more feeders from the U.S. as value added cattle feeding and processing activities increased in Alberta. The additional boxed beef was shipped south to the U.S.

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1 INTRODUCTION

1.1 Background

1.1.1 Competitiveness Issues

Competitiveness of Alberta beef internationally is important to many sectors of the Alberta economy including the government and the cattle industry. The cattle industry needs to know its competitiveness to make long-run plans. Assume, for example, statutory rates were altered or removed (adjusted) on grain exported from the prairies. Would excess supply of feed grain in Alberta translate into a reduction in Alberta livestock producer feed conversion costs? How would this impact on optimum feedlot location in north-western U.S. and Alberta? The answer would help clarify Alberta's competitive position in the cattle sector. If statutory grain rates are adjusted, feed grain shipment out of the province to eastern Canada could drop off. This should stimulate Alberta's feeding industry at the expense of eastern Canada's cattle feeding industry. Indirect effects of such a policy change may mean eastern U.S. states will draw beef supplies more from western states leaving open for Alberta the possibility of increased exports south to the California area.

Local government is also concerned with competitiveness of the Alberta cattle industry. Policies implemented by itself and others will impact on this competitiveness. Who are the gainers and losers of policy changes? What are the anticipated effects of various policy shocks on the cattle industry? Adjustment to the Crow Benefit Program[1] is one example of impending policy change. Implications of Crow Rate removal on Alberta's cattle feeding industry are examined in this study. Non-harmonized beef grading between Alberta and the U.S. influences trade patterns. Beef inspection problems hinder flow of Alberta beef south. Scrutiny and possibly adjustment faces these regulatory issues. Implications of changes to regulatory issues in the beef sector are of significance to the entire Alberta economy.

Livestock trade between Alberta and the U.S. currently enjoys freer movement than many other agricultural commodities. Alberta's competitiveness in this sector is a sensitive issue as trade surges in livestock products affect the domestic industry more with free trade than with restricted trade. Cattle trade (live and processed) between Alberta and U.S. is of note. In 1988, Alberta exported 226,426 live cattle to the U.S., of which 98 percent

1 Statutory grain rates on export of prairie grains are those set out in the federal **Western Grain Transportation Act.** They are alternately referred to in this paper as the Crow Benefit Program.

were slaughter cattle. In 1989, the pattern was similar with about 95 percent being slaughter cattle. The loss to Alberta of value-added beef processing is disconcerting. This study attempts to identify factors critical to these cattle movements.

Alberta-U.S. trade in beef for 1988 indicates Alberta exported about ten times as much beef to the U.S. as was imported (45 million lbs versus 4 million lbs). While the direction of these flows is encouraging, the quantity is not large. Alberta produced 800 million lbs of beef in 1988 of which approximately 25 percent (220 million lbs) was consumed in Alberta. Over 400 million lbs was exported to Ontario and further east. The fact that Alberta can ship beef to eastern Canada competitively (considering the distance and resulting high transportation cost), opens for inquiry the issue of moving beef a lesser distance to the south.

In a study of competitiveness issues in the U.S. beef sector (Johnson et al., 1989), it was predicted there would be increased worldwide demand for beef in the coming years due to rising incomes and improved policy coordination between countries. It is believed that this increased consumption will be met by imports from countries holding a competitive edge in beef production. Recent investment in new slaughter facilities in Alberta indicates a readiness to participate in this anticipated expansion of beef demand. Other measures also suggest Alberta can produce beef competitively.

First, for primary agriculture production such as cattle feeding or fluid milk production, production can be either feed source oriented or market oriented. A study done in the early sixties (King 1961) shows that fluid milk production would be located near consuming centers but that feedlot cattle would be feed source oriented. If Alberta has an abundance of cattle feeds (concentrates and roughages), feedlot cattle production in Alberta may be competitive with the highly developed U.S. cattle feeding areas.

Secondly, the U.S. is a major world importer of high quality beef as opposed to range-fed beef. This distinction between types of beef is important. Several countries (notably Australia, Argentina, Brazil and New Zealand) export range-fed beef. Range-fed beef imported into the U.S. is usually processed further, as are imports of European beef which often come from dairy cattle culls. Range-fed beef and beef from cull cattle is not competitive with the high quality beef that is produced in Alberta and demanded in the U.S.

Finally, Alberta's competitiveness in beef production is enhanced further by the low incidence of cattle disease in our temperate climate. North American imports of beef from Africa, Asia, South America and parts of Europe are restricted because of the prevalence of disease (primarily foot-and-mouth) in these countries.

1.1.2 King and Schrader Paper

The model used in this study follows one developed by King and Schrader (1963). King and Schrader make a distinction between general and partial equilibrium models: Determination of optimal production of an agricultural commodity in a **general** equilibrium framework depends on regional comparative advantage in producing that product in relation to production of all other agriculture products in the region. In the King and Schrader study the model takes regional production of all other livestock products as given and therefore undertakes a **partial** equilibrium analysis of feedlot location assuming as given the location of all other livestock production.

The King and Schrader paper had four objectives in mind:

> 1) to present a framework for the analysis of interregional competition for the case where a) both intermediate products, such as feed and feeders, and product may be shipped among regions and b) where alternative production activities are specified for conversion of intermediate products into the final product; 2) to apply the model to the analysis of the location of cattle feeding operations in the United States; 3) to determine the effect on location of modifying assumptions of the model as to nonfeed costs and feeding efficiency; 4) and to appraise the possible effect of other factors such as economies of scale in feedlot location. (King and Schrader 1963, 332)

The primary purpose of their study was to "...provide quantification of the effect of factors influencing location of feedlot facilities." (King and Schrader 1963, 332). Determined simultaneously in their model, along with feedlot location, were final product (beef) and factor (concentrates, roughages, and feeder cattle) shipment patterns, as well as beef prices that would result from perfectly competitive behavior.

1.1.3 Objectives and Organization of the Study

The objective of the present study is to estimate the optimal regional location of cattle feeding in Alberta and the north-west states.[2] In carrying out this objective, the model also determines optimal feeder shipments depending on various domestic and trade policies, exchange rates and demand scenarios. The study also indicates sensitivity of feeder shipment patterns to the above major variables.

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2 The eleven north-west states included in the study are: California, Colorado, Idaho, Montana, Nevada, N. Dakota, Oregon, S. Dakota, Utah, Washington, and Wyoming.

A cost minimization, spatial equilibrium model is used to generate results. The model minimizes cost of intermediate products, transportation costs, non-feed costs and processing costs. A production function relating quantity of intermediate product required per unit of final product is specified as are regional demand functions for boxed beef. The methodology used has several parallels with the King and Schrader study although the present study is modified in several ways. The beef production function and the demand function used in this paper are clear examples of modifications.

Is Alberta competitive with the north-west states in feeding and processing cattle? This model is not designed to deliver an unequivocal yes or no but to indicate optimal feeding and processing location given certain assumptions. By definition, the model abstracts from reality. For that reason not all factors impinging on equilibrium location are included. The model does deliver a framework that can be useful in analysis providing the user is fully aware of its assumptions and the resulting simplicity of the solution.

2 THE MODEL

2.1 Introduction

Optimal location of feedlots among regions depends on many complex relationships. Demand for various final products has an impact. If demand is for hamburger that can be supplied by imports or cull dairy cows, feedlot location may be different than if the predominant demand is for high quality beef. Production possibilities for feeds may also influence feedlot location. Since cattle production is feed source oriented, regional availability of basic factors such as land and favorable climate may determine feed production functions and therefore the feasibility of cattle production. Transfer costs linking all regions spatially will also have an influence. Cattle producers will seek markets in major consumption centers and prohibitive transfer costs would eliminate profitability.

In the present study, two Alberta regions are separated from five U.S. regions by an international border. This can also affect optimal feedlot location as trade barriers and protection measures utilized by each nation are brought to bear. It also permits assessing impacts on the livestock sector of various trade and policy scenarios such as differing grading regulations and the effect of exchange rates.

This study of regional location of cattle feeding is a partial equilibrium analysis since it does not examine the effects of cattle feedlot location on other sectors. Hogs, poultry, and the dairy industry, for example, consume the same feeds as cattle, but constraining effects on these sectors of feed consumption by feeder cattle is not considered. Further, the model is static with optimal feeding location determined for 1988. Model results can be compared with actual 1988 feeding location for policy analysis.

Each of the seven regions is represented by a single point for purposes of determining transfer costs. Regional demand is at these points and regional supply of fed and non-fed boxed beef is available at an assumed distance from these points for consumption in the home region or for shipment to other regions as required by regional demands.

Available at each of the seven points are given quantities of fixed factors (land, labor and capital) to support the cattle industry. Mobile intermediate products (feeder cattle, roughages and concentrates), that can be used to produce fed beef in the region or can be shipped to another region for use in fed beef production are also available at the regional points.

Regional demand functions for beef in the King and Schrader study are specified as a function of price, population, and per capita income. In the present study regional demand is per capita boxed beef consumption multiplied by regional population. The model is based on annual data and therefore abstracts from seasonal demand conditions (barbecues), or seasonal availability of feed and feeder cattle.

A fixed production function is utilized, although the framework exists to use alternative production processes to convert intermediate products into a final product (see King and Schrader 1963, 350). In models containing a production function, product supply is endogenous. Supply of beef in the present model, therefore, is determined in the model by considering a joint equilibrium for the intermediate product and the final product. Regional quantities of fed-beef production depends on the cost (interregional transfer cost, intermediate product cost, non-feed cost, and processing cost)[3] of regional production.

Transfer functions are given which specify unit cost of interregional shipping of intermediate products of concentrate, roughage and feeder cattle; and unit cost of inter and intra regional shipments of final product of boxed beef. Cattle are assumed slaughtered 50 miles from consuming centers to derive intraregional meat transfer costs. Feeds and feeders are assumed available at the feedlots. Slaughter weight cattle are not shipped in this model. Slaughter plants are assumed located at feedlot locations.

Regional supply of non-fed beef is taken as given at estimated levels with that supply being independent of feeding operations. Non-fed beef was considered a direct substitute for fed beef in most model runs, however in one model (section 4.2) a distinction is made between fed and non-fed beef to test this assumption.

One advantage of the linear programming framework is that subsequent inclusion of factors affecting equilibrium can be done by adding new constraints or integrating the material into existing constraints. Grading differences between Alberta and U.S. regulators are currently an issue. They are addressed in this study (section 4.1.1) by reducing factor inputs to fed-beef production in Alberta as a proxy for grade differences. These can be allowed to vary between U.S. and Alberta regions. Border inspection concerns can be added as some form of "risk premium" to transportation rates on product crossing the international border between Alberta and the U.S. The anticipated effect on Alberta livestock production of statutory rate removal for grains destined for export (Crow rate removal) can be simulated by adjusting price on concentrates fed in the two Alberta regions.

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3 Non-feed costs are incurred in the feedlot and processing costs refer to the packing sector. These are dealt with in section 3.3.4.2.

The next part of this chapter illustrates the mathematical model and notation used. The theoretical foundation for this study is spatial equilibrium theory and linear programming theory.[4] The objective function of this model is designed to minimize intermediate factor costs, transportation costs between spatially separated regions, non-feed costs and processing costs of beef production. The minimization is subject to constraints on the choice variables. These constraints are the regional resource availability and regional demand for boxed beef. The problem becomes one of determining the optimal level of use of the choice variables. In other words determining the process that will satisfy the resource constraints while minimizing cost. Such an outcome will describe optimal shipments of intermediate factors of feeder cattle, concentrates and roughages, as well as optimal regional location of cattle feeding given the assumptions noted above.

4 Spatial equilibrium theory and linear programming theory are developed in more detail in McKinnon 1991.

2.2 Notation and Mathematical Model

Notation used in the model is indicated in Table 1. Explanation of variables is as follows: Quantities available of the intermediate products of feeder cattle, concentrate feed, roughages and of non-fed beef[5] are taken as predetermined for 1988. Quantities of fed beef produced in each region will be derived from a fixed production function with parameters constant for U.S. regions and constant for Alberta regions. Total quantity of intermediate product used in fed beef production for each region is determined in the model as equilibrium between supply and demand is reached.[6] Total beef demanded in each region is predetermined by the fixed demand assumption.

Units of intermediate and final product quantities shipped from region i to region j are: numbers for feeder cattle, '000Mcal for concentrates and roughages, and '000lbs for boxed beef. Transfer costs for final and intermediate products are in dollars per unit (indicated above) per shipment distance. The "Input use" notation is included to allow costing of feeders and concentrates for sensitivity analysis. FC indicates feeder use and BC refers to barley use (corn use in U.S. regions). Input costs per unit available are: CDN$ per animal for feeders and CDN$ per tonne for the concentrate. Barley price per tonne is used to represent Alberta concentrate costs and corn price per tonne represents U.S. concentrate costs. Exports in the model go to either New York or Toronto, and Vancouver is given a fixed demand moderately higher than actual Alberta exports to British Columbia for 1988. Non-feed costs and processing costs are CDN$ per thousand pounds of boxed beef produced.

5 A description of non-fed beef is taken up in section 3.3.7.

6 Amounts of intermediate product required per unit final product is predetermined by the fixed production function.

Table 1.
Model Notation

Item	Fedr.Ctl.	Conc.	Ruff.	Fed.Bf.	Nfed.Bf.	Totl.Bf.
* Q avail in reg i.	W_i	Y_i	Z_i		X_i	
* Q prod in reg i.				V_{i1}		
* Q used/demnd in reg i.	W^i	Y^i	Z^i			DM^i
* Q shpd from i to j.	W_{ij}	Y_{ij}	Z_{ij}			X_{ij}
* Trnsfr cost/unit.	t^w_{ij}	t^y_{ij}	t^z_{ij}			t^x_{ij}
* Input use.	FC_i	BC_i				
* Input cost/unit.	C^w_i	C^y_i				
* Exports.						EX
* Non-feed/prcssng csts.				q_i		

Note: Based on notation in King and Schrader 1963, 341.

The objective is to determine the optimal regional location of cattle feeding and final and intermediate product shipment patterns that would result from perfectly competitive behavior under the assumptions of the model indicated above. To accomplish the objective, the linear programming framework will minimize transportation cost of final and intermediate product, non-feed and processing costs, cost of feeders and cost of concentrates:

$$\sum_i \sum_j X_{ij} t^x_{ij} + \sum_i \sum_j W_{ij} t^w_{ij} + \sum_i \sum_j Y_{ij} t^y_{ij} + \sum_i \sum_j Z_{ij} t^z_{ij}$$
$$+ \sum_i V_{i1} q_i + \sum_i W^i C^w_i + \sum_i Y^i C^y_i$$

Subject to:[7]

1) Shipments of beef from any region to itself and to all other regions must equal the nonfed beef available in the region plus beef produced in the region:

7 Based on notation used in King and Schrader, 341.

$$\sum_j X_{ij} = X_i + V_{il}$$

2) Amounts of intermediate products used in any region must be less than or equal to amounts available in the region plus in-shipments minus out-shipments:

$$0 \le W^i \le W_i + \sum_j W_{ji} - \sum_j W_{ij}$$

$$0 \le Y^i \le Y_i + \sum_j Y_{ji} - \sum_j Y_{ij}$$

$$0 \le Z^i \le Z_i + \sum_j Z_{ji} - \sum_j Z_{ij}$$

3) Supply of beef to a particular region, including shipments from that region to itself will be equal to regional demand:

$$DM^i = \sum_j X_{ji}$$

where j includes i

4) Two export points are included in the model to accomodate the excess supply of beef.

$$EX \le \sum_i X_{iox}$$

where i = 1,2,...,6.

A two region example of the model in the linear programming framework is shown in Table 2.

Table 2.
Linear Programming Example of A Two Region Model

	X_{11}	X_{16}	X_{1v}	X_{61}	X_{66}	X_{6n}	FC_1	FC_6	BC_1	CC_6	V_{11}	V_{61}	W_{16}	W_{61}	Y_{16}	Y_{61}	Z_{16}	Z_{61}
GM	$-t^x_{11}$	$-t^x_{16}$	$-t^x_{1ex}$	$-t^x_{61}$	$-t^x_{66}$	$-t^x_{6ex}$	$-C^w_1$	$-C^w_6$	$-C^y_1$	$-C^y_6$	$-q_1$	$-q_6$	$-t^w_{16}$	$-t^w_{61}$	$-t^y_{16}$	$-t^y_{61}$	$-t^z_{16}$	$-t^z_{61}$
$X_1 =$	1	1	1								-1							
$X_6 =$				1	1	1						-1						
$0 \geq$							-1				W^1		1	-1				
$W_1 \geq$							1											
$0 \geq$								-1				W^6	-1	1				
$W_6 \geq$								1										
$0 \geq$									-1.4		Y^1				1	-1		
$Y_1 \geq$									1									
$0 \geq$										-1.6		Y^6			-1	1		
$Y_6 \geq$										1								
$Z_1 \geq$											Z^1						1	-1
$Z_6 \geq$												Z^6					-1	1
$DM^1 =$	1			1														
$DM^6 =$		1			1													
$EX \leq$			1			1												

Note: Based on notation in King and Schrader 1963, 342.

2.3 Data Requirements

Data requirements for the model are extensive. Needed are: the regional availability and price of intermediate products required to produce final product; the production process for conversion of intermediate products into final product; the regional demand for beef; transfer costs for intermediate products and final product; and regional availability of non-fed beef. As noted above (section 3.2) several assumptions separate this study from King and Schrader (1963). The inclusion of intermediate product price in this model allows sensitivity analysis of hypothesized changes to statutory grain rates in Alberta.

A need to minimize data requirements for the beef production process resulted in simplifying the process to a single fixed production function applying to all regions. Additional research at a later date could add realism by providing quantification of alternative production processes that would accomodate input substitution in the production function.

2.3.1 Regional Demarcation

The seven regions used in this model are grouped into two regions in the province of Alberta and five regions encompassing eleven north-western U.S. states. For the Alberta regions, Alberta Agriculture Production Branch (Alberta Agriculture 1990) lists three cattle production areas in the province. Demarcation based on this study or one using alternate regional breakdowns would have been acceptable. It was felt, however, that two regions could provide conclusions as valid as three or four regions and, further, use of two regions allows some pooling of available resources in Alberta in order to compete with massive U.S. resource supplies. Alberta regions are by census divisions (C.D.).

For the US regions, boundaries are designed to include one USDA feeding state[8] in each region and to keep the regions geographically homogenous. States marked with an asterisk are feeding states. The central points are located close to the center of the region and are on primary transportation routes. Regions and central points are shown in Figures 1 and 2.

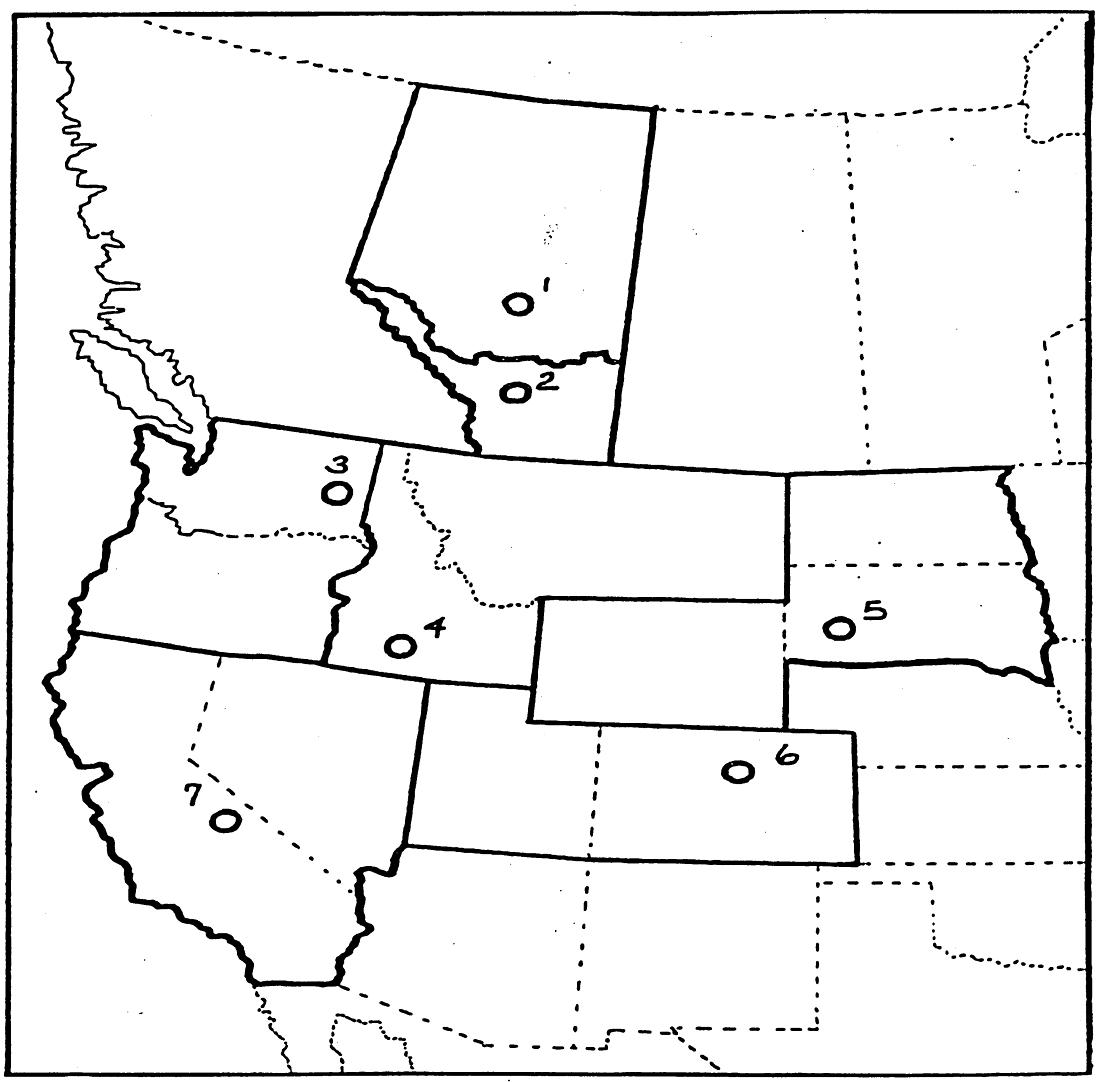
8 USDA NASS ASB Statistical bulletin No. 798 gives feeder cattle data for the "13 major feeding states" in the U.S. In this study it was determined to have one of these major feeding states in each of the five U.S. regions used.

Figure 1.
Regions and Central Points Used in the Model

REGIONS	AREA INCLUDED	CENTRAL POINT
1	Alta C.D. 7-14 & 16-19	Edmonton, Alberta
2	Alta C.D. 1-6 & 15	Calgary, Alberta
3	Washington*, Oregon	Spokane, Washington
4	Idaho*, Montana	Twin Falls, Idaho
5	S. Dakota*, N. Dakota, Wyoming	Rapid City, S. Dakota
6	Colorado*, Utah	Denver, Colorado
7	California*, Nevada	Bishop, California

Note: Adapted from King and Schrader (1963).
Note: * indicates feeding state.

Figure 2.
Regions and Central Points Used in the Model



2.3.2 Intermediate Product Supply

2.3.2.1 Feeder Cattle

Methodology for estimating feeder cattle supplies varies between Alberta regions and the US regions.[9] For the US, a "placements to number on feed"[10] ratio was calculated for feeding states. This ratio was then used to estimate placements for non-feeding states.

In Alberta, calf inventory numbers for July 1, 1987 were converted into placement numbers for 1988. While imports would be included in the US placement numbers, they must be added to the Alberta calf inventory numbers. The placements resulting are indicated in Table 3.

TABLE 3.
Estimated Placements for 1988 by Region

Region	Estimated Placements (#'s)
1	701,616
2	688,384
3	726,778
4	878,600
5	939,208
6	2,437,741
7	946,681
Total	7,319,008

Note: Based on notation in King and Schrader (1963).

2.3.2.2 Concentrates

Regional use of concentrate feed for livestock other than feeder cattle is assumed predetermined for the year beginning "fall 1987". All concentrates

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9 See Appendix B for preliminary data tables and methodology used for US and Alberta regions.

10 "Placements" refers to the number of cattle placed on feed during the period Oct 1, 1987 to Sept 30, 1988. "Number on feed" indicates number of cattle on feed Jan 1, 1988.

are converted to net energy in Mcal/tonne[11] and are seen as perfectly substitutable on these terms. Regional supply is taken as production plus imports plus beginning stocks, and regional use other than for feeder cattle is amounts fed to other livestock[12] plus exports plus industrial, food and seed uses. The difference between these two amounts is the supply variable used to feed feeder cattle. Regions 3 and 7 indicate a negative amount available to feed cattle. This indicates imports from other regions are necessary to satisfy feed requirements for other than feeder cattle before feeder requirements can be taken care of. As noted by King and Schrader (1963), this implies that other uses have first claim on feed supplies and may bias equilibrium feedlot location toward feed source. Concentrate availability is summarized in Table 4.

TABLE 4.
Regional Availability of Feed Concentrates Expressed in '000 Mcal
(For the year beginning "fall 1987")

Region	Available for all livestock	Fed to livestock other than beef cattle	Available to feed cattle
1	7,274,340	2,203,011	5,071,329
2	4,268,790	1,608,860	2,659,930
3	2,887,737	3,697,943	(810,205)
4	19,551,965	11,031,999	8,519,966
5	24,590,131	7,110,619	17,479,512
6	7,595,824	2,180,205	5,415,619
7	2,821,246	15,082,020	(12,260,774)
TOTAL	68,990,034	42,914,657	26,075,377

Note: Based on notation in King and Schrader 1963, 341.

2.3.2.3 Roughages

Regional amounts of roughages are determined in much the same way as the concentrates. Calculation is simpler since roughages do not have the same number of alternative uses as do concentrates, (for example industrial

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11 Mcal refers to million calories of net energy with the values specific for feeder cattle.

12 Feeding rates for livestock for both concentrates and roughages were required to calculate amounts "Fed to livestock other than beef cattle". These rates, along with concentrate and roughage data methodology are included in Appendix A.

and food uses do not apply to roughages).[13]

Included in the roughage category are silages. The high moisture content of these feeds translates to expensive per unit (1000Mcal net energy per tonne as fed) shipping costs and precludes interregional shipments. As a result, they are allowed as feed in region of origin only.

TABLE 5.
Regional Availability of Feed Roughages Expressed in '000 Mcal (For the year beginning "fall 1987")

Region	Available for all livestock	Fed to livestock other than feeder cattle	Available to feed cattle
1	4,902,603	1,259,474	3,643,130
2	2,123,767	761,639	1,362,128
3	4,821,408	2,337,428	2,483,980
4	8,275,305	4,572,020	3,703,285
5	12,248,749	4,323,080	7,925,669
6	5,914,152	1,946,060	3,968,092
7	9,416,392	4,915,581	4,500,811
Total	47,702,376	20,115,282	27,587,094

Note: Based on notation in King and Schrader 1963, 341.

2.3.3 Intermediate Product Cost

Feeder cattle and feed costs amount to approximately 85 percent of feedlot production costs with non-feed costs being a portion of the other 15 percent (Barkema and Drabenstott 1990, 59). As such, cost of the intermediate products of feeder cattle and concentrates are included in the mathematical model in their own column.[14] Separation of feeder and feed costs allows assessment of various policy scenarios that may affect the cattle sector through

13 The roughages included are not an exhaustive list. There are possibly other regional specific feeds that are used in the feedlot (sugar beet tops in southern Alberta) and these could be included for sake of completeness.

14 Roughage costs are not isolated in this study. The assumption is, consequently, that roughage costs are the same in U.S. and Alberta regions. Actual average hay prices in 1988 were about 50 percent higher in the U.S. than in Alberta (*USDA ERS FDS-318*, May 1991 and *Alberta Agriculture, Agriculture Statistics Yearbook - 1988)*. Had roughage costs been isolated, they would have helped to skew cattle feeding toward Alberta regions.

costs of these inputs. The particular concern here is with impending changes to the Crow rate on statutory grains for export. It is assumed by some (Alberta Agriculture 1990: Freedom To Choose) that removal of (or alterations to) the Crow will lead to reduced feed grain prices in western Canada as export markets for prairie grains shrink. This should stimulate the livestock sector through lower input costs. Analysis of effects of differing concentrate costs on optimum feeding location is undertaken in chapter 4.

Alberta feeder cattle and concentrate cost data for 1988 were taken from (Canfax 1988).[15] Average cost for a 650 lb steer in Alberta was $637.00. Concentrate cost in Alberta uses barley price as a proxy. Price in June 1988 at the feedlot for barley was (approximately) $90.00/tonne in southern Alberta and $85/tonne in northern Alberta. The Crow benefit offset payment in 1988 was $13/tonne. The base model, therefore, (section 4.2.1) uses barley price of $77/tonne and $72/tonne in the two Alberta regions.

U.S. costs for corn in 1988 are from (USDA 1990 Nov., 38). Corn #2 yellow, Central Illinois was $3.16 CDN/bu or $124.40/tonne. Feeder costs are from (USDA 1989 Feb., 22). Average price in 1988 for 600-700 lb feeder steers in Kansas City was $618.00CDN. Table 6 indicates these costs with feeder costs per lb and Alberta concentrate cost being approximate.

Table 6.
Intermediate Product Cost

	Alberta	U.S.
Feeders	$.98/lb	$1.03/lb
Concentrates	$75.00/t	124.00/t

Source: Data from references.

2.3.4 Production Process

2.3.4.1 Feed Conversion

The production process for feeders has been simplified relative to the King and Schrader study. Alternate production processes are not allowed, nor is input substitution. The following assumptions were made: Feeder animals in Alberta reach the feedlot at 295 kg (650 lbs) and are sold at 480 kg (1050 lbs). In the U.S. they go on feed at 275 kg (600 lbs) and are slaughtered at

15 The Canfax Trends West costing model has cost of gain date for feeder cattle.

500 kg (1100 lbs). The distinction is due primarily to U.S. feedlot operators feeding animals for a different grading system than Alberta feedlot operators.

In this study, model assumptions dictate that the feeder animal requires 14.5 Mcal per day of Net energy.[16] With an assumed concentrate to roughage ratio of 80/20, 11.6 Mcal per day must come from concentrates and 2.9 Mcal per day will come from the roughages. Multiplying these feed amounts by appropriate length of stay gives feed consumption per animal per feeding period.

According to USDA (1988), U.S. feeders are on feed for 180 days. With gain per period at 500 lbs this is 2.8 lbs gain per day. In Alberta, (Canfax 1988) assumes yearling feeders are on feed for 143 days (average stay for heifers and steers). At 400 lbs gain per period this is also 2.8 lbs gain per day.

The fixed production function in general form is:

$$V_{il} = f(W^i, Y^i, Z^i)$$

With the assumptions stated above this works out to be for Alberta regions;

$$480 kg V_{il} = 295 kg W^i + 1659 Mcal Y^i + 415 Mcal Z^i$$

Assuming a dressing percentage from live to carcass to boxed in Alberta of (.585)(.65)[17] = .380, gives;

$$182.4 kg V_{il} = 295 kg W^i + 1659 Mcal Y^i + 415 Mcal Z^i$$

Standardizing this to 1000 lbs of beef we obtain, for Alberta;

$$1000 lbs V_{il} = 2.49 W^i + 4131 Mcal Y^i + 1033 Mcal Z^i$$

16 As mentioned in the conclusion (section 5.1), the assumption that U.S. feeders and Alberta feeders have the same energy requirements is not entirely correct. U.S. feeders are fed to a heavier weight and they require more energy per day for that reason. This is an area where further work could improve specification of the production process.

17 The dressing percentages; (.585)(.65) for Alberta and (.63)(.755) for U.S. regions were obtained from, respectively, Cargill personnel at High River and USDA *Livestock and Poultry Situation and Outlook Report*. Aug 1990, 30-31.

For U.S. regions 3 thru 7, the production function is;

$$500kgV_{il} = 275kgW^{i} + 2088McalY^{i} + 522McalZ^{i}$$

Assuming a dressing percentage from live to carcass to boxed in U.S. regions of (.63)(.755) = .476, we get;

$$238.0kgV_{il} = 275kgW^{i} + 2088McalY^{i} + 522McalZ^{i}$$

Standardizing this to 1000 lbs of beef we obtain, for the U.S.;

$$1000\,lbsV_{il} = 1.91W^{i} + 3988McalY^{i} + 997McalZ^{i}$$

The main difference between Alberta and U.S. production functions is in the dressing percentages. Animals in Alberta are trimmed leaner than in the U.S. to reflect differences in consumer tastes. This results in considerably more feeder required (2.49) in Alberta than in the U.S. (1.91) to produce 1000 lbs of boxed beef.

2.3.4.2 Non-feed and Processing Costs

In this study, non-feed costs and processing costs are calculated on a per unit basis (1000 lbs boxed beef) and entered in the linear programming framework as the objective row value for the fed beef production activity. Non-feed costs in Alberta and U.S. regions are feedlot costs that include similar entries such as: vet and medicine, livestock hauling, marketing charges, death loss and overhead. Processing costs are packing plant slaughter costs only; fabrication costs were not identified and consequently are assumed identical between Alberta and U.S. regions. Processing costs are from a 1984 study (Dawson Dau, 1984) and reflect 1983 data. They can, however, be taken to reflect 1988 processing costs since the ratio between Alberta and U.S. processing costs varied little between 1983 and 1988 (Gietz 1991).

NON-FEED COSTS:
For Alberta, non-feed costs are derived from (Canfax 1988) where the average non-feed costs for 1988 for steers and heifers in at 650lbs, out at 1050lbs and on feed for approximately 143 days is $101.55/feeder/period. In Alberta it takes 2.49 feeders to produce 1000lbs of boxed beef. Non-feed costs for Alberta regions, therefore, are $101.55(2.49) = $252.86/1000lbs boxed beef produced.

US non-feed cost data is from (USDA 1989 LPS-35, 56). For animals in at 600lbs, out at 1100lbs, and on feed for 180 days, non-feed costs are given as $10.21/cwt of liveweight sold. Assuming slaughter weight of 1100 lbs leads to $10.21(11) = $112.31(US)/feeder/period. Converting to Canadian currency, \$112.31(1.2309) = \$138.24/animal/period. In the U.S., 1.91 feeders are required to produce 1000 lbs of boxed beef. U.S. non-feed costs then are taken to be \$138.24(1.91) = \$264.04(CDN)/1000lbs boxed beef produced.

The longer feeding period in the U.S. leads to higher non-feed costs than in Alberta. This difference has been reduced somewhat by the smaller amount of feeder needed to produce 1000 lbs of boxed beef in the U.S.

PROCESSING COSTS:
Processing costs in Alberta are biased upwards by labor costs that are higher than in the U.S. Costs of labor for processing are documented by Dawson Dau (1984). They claim that the major share of the difference between Alberta and U.S. processing costs is due to wages and salaries. The Dawson Dau study has processing costs for comparable size U.S. and Alberta plants (90 head per hour), and for a larger U.S. plant (300 head per hour). In this study the Alberta processing costs are compared with the similar size U.S. plant. Costs are indicated in Table 7.

Table 7.
Non-Feed/Processing Costs per 1000lbs Boxed Beef

Costs/1000lbs boxed beef	Alberta	U.S.
Non-feed	252.86	264.04
Processing	75.37	52.43
Total	328.23	316.47

Source: Data from references.

2.3.5 Transfer Costs

All transfer costs were derived with the help of Alberta Agriculture staff, the Trimac Trucking Model (TTM), and industry quotes. While such rates cannot be assured accurate they are thought to be representative and to be proportionally correct. Rates assume one way hauls only, no backhauls are included. Description of individual interregional product rates follows.

BEEF:
Rates for beef shipments contain the following assumptions: Trucks carry 45000 lbs of boxed beef except for shipments within Alberta where an industry quote indicated 48000 lbs. The procedure was to take the rate per mile/truck

obtained from TTM, multiplied by shipment mileage to get cost of truck load from region i to region j. This amount was divided by 45 or 48 to get cost per 1000lb unit of boxed beef.

FEEDERS:
Feeder rates are again derived from the TTM combined with several industry quotes (Alberta and U.S.) to give rates per mile/truck. This rate is multiplied by shipment mileage and divided by 70[18] (average number of 600-700lb feeders in a possum bellied livestock carrier) to get a rate per unit (1 feeder) of feeder cattle.

CONCENTRATES:
Rates used for concentrate shipments were boxed beef rates less 2-5 cents per mile depending on length of haul. Short hauls take off less per mile than longer hauls. This rate multiplied by mileage gives a total truck cost. Total truck cost is divided by 30 (on average 30,000 Mcal of concentrates on 45000lb load) to get cost per unit (1000Mcal) of shipping concentrate.

ROUGHAGES:
Roughage shipments are assumed not to cross the international border. Therefore we have Alberta rates and U.S. rates. Silage is assumed not hauled out of the region. Industry sources indicated 17 tonnes of roughage could be hauled on a flatbed truck. No industry quotes were available for rates so the TTM was used to estimate rates. The estimating procedure was to take rate per mile per truck multiplied by trip mileage divided by 14.3 (on average 14,300 Mcal of roughage on a 17 tonne load) to get the rate per 1000 Mcal unit of roughage. The U.S. rates are derived from Alberta rates.

Distances used in calculating transfer costs are from regional central points. Mileages between central points are shown in Table 8 in miles. Tables 8a through 8d indicate transfer costs for boxed beef, feeders, concentrates and roughages.

18 The number of feeders per truck were obtained from an industry quote (Rouget 1991).

TABLE 8.
Distance in Miles Between Regional Central Points

	1	2	3	4	5	6	7
1							
2	180						
3	600	435					
4	960	780	515				
5	1005	860	850	790			
6	1275	1100	1100	690	390		
7	1500	1320	935	540	1170	960	
Van	740	600	385				
Tor	2090	2110					
NY				2355	1690	1780	n/a

Source: Mileages are from Alberta Agriculture, Transportation Section.

Table 8a.
Beef Transfer Costs/1000lbs Boxed Beef

	1	2	3	4	5	6	7
1	1.90		22.25	35.11	34.68	44.41	48.08
2	5.86	1.90	17.26	27.84	30.61	37.85	42.73
3	21.89	16.72	1.90				
4	34.60	27.65	17.17	1.90			
5	35.80	31.36	28.33	26.33	1.90		
6	45.69	39.16	29.33	23.00	15.60	1.90	
7	48.90	43.33	31.17	18.00	31.20	32.00	1.90
Van	24.07	19.75	14.11				
Tor	78.38	79.13					
NY				62.67	45.07	47.47	n/a

Source: Rates derived from the Trimac Trucking Model, industry quotes, and Alberta Agriculture staff.

Table 8b.
Feeder Transfer Costs/Animal

	1	2	3	4	5	6	7
1	0.00		23.83	39.75	39.44	53.18	59.43
2	5.73	0.00	12.22	27.84	36.52	41.61	55.45
3	24.50	20.45	0.00				
4	40.62	28.97	16.19	0.00			
5	41.68	38.11	34.61	32.16	0.00		
6	55.54	44.17	44.79	28.09	12.26	0.00	
7	61.24	56.76	38.27	16.97	47.64	39.09	0.00

Source: Rates derived from the Trimac Trucking Model, industry quotes, and Alberta Agriculture staff.

Table 8c.
Feed Concentrate Transfer Costs/1000Mcal

	1	2	3	4	5	6	7
1	0.00		32.66	51.29	50.61	64.79	69.29
2	9.26	0.00	25.51	40.73	44.91	55.45	62.30
3	*	*	0.00				
4	*	*	25.41	0.00			
5	*	*	41.65	38.71	0.00		
6	*	*	42.53	34.04	23.14	0.00	
7	*	*	45.82	26.64	45.63	46.72	0.00

Source: Rates derived from the Trimac Trucking Model, industry quotes, and Alberta Agriculture staff.
* Barley shipments are not permitted to cross the international border to comply with CWB export regulations.

Table 8d.
Feed Roughage Transfer Costs/1000Mcal

	1	2	3	4	5	6	7
1	0.00						
2	24.80	0.00					
3	*	*	0.00				
4	*	*	54.02	0.00			
5	*	*	89.16	82.87	0.00		
6	*	*	115.39	72.38	40.91	0.00	
7	*	*	98.08	56.64	122.73	100.70	0.00

Source: Rates derived from the Trimac Trucking Model, industry quotes, and Alberta Agriculture staff.
* Roughages are not permitted to cross the international border.

2.3.6 Regional Beef Demand

July 1, 1988 regional population and 1988 annual per capita beef consumption data are used as a proxy for beef demand. For the US, per capita consumption in 1988 was 102.3lbs carcass weight or 77.2lbs of boxed beef.

Total beef demanded per region is per capita consumption multiplied by regional population. Assuming the above per capita consumption of boxed beef for the U.S. and Canada, regional beef demand is indicated in Table 9.

Table 9.
Regional Beef Demand for 1988

Region	Population July1/88	Per capita Consumption (lbs)	Rgn'l Dmnd for Boxed Beef (lbs)
1	1,376,000	77	105,952,000
2	1,019,000	77	78,463,000
3	7,415,000	77	570,955,000
4	1,808,000	77	139,216,000
5	1,859,000	77	143,143,000
6	4,991,000	77	384,307,000
7	29,368,000	77	2,261,336,000
Total	47,836,000		3,683,372,000

Source: Alberta population data are from *Alberta Statistical Review Q1 1990*, and U.S. population data are from *Statistical Abstract of the U.S. 1989.* Per capita consumption data are from Agriculture Canada: *Handbook of Food Expenditures, Prices and Consumption 1990, 282.*

2.3.7 Beef Other Than Fed

Non-fed beef for 1988 includes beef from cull dairy animals, beef cows and heifers, bulls, calves and other cattle as well as imports of beef. For the US regions, sources used were USDA (1989, Cattle) and USDA (1989, Agricultural Statistics). The process for determination of the non-fed beef supply variable involved subtracting regional fed cattle marketed from total marketings as indicated in USDA (1989, Agricultural Statistics, Table 399). This number plus calves marketed per region plus imports of meat equals the supply variable. Meat imports for U.S. regions was per capita imported meat consumption multiplied by regional population.[19] Non-fed cattle marketed were converted to lbs of boxed beef by multiplying by average U.S. live weight of 1125lbs and then by the dressing percentage of (.63)(.755). For U.S. calves the conversions used were 251lbs and (.56)(.755).[20]

For Alberta regions, total slaughter numbers of cattle and calves are taken from Alberta Agriculture (1989, Agriculture Statistics Yearbook). Fed cattle slaughter of steers and heifers was subtracted from total slaughter numbers to leave a difference of 170,407 animals which was taken as non-fed beef. For Alberta an average live weight of 1150lbs for cattle and 418.8lbs for calves was used. Dressing percentages used for Alberta cattle was (.585)(.65) and for Alberta calves (.52)(.65).

Alberta imported 1,925 tonnes of beef in 1988 (1.77lbs per capita). These amounts of non-fed beef are apportioned among Alberta regions according to shares of regional slaughter. The regional supply of non-fed beef is indicated in Table 10.

Table 10.
Regional Non-Fed Beef Supplies for 1988

Region	Non-fed cattle marketed (#)	Calves marketed (#)	Meat Imports (lbs)	Non-fed beef (lbs)
1	60,068	2,230	2,435,520	29,018,364
2	110,339	4,096	1,803,630	50,633,110
3	309,200	252,000	72,518,700	264,716,498
4	914,600	935,000	17,682,240	606,315,234
5	1,869,200	1,081,000	18,181,020	1,133,120,369
6	539,200	231,000	48,811,980	361,855,637
7	1,006,100	398,000	287,219,040	867,826,313
Total	4,808,707	2,903,326	448,652,130	3,313,485,525

Source: Study results.

19 Per capita imported meat consumption was 9.78lbs (total U.S. beef imports multiplied by U.S. population).

20 These live weights are from (USDA 1989, Agricultural Statistics). The cattle slaughter weight of 1125 lbs is heavier than fed cattle slaughter weight presumably because bulls, dairy animals, etc. are included.

Table 11 shows beef demanded per region and supplied by fed[21] and non-fed sources. The surplus must be shipped outside the regions to enable demand supply equilibrium. This results in the addition of export points in the model, Vancouver, Toronto, and New York. These points are demand centers only, they contribute no supply.

Table 11.
Equilibrium Beef Market for 1988

Region	Beef demanded ('000 lbs)	Fed beef produced ('000 lbs)	Nonfed beef available ('000 lbs)	surplus/ (deficit) ('000 lbs)
1	105,952	280,123	29,018	203,189
2	78,463	274,812	50,633	246,982
3	570,955	380,220	264,716	73,981
4	139,216	459,697	606,315	926,796
5	143,143	491,404	1,133,120	1,481,381
6	384,307	1,275,441	361,856	1,252,990
7	2,261,336	495,275	867,826	(898,235)
Total	3,683,372	3,656,972	3,313,484	3,287,084

Source: Study results.

21 Total fed beef produced in Table 11 assumes all feeders are fed and slaughtered in their respective home regions. This is a type of "status quo" fed beef production. If all feeders were shipped to U.S. regions for feeding, total fed beef produced would be 7319008/1.91 = 3,831,941,000 lbs. If all beef was produced in Alberta there would be 7319008/2.49 = 2,939,360,000 lbs.

3 MODEL VARIATIONS AND RESULTS

3.1 Introduction

Five variations of the model are used to illustrate cattle feeding allocations.[22] Models differ from each other by barley cost, exchange rate used, export destination allowed, and by proportion of fed-beef consumption required per region. Barley cost is $72-$77/tonne in the base model and models 3, 4 and 5. In model 2 (with removal of the Alberta Crow Benefit Offset Payment), barley price is $85-$90/tonne. In both cases the lower price is in region 1 and the higher price is in region 2. The barley cost difference between the base model and model 2 is intended to simulate effects of Crow Benefit rate removal on optimum location of cattle feeding. Crow rate removal would lower grain prices in Alberta and make cattle feeding more cost effective.

In model 5 a distinction is made between fed and non-fed beef. Forcing consumption to be one-half fed beef was attempted since an optimum allocation without this restriction may leave some regions consuming no fed beef and others with no non-fed beef. That would be unrealistic. The restriction was accomplished by two distinct runs of the model. One run was with regional demand halved and intermediate products and the production function removed from the model. The result was a simple transportation model that gave the optimum allocation of non-fed beef. The second run again halved regional demand but this time it removed availability of non-fed beef.

Beef shipments from Alberta to the U.S. experience resistance at border crossings. USDA inspectors use several methods to slow down shipments. U.S. inspectors discover bone fragments, grease, hair or bruises on the product that Canadian inspectors cannot detect. Determining per unit cost of this harassment is arbitrary but some indicators are available. One rejection at the border requires inspection of the following 15 shipments, and each inspection costs the packer at least $450 (The Edmonton Journal, Saturday, June 9, 1990. D8). Some Alberta beef processors have stopped beef shipments to the U.S. altogether, and one Alberta processor indicated that "we are basically out of business in the U.S." (Alberta Agriculture Trade Policy Secretariat staff). In this study the cost is accounted for by doubling transportation rates on beef shipments from Alberta to the U.S. regions.

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22 Actual 1988 regional marketings for Alberta are Alberta slaughter cattle marketings plus B.C. and Saskatchewan exports to Alberta of slaughter cattle. The data is from Alberta Agriculture Statistics Yearbook, Alberta and B.C. Brand Inspection data and the Sask Cattle Marketing Report. They are apportioned according to a chart in (Alberta Agriculture 1990). Actual marketings for U.S. regions are from (USDA 1989. Cattle, Final Estimates, 37-40).

The inclusion of "X" in Tables 13 through 17 refers to the two export regions used, Toronto and New York. Regions 1 and 2 can export to Toronto and regions 4, 5 and 6 can export to New York. Region 3 can export a limited amount to Vancouver ("V" in the Tables) as can the two Alberta regions. Region 7 does not export because it is a beef deficit area (see Table 11). Export regions are included since the model requires demand to equal supply and there is excess supply of boxed beef if all or even most feeder cattle are fed and marketed.

Demand at "X" is set high enough to force the model to feed nearly all feeders. Further, demand at "X" assumes all feeders are fed and marketed in the region of their availability. This is an arbitrary setting since, for example, if all U.S. feeders were shipped to Alberta regions where more animals are required to produce a given amount of beef (1.91 in the U.S. and 2.49 in Alberta), it would not be possible to satisfy the demand at "X". In the present case, however, there are enough surplus feeders in the model that this in not a major concern.

The possibility for interregional roughage shipment was allowed for but under no circumstances did roughage move across regional borders. The cost per unit of energy to ship these bulky products apparently precludes long shipments.

3.1.1 Grading Issues

Alberta beef is given a 20 percent price premium over U.S. beef. This was done to simulate a consumer preference for Alberta lean beef over the heavier U.S. product. In the U.S. there is currently a 12 cent per pound price premium (Canadian Meat Council 1990) for Choice beef over Select beef. Select beef is comparable to Alberta lean beef. In Canada this preference is reversed with the price premium going to the leaner Alberta product.

The price premium in Canada for Grade A1, A2 over the heavier A3 is approximately 10 percent (Agriculture Canada 1988). In this study, the 10 percent price premium is used, plus an extra 10 percent to account for intangible factors such as Canadian consumer allegiance to Canadian grading standards with which they are familiar.

No-roll beef, an ungraded U.S. product comparable to U.S. Select, is competing with Alberta lean beef in the eastern Canadian market where grade labelling is not mandatory. This product is popular with wholesalers since it is comparable with the leaner U.S. Select but less expensive. Canadian meat packers, on the other hand, consider the no-roll product to be inferior and of inconsistent quality. If no-roll is inferior, this is added justification for the price premium on Alberta lean beef.

Worldwide the trend is toward leaner meat although at this time it appears to be a niche market. The Japanese are said to prefer a leaner alternative to U.S.D.A. Choice beef (Canadian Meat Council 1990, 23) and results of this study indicate Alberta is in good position to exploit this market.[23] [24] Current consumer trends in the U.S. also indicate a move towards leaner more convenient beef products (Barkema and Drabenstott 1990).

The price premium is made operational by reducing quantities of intermediate product required to produce one unit (1000 lbs) of boxed beef in Alberta. The 20 percent price premium leads to intermediate products being reduced by a factor of: (1/1.20) = .833. This is essentially indicating that a smaller quantity of Alberta beef is equivalent in value to a larger quantity of U.S. beef.

3.2 Results

This section provides results of the various models and sensitivity analysis of relevant variables. At the end of the section is a table (Table 18) that provides a summary of results for the two Alberta regions.

3.2.1 Model 1

Model 1 is the base model. It is intended to duplicate the actual supply and disposition of Alberta beef in 1988. It has barley cost at $72/tonne in region 1 and $77/tonne in region 2.[25] Table 12 indicates differences between actual and Model 1 supply and disposition.

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23 See Model 3 where Alberta regions 1 and 2 ship 736 million pounds of beef to Vancouver for export.

24 A major benefit of the proposed reciprocal grading is that it would allow Alberta packers to compete head to head with U.S. packers for a larger share of the Japanese markets where U.S.D.A. grades are currently recognized by Japanese cattle buyers.

25 Barley price at the feedlot in Alberta in 1988 varied from $64/tonne early in the year to $120/tonne in the winter months with northern Alberta feedlots paying $5/tonne less (Alberta Agriculture Market Analysis staff). An average of $90/tonne was selected for region 2 and the $13/tonne Crow benefit offset payment was applied, resulting in the $72-$77 price range.

Table 12.
Actual and Model 1 1988 Beef Supply and Disposition

	Actual S & D Mln lbs	Model 1 S & D Mln lbs
Alta Production	798	750
Alta Consumption	220	184
Exports to BC	116	150
Exports to E. Can	416	402
Exports to US	46	14

Source: Alberta Agriculture, Statistics Branch publications and model results.

Looking at Table 13, the number of cattle marketed in this model (ie. 993 thousand in region 1) is related to production of fed beef by the coefficients in the production function. Region 1 produced 479 million pounds of fed beef. At 2.074 feeders/1000 pounds boxed beef this is 993 thousand feeders. Number of cattle marketed in Alberta in model 1 are greater than actual marketings by about 300,000 head. This is due partly to exports of slaughter weight cattle (216,000 in 1988) and partly to differences between coefficients in the actual and model production functions.

Results of the base model indicate more cattle being fed and processed in northern Alberta (Red Deer and north) than in southern Alberta. This is reverse to actual and would be attributable to quantities of resources available there as well as lower transport costs to key export points. For example, per unit shipping costs to Toronto are less from region 1 than from region 2 (see Table 8a). This would skew Alberta production to the north with exports to Toronto originating there.[26]

Non-fed beef production in Table 13 represents predetermined regional supply of dairy culls, imports of manufacturing beef etc. Total regional production is fed plus non-fed beef. Predetermined regional demand is subtracted from total production to arrive at regional surplus/deficits with deficits indicated by brackets.

Model equilibrium is accomplished by shipments of inputs and boxed beef from surplus to deficit regions. These movements are indicated in the lower portion of Table 13.

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26 In reality, economies of size and infrastructure in southern Alberta preclude the Alberta feeding allocation indicated by the base model. In the near future, northern Alberta will not likely feed and process more cattle than southern Alberta.

Region 1 supplies itself and eastern Canada while region 2 supplies itself, ships limited amounts to region 3, and supplies total demand at Vancouver. Region 3 and 7 ship 1,444 thousand feeders to region 4 for feeding. Table 13 also indicates that region 4 ships concentrate to regions 3 and 7 which are deficit in concentrate (see Table 4).

Sensitivity analysis indicates that if barley cost in region 1 dropped by 3 percent barley use would increase by 15 percent. At that point region 1 would begin shipping boxed beef to region 2. In region 2, if barley price dropped by 1 percent, barley use would increase by 75 percent and region 2 would begin exporting boxed beef.

Non-feed/processing costs in the two Alberta regions show sensitivity similar to barley cost with a 1 percent decline in these costs in region 1 leading to a 15 percent increase in region 1 fed beef production. A 1 percent decline in non-feed/processing costs in region 2 results in a 75 percent increase in fed beef production in the region. This result emphasizes the sensitivity of the southern Alberta cattle sector to economies of size. Size increases in the Alberta cattle industry would lower non-feed/processing costs and dramatically (according to this model) improve competitiveness of Alberta's cattle industry.

Table 13.
Model 1 Beef Production and Product Shipments

Region	Actual Cattle Mktd	Model 1 Cattle Mktd	FedBeef Prod'n	NonFed Beef Prod'n	Total Prod'n	Beef Demand	Surplus
	Ths hd	Ths hd	Mlnlbs	Mlnlbs	Mlnlbs	Mlnlbs	Mlnlbs
1	440	993	479	29	508	106	402
2	660	398	192	51	243	78	165
3	728			265	265	571	(306)
4	825	2,323	1,216	606	1,822	139	1,683
5	945	940	492	1,133	1,625	143	1,482
6	2,501	2,439	1,277	362	1,639	384	1,255
7	904			867	867	2,261	(1,394)
V						150	(150)
X						3,137	(3,137)
Total	7,003	7,093	3,656	3,313	6,969	6,969	0

Products From Region:	Beef To Region	ALL Beef Q	Feeders To Region	Feeders Q	Conc. To Region	Conc Q
		Mlnlbs		Ths hd		Mln Mcal
1	1	106				
	X	402				
2	2	78	1	291		
	3	14				
	V	150				
3	3	265	4	727		
4	3	292			3	506
	4	136			7	8,106
	7	1,394				
5	5	143				
	X	1,482				
6	6	384				
	X	1,254				
7	7	867	4	717		

Source: Derived from LP model 1 solution.

3.2.2 Model 2

In model 2, barley cost is raised by $13/tonne (amount of 1988 Alberta Crow Benefit Offset Payment) to $85/tonne in region 1 and $90/tonne in region 2. This is done to simulate the effect of Crow Benefit grain rates on Alberta livestock producers. Existence of the Crow Benefit opens potential export markets for prairie grains and increases domestic market price for Board grains by up to $26 per tonne (Alberta Agriculture 1990: Freedom To Choose). This model imitates the 1988 situation if Crow Benefit monies were disbursed via the pay the railways approach and the ACBOP was not made.

Table 14 indicates results. Fed beef production in Alberta decreases to 338 million pounds from 671 million pounds. Southern Alberta (Region 2) experienced the most decline as beef feeding disappears altogether. All southern Alberta feeders are shipped south to U.S. feedlots. Exports to eastern Canada decline to 84 million pounds from 402 million pounds, and exports to region 3 (Washington-Oregon) cease. Alberta maintains the Vancouver market with most beef originating in region 1 (99 million pounds).

This model is also very sensitive to changes in the cost of barley. In region 1 a decrease of 8 percent in barley price would result in a 95 percent increase in barley use as region 1 increases feeding. At that point region 1 would begin importing feeders from region 2. In region 2, a 4 percent decline in non-feed/processing costs would initiate feeding in southern Alberta as fed beef production increased to 99 million pounds.

Table 14
Model 2 Beef Production and Product Shipments

Region	Actual Cattle Mktd	Model 2 Cattle Mktd	FedBeef Prod'n	NonFed Beef Prod'n	Total Prod'n	Beef Demand	Surplus
	Ths hd	Ths hd	Mlnlbs	Mlnlbs	Mlnlbs	Mlnlbs	Mlnlbs
1	440	701	338	29	367	106	261
2	660	0	0	51	51	78	(27)
3	728			265	265	571	(306)
4	825	2,351	1,231	606	1,837	139	1,698
5	945	1,547	810	1,133	1,943	143	1,800
6	2,501	2,439	1,277	362	1,639	384	1,255
7	904			867	867	2,261	(1,394)
V						150	(150)
X						3,137	(3,137)
Total	7,003	7,038	3,656	3,313	6,969	6,969	0

Products From Region:	Beef To Region	ALL Beef Q	Feeders To Region	Feeders Q	Conc. To Region	Conc Q
		Mlnlbs		Ths hd		Mln Mcal
1	1	106				
	2	78				
	V	99				
	X	84				
2	V	51	4	126		
			5	562		
3	3	265	4	727		
4	3	306			3	506
	4	136			7	8,106
	7	1,394				
5	5	143				
	X	1,800				
6	6	384				
	X	1,254				
7	7	867	4	607		

Source: Derived from LP model 2 solution.

3.2.3 Model 3

In model 3 , the fixed demand at Vancouver was increased from 150 million pounds to 1,000 million pounds. This was done to explore Alberta's position had there been a substantial export market to Japan. The results are not surprising given comparative distances between Alberta and major U.S. feeding regions to Vancouver. Alberta dominates the export market to the Pacific Rim as indicated in Table 15. Regions 1 and 2 export 736 million pounds of boxed beef to Vancouver with southern Alberta benefitting the most.

Exports to the Pacific Rim are at the expense of eastern Canada as specification of the Japanese market alters total Alberta production but does not diminish it. Shipments of beef east from Alberta disappear under this scenario. Presumably, the eastern Canadian market would be supplied by eastern and midwest U.S. regions that are closer.

Region 3 supplies the remaining Vancouver demand of 265 million pounds. If a Pacific coast U.S. export point were included, however, results may be different as relative distances from Alberta and U.S. regions to the export point changed. Region 4 in particular would be able to export through Washington or California to the Pacific Rim.

Sensitivity analysis on this model indicates that a 1 percent decrease in non-feed/processing costs in region 2 would increase production by over 20 percent. At that point region 2 begins importing feeders from the U.S.
A 1 percent decrease in barley cost in region 2 has a similar effect as barley use would increase by over 20 percent with feeders again imported from the U.S.

Table 15
Model 3 Beef Production and Product Shipments

Region	Actual Cattle Mktd	Model 3 Cattle Mktd	FedBeef Prod'n	NonFed Beef Prod'n	Total Prod'n	Beef Demand	Surplus
	Ths hd	Ths hd	Mlnlbs	Mlnlbs	Mlnlbs	Mlnlbs	Mlnlbs
1	440	701	338	29	367	106	261
2	660	689	332	51	383	78	305
3	728			265	265	571	(306)
4	825	2,324	1,217	606	1,823	139	1,684
5	945	940	492	1,133	1,625	143	1,482
6	2,501	2,439	1,277	362	1,639	384	1,255
7	904			867	867	2,261	(1,394)
V						1,000	(1,000)
X						2,287	(2,287)
Total	7,003	7,093	3,656	3,313	6,969	6,969	0

Products From Region:	Beef To Region	FED Beef Q	Feeders To Region	Feeders Q	Conc. To Region	Conc Q
		Mlnlbs		Ths hd		Mln Mcal
1	1	15				
	V	353				
2	V	383				
3	V	265	4	727		
4	3	292			3	506
	4	136			7	8,106
	7	1,394				
5	1	91				
	2	78				
	5	143				
	X	1,312				
6	3	279				
	6	384				
	X	975				
7	7	867	4	717		

Source: Derived from LP model 3 solution.

3.2.4 Model 4

In this model, a 10 percent depreciation of the Canadian dollar is hypothesized. The depreciation is introduced to the model by increasing all costs of U.S. origin by 10 percent. Alberta cattle feeders would pay more for U.S. intermediate products brought into Alberta but fed beef production in Alberta would be relatively less expensive. Other than depreciation, model 4 is equivalent to the base model.

As Table 16 indicates, depreciation of the Canadian dollar increased Alberta fed beef production to 962 million pounds from 671 million pounds in the base model. Southern Alberta (region 2) fed 1,004 thousand cattle as opposed to 398 thousand cattle fed in southern Alberta in base model 1. Southern Alberta imports an additional 659 thousand feeders from region 3 as it's own feeders move north to region 1.

Apparently, the advantage southern Alberta producers realized due to relatively lower production costs than U.S. regions outweighs the increased cost of importing the feeders. This enables them to import resources and export value added products as region 2 ships 306 million pounds of boxed beef back to region 3.

In this model if non-feed/processing costs in region 2 declined by 1 percent, fed beef production would increase by 30 percent and region 2 would begin shipping beef to eastern Canada. The same outcome would result if barley cost in region 2 fell by 1 percent.

Table 16
Model 4 Beef Production and Product Shipments

Region	Actual Cattle Mktd	Model 4 Cattle Mktd	FedBeef Prod'n	NonFed Beef Prod'n	Total Prod'n	Beef Demand	Surplus
	Ths hd	Ths hd	Mlnlbs	Mlnlbs	Mlnlbs	Mlnlbs	Mlnlbs
1	440	991	478	29	507	106	401
2	660	1,004	484	51	535	78	457
3	728			265	265	571	(306)
4	825	1,767	925	606	1,531	139	1,392
5	945	940	492	1,133	1,625	143	1,482
6	2,501	2,439	1,277	362	1,639	384	1,255
7	904			867	867	2,261	(1,394)
V						150	(150)
X						3,137	(3,137)
Total	7,003	7,141	3,656	3,313	6,969	6,969	0

Products From Region:	Beef To Region	ALL Beef Q	Feeders To Region	Feeders Q	Conc. To Region	Conc Q
		Mlnlbs		Ths hd		Mln Mcal
1	1	106				
	X	402				
2	2	78	1	291		
	3	306				
	V	150				
3	3	265	2	659		
4	4	139			3	506
	7	1,394			7	8,106
5	5	143				
	X	1,482				
6	6	384				
	X	1,254				
7	7	867	4	891		

Source: Derived from LP model 4 solution.

3.2.5 Model 5

Model 5 makes a distinction between fed and non-fed beef. This is done to force regional consumption to be one-half fed beef and one-half non-fed beef. Since intraregional shipping is always lower cost than interregional shipping, regional consumption is always met first by internal supplies of beef. In some cases this may be all non-fed beef. Model 5 makes the distinction to ensure each region consumes some fed beef.

Total Alberta fed beef production of 671 million pounds in this model is the same as in the base model. Region 1 consumes 53 million pounds of fed beef and region 2 consumes 39 million pounds of fed beef. Region 2 ships 24 million pounds of non-fed (manufacturing) beef to region 1 and 267 million pounds of fed beef to the Washington-Oregon area (region 3).

Location of fed beef production in this model can be compared to base model location with the only distinction between model specification being quality of beef consumed. The present specification is more realistic than in the base model where quality of meat consumed is not known. Fed beef production is more evenly distributed between Alberta regions in this model than in the base model although total production is the same.

As Table 17 indicates, this model specification also results in location of beef production in Alberta being equivalent to location of beef production when Japan is the primary export market (model 3). That bodes well for the southern Alberta cattle industry as it authenticates Alberta's comparative advantage in producing beef for export to the Pacific Rim. With the Japanese market closed, as it is in this model, fed beef exports resume to eastern Canada with region 1 shipping 236 million pounds.

Sensitivity analysis indicates this allocation is fairly stable for region 2. A 7 percent decrease in non-feed/processing costs would induce only a 3 percent increase in region 2 fed beef production as feeders began to move south from region 1. Fluctuations in barley cost have a similar effect. A 10 percent decrease in barley cost leads to only a 3 percent increase in barley use in region 2.

Table 17
Model 5 Beef Production and Product Shipments

Region	Actual Cattle Mktd	Model 5 Cattle Mktd	FedBeef Prod'n	NonFed Beef Prod'n	Total Prod'n	Beef Demand	Surplus
	Ths hd	Ths hd	Mlnlbs	Mlnlbs	Mlnlbs	Mlnlbs	Mlnlbs
1	440	701	338	29	367	106	261
2	660	689	332	51	383	78	305
3	728			265	265	571	(306)
4	825	2,326	1,218	606	1,824	139	1,685
5	945	940	492	1,133	1,625	143	1,482
6	2,501	2,437	1,276	362	1,638	384	1,254
7	904			867	867	2,261	(1,394)
V						150	(150)
X						3,137	(3,137)
Total	7,003	7,093	3,656	3,313	6,969	6,969	0

Products From Region:	Beef To Region	FED Beef Q	NONFED Beef Q	Feeders To Region	Feeders Q	Conc. To Region	Conc Q
		Mlnlbs	Mlnlbs		Ths hd		Mln Mcal
1	1	53	29				
	2	39					
	V	10					
	X	236					
2	1		24				
	2		27				
	3	267					
	V	65					
3	3		190	4	727		
	V		75				
4	2		12			3	506
	3	18	96			7	8,106
	4	70	70				
	7	1,131	263				
	X		166				
5	5	71	72				
	X	420	1,062				
6	6	192	192				
	X	1,084	170				
7	7		867	4	722		

Source: Derived from LP model 5 solution.

3.2.6 Summary of Results

Table 18 summarizes results of Models 1, 2, 3, 4 and 5 for the two Alberta regions. A description of the fed beef production for the two Alberta regions is given. Also, beef shipments and quantity shipped; and feeder shipments and quantity shipped are given for the two Alberta regions under each model scenario.

Table 18
Summary of Results for Alberta Regions

Model #	Significant Change From Base	Region 1 Fed Beef Prod'n	Region 2 Fed Beef Prod'n	Beef From Region	Beef To Region	Quantity	Feeders From Region	Feeders To Region	Quantity
		Mlnlbs	Mlnlbs			Mlnlbs			Ths hd
1	Base Model	479	192	1	1	106			
					X	402			
				2	2	78	2	1	291
					3	14			
					V	150			
2	Increased Brly Price	701	0	1	1	106			
					2	78			
					V	99			
					X	84			
				2	V	51	2	4	126
								5	562
3	Increased X to Japan	338	332	1	1	15			
					V	353			
				2	V	383			
4	Depreciation of CDN $	478	484	1	1	106			
					X	402			
				2	2	78	2	1	291
					3	306			
					V	150			
							3	2	659
5	Fed/Non-fed Distinction	338	332	1	1	82			
					2	39			
					V	10			
					X	236			
				2	1	24			
					2	27			
					3	267			
					V	65			

Source: Derived from Tables 13, 14, 15, 16 and 17.

4 SUMMARY AND CONCLUSIONS

The Linear Programming approach used in this study stresses the importance of considering raw resources used in the makeup of final product. It indicates that Alberta has an abundance of these intermediate products necessary for a successful cattle industry, and suggests that Alberta is competitive in producing high quality fed beef.

The location of feedlots is determined by a spatial equilibrium model that minimizes cost of concentrates, cost of feeders, non-feed costs, processing costs, and transportation costs of intermediate and final products. Production functions that relate quantities of intermediate products required per unit of final product are specified, as are regional demand functions for boxed beef.

In all the models used in this study, transportation rates on boxed beef moving south from Alberta are doubled and a 20 percent price premium is placed on Alberta beef. These specifications were necessary to calibrate the base model. Non-feed feedlot costs and processing costs used in the model are representative of actual costs.

Results of the base model indicate beef shipments similar to actual 1988 Alberta beef shipments. Actual Alberta beef shipments to the U.S. were 46 million pounds and the base model indicated shipments of 14 million pounds. Actual Alberta beef shipments to eastern Canada were 416 million pounds and the base model indicated 402 million pounds. The proximity of Alberta to the west coast leads the cost minimization model to ship as much beef there as allowed by model specifications. Shipments to B.C. in the model are limited to 150 million pounds. In reality, shipments to the west coast are limited by demand as actual shipments to B.C. were 116 million pounds. When demand at Vancouver is artificially increased (as in model 3) Alberta regions benefit more than U.S. regions. The precondition for Alberta to benefit from increased demand would be (hypothetically), increased Japanese demand for Alberta lean beef.

In model 2, specifications and assumptions are identical to model 1 except concerning barley cost which is raised in accordance with effects of the Crow Benefit on Alberta livestock feeds. As suggested in section 4.2.2, model results are very sensitive to barley cost. Results indicate that when barley cost increases, cattle feeding in southern Alberta is suspended as feeders are shipped south. The loss of feeding is a direct consequence of higher barley costs. According to model 2 results, viability of the southern Alberta cattle sector is contingent upon removal of or alterations to the Crow Benefit. The Alberta Crow Benefit Offset Program (ACBOP) maintained a feasible cattle feeding industry in southern Alberta in 1988 by reducing barley cost by the amount of the Crow Benefit distortion.

Model 3 introduced a hypothetical scenario in which Japanese demand is for lean high quality beef. Alberta beef meets these requirements and appears able to expand production and exports, given the particular assumptions and specifications of the model (the critical assumption being continuance of the ACBOP on barley). Alberta would export 620 million pounds to Japan (736 Mln to B.C. less 116 Mln Vancouver demand) under this scenario, and southern Alberta has the most to gain.

Model 4 represents an equilibrium scenario with the Canadian dollar worth 10 percent less in 1988 than was actually the case. Other specifications as to costs and regional demand are unchanged from the base model. Results with this assumption indicate a feedlot allocation significantly different from the base model. Total annual production in Alberta is 291 million pounds higher than the 671 million pounds in the base model. The destination of this additional production (U.S. region 3) indicates that Alberta could export to the U.S. with a lower valued Canadian dollar. The pattern of feeding in Alberta is reversed with a lower Canadian dollar. Southern Alberta does the majority of feeding as opposed to the base model where northern Alberta had the lion's share. Southern Alberta fed an extra 659 thousand feeders that were imported from the Idaho-Montana area. Apparently the relatively lower production costs and therefore greater margin for Alberta cattle feeders allows movement of these animals.

In model 5, specification of regional demand as including fed and non-fed beef is the only change from base model specifications. This restriction is realistic. It differentiates between high quality fed beef and manufacturing beef from culled dairy animals and old cows or bulls. This consumption constraint leads to location of Alberta fed beef production in this model being the same as location in model 3 (the "Japan scenario"). This appears to strengthen the case for Alberta's comparative advantage in export to the Pacific Rim. It indicates that location of Alberta fed beef production in model 3 was realistic. Further, the location of production in this model appears more logical than production in the base model since it is evenly distributed throughout Alberta.

Total Alberta production of fed beef in model 5 (670 million pounds) is the same as production in the base model but regional allocation of this production is changed. Region 2 markets considerably more cattle in model 5 than in model 1. Total Alberta exports to eastern Canada are down from base model exports east. Southern Alberta exports to the U.S. are considerably higher than actual exports of 46 million pounds, and base model exports of 14 million pounds. Southern Alberta exports 267 million pounds of high quality lean Alberta beef to the Washington-Oregon area (region 3) when the distinction is made between fed and non-fed beef.

Region 3 and region 7 did not feed cattle in any model specification. This is due in part to these regions having a concentrate deficit (see Table 4) that must be eliminated prior to feeding cattle. A more thorough analysis of feed availability may change this result. California, for example, has considerable feed in the form of silage from irrigated crops that could affect concentrate availability. Southern Alberta also would have similar products that are not included in this analysis.

As noted in section 4.1, modifications were necessary to achieve the base model (ie. price premium and alteration to shipping rates). Firstly, the doubling of transportation rates for Alberta beef exported to the U.S. may seem unnecessarily harsh. However, any adjustments made to these rates would be speculation. Actual cost of shipping final and intermediate products across the border is difficult to model. Criticisms of the TTM arise because, as a model, it does not accurately represent ad-hoc situations such as the inspection problems encountered here. That some adjustment is required to compensate for aggravation to the Alberta cattle sector is well documented, and reports of border inspection delays are continually before us. When the cost of having one truck inspected is identified (section 4.1), a doubling of transportation rates does not appear unreasonable.

Secondly, absence of a reciprocal grading arrangement between Alberta and U.S. makes cross border hauls of boxed beef more complicated. This lack of harmonized grading led to the price premium discussed in section 4.1.1. U.S. no-roll beef, discounted in the U.S., is competing in Canada ungraded, and overfat cattle that would be discounted in Alberta can receive a price premium in U.S.. Depending on relative prices, it sometimes pays producers in both countries to produce these respective products for export. That confounds analysis of optimal allocation based on comparative advantage of factors of production as opposed to technological or regulatory advantages.

With the current grading scenario, Alberta product is perceived as inferior in the U.S. and U.S. Choice beef is generally acknowledged as inferior to A1 in Alberta. As long as grading regulations in the two countries remain unharmonized, penetration of Alberta boxed beef into the U.S. market may be restricted primarily to supplying feeders to the relatively more efficient U.S. feeding and packing industry.

For their part, industry analysts in the U.S. are aware of the need to market leaner beef. Explaining how the cattle industry must cut costs to remain competitive with other meats in the retail market, analysts note that; "The future of the cattle industry depends on whether it can lower it's costs while satisfying the consumer's demand for leaner, more convenient beef products." (Barkema and Drabenstott 1990, 49). Alberta already has the product consumers demand and may be positioned to establish markets before retooling of the U.S. cattle industry is complete.

At this time, the future of Alberta's cattle feeding and processing industry appears to lie in production of a high quality lean product for domestic and export markets that is differentiated from the heavier U.S. product. Alberta lean beef is a superior product appropriate to current consumer trends. If Alberta is to be successful internationally with beef exports, this quality difference must be emphasized. Some price premium is legitimate, the question is how much.

A third reason for difficulty in getting the model to feed in Alberta without adjustments is the size difference in the cattle sectors between Alberta and U.S. regions. In the U.S., three packers (Conagra, IBP, Excel) control the market that supplies 250 million people. The 4 largest companies have 70 percent of U.S. slaughter. In 1988, the 5 U.S. regions in this study had 245 slaughtering plants compared to a handful in Alberta, and 90 percent of U.S. slaughter took place in plants handling greater than 50,000 animals per year (American Meat Institute, 1989). In Canada there are several packers (XL Foods, Burns, Lakeside-Centennial, Cargill Foods, etc.) for 25 million. Economies of size in the U.S. packing sector lead to efficiencies that cannot presently be achieved in Alberta.

A final factor that predisposes cattle feeding away from Alberta relates to isolation. As the model is set up, the two Alberta regions are geographically separated from U.S. regions. This means transportation of final product out of Alberta and of intermediate product into Alberta is more costly than interregional product movement between adjacent U.S. regions. Demand in the U.S. regions dwarfs Alberta demand and this tends to skew cattle feeding and processing toward these areas where transportation costs are lower.

Conclusions drawn from this study pertain more to trends in production and product movement than to specific cattle feeding allocations indicated in the various models. For purposes of this study, policy implications arising from these location trends focus on the Crow Benefit. Of special interest is the sensitivity of study models to barley cost and the reflection of this result on Canadian grain transportation policy. This study concurs with the notion that the Alberta livestock sector would realize positive welfare gains from removal of or alterations to the Crow Benefit.

Second, future welfare of the Alberta cattle sector may depend on expanding Pacific Rim markets. Alberta appears able to take advantage of increased Japanese demand if it can compete with the dominant U.S. sector. Sensitivity of the models to non-feed and processing costs suggests Alberta would benefit from size increases in the livestock sector. Alterations to the Crow Benefit could leave a void in Alberta's agriculture sector as the export grain industry diminished. This would create an opportunity for the livestock sector to expand and capture economies of size presently possible only in the U.S. industry.

Third, north and north-central Alberta appear able to competitively ship beef to eastern Canada as well as to the Pacific Rim countries. Diversification of beef packing in the province may be warranted given the abundance of resources and raw materials available in this region. Again, alterations to the Crow Benefit could possibly hasten the diversification process.

Finally, results of model 4 illustrate the importance of Canada's monetary policy on the Alberta livestock sector. Alberta experienced a simulated 43 percent increase in fed beef production with a lower Canadian dollar. The increased production was made possible by 659 thousand imported U.S. feeders. Virtually all of the increased fed beef production was shipped back to the U.S. market.

For Alberta to source U.S. feeders, competitiveness in feeding and processing cattle in Alberta must improve. Model 4 indicates substantial inbound shipments of U.S. feeder cattle are a possibility if Canada had a lower valued dollar. More generally, sensitivity analysis indicates competitiveness in fed beef production in Alberta would improve with relatively lower production costs. Lower production costs can be achieved by lower barley costs, size increases in the Alberta cattle sector, or changes in exchange rates. Reduced barley costs and size increases may be possible with alterations to the Crow Benefit.

4.1 Recommendations for Further Study

Further study of Alberta's cattle industry could focus on the impact of economies of size on Alberta's competitiveness. Economies of size are not directly addressed in this study although they do play a major role. Larger U.S. feedlots and processors are able to reduce per unit costs because of their larger size. Structural change presently occuring in the U.S. industry, including vertical integration of the beef subsectors, allows cost savings in procurement and marketing.

In further studies similar to this one, the production function used should be modified to allow input substitution. When input substitution in the production function is allowed, per unit costs will also fall. Input substitution leads to an efficient Least Cost Expansion Path for processors that cannot be obtained with the production function used in this study. The current production function requires expansion along a factor beam. This does not allow cost savings that result from substituting lower cost inputs.

Another adjustment that could be made in further study would be to allow two types of beef in the demand function; a lean product and a heavier marbled product. If two types of beef were allowed, the fed beef production functions could be specified more explicitly. This would overcome a limitation of the present study where it has been assumed that daily energy needs for U.S. cattle are the same as for Alberta cattle. U.S. consumers have a preference for more marbling than Alberta consumers. In Alberta, the premium beef grade is leaner than the U.S. premium beef grade. Separation of demand may lead to more realistic feeding location as beef for the Alberta consumer would efficiently originate in Alberta. Harmonized grading between the two countries should further rationalize feeding location and improve efficiency.

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6 APPENDICES

6.1 Appendix A (Feed Data Methodology)

Concentrate and roughage availability was determined by first gathering regional quantities available (in tonnes), of various feedstuffs. Availability for all livestock is taken as production + imports + beginning year stocks - [ending stock + exports + seed and industrial use]. Regional feed availability for all livestock, feeding rates used and net energy of feeds are given in the Tables below.

Table A1.
Concentrate Availability (fall 1987)
('000 tonnes)

Region	wheat	oats	barley	rye	corn	sorghum	Total
1	414	1178	3548	33	-	-	5173
2	723	182	1959	78	-	-	2942
3	-	134	1185	-	592	-	1911
4	-	108	1433	-	8042	2501	12084
5	-	1633	4286	-	9064	599	15582
6	-	75	617	-	3520	412	4624
7	-	52	486	-	1142	70	1750
Total	1137	3362	13514	111	22360	3582	44066

Note: Based on Tables used by King and Schrader, 1963.

Table A2.
Roughage Availability (fall 1987)
('000 tonnes)

Region	tame hay	processed alfalfa	greenfeed cereal	silage cereal (barley)
1	6042	33	-	-
2	2122	-	22	171
3	5182	-	-	-
4	9690	-	-	-
5	12795	-	-	-
6	5703	-	-	-
7	9421	-	-	-
Total	50955	33	22	171

Table A2.
Roughage Availability "fall 1987" (continued)
('000 tonnes)

Region	silage hay	silage corn	silage sorghum	fodder corn	Total
1	-	-	-	-	6075
2	17	79	-	165	2576
3	-	1560	-	-	6742
4	-	958	109	-	10757
5	-	4391	331	-	17517
6	-	2991	245	-	8939
7	-	4387	76	-	13884
Total	17	14366	761	165	66490

Note: Based on Tables used by King and Schrader, 1963.

Table A3.
Livestock Feeding Rates (average)

Livestock Type	Concentrates (tonne/year)	Roughages (tonne/year)
Cattle and Calves:		
bulls > 500lbs	0.1	1.5
milk cows > 500lbs	2	4.7
dairy heifers > 500lbs	0.6	2.7
beef cows > 500lbs	0.1	1
beef heifers for breeding > 500lbs	0.2	1
backgrounding steers > 500lbs	0.4	1
Hogs:		
breeding stock 6 mos and over	1	-
all other pigs (pig crop)	0.7	-
Sheep:		
one year and older	0.02	.250
Poultry:		
chicken for meat	0.0204	-
turkey	0.0622	-
laying hens/pullets	0.0336	-

Note: laying hens/pullets and pullets of less than laying age have been combined to give concentrate use for "one bird/year".
Note: Feeding rates were obtained from U of A Animal Science professors and Alberta Agriculture staff.
Note: Based on Tables used by King and Schrader, 1963.

Table A4.
NET Energy of Various Feedstuffs
(with the values specific for feeder cattle)

Feedstuff Type	NET Energy/tonne (DM basis)	NET Energy/tonne (Mcal as fed)
CONCENTRATES		
wheat	1700 Mcal	1530
oats	1400 Mcal	1260
barley	1600 Mcal	1440
rye	1600 Mcal	1440
corn	1900 Mcal	1710
sorghum	1600 Mcal	1440
ROUGHAGES		
tame hay	900 Mcal	810
processed alfalfa	900 Mcal	810
greenfeed cereal	900 Mcal	810
silage cereal (barley)	900 Mcal	360
silage hay	900 Mcal	360
silage corn	1000 Mcal	400
fodder corn	1100 Mcal	550
silage sorghum	900 Mcal	360

Note: Based on Tables used by King and Schrader, 1963.

6.2 Appendix B (Feeder Data Methodology)

For the US regions, feeder cattle numbers were estimated using (USDA 1989, Cattle, Final Estimates 1984-88, NASS ASB #798), and (USDA 1989, Agricultural Statistics Yearbook 1989). For the five feeding states; California, Colorado, Idaho, South Dakota and Washington, feeder cattle placements and number on feed data are available. The other six states have data for the number on feed only. The average ratio of placements to number on feed for the feeding states is (2.64). Applying this ratio to the other six states gives estimated placements for each US region. This methodology assumes that for every animal on feed Jan 1/1988, 2.64 animals will be placed on feed during the year Oct1/87 to Sept 30/88. Results are indicated in Appendix Table B1.[27]

Table B1
US Placement Methodology

Region	State	Placements (Q4/87-Q3/88)	# on feed Jan 1/88	Ratio	Estimated Placements
	Washington	497000	198000	2.51	497000
	Oregon		95000	Avg 2.64	250800
3					747800
	Idaho	608000	195000	3.12	608000
	Montana		110000	Avg 2.64	290000
4					898000
	S.Dakota	695000	300000	2.32	695000
	N. Dakota		45000	Avg 2.64	118800
	Wyoming		100000	Avg 2.64	264000
5					1077800
	Colorado	2450000	940000	2.61	2450000
	Utah		45000	Avg 2.64	118000
6					2568000
	California	1160000	435000	2.66	1160000
	Nevada		28000	Avg 2.64	73920
7					1233920
Total		5410000	2491000		6525520

Note: Derived from data collection.

27 Not indicated by Table B1 (but considered in final totals used) is the fact that included in U.S. placement numbers are a category called "other disappearance". These animals are not marketed in the region and so must be taken off the regional placements used in this study. The assumption is that they are shipped east to Kansas and Nebraska as slaughter animals. This involved 600,000 animals.

In Alberta, methodology to determine supply of feeder cattle is based on calf numbers July 1/87. Alberta Agriculture Statistics Branch has these numbers broken out by census division in a publication called: **Cattle Numbers #2, December 6, 1988.** Of the total number of calves on July 1/87, (1,280,000), 90% (1,152,000) are assumed spring calves. Of this, one-half (576,000) are assumed steers and one-half are heifers. Of the heifers, 48% (289,000), are for slaughter. This gives a total of 856,000 animals on July 1/87 targeted for eventual slaughter. Of these 856,000, 30% (257,000), are assumed overwintered and 70% (599,000), go straight to finishing pens to finish in spring of 88 while the 30% are pastured in spring of 88 and finished in fall 88. Of the calf inventory, 60% were located in region 1 and 40% were located in region 2.

Imports of feeders to Alberta would not be included in this methodology so must be calculated separately. In 1988, Alberta imported 533,000 cattle (Alberta Agriculture, 1988 Alberta's Agricultural Exports) that are assumed feeders (Adam 1991). They were apportioned among the four regions according to shares of regional slaughter data found in (Alberta Agriculture, 1990. The Location of Cattle Production in Alberta). For 1988, region 1 had 35.2% of slaughter volume, and region 2 had 64.8%. These amounts were added to domestic feeders to get Alberta placements as in Appendix Table B2.

Table B2.
Alberta Placement Methodology

Region	Imports	Calf #s July 1/87	Placements
1	(.352)533000	(.60)856000	701616
2	(.648)533000	(.40)856000	688384
Total			1389862

Source: Derived from data collection.