Future Directions for the Alberta Sheep Industry

by

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Abstract

The primary focus of this study is to examine the short term, medium term and long term supply response for lamb, wool and cull sheep for the Alberta sheep industry. The sensitivity of supply to changes in market prices is estimated using two alternative analytical techniques. The first technique used is the representative farm linear programming procedure. This technique involves the estimation of medium term supply response for the three products from farm level information. The industry level supply response is then derived by summation of the individual farm level supply estimates. The alternative procedure relates to the estimation of short-run and long-run supply response directly from industry level data using an econometric procedure. The results from both procedures indicate that lamb supply is sensitive to changes in market prices in the medium and long term, but that the supply of wool and cull sheep are relatively stable over large price ranges.

Furthermore, the stability of the sheep industry is examined using a Markov chain process. This analytical technique examines the movement of farms between different size groups over a thirty-five year period from the early 1950s to the mid 1980s. The results indicate that there is a trend toward increased concentration in the industry with medium and large size sheep producers accounting for an ever increasing share of the industry. Small sheep producers over the same time period however, have shown a dramatic decline in terms of absolute number and industry share.

A minor focus of this study involves a preliminary analysis of the demand for fresh and frozen lamb in Alberta. The empirical estimates of demand indicate that price may not

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be as important a variable in influencing the demand for lamb as is the case with other red meats. This may be attributed to the special characteristics of the lamb market. These characteristics relate to the low volume, low frequency and seasonality associated with lamb consumption. In general, lamb is regarded as a specialty meat with peak consumption occurring at Easter and Christmas. For lamb, demographic and socioeconomic variables are key variables in terms of influencing aggregate demand.

The marketing strategies available to the sheep industry include demand expansion programs, supply management boards and centralized selling agencies. A centralized selling agency could have a significant positive impact on the industry in terms of increasing operational efficiency and perhaps pricing efficiency. Finally, a strategically oriented demand expansion program may be a more useful approach to increasing the aggregate demand for lamb.

1 Introduction

This study undertakes an economic analysis of the Alberta sheep industry, focusing in particular on producers' supply response. The analysis involves the application of both normative and positive estimation procedures to assess the industry's supply response. Furthermore, this study also examines consumer demand for lamb in Alberta and outlines a number of potential marketing scenarios for the industry.

Developing and analyzing a structural model of lamb supply is an important step in understanding the root cause(s) of the decline in the industry over the last thirty years. The basic premise of this study is that the estimation of statistically reliable relationships for lamb supply will provide an understanding of the economic forces which help to determine the structure of the industry. An understanding of the industry's responsiveness to different economic conditions is important to producers, consumers, regional and national policy planners. For policy planners the responsiveness of lamb supply to changes in market prices is crucial in designing appropriate marketing policies for the industry.

The sheep industry has been selected as the focus of this study for a number of reasons. First, there has been little emphasis on research into the structural problems of the industry as the sheep sector makes a relatively minor contribution to the province's agricultural industry relative to other livestock sectors. Second, with increasing surpluses of some agricultural commodities and consequently declining prices and returns to producers, there is renewed interest on enterprise diversification at the farm level. Third, the future of Canada's largest specialized sheep slaughtering plant (Lambco) depends to a large extent on having a strong domestic industry in order to provide a consistent supply of animals for processing. The decline in the national and provincial sheep flocks has resulted in a decline in throughput at domestic lamb slaughtering plants. Moreover, the lower volume of throughput has resulted in consolidation of the industry's infrastructure culminating in higher marketing costs. Furthermore, reduced output from the sheep industry has encouraged the location of slaughter plants in feeding areas and has accelerated the trend toward a few large slaughtering plants for the lamb industry. Increased concentration in the industry may encourage higher marketing costs as processing plants operate above optimum cost levels due to a lack of competition and/or an increase in the area of procurement and distribution.

Fourth, the Alberta sheep industry has experienced difficulties in the marketing of lamb apparently emanating from a number of sources. In particular, static or declining domestic demand for lamb and increased imports of fresh chilled lamb[1]. The increased competition on the domestic market especially, from lamb imports from Australia and New Zealand (N.Z.) has focused attention on the marketing performance of the domestic industry and on programs to improving this performance. Finally, a rigorous analysis of the supply response of the Alberta sheep industry and the influence of input and output prices on this response may shed light on the fluctuating lamb supply from the industry.

To date there has been little detailed research on the problems facing the Alberta sheep industry. This study will provide useful information on the short-term, medium-term and long-term supply response of the Alberta sheep industry, in addition to assessing the demand for lamb in Alberta and outlining potential marketing scenarios for the industry.

2 Objectives of the Study

The primary objectives of this study were threefold: (a) to develop and analyze a structural model of lamb supply, (b) to examine the demand for fresh and frozen lamb and (c) to assess potential marketing strategies for the industry. More specifically, the objectives of this study were as follows:

(i) To derive medium-term direct and cross price elasticities of supply for lamb, wool and cull sheep from microeconomic data for the Alberta sheep industry.

(ii) To estimate short-term and long-term supply elasticity estimates from aggregate or market level data using the adaptive expectations simultaneous equation model of supply.

(iii) To examine structural changes within the industry. More specifically, to analyze the stability of farms within the industry, the movement of farms between different size groups and entry and exit from the industry.

(iv) To estimate demand functions for lamb (chilled and frozen) for Alberta in order to determine the direct, cross price and income elasticities of demand for lamb. In addition, to focus attention on the conceptual and empirical problems of estimating demand for lamb in Canada.

(v) To determine by a market survey the degree of substitution between fresh and frozen lamb product and the growth prospects in the respective markets.

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1 Fresh chilled lamb is essentially fresh lamb which has been subject to cold treatment (cryovac) in order to increase the shelf life of the product.

(vi) To review the sheepmeat marketing strategies as operated by both Australia and N. Z. and to analyze the nature of their shipments of lamb and their impact on the Canadian market.

(vii) To outline and assess potential marketing strategies for the industry in order to meet the increased flow of imports.

3 Historical Background of the Study

The sheep industry occupies a special niche in Canadian agriculture. Although sheep are found in all provinces, the industry is concentrated within three provinces, Alberta, Ontario and Quebec, which together account for almost three quarters of the national flock (Appendix A, Table A:1). The national flock has declined from a peak of 3.5 million head in 1931 to a trough of 0.6 million head in 1977. During the 1980s the downward trend ceased and sheep numbers have exhibited a steady increase to reach 0.7 million head in 1989. The 1986 Census of Agriculture shows that there were approximately 11,000 farms in Canada reporting sheep, a decline of fifteen percent from the 1981 Census. Although the absolute number of sheep farms declined during the 1980s, the provincial shares of the national flock have remained fairly stable with a small decline in the eastern provinces and a slight increase in Alberta and British Columbia. The average number of sheep per farm in 1986 ranged from a low of 37 head in British Columbia to a high of 92 head per farm in Quebec. In eastern Canada the average flock size increased from 60 to 67 head from 1981 to 1986 while in western Canada the average number of sheep declined from 68 to 61 head per farm. However, a more accurate indicator of the number of sheep producers relates to the number of farmers reporting fifty percent or more of their gross farm sales from the sale of sheep, lamb or wool products. In 1986 approximately 2,793 farms reported more than fifty percent of their sales from sheep products.

The Alberta sheep flock reached a peak of 497,000 head, in 1961, and then declined to a low of 143,000 head in 1978. Over the last decade the Alberta flock has shown steady growth to reach 212,000 head in 1989 or approximately 29 percent of the national flock. The distribution of the Alberta sheep flock within the province is shown in Figure 3.1.

Figure 3.1. Distribution of the Alberta Sheep Flock by Census Division 1986, ('000 head).

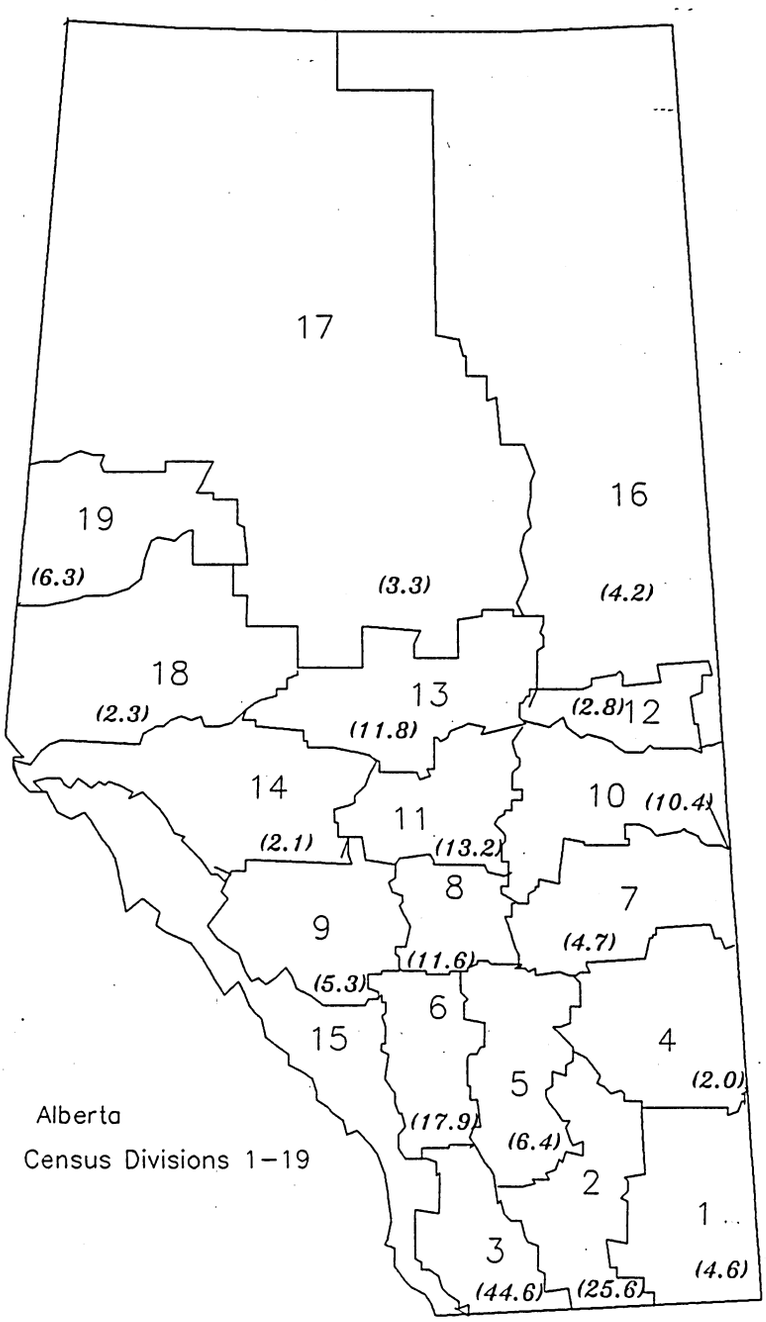
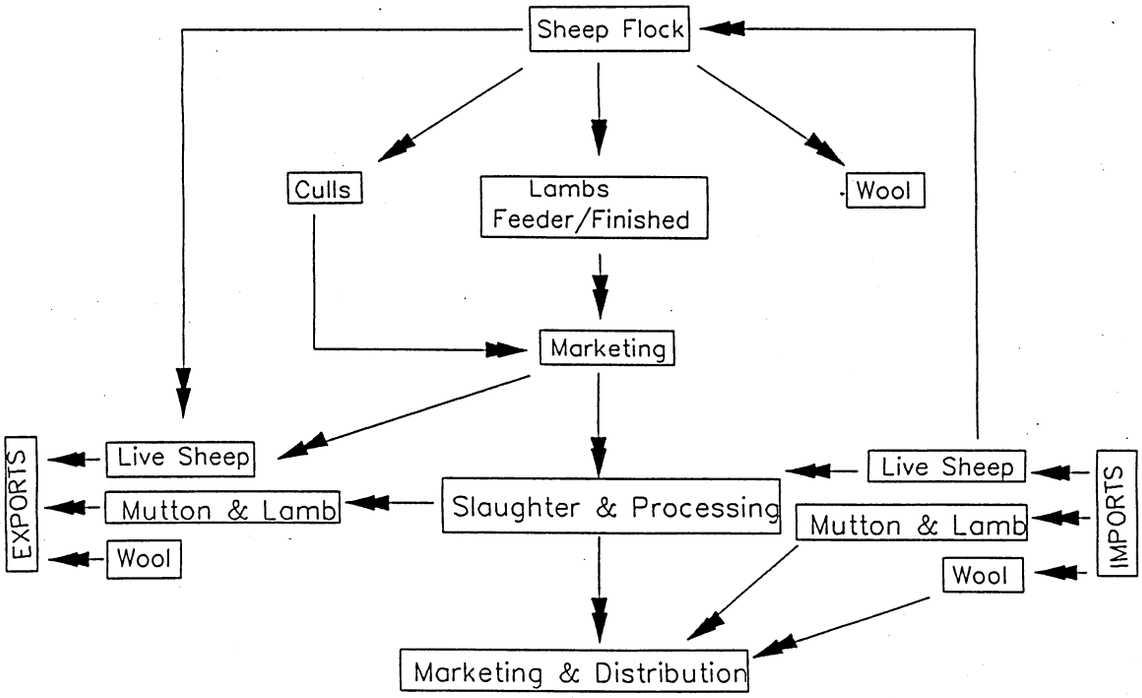


Figure 3.1 shows that sheep are present in all Census Divisions of Alberta (with the exception of Census Division 15). The provincial flock however, is concentrated in the southern more arid parts of the province.

Sheep producers can be broadly divided by production method into two groups, stock sheep producers and lamb feedlot operators. Stock sheep producers manage grazing flocks on pasture or range forage and sell lambs directly for slaughter or for further feeding. Many of the stock sheep producers also have a lamb feedlot, grain or cattle enterprise. Sheep producers compete primarily with beef cattle producers for resources such as grazing land, labor, marketing and transportation facilities[2]. In general, feeder lambs are raised on forage until they reach 27 to 33 kilograms and are then placed in feedlots for finishing on grain. A flow chart of the Canadian sheep and lamb system is shown in Figure 3.2.

Figure 3.2. The Canadian Sheep and Lamb System.



Source: Adapted from Agriculture Canada, *The Canadian Sheep and Lamb System*, 1977.

The sheep industry is small and susceptible to competition due to a number of factors including high production costs, low volume of output and the inability of many producers, processors and distributors

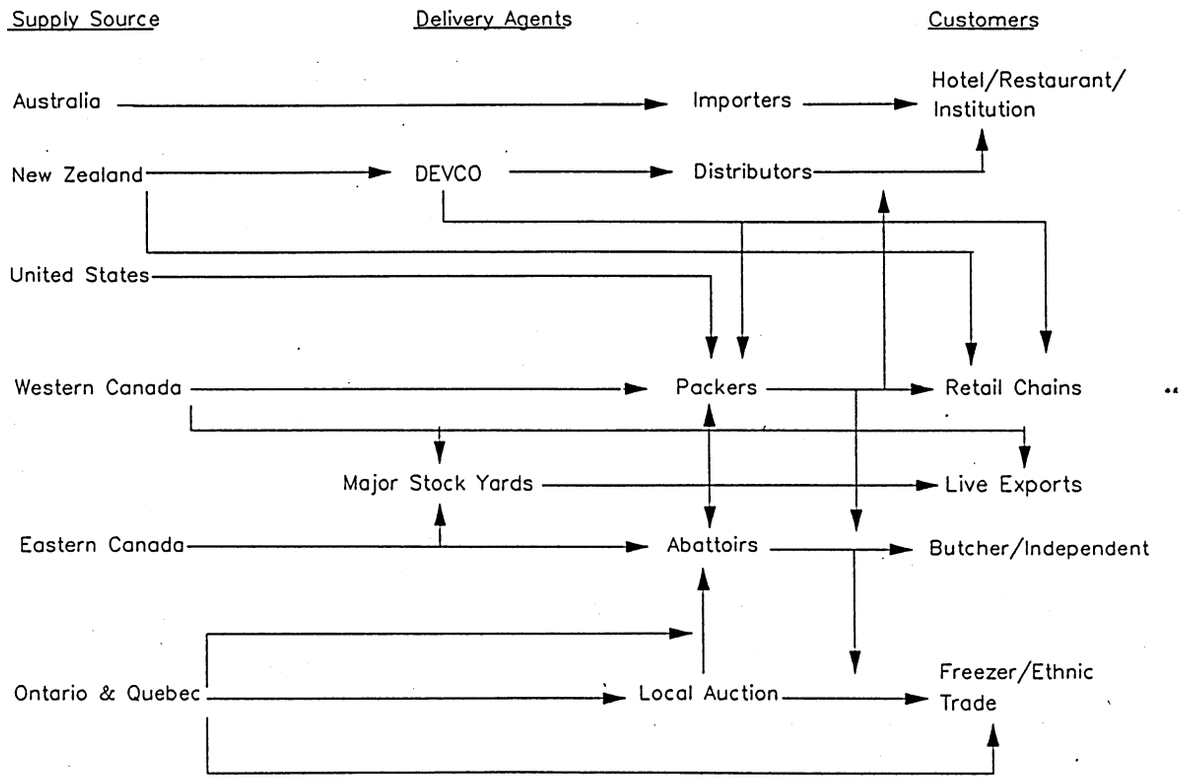
2 Competition for resources between sheep and cattle can be compared via feed consuming animal units. An animal unit is defined as one cow or five sheep.

to expand and adapt to changing economic conditions (McClelland, 1987). In many cases, producers have sheep as a secondary livestock enterprise and often do not have the finances or experience necessary to make changes to their facilities or production system.

The sheep industry is represented by a plethora of provincial and national producer organizations and associations which often differ with respect to the appropriate policies necessary to maintain a viable industry. Provincial and national sheep producer organizations support the industry via product promotion, producer education, marketing advice and lobbying efforts. These organizations attempt to bring greater coordination and stability to the industry. The Provincial and Federal Governments also support the sheep and wool industry via monetary and consultancy incentive programs, sheep production specialists, marketing information and representations with other countries regarding trade issues.

Lamb marketing in Canada is complex and involves a range of marketing channels including direct farm gate sales, sales via stockyards, direct sales to packing plants and live exports. The marketing channels for sheep and lambs are illustrated in Figure 3.3.

Figure 3.3. Marketing Channels for Sheep, Lambs and Sheepmeat in Canada.



Source: Derived from Agriculture Canada, *The Sheep Industry -- A Profile*, 1986.

Farm gate sales or the freezer/ethnic trade plays a major role in the sheep industry and distinguishes it from other livestock sectors. Direct farm sales including sheep and lamb consumed on the farm account for over forty percent of domestic sheep and lamb marketings in eastern Canada with the remainder sold through public stockyards. Direct sales to the Lambco packing plant is the major marketing channel for sheep and lambs in western Canada. The Lambco plant is the only specialized lamb processing facility in Canada and in 1987, approximately 70,000 sheep were slaughtered at the plant. As the provincial market for lamb is small due to the small population base, historically, approximately fifty percent of Lambco's output has been shipped to markets in eastern Canada, primarily Toronto and Montreal.

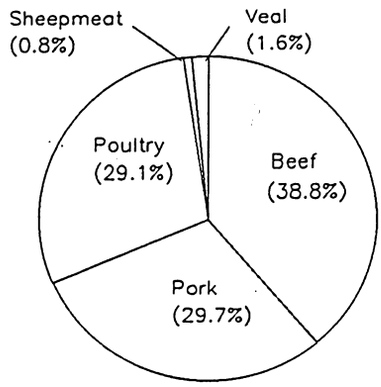
Lamb production in Canada is characterized by having a seasonal pattern of production with most of the lambs born between January and May, while lambs are slaughtered between six and twelve months of age. This results in lamb marketings reaching a peak in the third and fourth quarters with scarcities often occurring in the first and second quarters of the year. Seasonality of production and marketing

tends to adversely affect the provision of a consistent supply of Canadian fresh lamb throughout the year. During the January-April period when domestic lambs are in short supply, live lambs are imported from the United States to supplement the domestic product.

In eastern Canada the seasonality pattern is somewhat different with shortages of lamb occurring in the first quarter followed by high supplies in the second, a decline in the third quarter and an increase in the fourth quarter (Birchfield, 1988). This seasonality pattern is determined to a large extent by periods of peak demand. Demand for new crop lambs is greatest during the Christmas and Easter seasons, especially in the urban areas of Montreal and Toronto[3]. Closely associated with seasonality in supply is seasonality of prices with highest prices inversely related to supply levels. The lamb market, because of its small size and seasonality characteristics is more volatile than the pork, beef or poultry markets. The industry exhibits large fluctuations in market returns which may tend to undermine producers' confidence and acts as a deterrent to expansion.

The consumption of meat in Canada has shown a steady increase over most of the last twenty years. However, within this increase a considerable amount of substitution has taken place between the various meat types. In particular, there has been a shift in demand in favor of white meats at the expense of red meats. The relative shares of the major meats consumed in 1988 are shown in Figure 3.4.

Figure 3.4. Relative Shares of Meat Consumption, Canada, 1988.



Source: Derived from Statistics Canada, *Cat. No. 23-202 and Cat. No. 23-203.*

Figure 3.4 shows that sheepmeat (lamb and mutton) accounts for less than one percent of total meat consumed in Canada in 1988[4]. Consumption of lamb can be divided into two segments, fresh

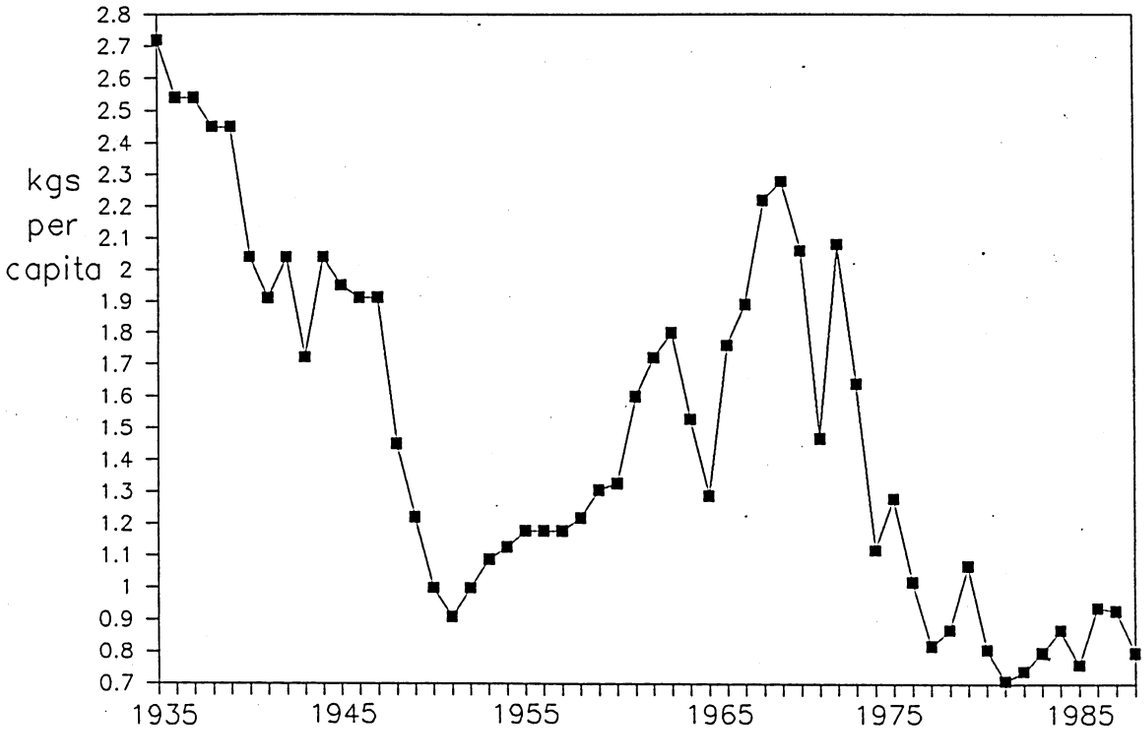
3 New crop lambs are usually less than three months of age and are marketed at live weights of less than thirty kilograms, primarily to the ethnic market.

4 Mutton accounts for less than 5 percent of total sheepmeat consumption and is used mainly in processed foods.

and frozen. Frozen lamb is supplied almost exclusively by imports while fresh lamb is predominantly of domestic origin. Fresh lamb can be regarded as a specialty meat due to the low volume of consumption and high retail price. Lamb consumption is highest among consumers with above average education and income levels (Contemporary Research Centre, 1985).

Canadian consumption of sheepmeat has shown wide fluctuations over the years declining from a high of 2.7 kilograms per capita in 1935 to less than one kilogram per capita in 1950. During the 1950s, 1960s and 1970s lamb consumption continued to be volatile. The downward trend in consumption continued during the late 1970s to reach a low of 0.7 kgs in 1981. During the 1980s, lamb consumption gradually increased to reach 0.8 kgs per capita in 1988. Figure 3.5 illustrates the secular trend in Canadian sheepmeat consumption from 1935 to 1988.

Figure 3.5. Sheepmeat Consumption (kgs per capita), 1935-1988.



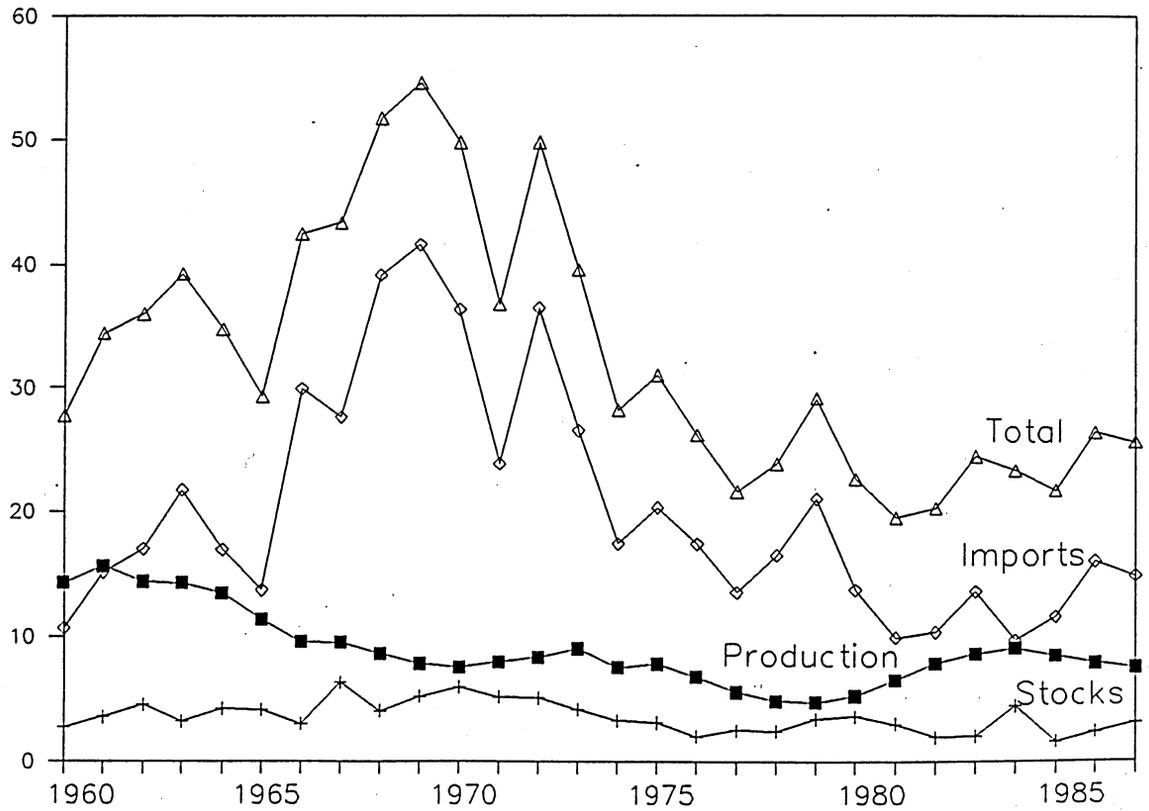
Source: Derived from Statistics Canada, *Cat. No. 23-203* (various issues).

The consumption of lamb in Canada is unevenly distributed compared to the consumption of other red meats and is characterized by having a strong ethnic influence with consumption largely confined to ethnic groups of European and Middle East origin. Traditionally, persons from the United Kingdom and Mediterranean origin have been the largest consumers of lamb. Canada is

approximately 35 to 40 percent self sufficient in sheepmeat with demand exceeding supply in all regions, except the Prairies. The sheepmeat deficit is filled by imports from a number of countries including the United States, N.Z. and Australia.

Imports of sheepmeat began in the early 1950s with Australia, N.Z. and the U.S. supplying market requirements in excess of domestic supply. The supply of sheepmeat has exhibited fluctuations varying from a peak of 54,610 tones in 1969 to 19,630 tones in 1981. The import share of total sheepmeat supply increased from 38 percent in 1960 to almost 58 percent in 1987. Figure 3.6 illustrates the contribution of imports, production and stocks to total sheepmeat supply from 1960 to 1987.

Figure 3.6. Supply of Mutton and Lamb, 1960-1987.



Source: Derived from Agriculture Canada's, *Handbook of Food Expenditures, Prices and Consumption,* 1988.

Historically, Australia has been the major supplier of mutton to the Canadian market, while N.Z. has been the major supplier of frozen lamb. Although, frozen lamb imports have displayed wide fluctuations during the 1980s, there has been little change in the overall volume of imports. However, fresh chilled lamb imports approximately doubled to 4,000 tonnes during the 1980s. Furthermore, an

important feature of chilled lamb imports during the 1980s has been the dramatic shift in the source of these imports. Specifically, chilled lamb imports from the U.S. have declined while chilled imports from Australia and N.Z. have increased.

The live trade in commercial sheep has been confined to the U.S., due to proximity and the relative ease with which sheep can be shipped between the U.S. and Canada. With the exception of the mid 1940s and early 1950s, imports of live sheep have always exceeded exports. In certain years when domestic prices are low, the U.S. provides an attractive alternative market for Canadian sheep producers, especially those located in the southern part of the provinces.

4 The Normative Programming Procedure to Analyzing Supply Response

The purpose of this section is to report on normative estimates of supply response for the Alberta sheep industry. In order to estimate supply response using the linear programming technique, data on the complete farm operation is required. From this data supply estimates for individual representative farms are derived and aggregated to estimate industry level response. Direct and cross price elasticities of supply for lamb, wool and cull sheep output are estimated using the parametric programming procedure. The supply elasticity estimates for aggregate farm output indicate the magnitude of output adjustments in response to changes in commodity market prices. Estimating supply elasticities is difficult because of the influence on supply of exogenous factors such as weather, and because of problems involved in quantifying factors such as changes in technology.

Several assumptions are adopted in constructing a normative supply model regarding specification of the production activities, determination of the relevant constraints with respect to each activity, exogenously determined input prices in addition to the standard linear programming assumptions of linearity, additivity, divisibility, finiteness, non-negativity and proportionality (Best and Ritter, 1985). The next section focuses on the theoretical framework of supply estimation as it relates to the programming approach, broadly following the procedure outlined by McKee and Loftsgard (1961).

4.1 The Linear Programming Procedure

Linear programming is a mathematical concept defined as the optimization of a linear function in several variables subject to a set of linear inequality constraints (Chiang, 1984). Basically, linear programming involves constructing a mathematical model of selected reference farms. The objective function, production activities, resource and institutional constraints for the reference farms are specified. The objective function is usually specified as a profit function but can also incorporate other

objectives, for example, risk aversion (Pomareda and Samayoa, 1979). The optimization problem is then solved using variable price programming which enables supply price relationships to be established for each commodity and reference farm. By attaching appropriate weights to each of the individual reference farm supply functions, an estimate of the aggregate or market level response relationship can be established. The weights attached to each individual supply function reflect the relative importance of the individual reference farm in the population of farms to which the aggregate supply function is to apply.

The linear programming approach to estimating supply response is characterized by a discontinuous step function, i.e., output is perfectly inelastic over relatively large price ranges. Derivation of a normative supply function involves assumptions about the price of a particular product relative to factor prices and other product prices (McKee and Loftsgard, 1961)[5]. The profit function implicitly assumes that all input and product prices hold over the production period. The derived supply function describes the optimum adjustment in resource allocation to price relationships at a particular point in time, under the assumption that profits are to be maximized. Summation of reference farms' normative supply functions yields an aggregate supply function for the industry. However, the results obtained by this normative approach are optimum only within the context of the assumed set of norms used in the analysis. Thus, normative results provide a useful point of reference against which divergent use of resources and goals can be compared. Traditionally, profit maximization has been assumed as the primary motivational hypothesis whereby producers vary input and output levels to ensure that profits are maximized.

A number of conceptual problems arise in constructing a mathematical model of a reference farm. The first problem relates to the range of alternative activities to be included in the model. Theoretically, the model should include all possible agricultural activities assuming that profit maximization is the principal behavioral criterion. However, incorporating all possible alternative activities into a linear programming model is not feasible due to:

(a) the lack of detailed reliable data required to distinguish between alternative activities; and

(b) the unmanageable size of the programming model.

Therefore, the list of activities to be included in the model is derived by arbitrary decisions based on the researcher's judgement and knowledge of the industry (McKee and Loftsgard, 1961, p. 155). The

5 Several terms are used in the literature including normative, conditionally normative and conditionally predictive to describe supply relations derived from the programming approach.

restrictions to be incorporated into a programming model depend on the primary objectives in analyzing the organization of the farm. To estimate supply response the relevant restrictions can be classified into three broad groups: resource, institutional and technical restrictions.

Resource restrictions refer to the physical resources of the farm, for example, land, equipment, buildings, machinery and capital. The relevant resources are incorporated into the programming model by designating separate equations which relate to the use of each distinct resource in the production process. The initial level of each resource restriction is taken as the current stock of the resource. The programming model is constructed in such a way as to allow for the purchase and/or sale of any resource by incorporating a purchase or sale activity for each resource. For resources such as farm buildings which have no value other than in direct use on the farm, the selling activity becomes the slack activity of the programming model when the initial restriction is stated as an inequality.

4.1.1 The General Model

In this study, the linear programming version of the mathematical programming approach is used in which the objective function as well as the inequality constraints are all linear. The essential components of a linear program are: an objective function, a set of constraints and a set of non-negativity restrictions. The general linear programming model for estimating supply response can be stated as follows:

(1) **Maximize** $\mathbf{c\,x}$

(2) **Subject to** $\mathbf{Ax \leq b}$

(3) $\mathbf{x \geq 0}$

where c is the row vector of gross margin for farm activities;
x is the column vector of activity levels for the farm;
b is the column vector of resource constraints; and
A is the technology matrix.

The technology matrix (A) is composed of elements, α_{ij} which can be interpreted as the amount of input i, required per unit of activity level in activity j. Thus, farm gross margin is maximized subject to the resource constraints on the production of the output mix.

The structure of the equations in the linear programming model for describing production activities can follow one of two approaches, an enterprise approach or a process approach. In this study, the process approach is used. The process approach involves treating activities in the linear programming model as interdependent. That is, the farmer selects activities not only on the basis of an activity's direct

contribution to the objective function but also on the production of commodities that can be used within the farming operation. Thus, the process approach includes material balance equations which allow for the transfer of resources between activities within the farm operation.

The optimization model outlined above is based on the linear programming formulation of the producer's decision making process subject to production, finance and resource constraints. Linear programming yields the optimum output response to price changes for a given set of input data and a given objective function. To the extent that the specification of the linear programming matrix and the form of the objective function are representative of the 'actual' situation, the output response specified by this optimum combination of activities is a realistic representation of the 'actual' output.

4.1.2 Inputs to the Model

The following simplifying assumptions were made in the development of the programming model. First, prices of all farm products and of resources are assumed to be similar for the reference farms. A further assumption relates to the markets for lambs, wool and cull sheep in Alberta: these markets are assumed to be highly coordinated and therefore market prices are assumed to be similar for all farms in the province. Also transportation costs from the reference farms to buying or selling centers and alternative marketing strategies for lambs, wool and cull sheep are not included in the programming model. Information was collected from two sample farms on relevant production activities and stocks of physical and financial resources[6]. This information together with the annual provincial production survey data were used in developing the matrices of the linear program. The programming matrix for each reference farm is basically composed of three interdependent segments namely production, finance and resource.

The concept of a representative firm approach (RFA) for studying firm and/or aggregate supply response dates back to the work of Marshall (1948). Several researchers including Barker and Stanton (1965) have adapted this concept and applied it to the problem of deriving agricultural output response. Barker and Stanton (1965) outline a five stage procedure to estimate aggregate agricultural supply for a commodity using the representative farm approach. The five stages are as follows:

(1) stratification of all farms in a region into uniform groups;

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6 The sample farms were selected by the industry with one of the farms considered representative of the medium size category and the other representative of the large size group. In addition, the sample farms were geographically dispersed with one located in the south of the province and the other in the north.

(2) defining a representative farm for each group;

(3) deriving supply functions for each farm;

(4) aggregation of the individual farm supply functions; and

(5) testing the sensitivity of the model's results in order to make predictions or prescriptions.

The representative farm approach provides an important link between the farm level and the industry level. Specifically, the impact of a change in a variable at the farm level where production decisions are made can be traced to the industry level where policy decisions are made. The farms which are included in the analysis relate not only to those that currently produce the product for which the supply function is to be derived but also to other farms operating in the region. When the price of a product rises, some farmers who are not currently producing the product may find it profitable to enter into the industry.

The static partial equilibrium reference farm approach is adopted in this study to derive the aggregate supply function for the Alberta sheep industry. A reference farm is defined as a synthetic construct which is assumed to react to price changes in a manner similar to actual holdings (Monypenny, 1975). The holdings as represented by the reference farms are assumed to be similar in terms of the characteristics that affect their production decision making. Before proceeding with a description of the components of the model, a brief outline of the structure of the Alberta sheep industry is presented.

The Alberta sheep industry consists of approximately 2,148 producers of which slightly less than half have flocks of 17 head or less. A detailed outline of the structure of the Alberta sheep industry is shown in Table 4.1.

Table 4.1. Classification of Farms Reporting Sheep by Number Reported, Alberta, 1986.

Sheep (No.)	Category	Farms (No.)	Total Sheep (No.)	Share of Provincial Flock (%)
1-17		1,009	6,447	3.6
18-47	small	474	14,153	7.9
48-122		330	26,150	14.6
123-527	medium	263	63,863	35.7
528-1,127		55	40,855	22.8
1,128 +	large	17	27,655	15.4
Total		2,148	179,123	100.0

Source: Derived from Statistics Canada, *Census of Agriculture,* (Alberta), Catalogue No. 96-111.

Sheep producers can be divided into three broad groups, small, medium and large based on flock size[7]. The 'small' category of sheep farmer, that is, with less than 47 head of sheep, accounted for approximately 11.5 percent of the provincial sheep flock in 1986. Because of the heterogeneous nature of producers within this group, any attempt to model supply response for this group would be extremely complex and would add little extra precision in attempting to derive an industry supply function. Therefore, this group has been omitted from further analysis with respect to the programming of supply response in this study.

Sheehy and McAlexander (1965) outline a theoretical framework for selecting reference farms which can then be used to estimate the aggregate output of a commodity. This framework relates to two basic selection approaches, a traditional approach and an alternative approach. The traditional approach involves classification of farms in a region based on the absolute level of resources. The alternative approach takes account of the level of resources on sample farms and the productivity of these resources. Specifically, this approach involves classification of farms on the basis of the most limiting resource used in the production of the particular commodity. Sorting of farms into groups with the same limiting resource yields reference farms based on the average of resource levels within each group. In such a grouping of farms, differences in output of a commodity from a farm in one group to a farm in another

7 Essentially, the medium and large sheep producers represent the commercial lamb industry in Alberta.

group is proportional to differences in the restricting resource(s). Multiplying by the number of farms in the group allows for the average resource level to be expanded to give an unbiased estimate of the group resources (Sheehy and McAlexander, 1965, p. 686).

Reference farms were constructed using the alternative approach, that is, the homogeneous restriction method. The two sample farms selected were used to identify the most limiting restrictions common to the individual farms in their respective groups. These restrictions were then used in the construction of representative farms. The number of holdings extracted from the Census data (1986) serve as weights to scale reference farm results to give information at an aggregate or industry level. In this study the model is a one period model therefore, no change in these weights is allowed for in the analysis. The data used to construct the reference farms were averaged over the three year period, 1986 to 1988. The relevant resources were identified to give the reference farm situations which were then expanded to the aggregate level.

The reference farms were programmed over a range of lamb prices and the output expanded to provide supply schedules for the farms. The optimization problem is then solved using the Mathematical Programming System 360 computer programming procedure (IBM Manual, 1971).

Basically there are two types of data input required for construction of the model: data related to the structure and data related to the technical coefficients. Parameters related to the structure have unique empirical values and are expressed per unit of production activity. Each production activity in a reference farm can use only one technology expressed as a unique combination of input-output and yield coefficients. The production activities specified in the reference farm matrices include crop and livestock activities. The crop activities are wheat, oats, barley, hay and pasture while the livestock activities are lambs, sheep and cow-calf activities. The unit of a production activity is one acre for crops and pasture and one head of breeding stock for livestock breeding activities. The technical coefficients for the model, in terms of the yield of crop and livestock activities, were based on the data from the sample farms in conjunction with the annual provincial production surveys. There is no provision made for technological change within the model.

The programming supply model has two reference farm sizes, with the difference between the two farm sizes related to their level of resource endowments. Resource activities include buying and selling activities for all crops and livestock. Also included are purchase activities for arable and pasture land as

well as a rental activity for pasture land. A machinery activity is allowed for as well as a building expansion activity. The model is sufficiently flexible to allow for mixed crop and cattle activities or complete specialization in crops or livestock.

The financial segment of the linear programming matrices incorporates a yearly cash flow, opportunity cost of capital and a maximum borrowing constraint. Included in the model are term deposit activities, credit activities, a mortgage restriction and an absolute constraint on loans available to the farm. A mortgage restriction is imposed on the model at 50 percent of the real estate value of the reference farm. The financial constraints play an important role in that they prevent unlimited acquisition of plant, breeding stock, machinery or land. In order to avoid having the farmer make a trading profit by simply engaging in buying and selling activities, the buying and selling activities in the linear programming model must be at least equal.

The model assumes that the prices of all farm products and of resources are the same for all reference farms. Empirical values for crop prices were extracted from Alberta Agriculture *Production Costs and Returns Tables For Crops* (various issues). Livestock prices were obtained from Agriculture Canada *Livestock Market Review* (various issues). Variable costs are not a constraint in the linear programming matrices and are used only to calculate the value of the gross margin in the objective function.

Gross margin is defined per acre for crops and pasture, per ewe for the sheep activity and per cow for the cow-calf activity. In order to take account of the fact that the gross margin of some activities such as the sheep activity is composed of several products, the gross margin for sheep has components for the sale of wool, lambs and cull sheep. Beef activities include sales from one main product namely, yearlings. Finally, the gross margin for crop activities has components for both the sale and on farm feeding of grain and alfalfa hay activities. The farm gross margins are calculated by the computer algorithm for each production activity as revenue less variable costs.

The solution vector of the linear program yields the representative farm's plan. However, the optimal solution in this model does not include payment to labor or other overhead costs (costs not attributable to a given production activity). The following sections of this chapter are concerned with the estimation, reporting and testing the supply elasticity estimates from the normative supply model.

4.2 Empirical Results

In this section, the direct and cross price elasticity estimates derived from the linear programming models are reported and discussed. The analysis of individual supply curves is based on observing wool, lamb and cull sheep supply when all other prices and other elements of the model are held constant.

The reference farms were analyzed over a range of prices (parametric programming) for lamb, wool and cull sheep independently, to provide step-supply schedules for the products. In this study, supply elasticities are measured as average or arc elasticities and are calculated as follows:

$$E_s = \frac{(IO - FO)/(IO + FO)}{(IP - FP)/(IP + FP)}$$

where IO is the initial level of output

FO is the final level of output

IP is the initial price of output

FP is the final price of output

The elasticity of supply measures the percentage change in quantity supplied due to a 1 percent change in the price of the product. More specifically, the estimated supply elasticities show the rate of change of lamb, wool and cull sheep output with respect to changes in their market price levels. The arc elasticity is defined between values obtained for the optimal solution of the linear programming model and those obtained in the first change of basis. Elasticity estimates can be used to compare the response of a given output variable in different representative farms or to compare changes over different price ranges.

The empirical results are reported in two parts. The first part presents the elasticity estimates for the medium size reference farm while the second part presents the supply elasticity estimates for the large size reference farm. The direct price elasticity estimates for lamb for the medium size reference farm are shown in Table 4.2. The reported elasticities are given over three price ranges.

Table 4.2. Supply Elasticity Estimates for Lamb for the Medium Size Reference Farm.

Price Range ($)	Elasticity Coefficient
52.46 - 85.00	1.11
63.37 - 85.00	1.71
60.89 - 63.37	0.70
< 52.46	----

From Table 4.2 it can be seen that the supply of lamb is inelastic at low lamb prices, but as lamb prices increase supply becomes more elastic. At the upper end of the price range, that is, from $63.37 to

$85.00 per head, a 10 percent increase in the price of lamb results in a 17 percent increase in supply, ceteris paribus. At intermediate price levels, that is, from $60.89 to $63.37 per head, supply is inelastic. On average the estimated elasticity coefficient over the complete price range is 1.11, that is, the supply of lamb is elastic. Finally, when the lamb price falls below $52.46 per head, sheep production is no longer profitable and farm resources are switched to alternative enterprises.

The aggregate supply of lambs for all sheep farms in the medium size category can be derived by horizontal summation of the reference farm's supply function. More specifically, multiplying the optimum output of the reference farm at different price levels by the number of farms in the medium size farm category (Table 4.1) yields the aggregate supply of lamb from this farm group. The aggregate supply of lamb from the medium size sheep farms is shown in Table 4.3, at several price levels.

Table 4.3. Aggregate Lamb Supply from the Medium Sheep Farms.

Price Level ($)	Ref. Farm Supply (no.)	Number of Farms (no.)	Total Lamb Supply (no.)
85.00	960	593	569,280
63.37	576	593	341,568
60.89	560	593	332,080
52.46	----	----	---------

The total supply of lamb from the medium size sheep producers varies considerably over the price levels shown. Specifically, the supply of lamb varies by 71 percent from 332,080 head to 569,280 head over the price range $61.00 to $85.00 per head.

With respect to the elasticity of supply for wool, *a priori* one would expect a low elasticity of supply, as revenue from wool accounts for less than five percent of total income per livestock unit (ewe). The elasticity of supply for wool is estimated as 0.12 (inelastic) over the price range from $0.37 to $2.46 per kilogram. For cull sheep prices, *a priori* one would expect that the elasticity of supply to be closely related to the culling rate, with higher elasticities associated with higher culling rates. The estimated supply elasticity for cull sheep varies from 0.11 over the price range from $40.00 to $246.34 to 0.28 over the price range from $246.34 to $352.00 per head. The cross price elasticity estimates for wool, cull sheep, beef, wheat and barley are shown in Table 4.4.

Table 4.4. Cross Price Elasticities of Supply for the Medium Size Reference Farm.

Commodity	Lamb with respect to the price of:
Wool	0.12
Cull Sheep	0.11
Beef	-1.61
Wheat	-0.84
Barley	-1.11

The estimated cross price elasticities are consistent with prior expectations in that they have the appropriate sign. That is, beef, wheat and barley can be regarded as substitute products with respect to lamb production. For example, a one percent increase in the price of beef results in a 1.61 percent decrease in lamb output, ceteris paribus. The cross elasticity estimates for wool and cull sheep are low as they are relatively unimportant with respect to total income from sheep production[8]. The own price elasticity estimates for lamb for the large size reference farm are shown in Table 4.5. The elasticities are given for the price range $38.64 to $85.00 per head.

Table 4.5. Supply Elasticity Estimates for Lamb for the Large Size Reference Farm.

Price Range ($)	Elasticity Coefficient
38.64 - 85.00	1.47
57.79 - 65.29	3.60
65.29 - 85.00	2.83
< 38.64	---

The supply of lamb is elastic over all price levels from $38.64 to $85.00 for the large sheep reference farm. More specifically, over the price range from $57.79 to $65.29 the own price elasticity is 3.6, that is, for a one percent increase in the output price of lamb, supply will increase by 3.6 percent. Over the price range from $65.29 to $85.00, supply is less elastic at 2.83. Finally, over the complete price range from $38.64 to $85.00, the estimated elasticity of supply is 1.47, that is, for a 10 percent increase in the

8 The total revenue from wool and cull sheep account for less than 10 percent of the total income per livestock unit.

price of lamb, the quantity supplied will increase by almost 15 percent. The aggregate supply of lambs for farms in the large size sheep category are derived from the above reference farm results and are shown in Table 4.6.

Table 4.6. Aggregate Lamb Supply from the Large Sheep Farms.

Price Level ($)	Ref. Farm Supply (no.)	Number of Farms (no.)	Total Lamb Supply (no.)
85.00	2,160	72	155,520
65.29	990	72	71,280
57.79	630	72	45,360

Large sheep producers are more sensitive to changes in the market price for lambs. For example, over the price range $58.00 to $85.00 per head, lamb output increases by 243 percent from 45,360 head to 155,520 head.

The supply of wool for the large sheep reference farms is inelastic at 0.09, that is, for a 10 percent increase in the price of wool, supply increases by 0.9 percent over the price range from $0.37 to $2.39 per kilogram. Also, the own price elasticity of supply for cull sheep is low and varies from 0.07 over the price range from $40.00 to $163.00 per head, to 0.14 over the price range from $163.00 to $235.00 per head. Over the complete price range, that is, from $40.00 to $235.20, the estimated elasticity of supply is 0.09, thus, for a 10 percent increase in the price of cull sheep, supply will increase by less than one percent. The cross price elasticity estimates for the large sheep reference farm for wool, cull sheep, beef, wheat and barley are shown in Table 4.7.

Table 4.7. Cross Price Elasticities of Supply for the Large Size Reference Farms.

Commodity	Lamb with respect to the price of:
Wool	0.06
Cull Sheep	0.05
Beef	-0.95
Wheat	-0.89
Barley	-0.80

The signs on all the cross price elasticity coefficients for the large reference farm are consistent with prior expectations.

4.3 Sensitivity Analysis

This section of the study tests the sensitivity of the price elasticity estimates presented in the previous section. Basically, sensitivity analysis relates to the stability of the estimated elasticity coefficients. Stability of the estimated elasticities is normally expressed in terms of a range of values over which the coefficients are stationary. In this section, the magnitude of change required to bring about a change in the elasticity estimates are presented.

Sensitivity analysis measures the magnitude of price change permitted for the particular commodity before a change in the estimated elasticity coefficient occurs. The extent of the price range over which the price elasticities are stable can be calculated by expressing the level of the price variable at the first change of basis as a percentage of the level in the initial linear programming solution. The change in the value of the objective function required to produce the first change of basis when the particular coefficients are parametized individually are shown in Table 4.8.

Table 4.8. Values in the Objective Function at which the First Change of Basis Occurs, Expressed as a Percentage of the Initial Level for the Two Reference Farms.

Activity	Medium	Large
	%	%
Lamb	25	23
Wool	419	341
Cull Sheep	515	307

Changes in the value of the lamb, wool and cull sheep gross margins required to produce the first change of basis cover a considerable range. For example, the wool activity coefficient in the objective function for the medium representative sheep farm has to increase 419 percent in the linear programming matrix for the first change of basis to occur. Table 4.9 shows the range over which the cross price elasticities are stable.

Table 4.9. Range of Price Values over which the Cross Price Elasticities are Stable, for the Two Reference Farms.

Activity	Medium	Large
	%	%
Wool	419	619
Cull Sheep	516	307
Beef	39	16
Wheat	85	23
Barley	58	18

The values in Table 4.9 for beef, wheat and barley indicate the levels at which the non-basic activities become basic activities during the parametric procedure. The elasticity estimates reported earlier in this section indicate the rate of change for the relevant activities, while Tables 4.8 and 4.9 show the magnitude of change between the initial linear programming solution and the first change of basis in the parametric procedure. For example, if the initial gross margin of wool is set at 100 percent, the wool gross margin must increase 419 percent for the first change of basis to occur. However, during this increase a one percent increase in gross margin produces a 0.12 percent increase in wool output.

In summary, the representative farm linear programming procedure suggests that the supply of lamb from the commercial sheep industry is sensitive to changes in market prices. Larger sheep producers however, are more sensitive than medium size producers. Furthermore in the case of wool and cull sheep, output is not sensitive to changes in market price levels. Finally, cattle, wheat and barley production are competitive enterprises with respect to sheep production at the farm level.

4.4 Validation of the Results

The elasticity estimates derived in this study are validated by comparing the results from this study with elasticity estimates from other linear programming studies of the sheep industry[9]. Programming studies of the sheep industry differ with respect to the time period, composition of the programming model and whether the price of the product increases or decreases during the period of analysis. Thus, a direct comparison between elasticity estimates from different studies is not possible. However, supply

9 The author is not aware of any comprehensive programming study of supply for the Canadian sheep industry. Most of the programming studies of sheep supply relate to the Australian sheep industry.

elasticity estimates from other studies provide some guidance with respect to the approximate magnitude of the elasticities that could be expected for the industry. In Table 4.10, direct and cross price elasticity estimates are presented from a number of programming studies of the sheep industry.

Table 4.10. Comparison of Direct and Cross Price Elasticity Estimates from a Number of Normative Supply Studies.

Source	Direct Price Elasticity Estimates for:			Cross Price Elasticity of Lamb Supply with respect to the Price of:				
	Lamb	Wool	Sheepmeat	Wool	Sheep	Beef	Wheat	Barley
Monypenny (1975)	0.02				-0.67			
Hall and Menz (1985)		2.02	1.04					
Cornell and Hone (1978)	0.27-3.44		5.29-9.64		-0.47-4.39			
Wicks and Dillon (1975)		0.25-0.36						
This Study								
Med. Size Ref. Farm	0.70-1.71	0.12	0.11-0.28	0.12	0.11	-1.61	-0.84	-1.11
Large Size Ref. Farm	1.47-3.60	0.09	0.07-0.14	0.06	0.05	-5.15	-0.89	-0.80

The supply elasticity estimates derived in this study appear reasonable when compared to elasticity estimates from other programming studies. More specifically, the direct price elasticities for the medium and large size reference farms are similar to the Cornell and Hone (1978) study. However, the direct price elasticity estimates for wool and sheepmeat in this study are low compared to other studies. This could be partly attributed to the fact that returns from wool and sheepmeat make a low contribution to gross income from sheep farming in Alberta.

One of the major sources of error in the programming type analysis relates to over estimation of supply at the industry level due to the failure to take account of changes in the industry's structure. This problem can be overcome by adopting a trend technique such as a Markov chain process which takes into consideration the number of existing and potential farms in the industry. Thus, a joint linear programming Markov chain model could provide a more accurate estimate of the aggregate supply response in the sheep industry. The following section adapts the Markov chain process to examine the effects of price changes on the structure of the Alberta sheep industry.

5 Structural Change and the Markov Process

Learn and Cochrane (1961) define structural change as resulting from a change in one or more of the factors included in the 'ceteris paribus' condition. Essentially, structural change relates to a change in the slope of the supply function which in turn results from a change in one or more of the following:

(1) the nature of the production function;

(2) managerial abilities;

(3) the institutional environment of producers; and

(4) changes in the number and distribution of producers.

Other factors which have structural implications for an industry include the size and degree of specialization among firms, government programs, and the extent of market integration within the industry. Many variables which impinge upon supply cannot be uniquely classified as giving rise to supply shifts or to structural change. For example, changes in some variables such as a new production function for a competing product may give rise to supply shifts of greater significance than structural effects.

An understanding of the process of structural change within an industry is important in order to evaluate alternative policy options for the industry. Structural change includes not only technical change but also relates to entry and exit of firms and the number and size distribution of firms within the industry.

This section of the study applies the traditional Markov model to measure structural change within the Alberta sheep industry. Both stationary and non-stationary transitional probability matrices will be estimated from aggregate Census data.

The Markov chain process is a widely used technique for analyzing structural change in an industry. The Markov process focuses on the movement of firms from one size category to another and attributes discrete probabilities to these movements. Essentially, the standard first order Markov process is a stochastic process whereby the probability of a firm moving from one size category in period t, to another size category in period t+1, depends only on the outcome in period t, and this dependence is assumed to hold over all time periods. A further necessary assumption for using Markov models is that the observed movement of firms between different size categories provide a satisfactory measure of the underlying probabilities (Disney et al., 1988). Hallberg (1969) points out that when a series of transition probability matrices are found to be changing over time the Markov chain model can be modified to incorporate this variability. In his study, Hallberg defined a procedure to incorporate a non-stationary assumption into the Markov chain model by replacing the stationary probabilities with probabilities that are a function of exogenous factors subject to change throughout the sequence of outcomes (Hallberg, 1969, pp. 289-302).

This study adopts the Markov chain process to estimate transition probabilities for the Alberta sheep industry under the assumptions of both stationary and non-stationary transition probabilities. The procedure involves categorizing sheep producers into different size cohorts (states) and tracing changes in "states" of producers over the time period 1951 to 1986. Finally, the probability of movement between "states" is estimated and presented. Both stationary and non-stationary transition probabilities can then be used to project the future structure of the sheep industry.

5.1 The Markov Model

A first order Markov chain process postulates that the probability of an outcome of a given trial depends only on the outcome of the immediately preceding trial and this probability is assumed to be the same for each trial in the sequence. Consistent with this definition of the Markov process the model may be outlined as follows:

Where: S_i denotes possible states or outcomes, i=1, ... n.

W_{it} denotes the probability that S_i occurs on trial t ($Pr(S_{it})$) or the proportion of occurrences of S_i in time period t of a multinomial population based on a sample of size n.

P_{ij} denotes the transitional probability which represents the probability that for any time t, the

process is in state S_i and that it moves in the next time period to state S_j i.e., $Pr(S_{j(t+1)}/S_{jt}) = P_{ij}$.

$P = p_{ij}$ denotes the transitional probability matrix which represents the transitional probability for every pair of states (i, j = 1, 2 ... n) and is subject to the following constraints on the elements of the matrix.

(1) $P_{ij} \geq 0$ for all i and j

(2) $\sum_j P_{ij} = 1$, for all i

In the case of the first order Markov chain, the probability of a particular change from S_i in time t to S_j in time t+1 is:

(3) $Pr(S_{it}, S_{j(t+1)}) = Pr(S_{it}) Pr(S_{j(t+1)}/S_{it}) = W_{it} P_{ij}$

and the probability of S_j occurring at time t+1 is:

(4) $Pr(S_{j(t+1)}) = \sum_i W_{it} P_{ij} = W_{j(t+1)}$

Equation (4) shows the sample observations $W_{j(t+1)}$ as a linear function of the realized values W_{it}. In a sampling theory context, if errors are admitted in equation (1) to account for the difference between the actual and estimated occurrence of $W_{j(t+1)}$, then the sample observations may be assumed to be generated by the linear statistical model shown in equation (5).

(5) $W_{j(t+1)} = \sum_i W_{it} P_{ij} + U_{jt}$

Estimation of transition probabilities from the above statistical model requires the assumption that the P_{ij}'s are functions of the price of commodity i. The average transition probabilities may be derived from the following estimation equation.

(6) $W_{j(t+1)} = \beta_0 + \beta_1 w_{jt} + \beta_2 P_i + u_t$

Application of the Markov chain approach to the estimation of non-stationary transition probabilities involves the estimation of regression equations in which the transition probabilities are expressed as a function of specified exogenous variables. The values in the cells of the transition probability matrix constitute the dependent variable observations for the regression equations (Hallberg, 1969). A regression equation is estimated for each cell of the probability matrix. Projections of the structure of the industry with the non-stationary transition probabilities may be determined as follows: $X_{(t+1)} = X_t(\hat{p}_{ij})$ where the $\hat{p}_{ij}$ is composed of transition probabilities estimated for each cell in the matrix.

Telser (1963) has shown that the assumption of proportional disappearance is implicitly enforced when no explicit account is made in the Markov model for entry and exit of firms. By modifying the model to include an "exit" state, non proportional movement between states can be explicitly taken into account. Thus, the model of industry structure under the assumption of non proportionality includes not only size categories but also an "exit" category[10]. This allows firms in time period t+1 to move not only between size categories, but also into and out of the industry, irrespective of their position in the industry. In this study, stationary transitional probabilities are estimated for sheep farms assuming proportional disappearance among the three size categories. Non-stationary probabilities are also estimated assuming non proportional disappearance among the farm size categories by including an "exit" category in the model.

5.2 Data Used

Data used in this analysis were obtained from Statistics Canada, *Census of Agriculture* (Alberta), 1951 to 1986. Information on the number of sheep farms in each of three different size categories were collected and converted to percentage of farms by size. Percentages by size and total number of farms over the period 1951 to 1986 are shown in Table 5.1.

10 The exit category refers to a net exit of producers from the industry since both entry and exit are included in this category. In the case of the exit category, shares are developed using a base year and defunct farms make up the fourth category in the analysis.

Table 5.1. Sheep Farm Size Distribution in Alberta, 1951 to 1986.

Census Year	Total Number of Farms Reported	Small %	Medium %	Large %
1951	5,327	77.755	20.575	1.670
1956	5,785	73.207	24.719	2.074
1961	5,274	63.974	32.784	3.242
1966	3,203	63.940	32.751	3.309
1971	2,063	58.652	36.840	4.508
1976	2,244	67.157	29.412	3.431
1981	2,332	66.595	30.146	3.259
1986	2,148	69.041	27.607	3.352

Note: Small farms are farms with 1 to 47 head of sheep.
Medium farms are farms with 48 to 527 head of sheep.
Large farms are farms with 528 head of sheep or more.

The total number of farms in the sheep industry have declined by 60 percent over the period 1951 to 1986. The largest decline has occurred in the small sheep category (64 %) while the medium and large sheep categories have declined by 46 percent and 19 percent, respectively. A limitation of this analysis is that reliable data are only available for eight observation points over the period 1951 to 1986. The following empirical section presents the results on the movement of farms between different size categories over the period for which data is available.

5.3 Empirical Results and Discussion

Telser's methodology for estimating transition probabilities using the least squares technique is adopted in this analysis. In this study, the regression equations are estimated in a system using the Seemingly Unrelated Regression Estimation Technique (SUR)[11]. This technique links the explanatory variables to the probability of producers moving between states.

11 Adopting the econometric estimator (SUR) to estimate transition probabilities for the Markov chain process implies that no binding constraints are imposed on the estimated transition probabilities and thus, estimates may occur outside the admissible range.

Both stationary and non-stationary transition probabilities are reported in this section. The estimated stationary transition probabilities are based on the assumption that the micro observation units behave according to a stationary first order Markov chain process. This allows for the estimation of the probabilities from aggregate data and permits structural inferences to be made from the results. The least squares estimates for the stationary transition probabilities are shown in Table 5.2[12].

Table 5.2. Least Squares Estimates of the Stationary Transition Probability Matrix.

Dependent Variable	Small (t)	Medium (t)	Large (t)
Small (t+1)	0.7197	0.2662	0.0141
Medium (t+1)	0.1206	0.8620	0.0174
Large (t+1)	0.0211	0.0758	0.9031

The diagonal elements in Table 5.2 indicate the probabilities of farms remaining in the same size category from period t, to period t+1. For example, the estimated results reveal that a small farm in period t has a 72 percent probability of remaining small in period t+1 and a 12 percent probability of moving to a medium size farm category. In the case of the medium and large sheep producers there is an 86 percent and 90 percent probability, respectively, of remaining in the medium or large size categories in the period t+1. The estimated probabilities of medium farms becoming small in time period t+1 is 27 percent and large farms becoming small approximately one percent. Finally, the probability of a small farm becoming large is 2 percent while the probability of a medium farm becoming large is higher at 8 percent.

In the case of the non-stationary transition probabilities a fourth category was included to take account of entry and exit (Hallberg, 1969; Disney et al., 1988). The inclusion of this extra category not only permits movement between different size categories but also allows farms to leave the industry and new farms to enter. Table 5.3 shows the least squares estimates for the non-stationary transition probabilities.

12 Alternative estimators of transition probabilities include, the probability constrained quadratic programming (QP) method (Lee et al., 1965), the probability constrained minimum absolute deviations (MAD) method and the probability constrained minimum median absolute deviations (MOMMAD) method (Kim and Schaible, 1988).

Table 5.3. Least Squares Estimates of the Non-Stationary Transition Probabilities.

Dependent Variable	Small (t)	Medium (t)	Large (t)	Exit (t)
Small (t+1)	0.4947	0.1244	0.0262	0.3547
Medium (t+1)	0.1333	0.6020	0.1658	0.0989
Large (t+1)	0.0004	0.0312	0.7669	0.2015
Exit (t+1)	0.3805	0.0073	0.0517	0.5605

Table 5.3 shows that under the assumption of non proportional disappearance the probability of remaining small declines to 49 percent. This decrease occurs because there is a high estimated probability (38 percent) that small farms leave the industry. The probability of medium and large sheep farms remaining in their respective size categories is 60 percent and 77 percent, respectively. The model also indicates that the most likely shift upwards in size occurs as small farms become medium size farms. Finally, the probability of large farms leaving the industry is 5 percent while less than one percent of the medium size producers leave the industry.

The non-stationary Markov chain procedure provides a means to examine the effects of exogenous forces on the structure of the Alberta sheep industry. The primary limitation of the non-stationary procedure used in this study is the inadequacy of the data. The non-stationary Markov chain procedure predicts more rapid adjustment in the industry structure than the stationary model and is more consistent with what has actually taken place in the industry over the last 30 years.

Table 5.4 shows the total supply of lamb from both the medium and large sheep farms when the Markov transition probabilities are combined with the normative programming elasticity estimates of supply.

Table 5.4. Aggregate Lamb Supply from the Joint Model for Both the Medium and Large Reference Farms over Different Price Levels.

Price Level ($)	Ref. Farm Supply (no.)	Number of Farms (no.) Stationary	Number of Farms (no.) Non-Stationary	Total Lamb Supply (no.) Stationary	Total Lamb Supply (no.) Non-Stationary
		Medium Reference Farm:			
85.00	960	511	357	490,560	342,720
63.37	576	511	357	294,336	205,632
60.89	560	511	357	286,160	199,920
		Large Reference Farm:			
85.00	2,160	65	55	140,400	118,800
65.29	990	65	55	64,350	54,450
57.79	630	65	55	40,950	34,650

Table 5.4 illustrates that lamb supply can vary substantially depending on whether stationary or non-stationary transition probabilities are considered. Therefore, the movement of farms between different size categories is not constant but changes over time. In the case of the medium size sheep farms lamb supply is 30 percent lower when non-stationary probabilities are incorporated into the model. For the large sheep farms the predicted lamb supply is 15 percent lower for the model with non-stationary probabilities.

The Markov transition probabilities can be combined with the normative programming supply model for predicting lamb supply for both the medium and large sheep farms. In the case of the medium size sheep farms the joint model predicts a 14 percent and a 40 percent reduction in lamb supply with stationary and non-stationary transition probabilities relative to the base model. However, the joint model for the large sheep farms with stationary and non-stationary transition probabilities predict a 10 percent and a 24 percent lower lamb supply compared to the base model.

In summary, the projection of industry structure under the assumptions of the Markov model suggests that:

(i) there will continue to be a decline in the total number of sheep farms;

(ii) both medium and large sheep farms will increase in number;

(iii) small sheep farms will continue to decrease in number and will represent a declining share of total lamb production; and

(iv) the increase in concentration in the industry will have important implications with respect to developing future marketing policies for the industry.

6 An Econometric Approach to the Estimation of Supply Response

In this section, the theoretical framework for estimating supply elasticities from market level data is outlined, in addition to a discussion of the restrictions and assumptions required for the empirical analysis. The simultaneous equation model that is used to estimate the short-run and long-run elasticities is specified and discussed. This model combines a stock formation equation with a supply equation to give the simultaneous model from which supply elasticities are estimated. Finally, the own and cross price elasticity estimates for lamb are presented and discussed, together with some econometric studies of supply response for the sheep industry.

The theory of supply emphasizes the importance of differentiating between the short-run and long-run supply elasticity estimates. Knowledge of both short-run and long-run elasticity estimates provide information on industry adjustments to price changes over time. In the livestock sector, production occurs in a changing environment due to the biological lags associated with the growth process. Thus, time can play a major role in supply response adjustments in the livestock industry. For example, short-run supply elasticity estimates for lamb vary from 0.01 (Whipple and Menkhaus, 1989) to 0.50 (Jones, 1965). In the long-run supply elasticities also show wide variation from 1.12 (Powell and Gruen, 1967) to 11.38 (Whipple and Menkhaus, 1989). A thorough understanding of the speed and magnitude of adjustments in the lamb industry to economic stimuli could provide useful information in anticipating the long-run production effects of alternative sheep policy options.

The purpose of this section is to estimate econometrically both the short-run and long-run supply elasticities for lamb, cull sheep and wool for the Alberta sheep industry. Econometrically estimated aggregate short-run and long-run supply elasticities in conjunction with the medium term normative supply elasticity estimates reported in section 4 provide a more comprehensive understanding of the industry. Moreover, accurate supply elasticity estimates lead to greater clarification of issues and policy options available to the industry.

6.1 Model Formulation

In this study, a simultaneous equation model is used to estimate the short-run supply elasticities for lamb, wool and cull sheep. The procedure adopted in this study is similar to the approach outlined by Tryfos (1974). Tryfos, in his study of Canadian livestock and meat supply, used a simultaneous equation approach which demonstrates the interdependence between livestock supply and inventories. The remainder of this section focuses on the formulation of the simultaneous equation model and discussion of results.

With a simultaneous equation system there is two-way causation, that is, the variables within the system are jointly determined. In a simultaneous model, endogenous variables are included as explanatory variables in some equations of the model. Therefore, application of the ordinary least squares estimation technique to a simultaneous equation model results in inconsistent parameter estimates due to the possible correlation between the disturbance term and endogenous variables which are included as explanatory variables in the equations. Furthermore, the disturbance terms of each structural equation

may be contemporaneously correlated with the disturbance terms of other structural equations. Therefore, a more sophisticated estimation technique such as the systems estimation procedure is required to provide efficient estimates of the structural parameters in a simultaneous equation model.

In this study, the purpose of estimating an econometric model of supply response for the sheep industry is to differentiate between short-run and long-run elasticity estimates for lamb, wool and cull sheep. The supply of a commodity during the current time period (t) can be expressed in a linear form as a function of inventories (I) at the end of the previous time period (t-1).

(1) $Q_t^s = a_0 + a_1 I_{(t-1)}$

where $a_1 > 0$

It is assumed that the desired levels of inventories (I_t^*) are determined by the expected price of the commodity (P_t^*) and the expected cost of inputs (W_t^*). This relationship can be approximated by a linear function of the form:

(2) $I_t^* = b_0 + b_1 P_t^* + b_2 W_t^*$

The following assumption is also made, that higher inventories are held in anticipation of higher prices or lower expected costs. Therefore, this permits the following *a priori* expectations with respect to the coefficients on output prices and input costs, i.e., $b_1 > 0$, and $b_2 < 0$. In livestock econometric models an additional assumption which relates to expectations is often adopted, that is, current prices (P_t) and current costs (W_t) may be used as proxies for expected market prices and expected input costs (Nerlove, 1958). This permits the substitution of P_t^* and W_t^* by P_t and W_t, respectively.

(3) $I_t^* = b_0 + b_1 P_t + b_2 W_t$

Thus, the relationship between the actual inventory level and desired inventory can be expressed as follows:

(4) $I_t - I_{(t-1)} = \Psi\{I_t^* - I_{(t-1)}\}$

where $0 < \Psi \leq 1$, indicates a "partial adjustment" of actual inventory to deviations of desired inventory from the actual level at the end of the previous period. Substituting equation (3) into equation (4) gives:

(5) $I_t = \psi b_0 + \psi b_1 P_t + \psi b_2 W_t + (1-\psi)\ I_{(t-1)}$

Therefore, total supply can be expressed as a function of the difference between the quantity of the commodity available during the current period (Q_t^s) and of inventory change as follows:

(6) $S_t = Q_t^s - \sigma(I_t - I_{(t-1)})$

where σ is a positive number between zero and one. Substituting equation (1) into equation (6) yields the following:

$$(7)\quad S_t = \alpha_0 + (\alpha_1 + \sigma) I_{(t-1)} - \sigma I_t$$

The theoretical model outlined above requires the simultaneous estimation of the following system of equations:

$$(8)\quad I_t = \alpha_0 + \alpha_1 P_t - \alpha_2 W_t + \alpha_3 I_{(t-1)} + \alpha_4 I_{(t-2)} + U_{1_t}$$

$$(9)\quad S_t = \beta_0 + \beta_1 I_t + \beta_2 I_{(t-1)} + U_{2_t}$$

where $U_1 t$ and $U_2 t$ are error terms, and the expected signs of the parameters are:

$\alpha_1 > 0$

$\alpha_2 < 0$

$0 < \alpha_3 < 1$

$\beta_1 > 0$, and

$\beta_2 > 0$.

The endogenous variables in the simultaneous equation model are I_t and S_t and the predetermined variables are P_t, W_t, and $I_{(t-1)}$.

The system to be estimated consists of two equations (equations (8) and (9)) within which inventory is determined by prices and costs while output is determined by flock size. Inventory or flock size is postulated to be explained by flock size lagged two periods, market prices and input costs. The lines of causation in the above model run from prices and costs to inventory levels which in turn determine lamb, wool and cull sheep output. In this study, the FI - "Seemingly Unrelated Regression" (SUR) estimation technique is adopted. The results are reported following an outline of the data sources used in the analysis.

6.2 Sources of Data

Data for the parameters of the simultaneous equation model were collected from several different sources. The basic sources of data are the publications of Statistics Canada and Alberta Agriculture.

The data series selected has 18 data points for each variable representing 18 years of annual values. This encompasses the time period from 1970 to 1987. Data on sheep and lamb prices were collected from the *Agriculture Statistics Yearbook* for Alberta and converted to dollars per tonne of sheep and lamb

output. The consumer price index (Consumer Price Index (CPI), 1981=100) for all goods was used as the deflator of livestock prices and input prices in the model. The CPI data were collected from Statistics Canada *The Consumer Price Index*, Catalogue number 62-001.

The cost of hay is taken as a proxy of input costs in the sheep industry. The data on inputs were extracted from the *Farm Input Price Index*, Catalogue 62-004. Finally, the remaining data on output quantities for sheep and lamb were collected from Statistics Canada *Livestock and Animal Product Statistics* and T. W. Manning (1986) *Alberta Agricultural Productivity: Methodology and Data Used.*

6.3 Empirical Results

This section presents the results from the Seemingly Unrelated Regression Estimation Technique that is employed to estimate the supply response for lamb, cull sheep and wool. The supply model includes six behavioral equations that describe the responses of the dependent variable. While the estimated parameters of the endogenous variables are determined within the model the values of the exogenous variables are established by factors outside the sphere of influence of the Alberta sheep industry. Lagged variables are classified as predetermined because their values in the current time period are known.

The six behavioral equations are estimated in three groups using Shazam, version 6.1 (White et al., 1988) econometric computer program. The following equations outline the results obtained when the Seemingly Unrelated Regression Estimation Technique is applied to the supply and inventory models for lamb, wool and cull sheep[13].

Lamb :

$$(10a) \quad \hat{S}_t^l = -1046.7 + \underset{(0.9634)}{0.03745 I_t} + \underset{(4.2461)}{0.03037 I_{(t-1)}}$$

$R^2 = 0.74$

$$(10b) \quad \hat{I}_t = 6225 + \underset{(15.807)}{0.1984 I_{(t-1)}} - \underset{(-6.8156)}{0.6971 I_{(t-2)}} + \underset{(4.0082)}{28.078 P_t} - \underset{(-2.188)}{195.95 W_t}$$

$R^2 = 0.94$

Wool :

$$(11a) \quad \hat{S}_t^w = -29.603 + \underset{(2.6967)}{0.0017 I_t} + \underset{(0.9304)}{0.0006 I_{(t-1)}}$$

$R^2 = 0.76$

13 The t-ratios are shown in parentheses below each estimated coefficient.

$$(11b) \quad \hat{I}_t = 25901 + 0.3184 I_{(t-1)} - 0.5129 I_{(t-2)} + 16.208 P_t - 134.57 W_t$$
$$(11.792) \quad (-4.724) \quad (2.1076) \quad (-1.1575)$$

$R^2 = 0.93$

Cull Sheep :

$$(12a) \quad \hat{S}_t^s = -198.71 + 0.0020 I_t + 0.01782 P_t$$
$$(2.5521) \quad (3.2592)$$

$R^2 = 0.22$

$$(12b) \quad \hat{P}_t = 457.83 + 0.0071 I_t - 0.1593 I_{(t-1)} + 9.1666 W_t$$
$$(1.1471) \quad (0.9560) \quad (-1.5489) \quad (5.7424)$$

$R^2 = 0.76$

The overall explanatory power of the lamb and wool equations and the magnitudes of the coefficients are satisfactory. The parameter estimates in these equations have signs which are consistent with the theoretical model developed earlier in this study. In the stock formation equations the price coefficients are positive while all input cost coefficients are negative. The coefficients on price are significant in all equations at the 5 percent level of significance as are the coefficients on the input cost parameters with the exception of the inventory equation with respect to wool supply. One period lagged inventory coefficients in the stock formation equations for lamb and wool are positive while the two period lagged coefficients are negative in the lamb and wool equations. In the case of the cull sheep equation the lines of causation run from inventory levels to price to output supply. The estimated coefficients for inventory and sheep prices are significant in the supply equation at the 5 percent level of significance.

6.3.1 Estimation of Short-Run and Long-Run Supply Elasticities

In the estimation of supply response for the three commodities lagged inventory is used as a proxy measure of short-run capacity. This approach to locating short-run production frontiers permits formal equivalence to Nerlove's distributed lag model of supply adjustment (Nerlove, 1958). Thus, short-run price elasticities can be estimated directly from the linear supply system using the following formula:

$$\eta_{(ij)} = \beta_{(ij)} \{P_j^* / Q_i^*\}$$

where, $\eta_{(ij)}$ = short-run price elasticity of supply for product i with respect to expected price j;

$\beta_{(ij)}$ = parameter estimate;

P_j^* = sample mean of expected output prices; and

Q_i^* = sample mean of expected output quantities.

The long-run supply elasticities can be calculated from the short-run estimates by multiplying the short-run elasticities by the factor $\{1 - \hat{I}_{(t-1)}{}^{(-1)}\}$ where $\hat{I}_{(t-1)}$ is the estimated one period lagged inventory coefficient within the supply equation. Powell and Gruen (1967, p.72) point out that long-run elasticities are operationally obscure and more sensitive to arbitrary assumptions with respect to the structure of price expectations than are short-run elasticities. The long-run supply elasticities are calculated as follows:

$$\eta^{l}_{(ij)} = \eta_{(ij)} \{1 - \hat{I}_{(t-1)}{}^{(-1)}\}$$

The own price supply elasticities for lamb, wool and cull sheep are computed from the livestock supply and inventory equations and are presented in Table 6.1.

Table 6.1. Own Price Elasticities of Supply for Lamb, Wool and Cull Sheep, Calculated at Point of Means.

Supply of:	Short-Run Elasticity	Long-Run Elasticity
Lamb	0.3615	1.2187
Wool	0.0743	0.1586
Cull Sheep	0.0384	0.2795

For lamb, wool and cull sheep the short-run supply elasticity estimates are low, implying that the supply of these commodities is highly inelastic. Livestock supply in the short-run is therefore related to output prices and input costs in previous periods rather than to current prices and costs. This is due to the biological lag involved in the production and marketing of livestock. For example, a rise in the market price for livestock cannot be accompanied by an immediate increase in supply. Favorable market prices and input costs are expected to increase the current level of livestock inventories which in turn will result in an increase in lamb supply. In this study, the long-run supply estimate for lamb is elastic while the supply estimates for wool and cull sheep are inelastic.

In summary, this study suggests that the short-run and long-run supply elasticity estimates for lamb are 0.36 and 1.22, respectively. That is, if the market price for lamb increases by 1 percent then the supply of lamb will increase by 0.36 percent in the short-run and by 1.22 percent in the longer run. For wool, both the short-run and long-run elasticity estimates are low at 0.07 and 0.16, respectively. In this case if the market price for wool increases by 1 percent then the supply of wool will increase by 0.07 percent in

the short-run and by 0.16 percent in the long-run. Lastly, the supply elasticity estimates for cull sheep are also low at 0.04 for the short-run and 0.28 for the long-run. That is, for a 1 percent increase in the market price for cull sheep, the supply will increase by 0.04 percent in the short-run and by 0.28 in the long-run.

7 Estimation of Demand for Lamb

The demand for meats is determined not only by the traditional economic variables of prices and income but also by demographic and socioeconomic factors. Demographic factors include population characteristics such as size, distribution, age structure and ethnicity. On the other hand socioeconomic factors include employment patterns, household size, composition, consumer tastes and preferences. Demographic and socioeconomic variables play an important role in influencing the demand for some meats especially lamb which tends to have a more seasonal pattern of consumption. Historically, meat demand studies have attributed per capita consumption to the price of the product, prices of other meats and an income or expenditure variable. This section consists of two parts. The first part discusses the price and income elasticity estimates for lamb from some Canadian meat demand studies. In the second part some estimates of demand for fresh and frozen lamb in Alberta are reported.

7.1 Review of Some Relevant Demand Studies

Economic theory provides some guidance with respect to certain *a priori* expectations regarding demand elasticity estimates. For example, the own price elasticity of demand for a product is normally negative. The own price elasticity refers to the percentage change in the quantity demanded caused by a 1 percent change in price, ceteris paribus. In the case of cross price elasticities, these indicate whether a good is a substitute (positive cross elasticities) or a complement (negative cross price elasticities). The cross price elasticity refers to the percentage change in quantity demanded of a particular product caused by a 1 percent change in the price of the other product.

The income elasticity of demand refers to the percentage increase in quantity demanded caused by a 1 percent change in income. For most goods the income elasticity is positive, that is, an increase in income will result in an increase in consumption. However, inferior goods have a negative income elasticity of demand. Conversely, luxury goods have an income elasticity greater than one while necessities have an income elasticity less than one. Neoclassical demand theory indicates that the sum of the own

price, cross price and income elasticities equals zero. Specifically, this implies that estimation of the own price and income elasticities for a product permits the sum of the cross price elasticities to be calculated from the difference.

There are a number of factors which determine the magnitude of the elasticity estimates including the levels of prices, number of substitutes, preferences and the size of the budget share. More specifically, it is expected that the higher the price of a product the higher the own price elasticity (more elastic), and the lower the product price the lower the own price elasticity (inelastic), ceteris paribus. In terms of the cross price elasticity estimates, the larger are the estimates for two products the greater is the substitutability between the products. That is, the availability of close substitutes allows consumers to switch to similar products if the price of the first product increases. Furthermore, the demand for a particular product is likely to be price elastic where a large number of substitutes are available. Lastly, the stronger the preferences of consumers for a particular product, the lower the magnitude of the own price elasticity. Similarly, the demand for a product which accounts for a small share of the consumer's budget is expected to be price inelastic.

Table 7.1 provides a summary of results for lamb from some studies of meat demand in Canada and includes the source of the study, time period of the sample, estimation method, direct, cross price and income elasticity estimates for lamb.

Table 7.1. A Summary of Some Canadian Meat Demand Studies Showing the Price, Cross Price and Income Elasticity Estimates for Lamb.

Source	Period	Method of Estimation	Income Elasticity	Direct Price Elasticity	Cross Price elasticity w.r.t. the price of: Pork	Veal	Beef
Tryfos and Tryphonopoulos (1973)	1954-1970	SUR	-2.909	-1.801			
Reimer and Kulshreshtha (1974)	1949-1971	TSLS	-0.113	-1.043			
Hassan and Johnson(1976)	1957-1972	SUR	0.390	-1.862	0.968		
"	1957-1972	FIML	0.393	-1.866	0.964		
Hassan and Katz (1975)	1954-1972	SUR	0.488	-2.042	0.834		
"	1954-1972	FIML	0.487	-2.067	0.843		
"	1954-1972	SUR	0.390	-1.862	0.968		
"	1954-1972	FIML	0.393	-1.866	0.964		
McIntosh (1972)	1953-1969	OLS		-1.323		3.625	-2.337

where: SUR = Seemingly Unrelated Regression
TSLS = Two Stage Least Squares
FIML = Full Information Maximum Likelihood
OLS = Ordinary Least Squares

The range of price and income elasticity estimates reported in Table 7.1 can be attributed to the following factors: different model specifications, functional forms, time periods and estimation methods. The direct price elasticity estimates for lamb have the correct sign and range in magnitude from -1.043 to -2.067. The inverse relationship between the price and quantity of lamb suggests that for a 1 percent increase in market prices the quantity of lamb that will be demanded will decline by 1 to 2 percent. Conversely, a decline in market price will result in an increase in producers' total revenue from the sale of lamb. As pointed out by Hassan and Katz (1975), lamb, veal and turkey are seasonal commodities with peak consumption occurring during public holidays. Therefore, these meats are more price elastic than pork, beef or chicken which are characterized by more frequent consumption.

The estimated cross price elasticities are all positive with the exception of beef in the McIntosh (1972) study. This implies that consumers view these meats as substitutes rather than as complements. The estimates indicate that lamb consumption is affected by changes in pork prices. For example, the cross price elasticity estimates for lamb with respect to the price of pork varies from 0.834 to 0.968. That is, for a 1 percent increase in the price of pork, the consumption of lamb increases by 0.8 to one percent, ceteris paribus. Therefore, due to the apparent complementary nature of pork and lamb a more coordinated approach to advertising and promotion of these products may yield greater returns to producers.

The income elasticity estimates are all positive with the exception of the Tryfos and Tryphonopoulos (1973), and Reimer and Kulshreshtha (1974) studies. The estimated income elasticities for lamb vary from 0.390 to 0.487, i.e., a 10 percent increase in income is associated with a 4 to 5 percent increase in lamb consumption. Hassan and Katz (1975) point out that estimating income elasticities from time series data may encounter statistical problems, for example, high correlation between prices and income. In addition, persistent annual increases in per capita disposable income makes it difficult to statistically distinguish the effects of income from trend and to obtain accurate estimates of these parameters.

In order to overcome some of these statistical problems some researchers have attempted to estimate income elasticities for meats from cross sectional data. More specifically, Hassan and Lu (1974) have estimated the income elasticity for lamb from cross sectional data to be 0.676. Curtin et al. (1987) in their study of the demand for food in Canada, estimated the own and cross price elasticities from time series data but income elasticities were estimated from both time series and cross sectional data. They found that the income elasticities based on time series data were strongly negative and varied from -1.4 to -2.8, indicating that lamb is an inferior good. That is, as the level of disposable income increases by 1

percent, the demand for lamb declines by 1.4 to 2.8 percent. Conversely, the income elasticity estimate derived from the survey data was 0.715, indicating that a 1 percent increase in the level of income results in a 0.715 percent increase in the demand for lamb.

7.2 Estimation of Demand for Lamb in Alberta

The purpose of this section is to examine the demand for lamb in Alberta over the period 1977 to 1987. Two alternative models of lamb are estimated. These models are identical in all respects except for the specification of the income variable. In both of these models, the consumption of lamb is assumed to depend on the price of lamb, quarterly intercept dummies, a time trend variable and an income variable. The income variable is either per capita expenditures on all goods deflated by the consumer price index or per capita expenditure on the meat group deflated by the consumer price index. With time series analysis an implicit assumption is that the structure of demand and the values of the coefficients remain stable over the period of the study. However, a time variable is included in the regression equation to account for changing technology over time. Interpretation of the time coefficient may be difficult as the time variable absorbs most of the unexplained variation in addition to the effects of technology. Finally, seasonal intercept dummies are also included in the model.

Alston and Chalfant (1987) discuss the effects of deflating by the consumer price index as it imposes homogeneity of degree zero in income and prices. The two models are identical with the exception of the income variable. The regression models are linear in both cases with the dependent variable specified as per capita consumption of lamb.

Model 1 includes expenditures on all goods:

$$(1) \qquad Q_i = a_i + \sum_j b_{ij}(P_j/CPI) + C_i X_1/CPI + d_i T$$

Model 2 includes expenditure on the meat group:

$$(2) \qquad Q_i = a_i + \sum_j b_{ij}(P_j/CPI) + C_i X_2/CPI + d_i T$$

where Qi = per capita consumption of meat

Pi = price of meat

X1 = expenditure on all goods

X2 = expenditure on the meat group

CPI = consumer price index for all goods

T = time trend variable

Data for the parameters of the model were collected from several different sources. The retail price data for beef, pork, chicken, Alberta lamb and New Zealand lamb were obtained from the Statistics Branch, Alberta Agriculture. Specifically, the price data were extracted from the weekly Retail Price Survey Reports for Edmonton and Calgary over the period 1977 to 1987. Since quarterly consumption data for the four meats for Alberta were unavailable, national quarterly consumption data were incorporated into the demand models with the assumption that the consumption of these meats in Alberta closely follows the national consumption pattern over the period of the study. In the case of lamb consumption it was also assumed that the ethnic composition of the Alberta population was similar to that of the total population. The population statistics used in the empirical analysis were extracted from the Quarterly Estimates of Population for Canada and the Provinces. Personal expenditures figures for Alberta were obtained from the Alberta Statistical Review. Finally, the nominal retail price for the various meat types was deflated by the consumer price index (CPI) for all items. The CPI was taken from various issues of the Consumer Price Index Catalogue of Statistics Canada.

Various specifications of the lamb demand model and various functional forms were used to identify the most appropriate model to explain the demand for lamb in Alberta. Disaggregation of total lamb consumption into chilled and frozen was also undertaken in order to estimate demand for chilled and frozen lamb in Alberta.

The empirical estimation procedure involved estimating the single equation linear demand model using ordinary least squares estimation. A systematic approach was taken to estimating other functional forms (semi-log, double log and inverse demand) and other specifications including dummy variables and lagged explanatory variables. The demand equations were estimated using quarterly data for the period 1977(1) to 1987(4).The estimates of the first two models are reported in Table 7.2.

Table 7.2. Single Equation Estimates of Demand for Lamb

Independent Variables	Dependent Variable Values (Quantity of Lamb)	
	Model 1	Model 2
Price of lamb	0.19*	0.12
Price of beef	0.04	0.10
Price of pork	0.20*	0.23
Price of chicken	0.34	0.15
Time	0.01	----
X1	----	----
X2	----	----
Intercept	-0.38	-0.54
R^2	0.43	0.31
D.W.	2.27	1.90
$\hat{\sigma}^2$	0.01	0.01

Note. * statistical significance at the 5 percent level.
Model 1 includes expenditure on all goods;
Model 2 includes expenditure on meats as the income variable; and
$\hat{\sigma}^2$ is the estimated variance of the error term.

On the basis of R^2 Model 1 is superior in terms of explaining the variation in meat consumption in the lamb equations. The positive sign on the own price variable would appear to indicate that price may not be a significant factor in determining the consumer demand for lamb. However, closer examination of the empirical results indicate that there may be a number of possible explanations for the apparent insignificant effect of lamb prices on quantity demanded. First, the effects of the price increase may be more than compensated for by other factors such as price increases for substitutes or a shift in consumer preferences. Second, relevant demographic variables may have been omitted from the model. Third, the assumptions made in formulating the model and data used may require further testing. Finally, the price of lamb may not be as important a factor with respect to lamb consumption as in the case of other red meats, due to the special characteristics associated with the lamb market and lamb consumers. These characteristics relate to the low volume, low frequency and seasonality associated with lamb consumption. Lamb is regarded as a specialty meat with highest level of consumption occurring at

Christmas and Easter. Extending the basic model to include seasonal dummy variables and lagged explanatory variables improved the explanatory power of the lamb equation significantly as shown in the following section:

$$(1)\quad \hat{Q}_l = -0.029 + 0.031P_l + 0.092P_b - 0.046P_p + 0.472P_c$$

$$(0.511)\quad (0.120)\quad (0.126)\quad (0.154)\quad (0.263)$$

$$-0.001X_1 + 0.009T - 0.073P_{(bl-1)} + 0.208P_{(ll-1)} + 0.329P_{(pl-1)}$$

$$(\ )\quad (0.003)\quad (0.122)\quad (0.134)\quad (0.141)$$

$$-0.161P_{(cl-1)} - 0.091D_1 + 0.012D_2 - 0.010D_3$$

$$(0.280)\quad (0.074)\quad (0.077)\quad (0.068)$$

N = 43 $R^2 = 0.60$ D.W. = 2.20

A number of different functional forms were estimated including, the semi-log and double log forms. The different functional forms however yielded no improvement in the explanatory power of the model. Also the demand for chilled and frozen lamb in Alberta were estimated and the results are as follows:

$$(2)\quad \hat{Q}_{(lc)} = -0.070 + 0.047P_{(lc)} + 0.035P_b + 0.090P_p$$

$$(0.162)\quad (0.029)\quad (0.031)\quad (0.032)$$

$$+0.135P_c - 0.000X_1 + 0.003T$$

$$(0.118)\quad (\ )\quad (0.001)$$

$R^2 = 0.49$ D.W. = 2.28 N = 44

$\hat{Q}_{(lc)}$ = chilled lamb consumption.

$$(3)\quad \hat{Q}_{(lf)} = -0.160 + 0.058P_{(lf)} + 0.050P_b + 0.116P_p$$

$$(0.190)\quad (0.041)\quad (0.027)\quad (0.032)$$

$$+0.135P_c - 0.000X_1 + 0.002T$$

$$(0.119)\quad (\ )\quad (0.001)$$

$R^2 = 0.40$ N = 44 D.W. = 2.09

$\hat{Q}_{(lf)}$ = frozen lamb consumption

The disaggregated estimates with respect to chilled and frozen lamb also yielded positive signs on the price variable.

To conclude, the empirical results with respect to the estimation of the demand for lamb in Alberta would appear to indicate that because of the speciality nature of lamb as a meat and special characteristics of the market, the demand for lamb differs substantially as compared to the demand for the other major meats such as beef, pork and chicken. In addition, greater effort must be made to collect more detailed data with respect to lamb consumption, regional markets and ethnic groups. Furthermore, greater consideration should be given to demographic factors such as family size, marital status, education level and ethnic background. Finally, other factors such as the convenience aspect, health, nutritional, and macro economic factors also play a role in influencing the demand for speciality meats such as lamb.

8 Australian and New Zealand Lamb Marketings in Canada

This section provides a brief review of lamb and mutton imports from Australia and New Zealand (NZ). Imports of lamb from N.Z. follow a well defined marketing system in the Canadian market. The N.Z. Meat Export Development Company (DEVCO) is responsible for the orderly marketing of N.Z. lamb carcasses and portion cuts in Canada and the United States (U.S.). New Zealand lamb sales to North America are controlled by DEVCO. The directors of DEVCO are nominees of the N.Z. Meat Producers Board and representatives of the private freezing companies. The Producers Board engage in many marketing and promotional activities in the export trade on behalf of producers. For example, the board plays a major role in influencing export meat marketing policies through regulation of shipments, control over quality and the development of markets through promotion.

The companies purchase the sheep destined for slaughter under the export schedule and take responsibility from delivery at the slaughter house until the final carcass is produced. Essentially, the board controls both the grading and payment systems for sheepmeat carcasses. Prior to 1985, the board was responsible for setting the export schedule for lamb. However, since 1985 the individual companies have been setting their own schedules. Basically, the export schedule sets a floor price for mixed cross lambs and lambs from the wool breeds produced for meat. Generally, DEVCO purchases lambs in carcass form from the freezing companies. Having purchased the carcasses, DEVCO arranges for their subsequent processing and export. Chilled lamb portions are transported by airfreight in special cartons to markets in Canada and the U.S. On arriving at the ports of entry namely, Vancouver, Montreal and Toronto the lamb carcasses and portion cuts are shipped to local depots for distribution to final markets. Virtually all N.Z. lamb imports are sold directly to the institutional trade and to retail chain stores.

The Australian Meat and Livestock Corporation (AMLC) carefully monitors and facilitates lamb and sheepmeat exports from Australia. The AMLC not only administers export licenses for lamb to private exporters but also engages in marketing activities for Australian lamb in export markets. The major activities of the AMLC include enforcing the regulations regarding meat grading and preparation standards and in general promotional efforts for Australian meat in overseas markets. The export of meat from Australia falls under the jurisdiction of the Federal Government. Federal regulations require that all export meat is prepared in licensed premises and is inspected and passed by Federal Meat Inspectors. Almost all the Australian prime chilled lamb entering Canada is sourced in Victoria and New South Wales (N.S.W.). However, frozen sheepmeat exports arise not only from N.S.W. and Victoria but also Queensland and Western Australia. The transportation and distribution systems in N.S.W. are well developed and directed to Sydney. The airfreight capacity from Sydney to Canada is greater than for any other Australian export port while in addition the unit costs are lower.

Almost all Australian exports of prime lamb to Canada are in chilled form and are therefore shipped via airfreight. The safe commercial life of chilled lamb from slaughter to final user is approximately 28 days, thus eliminating other modes of transport for this particular product. During transit lamb is kept chilled in containers using solid carbon dioxide (dry ice). The major factor limiting exports of chilled prime lamb to Canada has been the limited airfreight capacity between Australia and Canada. On arrival in Canada Australian lamb is traded via brokers and/or distributed by wholesalers to final markets. Like N.Z. lamb imports, Australian lamb also serves the institutional trade and retail chain stores in Canada. The final destination of imported N.Z. and Australian lamb is difficult to determine as interprovincial movement of lamb is virtually impossible to trace. Lastly, a recent development with respect to lamb imports from Oceania has been the shipment of live lambs from N.Z. to Vancouver.

Traditionally, N.Z. has been the main supplier of frozen lamb to the Canadian market while Australia has been the main source of mutton supplies. In 1989, imports of fresh sheepmeat amounted to 11,529 tonnes while total frozen imports amounted to 8,252 tonnes. During the 1980s imports of sheepmeat, in particular, chilled lamb have increased dramatically. More specifically, chilled lamb imports from Australia and N.Z. increased from 770 tonnes in 1981 to 2,452 tonnes in 1989. Most of this increase can be attributed to increased imports of Australian lamb. Imports of chilled lamb from Australia have increased from 7 tonnes in 1981 to 1,206 tonnes in 1989. With respect to N.Z., chilled lamb imports have also shown a dramatic increase from 94 tonnes in 1981 to 1,246 tonnes in 1989. However, during the 1980s imports of chilled lamb from the U.S. have increased only marginally from 669 tonnes in 1981 to 695 tonnes in 1989.

In the case of frozen lamb, imports from N.Z. in 1989 were 6,764 tonnes or 82 percent of total frozen lamb imports while imports from Australia were approximately 541 tonnes. Finally, mutton imports represent only a small proportion of total sheepmeat imports. In 1989, 783 tonnes of mutton were imported from Australia. This accounted for approximately 87 percent of total mutton imports for that year. The increased imports of sheepmeat from Australia and N.Z. in recent years can be related to a number of factors including, the low international prices for other Australian and N.Z. agricultural products in addition to a decline in the value of the Australian and N.Z. dollar which has provided a price advantage to these countries on foreign markets.

9 Potential Marketing Options for the Alberta Sheep Industry

This section outlines the marketing options available to the sheep industry. The potential marketing options open to the industry can be divided into two broad groups, demand expansion programs and producer marketing agencies.

9.1 Demand Expansion Programs

Demand expansion programs include all programs which attempt to maintain or increase the demand for lamb. More specifically, demand enhancement programs have a twofold objective: to shift the product demand curve to the right and to make the demand for the product more inelastic. The demand expansion programs focus primarily on advertising and promotional efforts which directly expand the demand for the particular product or group of products. Promotional efforts can be divided into two classes. First of all there are those programs that concentrate on disseminating information about the characteristics of a particular brand of a commodity. Alternatively, promotional efforts may involve a cooperative approach among producers to promote consumption of the particular commodity. The effects of cooperative or generic advertising differ from the effects of competitive or brand advertising.

Promotional and advertising efforts provide information about product alternatives, quality differences, prices and reliability of the product to both existing and potential customers. Furthermore, advertising is a useful means of creating and enforcing product differentiation with respect to a commodity. The success of advertising to attain product differentiation depends on the attributes of the product and the ease with which these attributes can be measured. For many food products attributes such as taste and packaging, etc. can be easily judged.

Finally, the level and intensity of advertising depends on product differentiation or elasticity of demand, barriers to entry and scale economies in addition to characteristics of the particular commodity and markets. These characteristics include the extent of product transformation, quality standards, potential uses of the product, number of substitutes, product availability, nutritional and health attributes in addition to features of the market such as structure and the degree of market saturation. In addition to advertising and promotional policies, other types of demand expansion policies include product policies (e.g. product proliferation) and price policies (e.g. price discrimination).

In summary, it would appear that because of the high elasticity of demand for lamb that the above strategies could be an effective means of expanding the demand for lamb in Canada.

9.2 Producer Marketing Agencies

The alternative marketing option available to the sheep industry relates to the supply side of the industry and involves some form of producer marketing agency. Essentially, these marketing agencies are marketing institutions which perform some or all of the marketing functions on behalf of producers of the particular agricultural commodity. Agricultural marketing agencies are diverse in terms of their composition, power and nature of their activities. The general objectives of these agencies have been to improve prices and incomes of producers, to reduce uncertainty and instability in prices and incomes and to provide greater access to market opportunities. In essence, marketing agencies for agricultural commodities can be divided into two categories: supply management boards and centralized selling agencies

9.2.1 Supply Management Boards

The primary function of supply restricting management boards is to limit marketable supplies by imposing production or marketing quotas and thus to achieve higher prices and revenues for commodities for which demand is price inelastic. In principle, supply management can be an effective means of controlling marketable supplies and of raising and stabilizing farm prices and incomes in agriculture provided that the demand for the commodity is price inelastic. The effectiveness of supply management as a marketing option depends not only on the magnitude of the demand and supply elasticity estimates but also on the ability to restrict imports of the product. In order to influence the domestic demand for a product control is required over imports of the product in addition to domestic production quotas. For a commodity where demand is price inelastic, a supply management program results in a greater transfer of income from consumers and/or retailers and processors to producers. In essence, supply restricting management boards have monopoly power.

This remainder of this section presents some empirical estimates of the aggregate annual short-run income transfers and losses in allocative efficiency due to a supply management program. In order to quantify the market outcome of the program the analyses draws on the supply elasticity estimates derived in Sections 4 and 6 of this study and the demand elasticities presented in Section 7. The losses in consumer surplus, gains in producer surplus and social costs associated with a supply management marketing program are calculated from the following formulae[14]:

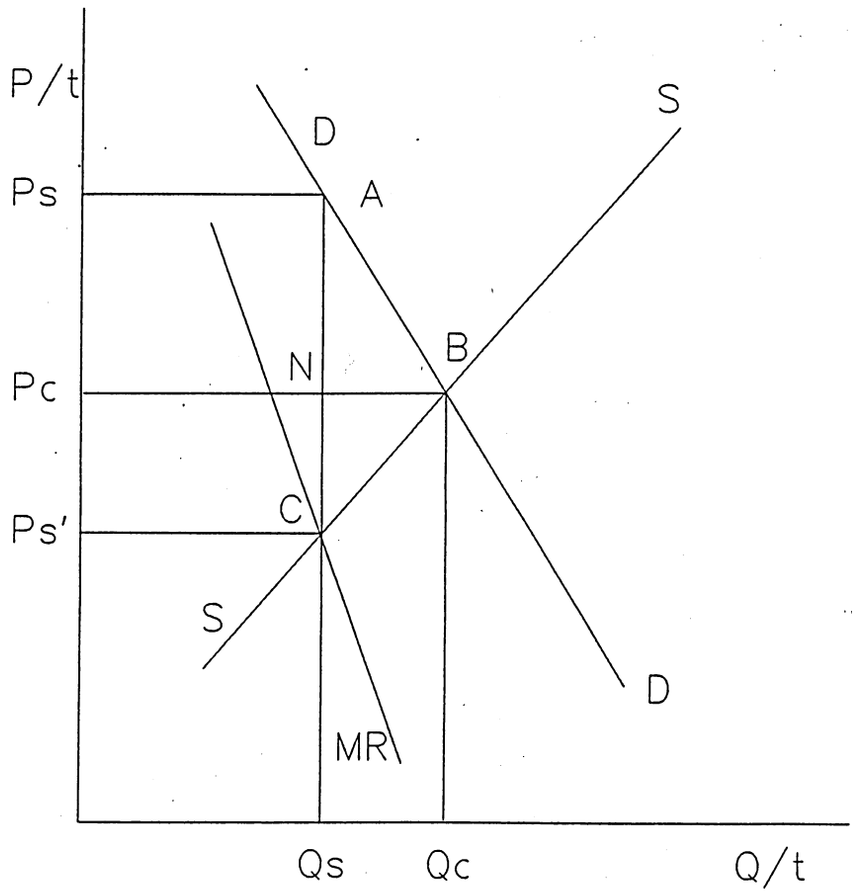
(3) $CONSUMER\ \ SURPLUS\ \ LOSS = Q_s(P_s - P_c) + 0.5(Q_c - Q_s)(P_s - P_c)$

(4) $PRODUCER\ \ SURPLUS\ \ GAIN = Q_s(P_s - P_c) - 0.5(Q_c - Q_s)(P_c - P_s')$

(5) $SOCIAL\ \ COSTS = 0.5(P_s - P_s')(Q_c - Q_s)$

The parameters in the above formulae are described in the following section.

Figure 9.1. Market Level Impact of a Supply Management Scenario (Short-Run).



14 The estimates are derived by solving for linear demand and supply functions.

In the above figure, DD and SS are the market demand and supply curves, and MR the corresponding marginal revenue curve. The competitive price and quantity are denoted by P_c and Q_c, respectively, while P_s denotes the administered price and Q_s the quota supply level which is consistent with achieving P_s. A perfectly competitive industry would produce Q_c whereas a monopolist would produce Q_s where marginal revenue equals marginal cost. The existing lamb market structure approximates the perfectly competitive situation, that is, the base model to which the welfare changes associated with the introduction of a supply management program are compared. The supply management approach requires the imposition of quantitative restrictions on imports and output so as to facilitate the setting and maintenance of the desired price level.

The empirical results are reported for two scenarios with four different supply elasticities and three different demand elasticities for lamb. More specifically, Scenario A relates to a 10 percent increase in the market price for lamb while Scenario B relates to a 5 percent increase in market prices arising from the introduction of a supply management marketing program. Furthermore, for each scenario it is assumed that there is no change in imports or exports of lamb from historic levels[15]. Table 9.1 shows the range of supply and demand elasticities used in the estimation together with the annual losses in consumer welfare, gains in producer welfare and allocative efficiency losses associated with a supply management marketing program for the Alberta sheep industry.

15 In practice, the GATT rules which relate to supply management (Article 11) require that the proportion of imports to production remain unchanged.

Table 9.1. Estimates of Short-Run Income Transfers and Social Costs of a Supply Management Marketing Option under Different Elasticity Estimates.

Supply Elasticity	Demand Elasticity	Consumer Surplus Loss ('000 $)	Producer Surplus Gain ('000 $)	Social Costs (000 $)
		Scenario A		
1.47	-2.067	626.59	452.65	173.94
	-1.748	637.73	503.96	133.77
	-1.043	662.40	600.08	62.32
1.22	-2.067	626.59	431.94	194.65
	-1.748	637.73	374.33	263.40
	-1.043	662.40	594.76	67.64
1.11	-2.067	626.59	419.52	207.07
	-1.748	637.73	480.39	157.34
	-1.043	662.40	591.72	70.68
0.36	-2.067	626.59	139.40	487.19
	-1.748	637.73	279.42	358.31
	-1.043	662.40	520.28	142.12
		Scenario B		
1.47	-2.067	331.34	287.80	43.54
	-1.748	334.18	300.79	33.39
	-1.043	340.32	324.74	15.58
1.22	-2.067	331.34	282.52	48.82
	-1.748	334.18	297.13	37.05
	-1.043	340.32	323.41	16.91
1.11	-2.067	331.34	279.51	51.83
	-1.748	334.18	294.90	39.28
	-1.043	340.32	322.65	17.67
0.36	-2.067	331.34	209.20	122.14
	-1.748	334.18	244.82	89.36
	-1.043	340.32	304.79	35.53

Note: In Table 9.1 changes in consumer and producer surplus were calculated relative to some base period price and quantity levels. The base period price was taken as $1,920 per tonne and quantity of output as 3,640 tonnes of lamb. These values were estimated as annual averages over the time period 1985 to 1987.

Table 9.1 shows that the annual income transfers and social costs of a supply management marketing program vary substantially depending on the magnitude of the supply and demand elasticity estimates. In general, as the supply elasticity estimates increase from 0.36 to 1.47, the producer surplus gains increase while the social costs of the program decrease. More specifically, producer surplus increases by 66 percent for Scenario A and by 13 percent for Scenario B while the social costs of the program decrease by approximately 63 percent for Scenarios A and B, respectively. Moving from Scenario B to Scenario A, the gains in producer surplus increase by 70 percent for the large supply elasticity (1.47) and by 16 percent for the low supply elasticity (0.36). In the case of the demand elasticity estimates, as the magnitude of

the own price elasticities increase, the losses in consumer surplus decrease, gains in producer surplus decline and the social costs of the program increase. Specifically, as the demand elasticity increases from -1.043 to -2.067, the losses in consumer surplus decrease by 5 percent for Scenario A and by 3 percent for Scenario B. Lastly, the social costs of the program increase by approximately two fold for Scenarios A and B as the demand elasticity estimates change from -1.043 to -2.067 and supply elasticities vary from 0.36 to 1.47. In the long-run, the potential efficiency losses of the supply control program can be substantial and have been discussed by Veeman (1987) and others. These losses are briefly outlined in the following section.

A supply management program may result in quota rights acquiring a capitalized value which in turn may increase the overall cost structure of future generation quota holders. In the long-run, this increase in the cost structure of firms in the industry may cause the industry supply curve to shift upward and to the left. However, improvements in technology may have the opposite effect; reducing the cost of production and causing a downward shift in the industry supply curve. Therefore, the position of the long-run supply curve will be determined by the extent of the trade-off between increasing quota values and adoption of new production technology in the industry.

The existence of production or marketing quotas may adversely affect the long term structure of the industry. More specifically, the supply control program may encourage relatively inefficient high cost producers to remain in the industry and may reduce the economic incentives to adopt cost reducing technology. In addition, supply management inhibits the operation of comparative advantage in production. These losses in specialization and trade further add to the overall welfare losses of the program. Moreover, bureaucratic restrictions on the transfer of quota not only increase transaction costs but may also limit the ability of many producers to achieve economies of scale in production. Lastly, an increase in welfare losses may also occur where restrictions on the transfer of quota result in underutilization of existing productive capacity.

Additional sources of welfare costs of a supply management program include the administrative costs of the program as borne by producers, provincial boards and government. These costs arise primarily from monitoring and enforcing quota and levy regulations. Other costs include rent seeking activities by producers and producer organizations. In addition, quotas on imports of the supply managed commodity may also give rise to rent seeking activities induced by the rents associated with the allocation of import licenses. Supply management programs reduce the market risks to producers in the industry and consequently may reduce the production costs of risk averse producers. However, in many cases

these risks may be substituted by additional bureaucratic risks which may offset the benefits arising from reduced market risks. These bureaucratic risks and uncertainties are often induced by the possibility of bureaucratic or legislative changes in the supply management program. Finally, a supply management program tends to promote the status quo in the industry and thus may reduce the incentives required for the development of new products and new markets.

In summary, the welfare losses associated with a supply management marketing program are substantial and as such this form of marketing option may not be the most economically suitable option for the industry. More specifically, the potential costs of a supply program could outweigh the potential benefits in the case of the sheep industry. This occurs because the supply and demand elasticity estimates for lamb are highly elastic. In order for a supply management marketing option to be most effective, the demand elasticity estimate for lamb should be inelastic.

9.2.2 Centralized Selling Agencies

The primary objective of a centralized selling agency is to sell the product or to operate a centralized sale mechanism on behalf of producers. This form of marketing agency often improves operational efficiency in the industry by providing a more coherent and coordinated approach to marketing and consequently, returns to producers. The pricing and operational efficiency of a centralized selling system have been analyzed by Leavitt et al. (1983), Adamowicz et al. (1984), McKeague et al. (1987) and Higginson et al. (1988).

Leavitt et al. (1983) evaluated the market performance of the Alberta Pork Producers' Marketing Board after it became a single selling agency for hogs in 1969. Both pricing and operational efficiency were evaluated by comparing with other markets in Canada and the U.S. Operational efficiency was assessed by examining the cost reductions in the hog marketing system while pricing efficiency was evaluated using a number of techniques including graphic, statistical and econometric methods. The authors concluded that the board's selling and market information procedures have improved operational efficiency but that the evidence with respect to pricing efficiency was inconclusive.

Adamowicz et al. (1984) used a number of analytical techniques including the Box - Jenkins Autoregressive Integrated Moving Average (ARIMA) model and the Geweke method for identification of the lead - lag structure to analyze pricing efficiency in a number of hog markets including the Alberta hog market. The authors concluded that hog markets in Canada and the U.S. were becoming more isolated during the 1970s and early 1980s and that this trend corresponded to changes in marketing techniques in the industry. McKeague et al. (1987) examined the impacts of the grain grading system on

the operational efficiency of the Vancouver grain terminals. In their study, the authors focused on the least cost approach to measure operational efficiency, that is, the physical functions of marketing such as storage, transportation and processing.

Higginson et al. (1988) adapted the vector autoregressive (VAR) technique to analyze the impact of the U.S. countervailing duty on pricing efficiency in the Canadian slaughter hog markets. The authors concluded that the imposition of the countervailing duty reduced the feedback between the hog market in eastern and western Canada and in addition had a negative impact on pricing efficiency in the hog markets. Lastly, their empirical analysis indicated that the countervailing duty resulted in a greater isolation of the markets for hogs in Canada.

In summary, a centralized selling agency could act as a coordinating agency with respect to supply and demand for lamb, relate market price information to producers, facilitate the marketing of lamb in the export market, ensure consistency with respect to supply and quality of lamb marketed, coordinate research and development efforts for new products and markets and finally, could act as a negotiating agency for lamb producers.

10 Summary and Policy Implications

The central focus of this report involves an analysis of the Alberta sheep industry in order to aid in developing suitable marketing options for the industry. The Alberta sheep industry has encountered serious economic difficulties, while there has been no in-depth analyses of the problems facing the industry. Supply and demand elasticities are not static but change over time. Obtaining accurate estimates of supply and demand elasticities for lamb is crucial in designing a marketing strategy for the industry.

A key objective of this study concerned a rigorous analysis of the supply response of the Alberta sheep industry using both a normative programming technique and a positive econometric technique. Medium term supply elasticities were estimated for the commercial sheep industry using the normative approach. The results show that supply of lamb from both the medium and large sheep producers are elastic in the medium term. However, the large producers are more responsive to price changes than the medium size producers. Furthermore, the output of lambs from the industry is inelastic in the short-run but elastic in the long-run. In the case of wool and cull sheep output, supply is inelastic in the short, medium and long-run. Thus, government policies which are aimed at increasing the income of

producers in the industry should be confined to the medium and large sheep producers and directly related to lamb supply. In addition, policies which attempt to increase sheep farmers' incomes via a wool incentive program have an insignificant impact on the overall industry.

The Markov chain process was used to examine structural change within the industry since the early 1950s. The results show that there has been a trend toward increased concentration in the industry in favor of medium and large sized producers while small producers tended to decline. This trend may have important implications with respect to future marketing policies for the industry. Specifically, these relate to assembly costs, negotiating power, research and development with respect to new products/markets and greater consistency in quality and supply of lamb.

With respect to demand analysis, an attempt was made to estimate the demand for chilled and frozen lamb for Alberta over a 10 year period using quarterly data. However, the estimates obtained from the demand models suggest that the price of lamb may not be as important a variable in influencing demand as in the case of other red meats. Furthermore, in the case of a speciality meat such as lamb which is characterized by having a large ethnic component in the aggregate demand, greater emphasis should be given to demographic and socioeconomic variables. Finally, a major limitation of demand analysis for lamb is the lack of detailed data on fresh and frozen lamb consumption in Canada.

Finally, the three main marketing scenarios available to the lamb industry include demand enhancement type programs, supply management programs and a centralized selling agency. Given that the supply and demand elasticity estimates for lamb are elastic, implies that a demand expansion type program is the suitable primary marketing scenario for the industry. However, a centralized selling agency could provide improvements within the industry in terms of market operation efficiency and thus culminate in higher returns to producers.

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12 Appendix A

Table A:1. Number of Sheep on Farms by Province, July 1, 1988 and 1989.

Province	Total Sheep and Lambs		
	1988	1989	1989/1988
	('000)	('000)	%
Nfld.	7.1	7.4	104
P.E.I.	6.1	5.8	95
N.S.	38.0	36.0	95
N.B.	9.0	9.0	100
Que.	111.0	114.0	103
Ont.	201.0	212.0	105
Man.	22.0	23.0	105
Sask.	51.0	52.0	102
Alta.	198.0	212.0	107
B.C.	53.5	57.0	107
Canada	696.7	728.2	105

Source: Adapted from Statistics Canada, Livestock Report, July 1, 1989.