THE UNITED STATES SHEEP INDUSTRY:

PRODUCER BEHAVIOR AND SUPPLY RESPONSE

by

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(ABSTRACT)

Regional and national supply models of the U.S. sheep industry are developed using economic and subjective factors determined from surveys of current producers. Breeding inventories are determined to be positively related to total returns per ewe and crop acreage harvested and negatively related to calf price and hay price. Breeding inventories are projected to decline through 1993 based on current information.

The sheep industry is found to be more prone to contraction than to expansion and elasticities indicate a relatively inelastic response by producer in the short-run. Subjective factors are found to be important determinants of flock size. The supply function of U.S. sheep inventories is hypothesized to operate under asset fixity in reverse. Implications for further research are discussed.

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Chapter 1

Introduction

The sheep industry in the United States has suffered a decrease in size unequaled by any other livestock sector in the nation. Sheep numbers in the United States declined by more than 65 percent over the last three decades, from 33.2 million head in 1960 to 10.8 million head in 1989 (Fig. 1.1). This decline occurred despite government incentive payments for wool and efforts to counter the trend by organized national industry groups. Though the decline has slowed considerably in recent years, questions about the cause of flock liquidation and the possibility of future growth or continued liquidation remain unanswered.

Resources used for sheep production usually can be used for other ruminant production or, in some cases, for crops. The reverse, however, is not necessarily true since sheep usually require better fencing and more specialized facilities than other grazing species. However, sheep are more adaptable to poorer pasture conditions than most other ruminants and can therefore utilize some areas other domestic species cannot. Sheep are known to be less resistant to internal parasites, more susceptible to predation from wildlife and domestic pets, and more labor intensive than most other livestock (Stillman, Crawford, and Aldrich, March 1989).

Sheep production is unique compared to other livestock since sheep produce two products, meat and wool. Both outputs have different uses and different competitive products. Genetically, wool and meat production

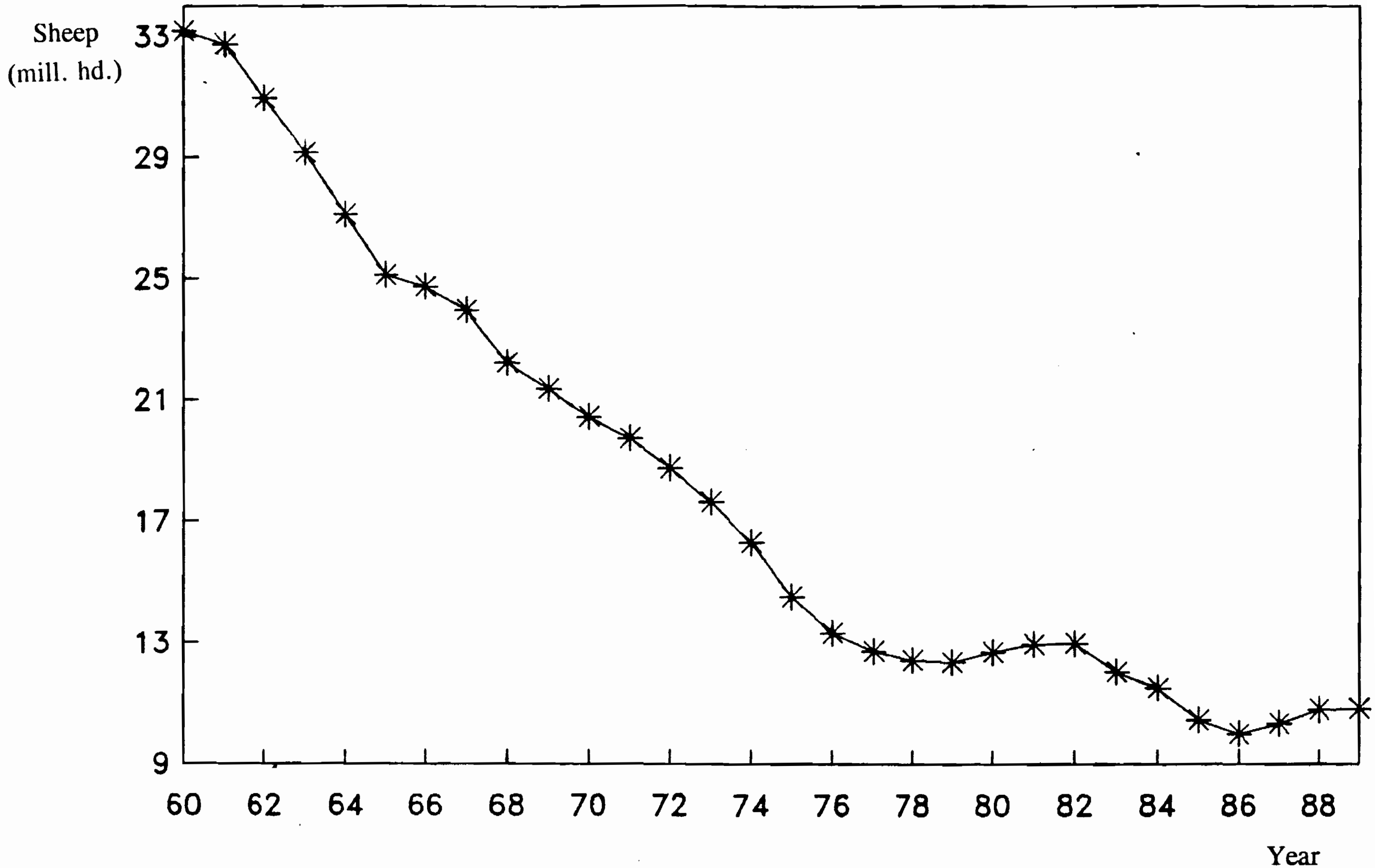

Figure 1.1 United States Sheep Inventories, 1960 - 1989

are competitive. Few breeds of sheep are capable of producing both high lamb crops and high quality wool, which hampers genetic improvement and adaptability to changing lamb and wool markets.

The uniqueness of the sheep industry makes analysis of change within the industry difficult compared to other agricultural enterprises. Historically, few conclusive results have been obtained as to the reasons for changes in sheep numbers within the United States. Gee, Magleby, Neilsen, and Stevens cited predator and labor problems as primary factors influencing contraction. Parker and Pope suggested seasonality of production, high seasonal labor requirements, and predator difficulties as probable causes of the decline in inventories. Predator losses and labor costs can be included in costs of production. Budgeted profitabilities for sheep, however, show positive returns to producers during most years of the decline (USDA-ERS, Costs and Returns). The failure of budgeted profitabilities to explain declining inventories suggests that some other factor or factors other than predator losses or labor problems have had a significant effect on sheep producers' decisions.

1.1 Problem Statement

There is scarce statistical evidence regarding the factors influencing the decline in sheep numbers. This lack of evidence makes it difficult for industry support groups to develop an effective strategy to reverse the industry decline. The current status of the industry along with historical changes need to be analyzed to provide a base for industry policy and promotion. Past studies have failed to provide conclusive information which can be used for such planning.

1.2 Objectives

The purpose of this study is to re-evaluate past studies, analyze the current situation and historical trends, and combine this information into a conclusive supply model that effectively explains the decline in sheep numbers and accurately predicts future flock sizes. Implications will then be drawn from this analysis to aid industry groups in development of effective strategies to cope with the issues surrounding changes in national flock size.

1.3 Procedures

A national survey of the sheep industry will be conducted to determine current producer characteristics, attitudes, and plans for the future and to determine which factors influence producers' decisions regarding changes in flock size. The survey will also be used to compare the importance of these various factors among different demographic groups and geographic regions to gain insight as to what groups of producers and which specific problems industry groups should target.

The factors of importance will then be incorporated with conventional econometric supply model variables into regional and national models of breeding sheep inventories to obtain parameter estimates of variables affecting sheep production. Models will then be used to explain past behavior and forecast breeding inventories through 1993.

Chapter 2

Literature Review

Few studies of supply response exist for the United States sheep industry. Several studies and surveys of the industry have been conducted to attempt to determine the factors causing the decline in inventories. These studies, however, do not include statistical modeling efforts. Existing models of U.S. sheep inventories vary in both structure and content with few conclusive results. The presence of autocorrelation and/or a lack of variable significance exists in all U.S. models. Development of an industry strategy based on models exhibiting these problems is risky.

2.1 Industry Studies

The Production and Marketing Administration along with the Bureau of Agricultural Economics of the U. S. Department of Agriculture conducted a study of the sheep industry in 1949 to determine the status of the domestic wool supply. The report considered lack of dependable labor, increased labor costs, predation losses, and loss of public grazing lands as key factors influencing the decline in sheep numbers from 1942 to 1950. The study predicted a leveling off of inventories and a gradual increase through 1955, primarily occurring in Texas and Rocky Mountain states. The study also estimated that approximately 37 million head of sheep were needed for full economic utilization of feed resources particularly suited for sheep. The researchers involved saw cattle as the primary competitive enterprise on sheep farms and ranches. They found returns per animal unit for sheep to be historically higher compared to returns for cattle. They stated, however, that risk and labor requirements associated with sheep create a non-budgeted cost for sheep producers that closely equates cattle and sheep returns (USDA Bureau of Ag. Econ. 1950).

Gee, et al., conducted a series of four surveys of the sheep industry in seventeen Western states in the mid 1970's. These surveys were conducted to determine factors causing the decline in inventories beginning in 1961. The first survey of a random sample of sheep farmers analyzed producer characteristics. Gee found producers to be in good financial positions with generally diversified operations. Producers' average age, however, was high with over one-fifth nearing retirement. The later three studies included only previously surveyed producers with more than 50 sheep. One survey focused on predator losses while aggregated budgets for different regions and flock sizes were developed from another. The final study involved a survey of former producers in representative states to determine specific factors behind the decline in sheep numbers. Major factors influencing exodus from the industry were low prices, predator losses, and labor shortages. A majority of former producers remained in farming and shifted to cattle production. Most producers exiting the sheep industry had good equity positions, but their returns were lower than most producers and sometimes below cash costs. U.S. budgets, however, showed positive returns above cash costs of $4.61,

$3.40, and $2.24 per ewe on average for 1972, 1973, and 1974, respectively (Stillman, Crawford, and Aldrich, 1989). The largest number of producers exiting the business had less than 1,000 head but the largest percent decline occurred among producers with more than 2,500 head.

In 1982, Parker and Pope conducted an in-depth analysis of the U.S. sheep industry. They discussed several possible factors influencing declining inventories including predation, lack of adequate ovine research, labor shortages, and the inherent seasonality of production of sheep. Parker and Pope perceived a trend toward increased numbers of smaller commercial and purebred farm flocks as demonstrated by the past decade's increases in breed registrations. They also pointed out the increasing amount of vacant public grazing permits and unutilized resources suited primarily for sheep.

In March of 1989, Stillman, Crawford, and Aldrich completed a study of the current situation of the sheep industry in compliance with the Omnibus Trade and Competitiveness Act of 1988. Their review of the industry dealt primarily with lamb production since the study was conducted to aid in determining the questioned effects of lamb and mutton imports in 1988. Along with findings indicating that lamb imports had no significant effect on domestic prices in 1988, they also suggested several factors that may have influenced the decline in the industry since World War II. Included in these factors were competition for resources with beef cattle, labor difficulties, and predation. Stillman, Crawford, and Aldrich also suggested that sheep required higher returns than similar competitive enterprises to compensate managers for additional management skills and increased labor intensity.

The concurrent decline of lamb and mutton imports in the 1960's and 70's with declining domestic production also suggest declining consumer demand as a key factor in decreasing sheep inventories. Though the wool incentive program and returns from wool were included in profit analysis, changes in the wool industry structure and wool imports were not considered. Stillman, Crawford, and Aldrich suggested, however, that the decline in inventories had ceased and that the industry was entering a typical livestock cycle of expansionary and contractional phases.

2.2 Supply Modeling

Very little supply modeling research relating to the United States sheep industry exists. Gardner developed several models of inventories and wool production in his evaluation of U.S. wool policy. Whipple and Menkhaus developed a dynamic supply model for the U.S. sheep industry based on a dynamic framework originally designed to model the U.S. dairy industry (Chavas and Klemme). Whipple and Menkhaus also released a revised model in a study of lamb import policies. Due to the similar biological and pricing cycles of livestock, models of other livestock sectors or of sheep industries in other countries can also be applicable to the U.S. sheep industry and several are included in this review.

Gardner's model of total sheep numbers was a weighted lag model that included lagged inventories as an explanatory variable. Sheep numbers were modeled as a function of inventories lagged one year, time trend, and weighted lagged price variables over the period from 1949 to 1979. Lamb and wool prices were combined into a weighted average price in accordance with their relation to total returns. Representation of expectations was incorporated through a four-year weighted lag. This four-year weighting procedure was also used with beef cattle prices and with wool incentive payments to producers. Beef prices were included as a proxy for competitive returns of beef cattle enterprises. Time trend was included to account for unmeasured factors of labor difficulties, predator problems, technological change associated with the sheep industry, and other omitted variables.

Gardner's results implied an elasticity of sheep numbers to the weighted price variable of .30 and an elasticity with respect to beef prices of -.19. All variables except time trend were significant and the equation's R^2 was .989. No Durbin Watson statistic was reported, but autocorrelation was said to be a problem with both models. Several different model specifications were considered outside of those reported, including various time periods and price weighting schemes, with no success. Ability of the model to predict was not discussed, so comparison to other models regarding predictive power is not possible.

Whipple and Menkhaus developed a dynamic model of sheep supply in a capital stock management framework. Whipple and Menkhaus modeled the replacement decision and incorporated these results into a model of stock sheep of each age bracket. Fleece weight and lamb weight were also estimated and combined with identities for stock sheep to determine total output. Data from 1924 to 1983 were used in model estimation.

The model included changes in lambing rates and death loss rates. The number of replacements retained was modeled as a function of lamb price, wool price, and beef price all indexed over alfalfa hay price with lags of two, one, and one year, respectively. Labor price and a measure of the five year variation in lamb price were also included. Stock sheep were then modeled by adding replacement estimates to estimates of stock sheep. Age cohorts were modeled as a function of lamb price, wool price, and slaughter ewe price indexed over labor prices with lags of one year. Other explanatory variables included were the number of sheep deaths (non-slaughter), hay price, beef price, and a variable measuring the productivity of different age groups in the flock. Live weight of lambs was modeled as a function of lamb price, corn price, and time trend. Fleece weight was modeled as a function of lagged fleece weight, the price of wool, and lamb prices. These models were then combined with stock sheep estimates in identities to determine lamb and wool production.

Whipple and Menkhaus' replacement model results indicated only the lamb-to-hay price and wool-to-hay price ratios were significant, but all variables had theoretically correct signs. The stock sheep model showed higher statistical significance across all variables when compared to the replacement model. Calf price, however, had a positive sign which is inconsistent with the hypothesis that cattle compete with sheep for resources. The lamb weight equation showed significance and anticipated signs across all variables while the fleece weight model showed signifi cance in only the lagged fleece weight variable. No autocorrelation measures were reported for the models. Elasticities for lamb production with respect to lamb price ranged from .68 in two years to 2.83 in ten years. The estimated elasticity of wool with respect to wool price was .35 in two years and 1.38 in ten. The elasticity of inventories to lamb price was .87 in two years and 3.05 in ten years while elasticities in relation to wool price were .32 and 1.34 respectively.

Model results have limitations, however, due to the length of time over which estimation was done, the failure to deflate price variables in several models, and the problems of possible multicollinearity that exist among price ratio variables. An updated model presented by Whipple, Menkhaus, and Hewlett in an analysis of lamb import policies using data from 1950 to 1987 changed several explanatory variables. Output-to-hay price ratios were used in both the replacement and stock sheep equations in place of output-to-labor price ratios used previously in the stock sheep equation. Explanatory variables generally had lower or insignificant t-values. The stock sheep model exhibited a mean simulation error of -7.1 percent.

Reynolds and Gardiner developed a dynamic model of Australian sheep inventories in a capital goods framework. Inventory adjustment, turn-off (culling) behavior, and production rate were modeled and combined through simple mathematical identities to establish outputs of lamb and wool for the industry. Changes in wool price were shown to be the primary long-run industry stimulus while lamb and mutton prices dictated short-run changes in flock size and composition. Resource substitution between beef cattle and sheep showed considerable significance, but very little competition with crops appeared to exist. Changes in seasonal conditions also proved to be of considerable importance in short-run production decisions of producers. Pasture acreage was also found to be a primary factor in determining total production but was almost totally explained by a measure of seasonal conditions. This model effectively estimated changes in output, but some autocorrelation was obvious. Reynolds and Gardiner's research also suggested the presence of greater restrictions on expansion than on contraction in the sheep industry of Australia.

Martin and Haack developed a dynamic model of the U.S. cattle industry based on quarterly data. The model included nested equations estimating stocker price, breeding inventories, heifer and steer slaughter, culling, and carcass weight. Results were then combined into an identity determining total quarterly production. Production was shown to be directly linked to lagged steer and feed prices as far back as four years. Lag structures exhibited both short and long run price effects on inventories and production. Regional modeling and the inclusion of some measure of seasonal conditions were suggested as possible improvements to the accuracy of these livestock models.

2.3 Conclusions

Previous research regarding livestock supply response suggests sheep modeling efforts should include lagged measures of returns, returns for competitive enterprises, input costs, changes in technology, and seasonal conditions. Previous models of U.S. inventories have exhibited problems with autocorrelation and a lack of significance among explanatory variable. Modeling efforts presented in Chapter 4 will attempt to improve upon previous research and provide for accurate estimation of changes in sheep inventories.

Chapter 3

Survey Procedure and Results

A national survey of sheep producers was conducted in the fall of 1988 to obtain information on current producer attitudes and characteristics, and to obtain previously unsolicited information on the degree to which various factors may influence producers' decisions regarding changes in flock size. A follow-up survey on labor issues was conducted in June of 1989 to further analyze factors influencing producers' decisions regarding expansion and contraction. For a copy of both survey forms, see Appendix 1.

3.1 Survey Development

Development of the first survey revolved around three goals. The primary goal was to obtain information regarding the influence of various factors such as competitive enterprises, forage conditions, labor and facility availability, capital availability, market conditions, personal preference, and other factors on producers' decisions regarding changes in flock size. The second goal was to obtain information regarding producer attitudes toward the industry and their future plans for their sheep enterprises. The third objective was to obtain demographic information regarding size, location, economic status, and current marketing and production practices among producers to aid in the analysis of responses to other questions. Questions were developed in coordination with the

National Wool Growers' Association and The American Sheep Producers' Council.

As with all surveys, a compromise was reached regarding the volume of information obtained and the response rate desired. The survey was limited to four pages to encourage a high response rate. Guidelines from Frary and from Dillman were used in developing questions, in page formatting, and in cover-letter content. To insure question clarity and reduce respondent confusion, the survey was field tested informally with several local producers and extension personnel before it was mailed.

3.2 Survey Sampling Procedure

A national sample of 1,000 sheep producers was generated from names and addresses obtained from the American Sheep Producers' Council's list of producers receiving incentive payments for wool produced in 1987. To obtain a sample representative of sheep numbers and producer concentration, the sampling was first stratified according to sheep numbers. Seventy-five percent of the surveys were allotted to the four Western regions and 25 percent to the three Eastern regions of the American Sheep Producers' Council. The regions are as follows (See Appendix 2 for a complete description):

<u>East</u>

Region 1 - East Coast and Southeastern states;

Region 2 - Ohio Valley and Great Lake states;

Region 3 - Midwestern Plains states;

<u>West</u>

Region 4 - Northern Plains states;

Region 5 - Texas;

Region 6 - Rocky Mountain states;

Region 7 - West Coast and Southwestern states.

After the initial stratification, surveys were allocated based on the number of producers within each region. A random sample of the predetermined number of producers was drawn from each region to make up the sample used. The number of surveys sent to each region along with response rates are presented in Appendix 3.

The original mailing contained a cover letter from the American Sheep Producers' Council. A reminder card was mailed one week later. Three weeks after the original mailing, a follow up mailing of a second cover letter and replacement survey was mailed to those who had not yet responded.

3.3 Survey Results

An overall response rate of 60 percent was obtained with regional response rates varying from 55 to 65 percent. A total of 530 usable responses were obtained. Surveys returned due to incorrect address and those respondents who returned the survey uncompleted because they liquidated their sheep enterprise were subtracted from the original sample for response rate calculations. The tabulating procedure allowed use of all valid responses for each question. Data were entered into the computer package Statistical Analysis Systems (SAS) for tabulation and comparison. All questions were analyzed by region, and select questions were analyzed by producer size and type categories.

3.3.1 Producer Demographics

3.3.1.1 Size Distribution of Sheep Operations

The size and type of sheep enterprises is likely to dominate any strategic planning by industry groups. Table 3.1 shows the differences in operation size among regions and between full and part-time producers. Of all producers surveyed, over 56 percent have less than 50 head of breeding sheep and 26 percent have 51 to 299 breeding sheep. East Coast and Southeastern states and Ohio Valley and Great Lake states have the highest proportion of small producers with 79 and 84 percent of those surveyed having less than 50 breeding sheep, respectively. The Northern Plains states and Texas have the highest percent large operations. Almost 6 percent of Region 4 producers and over 13 percent of Texas producers have more than 1,000 breeding sheep. Both of these regions also have a larger percent of their producers in the 300 to 599 and 600 to 999 head brackets than other regions in the United States. The largest percent of full-time

Table 3.1: U.S. Breeding Flock Size Distribution
{Percentages, 1988}

	Flock Size							
Category	1 -50	51 -299	300 -599	600 -999	1000 -2499	>2500	Feedlot	None
Region:								
East Coast	78.6	16.6	0	0	0	0	2.4	2.4
Ohio Valley	84.6	10.3	2.6	0	0	0	0	2.6
Midwest	62.9	27.4	3.2	0	0	0	3.2	3.2
N. Plains	35.2	45.1	6.6	2.2	3.3	2.2	5.5	0
Texas	24.3	35.1	13.5	4.1	10.8	2.7	2.7	6.8
Rocky Mts.	64.9	21.6	5.4	1.4	2.7	1.4	2.7	0
West Coast	65.0	19.3	3.6	0.7	0	1.4	6.4	3.6
Operation Type:								
Full-time	37.7	35.4	11.3	2.4	5.7	3.3	3.3	0.9
Part-time	69.3	20.5	1.3	0.3	0	0	4.6	4.0
U. S.	56.3	26.4	5.4	1.3	2.5	1.3	4	2.7

Source: Original Survey by Author

farmers also have less than 50 head, indicating that the sheep enterprise is secondary to other farm enterprises. Similarly, almost 70 percent of part-time producers have less than 50 breeding sheep.

3.3.1.2 Acreage Distribution of Sheep Operations

Acreages used for sheep follow patterns similar to flock size distribution, with the largest mean private land usage in Texas and the greatest mean public grazing use in the Rocky Mountain region. The smallest average acreages devoted to sheep are in the Ohio Valley and Great Lake states and in the Midwestern Plains.

3.3.1.3 Proportion of Income Received From Sheep

The amount of total farm receipts for sheep producers that originate from their sheep enterprise shows moderate regional differences but practically no difference between full and part-time operations. Nationally, sheep enterprises account for less than 25 percent of total farm receipts for 60 percent of sheep producers. Only 25 percent of producers receive more than 50 percent of their total farm receipts from sheep. Forty-two percent of producers with more than 1,000 head receive more than 75 percent of their total receipts from sheep, while 48 percent of producers with 51 to 999 head receive less than 25 percent of their receipts from sheep. Slightly more part-time than full-time producers receive over 75 percent of their farm receipts from sheep.

3.3.1.4 Distribution of Alternative Enterprises

Since most sheep producers rely on sources of income other than their sheep enterprise, consideration must be given to what enterprises compete with sheep for resources and labor. Table 3.2 shows the breakdown of alternative enterprises from which sheep producers receive income. As anticipated, beef cattle account for the largest percent of all alternative enterprises sheep producers have, which is due to the use of similar resources by sheep and cattle. Nationally, over 41 percent of all additional enterprises are beef cattle. As operation size increases, so does the percent of sheep producers having beef cattle enterprises. Beef cattle account for 38 percent of all other enterprises for sheep farmers with less than 50 sheep, but account for 57 percent of alternative enterprises for producers with more than 1,000 head. Over 50 percent of all additional enterprises in Texas and in the East Coast and Southeastern states are beef cattle.

In the Ohio Valley and Great Lake states and in the Midwestern Plains states, beef cattle account for only 25 percent of alternative enterprises for sheep producers. In these two regions, cash crops are the most commonly indicated alternative enterprises. Cash crops are the second most common enterprise nationally but are considerably less common to sheep producers in Texas and in the West Coast and Southwestern states. Cash crop enterprises are more prevalent, however, among small and medium sized sheep producers. Dairy cattle account for less than 4 percent of additional enterprises nationally. Only in East Coast and Southeastern

Table 3.2: Regional and Flock Size Distributions of Alternative Enterprises {Percent of All Enterprises, 1988}

Category	Beef Cattle	Dairy	Other Livestock	Cash Crops
East Coast	52.8	11.1	11.1	25
Ohio Valley	26.3	2.6	15.8	55.3
Midwestern Plains	29.3	4.3	19.6	46.7
Northern Plains	40.4	3.5	16.7	39.5
Texas	54.9	0	23.2	22
Rocky Mountains	40.7	5.1	10.2	44.1
West Coast	44.7	2.6	29.8	22.8
1-50 Head	38.1	4.5	23.2	34.3
51-999 Head	43.7	2.5	15.2	38.6
> 1000 Head	57.1	0	19	23.8
U.S.	41.5	3.6	19.8	35.1

Source: Original Survey by Author

states do dairies make up more than 10 percent of additional enterprises from which sheep producers receive income. Other livestock, which may include such enterprises as swine, poultry, goats, and horses, are the third most popular for sheep producers, accounting for almost 20 percent of all additional enterprises. Regionally, Texas and the West Coast and Southwestern states have other livestock as the second most important alternative enterprise.

3.3.1.5 Proportion of Full and Part-time Producers

Operation type shows significant but anticipated differences across the country, with 41 percent of the nation's sheep producers classifying themselves as full-time farmers. Over two-thirds of sheep producers in the Ohio Valley and Great Lake states and in the West Coast and Southwestern states and over four-fifths of producers in East Coast and Southeastern states consider their farm operation as part-time employment. Only Midwestern Plains states and Northern Plains states have over 50 percent of their sheep producers farming full-time.

3.3.1.6 Distribution of Producer Age and Years In Business

The number of years producers have been in the sheep business shows only small differences from region to region. In the United States, 36 percent of producers have been in the sheep business for more than 20 years while 17 percent have been in the business for less than 5 years.

Thus, only a moderate influx of new sheep producers has occurred in recent years. Of those producers entering the business within the last 10 years, 73 percent are part-time producers, but only 50 percent of producers in business for more than 10 years are part-time producers. Regionally, the Midwestern Plains states exhibit the largest number of new producers, while 58 percent of Texas' producers have been in the sheep business for more than 20 years. Age distribution of producers shows similar results, with 30 percent of all producers above the age of 60 and 12 percent under the age of 30. Texas has the oldest producer group, with 41 percent of producers over 60 years old and less than 18 percent under the age of 40. Differences in age distributions between full and part-time farmers are small, with slightly more part-time producers under the age of 30 and over the age of 60.

Initial analysis of producer characteristics suggested a logical grouping of producer size categories for further analysis of the remaining questions. Producers with less than 50 head are considered small producers. This size group represents mostly part-time farmers who maintain sheep as a primary or secondary enterprise for personal use or supplementary income. Results indicate that most part-time operators are small, single enterprise producers who rely on off-farm employment or are retired.

Mid-size producers were considered to be producers with 51 to 999 head. This category should represent mostly diversified full-time farmers who maintain sheep as a primary, secondary, or tertiary enterprise. The third category, large producers, consists of those producers with more than 1,000 head for whom sheep are most likely a primary or secondary enterprise. These size category groupings also roughly represent the levels of land, facility, and labor requirements that follow flock size differences.

3.3.2 Production and Marketing Practices

Several questions were asked regarding production practices to enable comparison of producer attitudes to various production scenarios.

3.3.2.1 Lambing Practices

Lambing seasons vary from region to region, but a slim majority of producers in the United States lamb in the spring. Winter lambing is most popular in the East Coast and Southeastern states while Texas is the only region showing a significant percentage of producers lambing in the fall. Over 90 percent of producers in the East and Midwestern regions lamb in barns or sheds. Almost 76 percent of Texas producers and over 42 percent of producers in the West Coast and Southwestern states lamb on range or pasture. Only 16 percent of large producers lamb under shelter, while 65 percent of mid-sized producers and 82 percent of small producers lamb indoors.

3.3.2.2 Lambing Rates

In the United States, the largest group of producers (28 percent) had lambing rates between 1.0 and 1.25 lambs per ewe in 1987, while 26 percent had less than 1 lamb per ewe, and 23 percent had more than 1.5 lambs per ewe. Large regional differences exist in lambing rates. The East Coast and Southeastern states had the largest percent of producers with more than 1.25 lambs per ewe, followed closely by the Northern Plains states. Producers in the Midwestern Plains, Rocky Mountain, and Ohio Valley and Great Lake states showed similar distributions of lambing rates. Slightly more than half of the sheep producers in these regions had lambing percentages greater than 1.25 in 1987. Texas was strikingly different from other regions with almost 57 percent of its producers having less than 1 lamb per ewe and nearly 90 percent having less than 1.25 lambs per ewe. The West Coast and Southwestern states had 69 percent of their producers with lambing percentages below 1.25 lambs per ewe. Producers with less than 50 head and mid-sized producers had similar lambing rate distributions. Over half of large sheep producers, however, had lambing rates below 1 lamb per ewe. Full-time producers were mostly grouped around 1 to 1.5 lambs per ewe while part-time producers were more evenly distributed through all ranges in 1987. As expected, smaller flocks had higher lambing rates and lamb mostly indoors, indicating more intensive management by smaller producers.

3.3.2.3 Death Loss

Death loss has been considered a major drawback to sheep production since sheep are more prone to sickness and predation than other livestock. Death losses reported in the survey are representative of 1987 and only can serve as a proxy for other years since weather conditions and predation cycles vary between years and regions. The majority of producers in the United States had losses between 0 and 5 percent of all sheep in 1987 and one-fourth had losses between 6 and 10 percent. Six percent had losses between 11 and 15 percent and approximately 3 percent had losses of 16 percent or more. Death losses appeared to be higher in the East Coast region and in the Northern Plains, but this may be partially attributable to more intensive management and therefore more knowledge of actual losses. Death losses were higher in 1987 for larger producers and for full-time producers, which probably results from more extensive management by larger operations.

Causes of death loss were rated by respondents as major, moderate, minor, or none. Values were then assigned and mean values used to compare different factors. Values are: Major=1, Moderate=2, Minor=3, and None=4. The highest rated factor in death losses in the U.S. is unknown causes with a mean value of 2.94. Second is lambs lost to predators with a mean score of 3.14. These causes are followed in rank by lambs lost to starvation or exposure, ewes lost to disease, lambs lost to disease, and ewes lost to predators, with only minor differences in mean values. Losses of lambs and ewes to predators is more significant to producers in Texas and the Rocky Mountain states than in other regions. This indicates that predator losses are not tied only to public grazing since there are no public grazing lands in Texas. Lamb loss to starvation or exposure is rated higher in the Northern Plains states than other regions with a mean value of 3.09. Producers with more than 1,000 head ranked lambs lost to predators first with a mean value of 1.7 followed by lambs lost to exposure and ewes lost to predators at 2.5.

3.3.2.4 Lamb Marketing

Marketing of lambs can also be a key factor in determining profitability, especially in variable markets. To aid in determining which price series producers would be most familiar with, producers were asked what percentage of lambs were sold as feeders or for slaughter and what percent was kept as replacements in 1987. In the United States, almost half of all lambs were sold directly to slaughter, approximately one-third were sold as feeders, and approximately one-fifth kept as replacements in 1987. Regionally, almost three-fourths of all lambs were sold as slaughter lambs by breeders on the East Coast and in the Southeast in 1987. Most other regions had slightly over half of all lambs marketed as slaughter lambs except Texas and the Northern Plains. Slightly over half of the lambs in Texas were sold as feeders. In the Northern Plains, approximately two-fifths were sold as slaughter lambs and slightly more than two-fifths were sold as feeders. As producer size increased, so did the percentage of lambs sold as feeders. Replacement rates among the seven regions ranged between 17 and 24 percent of the lamb crop.

The marketing channels used by producers also differ greatly from region to region and among size groups. The most commonly indicated sales method is through stockyards, which accounts for over half of all sale methods used by producers in the United States. Order buyers are second and account for almost one-fourth of options used, while feeder buyers are the third most popular option. Direct to packer sales is fourth followed by electronic marketing. Stockyards are used less in West Coast and Southwestern states, where order buyers and direct to packer sales are more common. Electronic marketing has only limited usage, primarily in the two Eastern regions. Direct to packer sales are more popular in the Midwestern Plains and West Coast and Southwestern states. Large producers market through order buyers more than any other option, while mid-size and smaller producers primarily use stockyards to market their lambs.

3.3.2.5 Wool Production and Marketing

Wool production is known to be more important in western regions and can also be used as a good indicator of mean flock size for a given region. The largest mean wool production per producer is in Texas at 3349 pounds, which also indicates Texas has the largest mean flock size. Texas is followed by the Northern Plains region and then by the Rocky Mountain and West Coast regions. The eastern regions had mean wool production levels less than half those of the western four regions. Among the eastern three regions, the Midwestern Plains states had the highest mean production (536 pounds) followed by the Ohio Valley and East Coast regions.

3.3.3 Current Producer Attitudes and Behavior

The current status of the sheep industry and its future greatly depend upon the attitudes of individual producers. Producers' attitudes and beliefs influence all decisions and may be as important as economic influences. Therefore, a major portion of the survey was dedicated to determining producer attitudes and evaluating factors that influence producer decisions.

3.3.3.1 Wool Incentive Program

To obtain an indication of the effect of the current wool incentive program, producers were asked to indicate whether they agreed, tended to agree, tended to disagree, or disagreed with the following statement: "The wool incentive program is a major factor in my decision to continue my sheep enterprise." Nationally, 40 percent of producers agree with that statement and 69 percent agree or tend to agree. Regionally, Texas has the largest percentage agreeing (nearly 63 percent) while the East Coast has the most disagreeing (almost 29 percent). This follows expectations since wool accounts for a larger proportion of income for western producers. Of those surveyed, no producers with more than 1,000 head tend to disagree or disagree with the statement. Also, 75 percent of full-time farmers raising sheep tend to agree or agree with the statement, while 65 percent of part-time farmers agree or tend to agree. This suggests that part-time producers may be less responsive to income from wool or other economic factors.

3.3.3.2 Future Plans

Producers were asked about their plans for 1989 and over a five year horizon to obtain information for comparison with modeling predictions. Nationally, 20 percent of producers plan on expanding by 10 percent or more in 1989, 18 percent plan on expanding by 1 to 10 percent, 40 percent plan on remaining stable, 8 percent plan on decreasing flock size by 1 to 10 percent, 8 percent plan on decreasing by more than 10 percent, and 6 percent plan on liquidating their sheep enterprises. The Northern Plains has the largest proportion of its producers planning on increasing flock size in 1989. The East Coast and Southeastern states have the largest percentage of producers planning to decrease or drop their sheep enterprise in 1989. No region, however, has a larger proportion of producers decreasing flock size than increasing, especially in the more than 10 percent category. Over 44 percent of mid-size producers plan on increasing flock size in 1989 while only 18 percent plan on decreasing. Almost 39 percent of producers with more than 1,000 head plan on expanding but 33 percent plan on contracting. Compared to other size categories, fewer small producers plan on expanding or contracting. Six percent of small producers plan on selling all their sheep, which is over twice the percentage of the other size categories.

By 1993, almost 46 percent of sheep producers plan on expanding. Both part-time and full-time producers and sheep producers who also have beef cattle indicated similar plans for expansion. Among the size catagories, mid-sized producers have the largest percentage of respondents planning on expansion. Small producers have the lowest percent planning to expand in five years. Regionally, over half of the producers in the Northern Plains plan on expanding by 1993, with 33 percent expanding by more than 10 percent and only 13 percent decreasing by any amount. The East Coast and Rocky Mountain regions exhibit the largest percentage decreasing their flock by 1993. Almost 16 percent of producers in the Rocky Mountain states plan on selling out in the next five years, which is the highest of all regions. The Rocky Mountain region did not have the oldest producer age or years in business distribution, suggesting factors other than retirement as the cause behind this planned exodus. In all, 80 percent of producers plan on maintaining their herd size or expanding by 1993.

3.3.3.3 Factors Influencing Expansion and Contraction

Factors influencing expansion or contraction of sheep numbers have been sought in several surveys. Due in part to failure of models to explain changes in flock size, and to undeniable changes in producer types and attitudes over time, producers were asked why they had or had not expanded their flocks in the past five years. Specifically, respondents were asked to rate a list of factors regarding their decision to expand or not to expand. Factors could be rated on a scale of 1 to 4 with: 1 = Strong; 2 = Moderate; 3 = Weak; and 4 = None.

The largest percentage of producers expanding over the past five years has been in the Northern Plains and in the Midwestern Plains, with slightly over 50 percent expanding. The regions of Texas, the Rocky Mountains, and the West Coast and South West all had more than 60 percent of their producers contracting or remaining stable over the same time period. The East Coast and Ohio Valley regions both had 50 percent of their producers expanding over the same five years. Fifty-seven percent of mid-sized producers have expanded with the highest percentage being among those producers with 300 to 599 head. Only 21 percent of producers with more than 1,000 head and 41 percent of small producers have expanded since 1983. This may suggest a shift in comparative advantage in sheep production toward mid-sized, diversified producers in the Midwest and Northern Plains.

Affecting these changes were several nonfinancial factors which have previously been neglected in supply response research. Table 3.3 summarizes the results for both those people who have expanded and for producers who chose not to expand. Respondents rated personal preference for sheep as the factor having the greatest influence on their decision to expand. Across all size groups and regions, personal preference had the highest mean influence level. Although part-time producers rated personal preference slightly higher at 1.67 than full-time operators at 2.0,

Table 3.3: Mean Responses for Factors Influencing Flock Size

Factor	Producer Category by Flock Size			
	1-50 head	51-999 head	>1000 head	All
Influencing Expansion:				
Personal Preference	1.91*	1.71	1.00	1.81
Higher Profitability	2.39	2.04	1.00	2.22
Underutilized Forage	2.45	2.65	2.00	2.54
Stabilize Income	2.91	2.38	2.25	2.65
Available Facilities	2.84	2.88	3.00	2.86
New Lamb Markets	2.80	3.01	3.00	2.91
Available Capital	3.21	3.14	3.50	3.18
Available Financing	3.54	3.23	2.75	3.37
Lower Predation	3.60	3.50	3.25	3.56
Available Labor	3.62	3.48	3.75	3.57
Percent Expanding	40.9	57.5	21.1	44.7
Influencing Non-Expansion:				
Limited Acreage	2.34	2.26	2.08	2.33
Drought Conditions	3.06	2.75	2.30	2.92
Lower Profitability	2.98	3.21	3.42	3.07
Higher Predation	3.34	2.86	2.31	3.09
Near Retirement	2.98	3.12	3.83	3.12
Personal Preference	3.11	3.08	4.00	3.13
Inadequate Fencing	3.05	3.23	3.75	3.13
Limited Lamb Markets	3.25	3.16	3.25	3.22
Limited Wool Markets	3.31	3.08	3.25	3.25
Limited Labor	3.49	2.98	3.00	3.27
Limited Capital	3.39	3.35	2.82	3.35
Excessive Debt	3.49	3.27	2.64	3.38
Percent Not Expanding	59.1	42.5	78.9	55.3

* Possible responses for degree of influence: 1 = Strong; 2 = Moderate; 3 = Weak; 4 = None;

Source: Original Survey by Author

preference was still the most influential factor for both groups. Perhaps contrary to expectations, larger producers ranked preference higher than smaller producers. The second most influential factor with a mean influence of 2.22 for all size groups and operation types was the comparative profitability of sheep to other enterprises. Mean influence level increased with operation size, and was higher for full-time compared to part-time farmers.

Overall, the third highest ranked reason for expansion was the presence of underutilized pasture or range with a mean response of 2.54. For the mid-size operators, the third ranked factor was the desire to stabilize income and pasture availability was ranked fourth. Stabilizing income was ranked fourth for all operators and by large producers, but was sixth for producers with less than 50 breeding sheep.

The availability of unused facilities was ranked fifth overall and by both small and mid-sized producers, while producers with more than 1,000 head ranked the availability of financing as their fifth most influential factor regarding expansion. The presence of new lamb markets ranked fourth among small producers, sixth for mid-size producers, and was sixth behind the availability of facilities for all producers. As seen in Table 3.3, remaining factors including lower predation and labor availability had mean influence levels above 3.0 indicating these factors as having weak or almost no influence on producers' expansion decisions. Prior analysis of the sheep industry (Gee, et al; Parker and Pope) had indicated that labor and predation were key factors in producers' decisions regarding flock size. The lack of influence of these factors on current producers' decisions to expand may indicate either technological advancements which diminished the impact of labor availability and predation or an exodus of producers who were afflicted by these problems.

In contrast to the reasons for expansion, preference for other enterprises played a much smaller part in producers' decisions not to expand during the 1983 to 1988 period. Among all size groups, the most influential factor governing decisions not to expand was limited range or pasture acreage with a mean influence of 2.33. The second most important factor, which is closely related to limited acreage, was drought conditions with a mean influence level of 2.92. Drought conditions were second among all producers except those with less than 50 head, for which higher profitability of other enterprises (likely off-farm employment) and retirement tied as the next most important factors.

After the two highest ranked factors, differences in mean influences from one rank to the next were generally very small for the aggregate sample. Profitability of other enterprises was the third most important factor influencing producers' decisions to not expand with a mean level of 3.07. Increased predation, however, was third for producers with more than 1,000 head. Predation was ranked fourth by all producers followed by retirement in fifth. Small producers ranked inadequate fencing and drought as fourth and fifth, while mid-sized producers ranked lack of labor and limited wool markets in those positions. Large producers ranked excessive debt and and lack of capital in fourth and fifth, possibly indicating lower equity positions compared to smaller producers. Preferences for other enterprise was ranked sixth overall and by both small and mid-sized producer groups, but was much less important for large producers.

In comparing factors influencing producers' decisions regarding flock size, it appears that forage availability, profitability, predation and other economic factors significantly influence industry expansion or contraction. Other non-financial factors such as preference and a desire to stabilize income, however, are also shown to be significant in determining changes in flock size. In addition, preference for the sheep enterprise appears to play a much larger role in expansion decisions than in decisions not to expand, suggesting the existence of a nonfinancial constraint.

3.3.3.4 Comparative Profitability Of Sheep and Cattle

In order to obtain an indication of producers' perceptions regarding the profitability of sheep and cattle, producers were asked to indicate how they perceived the long term comparitive profitability of these two enterprises. Nationally, 45 percent of sheep producers responding think sheep are more profitable than cattle, 25 percent think they are equally profitable to cattle, and 13 percent think cattle provide higher returns than sheep in the long run. Seventeen percent indicated they lack the information to compare. Over half of all sheep producers in the larger grazing regions of Texas, the Rocky Mountain states, and the Northern Plains thought sheep were more profitable. Compared to the larger grazing regions, a higher percentage of respondents in the remaining regions indicated they do not know enough to compare the two enterprises.

To determine the profit incentives required for sheep and cattle for producers to change their flock sizes, producers who had both sheep and cattle were asked if they would increase, decrease, or maintain their flock size given different comparative returns. Substantial confusion was apparent on the part of respondents answering the question and therefore results cannot be considered conclusive. Suprisingly, response to increased profitability of sheep appeared to be more elastic than response to increased profitability of cattle. Thirty-three percent of producers with sheep and cattle indicated they would decrease their flock size if sheep were 25 percent less profitable, while 44 percent indicated they would increase their flock if sheep were 25 percent more profitable. Similar results were obtained for 50 and 75 percent differences in profitability with a larger positive response to increased profitability than negative response to decreased profitability of sheep compared to cattle.

3.3.3.5 Solicited Respondent Comments

Three open-ended questions were included at the end of the survey to solicit producers' perceptions of their lamb and wool markets and other factors affecting their sheep enterprise that may not have been covered in the survey. Those responding to the question regarding lamb markets expressed a desire for the establishment of industry standards regarding weight and cutability and both education and incentives to direct production toward these goals. Concerns were also voiced regarding increasing instability of prices during the year and increased packer concentration and feeder-packer integration.

Fewer concerns were expressed about wool markets. Primarily, producers requested incentives for clean, plastic and tag free wool that were adequate enough to increase producer awareness and response. Several respondents called for an end to buyer grading, particularly at wool pools, and a more accurate and consistent grading system in general.

Remaining comments regarding individual operations centered around the lack of effective predator control and personal reasons for maintaining the sheep enterprise. Many felt there were inadequate pet control systems in their areas, which contributed to their predator losses. Others expressed concern over environmental issues protecting predators at the expense of producers. Most producers stated that their sheep enterprises were used for supplemental income and to graze untillable or poor pasture land because sheep required a lower initial investment and were easier to handle than other livestock.

3.4 Follow-up Survey

The lack of influence of labor issues on flock size in the first survey raised concerns regarding the validity and accuracy of producer responses. Previous research had indicated labor problems as a major factor in producers' decisions to contract or exit the industry (Gee, et.

al., Parker and Pope). The low influence of labor availability on producers' decisions thus contradicts the results of previous research. This could be the result of question structure, or it could indicate that producers have scaled down to sizes where hired labor is no longer a problem. To clarify this issue, a survey regarding the influence of labor problems on flock size was sent to all producers responding to the first survey. Questions were also asked about activities competing for producers' time and resources, and the level of lamb and wool prices needed for them to expand their sheep flock. Response rate results are presented in Appendix 4.

Respondents were asked four questions regarding decisions to change flock size during the 1970s and 1980s. They were then asked if labor costs or labor availability was the major factor influencing that decision. If it was not, respondents were asked to list in order of importance the three major factors that influenced that decision. The answers to the open-ended list of factors were catagorized in the tabulation procedure. To obtain a measure of importance, the number of responses for each factor in each rank was determined and taken as a percentage of the total number of factors listed in all ranks. These percentages were then multiplied by 3, 2, or 1 for rank catagories of first, second, and third, respectively. The sums of these three values for each factor were then used to compare the importance of various factors. Higher values indicate greater factor frequency and higher levels of importance to producers.

3.4.1 Factors Influencing Contraction

One of the four questions asked of producers was whether the last change in flock size of more than 5 percent was a reduction. Forty-five percent of producers responding indicated that their last change was a reduction while 55 percent said it was not. Factors influencing contraction are presented in Table 3.4. The highest ranked factor influencing the decision to contract was labor difficulties with a value of .76. This was followed in second by drought conditions with a value of .37 and in third by profitability at .34. The fourth and fifth rated factors were acreage restrictions and predator problems, respectively. Other factors were listed and included preference, age or health, retirement, and disease, but these factors had low rank values with very little difference between ranks.

These results follow those of the initial survey except for the rank of labor. Though persons listing time constraints as a factor were included in the labor category and producers who indicated labor as the primary factor influencing their decision generally did not list other factors, the importance of labor on decisions to contract appears to be larger than the initial survey indicated. This may be due to the consideration of their own labor by respondents in answers to the second survey.

Table 3.4: Follow-up Survey: Factors Influencing Flock Size.

Factors	Calculated Value~
Influencing Contraction:	
Labor Costs or Availability	0.76
Drought Conditions	0.37
Profitability of Sheep	0.34
Limited Acreage Available	0.22
Predator Problems	0.18
Limiting Expansion:	
Limited Acreage Available	0.79
Labor Costs or Availability	0.42
Limited Buildings or Facilities	0.27
Profitability of Sheep	0.17
Limited Capital to Invest	0.17
Drought Conditions	0.12
Influencing Change of Decision:	
Labor Costs or Availabilty	0.67
Limited Acreage Available	0.39
Profitability of Sheep	0.35
Drought Conditions	0.22
Limited Buildings or Facilities	0.18
Predator Problems	0.11

~ Calculation Procedure
Sum [(Factor Frequency within rank / Total # Factors) * Rank Value] where rank value is First = 3; Second = 2; Third = 1.

Source: Follow-up Survey by Author

3.4.2 Factors Constraining Expansion

A question of the same format was asked regarding expansion. Thirty-nine percent of producers indicated that their last change in flock size was an expansion of more than 5 percent. Producers were then asked if labor was the primary constraint stopping expansion and if not, they were asked to list the top three constraining factors. Results are presented in Table 5. The primary factor limiting producer expansion was acreage with a value of .79 followed in second by labor at .42. These were followed by buildings and facilities in third and profitability in fourth. Lack of capital and drought conditions were ranked fifth and sixth while the remaining factors all had values less than .06 with very little difference among them. Results of the second survey once again indicate that acreage or forage availability are primary constraining factors but labor was ranked higher in this follow-up survey, possibly due in part to question structure and respondent perception as mentioned earlier.

3.4.3 Factors Preventing Expansion

Respondents also were asked if they had considered but decided not to expand their sheep operations in the 1970s or 1980s. Forty percent indicated they had, while 60 percent said they had not considered such actions. Major factors influencing this decision pattern followed those of earlier questions. Labor was ranked first with a value of .67, followed by acreage constraints with a value of .39. Profitability was ranked third, followed by drought conditions, buildings and facilities, and predators in fourth, fifth, and sixth.

3.4.4 Factors Influencing Change in Farm Type

The fourth of these similarly formatted questions was to determine if producers had shifted to part-time farming due to labor constraints. Almost 13 percent of producers had changed from full to part-time farming in the 1970s or 1980s. Since only a small number of respondents had actually changed their operation status, the ranking procedure used for previous questions was not applicable. Generally this decision, however, appeared to be most affected by age or health, retirement, or off-farm employment rather than labor considerations.

3.4.5 Price Incentives

Producers were queried about their current local lamb price and the price level for lambs required for them to expand, assuming wool prices remained constant. They were also asked to list the two primary constraints facing them should prices increase by the needed amount. The mean price increase needed for producers to expand their sheep flock was $18.55 above the current respondents' average price of $66.72 per hundred pounds. Should prices rise by the needed amount, the three primary constraints facing producers were acreage, labor, and facilities. This margin, therefore, most likely measures the returns needed to finance additional capital investment or expand to full-time farming. A similar question regarding wool resulted in uninterpretable prices due to the failure of many producers to include incentive price adjustments in their estimates and the inability to accurately discern producer responses.

3.4.6 Competitive Enterprises

Producers also were asked what category and what specific enterprise in that category competed most with the sheep enterprise for the producer's time, efforts, and capital. Responses followed expectations with beef cattle ranked as the primary competitive enterprise by 43 percent of the respondents. This was followed in second by off-farm jobs as the primary competition for 16 percent of respondents and in third by small grain enterprises at 10 percent. Corn and soybeans were ranked fourth and fifth. The remaining enterprises of dairy, horses, and others each accounted for less than 4 percent of respondents.

3.4.7 Labor Affordability

Over 76 percent of producers indicated they did not feel they could afford quality labor for their sheep enterprises. Some commented that this was due to the small size of their operations, while others indicated that worker's compensation and social security payments made hired labor cost prohibitive. Several also indicated they were unable to pay competitive wages and maintain profitability at the same time.

3.4.8 Solicited Comments

Solicited comments on producers' opinions regarding the influence of labor cost and availability on flock size generally followed results of both surveys. Most producers had adjusted their flock size based on the amount of labor that they and their families could supply. Seasonality of labor requirements along with the scale required to justify hiring labor further limited expansion by producers. Respondents also indicated a lack of knowledgable laborers or persons willing to work with sheep for wages producers could afford to pay. Some producers stated they could expand, but profitability would decrease due to lower lambing rates or increased predator losses. In general, sheep were viewed as a labor intensive enterprise used to supplement income generated on or off the farm.

3.5 Survey Implications

Results of the two surveys create an interesting portrait of the United States sheep industry. As expected, beef cattle are the primary competitive enterprise for sheep along with cropping enterprises. The large proportion of part-time sheep farmers and the inherent labor intensity of sheep provide evidence of competition from off-farm employment for producers' time. Not only is time a constraint, but also forage availability, acreage, and facilities are especially restrictive for part-time producers. Results further indicate that preference for the sheep enterprise, not just comparative profitability, plays an important role in sheep producers' decisions to expand.

The combination of these factors along with other problems associated with sheep such as predators and breeding seasonality create a picture of an industry that is inherently more prone to contraction than expansion. The use of sheep by many as supplemental income decreases constraints on contraction or liquidation, and also submits the sheep enterprise to additional constraints from other primary enterprises. The following chapter develops a supply response model based on information obtained in the surveys and on past modeling efforts.

Chapter 4

Model Development and Results

4.1 Theoretical Foundations of Model Development

Modeling of supply response for livestock production is traditionally based on the assumption of profit maximization by managers. In theory, livestock producers attempt to maximize returns for a given set of capital resources given input prices, expected output prices, and opportunity costs. For livestock sectors, seasonal conditions and reproductive and genetic constraints also influence producer decisions. The estimation of a supply function therefore must incorporate these factors into a mathematical expression of the supply curve.

Resources usable for sheep production, primarily land and facilities, generally have usage limited to agricultural enterprises. Other major enterprises in the U.S. that can utilize the same land and facilities consist primarily of beef cattle and cash crops. A third resource that is not limited to agricultural use is the manager's labor. Off-farm employment therefore also competes with the sheep enterprise for labor resources. Theoretically, an increase in revenue for one of these enterprises, ceteris paribus, should result in investment in that enterprise and disinvestment in those enterprises for which resources can also be used. For livestock, this means increases or decreases in breeding inventories.

Breeding inventories dictate output of both lamb and wool. Though the amount of lamb produced can be increased or decreased slightly by changes in lambs saved at birth, replacement retention, and changes in slaughter weight, output is ultimately limited by breeding inventories. Modeling of inventories therefore separates longer term resource adjustment decisions from weekly or monthly management decisions. The general supply model is:

$INV = f(P_o, P_c, P_i, G, S.)$

where,

INV = breeding inventory
P_o = price of outputs
P_c = price of competitive enterprises' outputs
P_i = price of inputs
G = genetic and physical constraints
S = subjective factors.

In general, increased revenue for a given enterprise, either from higher output or lower input prices, should result in investment in more productive units, primarily the breeding inventory. Similarly, decreases in revenue should result in liquidation of some of the breeding inventory. Increases in output price and therefore increased revenue from an enterprise competing for similar resources should result in a shift in resource use to the competitive enterprise and a decrease in breeding inventories. Genetic and reproductive constraints associated with livestock enterprises restrict the rates at which producers can adjust resource use and inventories to match profit incentives and maximize revenue. Subjective factors such as changes in tastes and preferences may also affect producers' decisions to change inventories by shifting their perceived costs or returns.

4.1.1 Regionalization

Modeling of U.S. sheep inventories is hypothesized to be more accurate when done through regional models. Operation type and production practices differ greatly from region to region as exhibited by survey results (Chapt.3). Some regions rely more on wool income, while others primarily depend upon lamb sales. Lambing rates and fleece weights and qualities along with producer attitudes therefore differ greatly from region to region. Further complicating these differences is the payment calculation for the wool incentive program. Producers are paid a nationally constant percentage of their individual total returns from wool sales. Therefore producers with higher wool yields and higher wool prices receive a larger incentive payment per ewe. Other factors varying by region which influence producers include seasonal conditions and predator concentrations. For this reason, regional supply models are estimated. Though a state by state model may be the most accurate estimation procedure, data limitations and the marginal returns in accuracy rule out this option. Regional models based on the regions of the American Sheep Producer's Council used in the surveys are developed and are assumed to represent producer differences adequately. A national model is also developed for comparison with regional accuracy.

For several variables, values from chosen representative states are used in each region due to data availability and collection requirements. Values for these states are used for all variables that are not aggregated for each region. The representative states used for each region are:

East Coast and Southeastern region - Virginia
Ohio Valley and Great Lake region - Ohio
Midwestern Plains region - Iowa
Northern Plains region - Wyoming
Texas region - Texas
Rocky Mountain region - Utah
West Coast and Southwest region - California.

These states were chosen based on the proportion of regional sheep numbers in each state, geographical location, and other factors including production practices, wool type, and climate.

4.1.2 Profitability of Sheep

Any model explaining changes in breeding inventories must include some measure of returns for the sheep enterprise. Sheep are unique since they produce two outputs, meat and wool, which are inputs in two entirely different industries. Genetically, wool and meat production are competitive since those breeds that excel in meat production generally have poorer wool quality and yield and vice versa. Production levels of one output alone cannot be changed significantly without affecting the other. Therefore, one output is generally constrained by production of the other output. Production can also be complementary to some extent. Increased feed inputs increase both wool and meat output slightly and increased lambing rates increase total lamb meat and lamb wool production.

Technological changes in lamb and wool production make the sole use of lamb and wool prices inadequate measures of the value of output from breeding inventories over time. Both average lamb weights and lambing percentages have shown significant increases over the past 30 years, while fleece weights have exhibited very little change in most regions. Further complicating measures of returns is the wool incentive program and its payment procedures. It is therefore assumed that a measure of total returns per ewe is the most comprehensive method of accounting for changes in enterprise returns.

The sheep returns variable used in this modeling effort is designed to represent both changes in lamb and wool returns. The calculated variable is:

Total Returns = (Annual Lamb Weight X Annual Lambs/Ewe X Lamb Price) + (Fleece Weight X Wool Price) + ((Fleece Weight X Wool Price) X Incentive %)

The annual lamb weight used is the national average since average slaughter weights have exhibited few regional differences over time. National lamb prices are included under the assumption that changes in regional prices follow those of national markets. Constant representative values for regional fleece weights are used since weights vary between regions but have shown little change over time. Representative state values for annual lambing rates and annual wool prices from those states listed in section 4.1.1 are used in regional returns calculations. Lambing rates, which are actually lambs saved per ewe, are incorporated on a regional basis to account for genetic and technological lambing rate improvements and changes in predator losses. Representative state annual wool prices are used to account for quality and incentive payment differences. The returns-per-ewe variable for the national model is similar except lambing rates and fleece weights are based on national averages and the wool price is the national incentive level price. An increase in total returns per head should result in expansion of sheep inventories. Any positive changes in returns due to one output that are offset by decreased returns from the other output should therefore have no effect on producer decisions and resulting inventory levels.

4.1.3 Competitive Enterprises

Comparative profitability of alternative enterprises is also important in determining sheep numbers. As illustrated by both surveys, the primary competitive enterprise for sheep is beef cattle. Not only can cattle utilize similar forages and facilities, but also require somewhat similar management skills and investment. Since sheep are better adapted to poor forage than cattle, combined grazing of sheep and cattle is a common practice. The combination of sheep and cattle enterprises is also encouraged by the added diversity of income that cattle and sheep provide. The presence of cattle on sheep operations also decreases restrictions on changes in inventories of both species. Brood cows are the primary beef enterprises competing with breeding ewes since both utilize primarily low quality forage. The price of a beef cow's output, the weaned calf, is therefore the most suitable proxy for returns for the competitive cattle enterprise. A national calf price is used under the assumption that regional changes follow those of the national markets. Increases in calf prices are hypothesized to result in a shift of resource utilization to cattle and a decrease in sheep inventories.

The secondary competitive enterprise revealed in the surveys that competes for resources used by sheep is cash crops. The type of crops, however, that compete for land and labor resources vary greatly. Using a single commodity price as a proxy for returns from cash crops, even on a regional basis, would result in biased and inconsistent coefficients for other variables. If other crops also competed for resources, changes in inventories resulting from changes in the prices of those crops would be reflected in coefficients for other variables. The inclusion of several major crop prices, however, would result in decreased degrees of freedom in a time series sample with limited observations. The most representative proxy for crop returns for major crops is therefore assumed to be the acreage of principal crops harvested.

Acreage harvested should depict the actual level of resources designated for crop production rather than only the quantity of crops produced, and should reflect historical profitability of principal crops. Increases in crop acreage harvested should represent increased profitability of cash crops and decreased resources designated to sheep, thereby lowering sheep inventories. Total regional harvested acreage estimates are used in modeling efforts to delineate regional differences. National principal crop acreage harvested is used in the national model.

4.1.4 Input Costs and Seasonal Conditions

Primary feed inputs for breeding sheep depend upon lambing season and production scenarios. Typically, ewes are fed good quality hay in seasons when pasture is unavailable, with grain supplemented for three to four weeks prior to and six to eight weeks after lambing (SID). Some alternative feeds and winter pastures are also used, but feeds used depend mostly upon the season in which ewes are lambed. Most ewes are lambed in the spring and wintered on hay. Hay price is included in the model for several reasons. First, it serves as a proxy for feed input prices used in breeding ewe operations. Second, hay prices reflect seasonal conditions and forage availability. Pasture condition estimates do not include estimates of range condition in western regions in a consistent time series. As both surveys indicated, drought conditions and forage availability are key factors in decisions regarding flock size. Hay price is assumed to accurately reflect forage availability in a given region through valuation of feed resources. Season average hay prices from the representative states for each ASPC region listed in section 4.1.1 are used as a proxy of feed costs and seasonal conditions. An increase in hay prices indicates lower forage availability and higher feed prices and should result in decreased sheep inventories.

4.1.5 Subjective Factors

The United States sheep industry is unique. Both the historical background of the industry and the current attitudes of producers reflected in the surveys suggest that factors other than profitability affect producer decisions regarding flock size. The magnitude and duration of the decline in inventories in the 1960s and 1970s suggests that nonfinancial factors are important determinants of sheep supplies. Budgeted profitabilities for sheep and cattle for various Western regions showed returns for sheep and cattle to be similar in magnitude on an animal unit basis during the 1960s. National budgets for sheep and cattle estimate sheep to be more profitable than cattle for all but two years between 1971 and 1987. The decline of sheep inventories in the presence of positive budgeted profits indicates the presence of a non-financial cost of producing sheep. This "cost" may be a dislike for sheep, difficulty in finding labor, the need for more specialized management skills, or frustration with predators. This non-financial cost would effectively shift the marginal cost function up, creating a lower level of output for a given level of profitability.

Along with the presence of a non-financial cost, there is evidence suggesting the existence of a kinked or asymmetric sheep supply function. The magnitude of the decline in sheep inventories in the 1960s suggests a very elastic response, while the lack of postive response to the higher comparative profitability of sheep to cattle in the 1970s and 1980s suggests a very inelastic response. This asymmetry in elasticity along with the survey results suggest that the sheep supply function may be characterized by the operation of asset fixity in reverse.

A hypothetical supply function depicting this concept is presented in Figure 4.1. In the survey, producers indicated that preference for the sheep enterprise was the primary factor in their decision to expand. This suggests that mainly those persons with a preference for raising sheep respond to positive incentives for production, thereby limiting industry supply response. Those producers who do respond are also limited by their individual resource constraints of labor, land, or capital. The combination of these resource constraints and limited response creates a very inelastic positive response depicted in Figure 4.1 by the segment A-S(A). If the industry is operating at point A, any response to positive price or profit incentives is very limited.

Conversely, all producers tend to respond to negative pressures on the industry and contract, shifting production down the supply function to point B. If the industry is at point A, negative incentives can bring a substantial reduction in output. The segment of the supply curve from A down to B is quite elastic. During this contraction, some resources are shifted from sheep production to other uses. When positive incentives return, rather than shifting production back to point A, only those persons with a preference for raising sheep respond. These producers are once again limited by resource constraints and therefore create an inelastic response along the segment B-S(B). This "ratchet effect" places downward pressure on the industry over time and limits expansion in the short run.

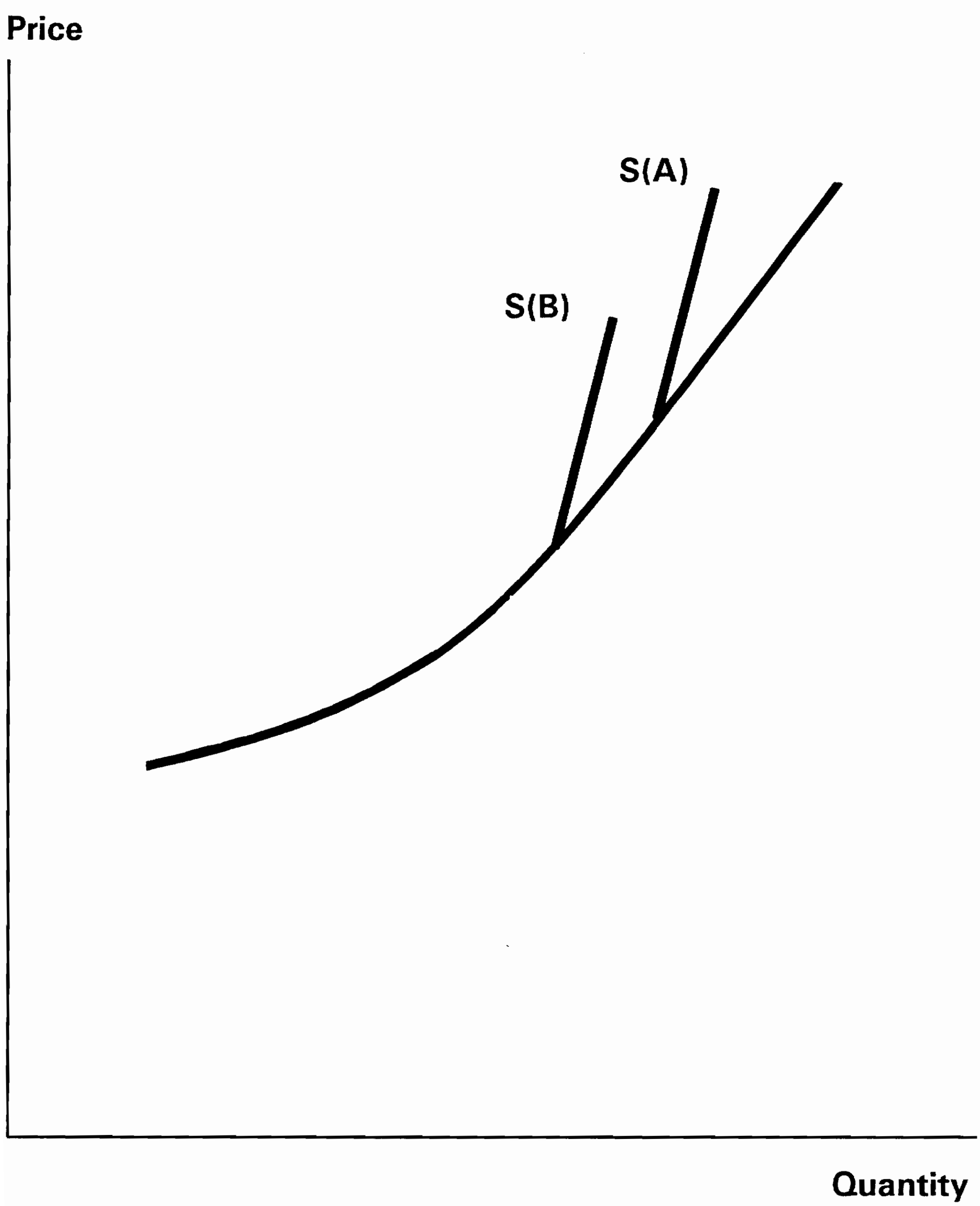

Figure 4.1. Hypothetical Supply Function

Empirical modeling of this change in resources and possible changes in subjective costs is difficult. The use of dummy variables depends upon the ability to determine when production was in an inelastic or elastic portion of the supply function. Though a trend variable may explain a persistent decline in preference, an increase in subjective cost, or an increase in physical constraints, it fails to explain the actual changes in resources over time. The large proportion of part-time sheep farmers leads to consideration of some measure in the change in numbers of part-time farms.

Part-time farmers are more limited by labor and acreage constraints (the primary limiting factors indicated in the surveys) than full-time producers because of farm location and size and the time constraints of off-farm employment. As the proportion of part-time farms increases, the proportion of sheep producers facing major constraints to expansion also increases. Increased numbers of constrained producers correlates to decreased resource availability among producers and lower sheep numbers. It is therefore hypothesized that as proportion of part-time farms increases, sheep numbers should decrease due to increased labor and acreage constraints.

Changes in the proportion of part-time farms may also have other implications. Part-time and small farms generally rely on off-farm income and have low or even negative farm incomes (Salassi). Part-time farmers should therefore be more influenced by the preference dimension since they do not rely totally on farm income. Survey results also exhibited a higher influence level for the preference factor for part-time producers.

Whether or not a change in preference for raising sheep has occurred among full or part-time farms is impossible to determine. Preference for the sheep enterprise could have increased among part-time producers due to sheep's ease of handling or low initial investment, which would result in increased sheep inventories as the proportion of part-time farms increases. Preference among these producers, however, may have declined due to high labor requirements or predator losses which would result in lower inventories. Similar changes could have also occurred among full-time producers. Therefore, the effect on sheep supply of changes in preference cannot be linked to changes in the proportion of part-time farms. The proportion of part time farms does, however, measure changes in resource constraints on the sheep industry.

4.2 Model Structure

The variables previously discussed are each given a lag structure and combined into a model for each region and the United States. The resulting model is as follows:

$BEI_t = f(DTR_{t-2}, DCP_{t-3}, DHP_{t-1}, CAH_{t-1}, PPF_{t-1},)$

where,

BEI = January 1st breeding ewe and ewe lamb inventory, (1,000 head)
DTR = deflated total returns per ewe, ($/ewe)
DCP = deflated calf price, ($/cwt.)
DHP = deflated season average hay price, ($/ton)
CAH = principal crop acreage harvested, (millions of acres)
PPF = percent part-time farms of total farms, (%).

Breeding inventory is the number of stock ewes and ewe lambs (in thousands of head) for each respective region and the U.S. on January 1st of each year as calculated from state estimates by the U.S. Department of Agriculture. Total returns per ewe per year in dollars per head are calculated for each regional model and for the U.S. using the formula discussed in section 4.1.2. Data used in returns calculations are USDA estimates for each year except for fleece weight. Fleece weights used are constant over the entire time series. They were estimated based on regional and national average fleece weights calculated from USDA estimates. Deflated calf prices are measured in dollars per hundred pounds and are annual average national prices reported by the USDA. National average calf price is used in both national and regional models. Hay price is the season average price per ton for all hay for representative states in regional models and for the entire U.S. in the national model. Crop acreage harvested is the sum of harvested acres of principal crops measured in millions of acres as reported by the USDA for each region and for the U.S. Revised data are used for the period prior to 1973 because the definition of principal crops was changed in that year. The percent of all operators who farm part-time is the number of farm operators working off the farm 200 or more days per year, divided by the total number of farm operators, and multiplied by 100. This information was obtained from the U.S. Census of Agriculture and therefore was not available in an annual series. Census year observations are used and values are interpolated for years between censuses. Again, regional values for part-time farms are used for regional models.

4.2.1 Lag Structure

Variables are lagged under the assumption that producers base decisions upon historical profitability. A single lag structure is used because of the limited number of observations and the difficulty of determining a weighting scheme that accurately follows the weight each year's prices have on producers' decisions. Livestock cycles also generally create price trends that continue for several years thereby enabling annual changes to reflect past and future price levels.

Lags are determined through graphic comparison of trends and correlation matrices of the dependent and explanatory variables. Consideration is also given to previous modeling results and expectations of producer behavior. Turning points of inventories generally follow turning points in total returns by two to three years. Correlation matrices exhibit a negative correlation for most lags between total returns and inventories for most regions. Total returns per ewe are therefore lagged two years under the assumptions that producers do not respond to incentives immediately and that ewe lambs enter the January 1 inventory the year after they are born. Producers will not retain ewe lambs in a given year of high prices due to their inherent value and to lagged responses prevalant in all agricultural industries. The following year, however, expansion will occur based on the previous year's prices. Similarly, one year of low prices will not greatly reduce ewe lamb retention.

A high negative correlation exists between calf prices lagged two, three, and four years and breeding ewe inventories. Comparison of turning points indicates similar lags of 3 to 5 years. Calf prices are lagged three years based on these findings. A longer lag also accounts for the lack of producer knowledge of other livestock prices and the longer term trends associated with the cattle cycle.

Both hay price and crop acreage harvested show high negative correlations when lagged one and two years. Hay prices are lagged one year in the models since forage availability and price in a given growing season will affect the number of animals carried through the winter. Negative correlations in later years are most likely the residual effect of producer decisions in previous years. Crop acreage harvested is lagged one year since it reflects past cash crop profitability and the acreages designated to crop production for the following year. The percent of part-time farms is lagged one year to represent the change in resources for the year prior to January 1st.

4.2.2 Model Estimation

Models were estimated for the period from 1953 to 1984 to avoid World War II market disturbances, but include years prior to the Wool Act of 1954. Preliminary model results varied by region, but variables generally exhibited hypothesized signs and were significant. All models had R^2's above .95, but Durbin Watson statistics exhibited severe autocorrelation for all models, therefore making t-tests unreliable.

Previous modeling research with other explanatory variables also encountered autocorrelation problems (Gardner, Whipple and Menkhaus). Changes in lag structure and the inclusion of several variables used in previous research in the hypothesized model did not remove autocorrelation problems. The Cochrane-Orcutt iterative procedure was then used to estimate the unknown coefficient of autocorrelation, rho. The coefficient rho increased from around .5, depending upon the region, to 1 after five to six iterations. A value of one for rho indicates the presence of perfect positive autocorrelation, or consistent underestimation or overestimation. Since livestock production and therefore expansion is limited by biological production constraints, present inventories have a direct dependence on previous inventory levels. Including lagged inventories as an explanatory variable should account for the consistent underestimation and overestimation present in models. The estimated models under the autoregressive framework are:

$$BEI_t = f(BEI_{t-1}, DTR_{t-2}, DCP_{t-3}, DHP_{t-1}, CAH_{t-1}, PPF_{t-1},)$$

4.2.3 Partial Adjustment Model

Including lagged inventories alters the linear model in several ways. The actual model estimated is a partial or stock adjustment model. This model assumes that the inventory level producers desire is dependent upon the current inventory. This is in fact the case with breeding ewe inventories since genetic and resource constraints do limit the amount of response possible in the short-run. Assuming $BEI*_t$ is the desired inventory level, the amount of actual adjustment in a given year, $(BEI_t - BEI_{t-1})$, is equal to the desired adjustment, $(BEI*_t - BEI_{t-1})$, multiplied by P, where P is the fraction of desired adjustment obtained in a given year. In estimation of the partial adjustment model, the actual inventory level BEI_t is equal to:

$$[P\alpha_0 + (1 - P)BEI_{t-1} + P\alpha_1 DTR_{t-2} + P\alpha_2 DCP_{t-3} + P\alpha_3 DHP_{t-1}$$

$$+ P\alpha_4 CAH_{t-1} + P\alpha_5 PPF_{t-1}]$$

where,

P = ajustment coefficent estimate
α = long-run parameter estimate.

Parameter estimates obtained for explanatory variables during regression on actual inventories are short-run estimates. Long-run estimates can be obtained by dividing coefficients by P.

Conventional Durbin Watson measures of autocorrelation are not valid for partial adjustment models because the d value tends toward 2, indicating truly random error terms. Durbin d statistics in partial adjustment models therefore are biased against finding first order autocorrelation. For large samples, the Durbin h test is a valid measure of autocorrelation. The Durbin h statistic is:

$$h = (1 - .5*d)[\ N/(1 - N*var(1-P))]^{.5}$$

where,

h = Durbin h statistic
d = Durbin d statistic
N = Sample size
var(1-P) = variance of lagged dependent variable coefficient.

Testing procedures for the Durbin h statistic follow those of a normal distribution and are strictly valid for large samples. Since no exact limitations of sample size exist, the sample used in model estimation is assumed to be adequate for valid results.

Inclusion of lagged inventories corrected auotcorrelation problems in the national model and most of the regional models based on the Durbin h test.

4.3 Model Results

Models were estimated on the econometric package PC Give for the period of 1953 to 1984 with 1985 through 1988 used as an out of sample test. Regional and national models and their results are presented in Table 4.1. In general, variables exhibited expected signs for all regional models, and Durbin h statistics and R^2's were also generally within acceptable ranges. Significance of variables varied from region to region because of differing influences on producer decisions among regions. Only crop acreage harvested varied consistently from its hypothesized sign, having a positive rather than negative influence on sheep numbers for most regions and for the national model.

The model of Region 1 inventories had a high R^2, but the hypothesis of no autocorrelation was rejected. The lagged inventory variable was significant with a coefficient of .898. Returns per head had the hypothesized sign but was not significant at the 10 percent level. Calf price and percent part-time farm variables also had expected signs but

Table 4.1: Regional and National Supply Model Estimates, 1953-1984.

ASPC REGIONS	1 East Coast	2 Ohio Valley	3 Midwestern Plains	4 Northern Plains
VARIABLE	PARAMETER ESTIMATES			
BEI	0.898**	0.922**	0.864**	0.924**
(t-1)	(16.40)	(14.76)	(12.03)	(10.88)
DTR	0.872	3.038**	1.152	3.269
(t-2)	(1.20)	(3.80)	(0.83)	(1.35)
DCP	-1.166	-0.309	-2.805**	-3.806**
(t-3)	(-1.64)	(-0.57)	(-3.02)	(-2.41)
CAH	9.150**	-3.028	8.699**	26.31
(t-1)	(3.45)	(-0.73)	(3.18)	(1.07)
DHP	0.172	-1.213	-3.725**	-5.497*
(t-1)	(0.23)	(-0.97)	(-2.27)	(-2.06)
PPF	-10.91	-15.24*	-29.88**	-26.92
(t-1)	(-1.70)	(-1.75)	(-2.28)	(-1.01)
CONSTANT	-147.78	555.83	196.33	343.95
	(-0.57)	(1.09)	(0.30)	(0.29)
R2 =	0.995	0.996	0.994	0.987
Durbin h=	2.162	0.635	1.124	0.316
F(6,25) =	798.92	941.83	688.42	321.52
FORECAST PERCENT ERROR~				
1985	-0.9	11.1	-9.7	-20.4
1986	4.6	-7.3	-17.0	0.9
1987	25.6	-0.1	6.8	-4.1
1988	16.3	-16.2	5.8	-1.0

* = Significant at 10% confidence level
** = Significant at 5% confidence level

~ Forecasts generated for each year from re-estimated models for the previous year.

Table 4.1 Continued.

ASPC REGIONS	5 Texas	6 Rocky Mountain	7 West Coast	United States
VARIABLE		PARAMETER ESTIMATES		
BEI (t-1)	0.812** (12.90)	0.973 (18.39)	0.988** (20.63)	0.845** (13.24)
DTR (t-2)	1.298 (0.59)	2.896** (2.24)	4.175** (2.32)	19.608** (2.58)
DCP (t-3)	-2.398* (-1.78)	-2.588** (-3.10)	-1.760 (-1.7)	-17.12** (-4.12)
CAH (t-1)	55.34** (3.99)	75.98** (2.64)	44.088* (1.72)	16.729** (3.74)
DHP (t-1)	-15.84** (-5.06)	-2.890* (-1.74)	-1.144 (-0.67)	-43.27** (-3.63)
PPF (t-1)	-37.77** (-3.04)	-16.04 (-1.41)	3.262 (0.23)	-200.06** (-2.62)
CONSTANT	2021.44** (2.30)	-208.53 (-0.36)	-979.58 (-1.42)	5867.91 (1.33)
R2 =	0.988	0.993	0.992	0.997
Durbin h=	0.515	2.964	0.147	0.256
F(6,25) =	349.74	592.05	546.06	1265.97
FORECAST PERCENT ERROR~				
1985	13.2	-16.3	-1.1	-15.4
1986	-23.1	-4.1	0.04	-9.9
1987	-3.5	-2.8	0.07	-1.2
1988	-1.8	7.1	12.4	3.1

* = Significant at 10% confidence level
** = Significant at 5% confidence level

were not significant. Hay price had a positive coefficient and was insignificant, but due to the wide diversity of this region the chosen state hay price may not be truly representative. Crop acreage harvested had a positive sign and was significant. East Coast and Southeastern region forecast errors ranged from -.9 to 25.6 percent with 25.6 percent being the highest percent error of any regional model.

Ohio Valley and Great Lake region results were consistent with hypothesized signs, but several variables lacked significance at the 10 percent level. Lagged inventories, returns per ewe, and part-time farm variables were all significant. Though calf price, hay price, and harvested acreage variables had hypothesized signs, none were significant. The Durbin h statistic of .635 indicated that autocorrelation was not present in the model. Region 2 had the highest R^2 and F-value of all regional models and forecast errors ranged from -16.2 to 11.1 percent.

Modeling efforts for Region 3, the Midwestern Plains region, exhibited encouraging results. Only the harvested acreage variable had a sign inconsistent with the hypothesized model. Its coefficient was positive and significant, which may reflect increased feed availability. Returns per ewe had a positive sign but was not significant. All other variables exhibited hypothesized signs and were significant at the 5 percent level. Autocorrelation was not observed and the R^2 was once again high. Forecast errors ranged from -17.0 to 6.8 percent.

Lagged inventories, calf price, and hay price were all significant and had hypothesized signs in the model for Region 4, the Northern Plains states. Returns per ewe and percent part-time farms had hypothesized signs but were not significant at the 10 percent level. Once again harvested acreage had a positive coefficient, but was not significant in Region 4. The model had the lowest F-value of all regions. Its Durbin h statistic of .316 failed to reject the hypothesis that autocorrelation was not present. Forecast errors ranged from -20.4 to .9 percent.

The model for Texas exhibited significance at the 10 percent level for all variables except returns per ewe. All explanatory variables exhibited anticipated signs except harvested acreage, which had a positive coefficient and was significant. Hay price had a higher t-value than in any other region, possibly reflecting the higher variability and importance of seasonal conditions in Texas. Region 5 had a Durbin h statistic of .515 indicating no autocorrelation at the 5 percent level. Forecast errors ranged from -23.1 to 13.2 percent.

Region 6, the Rocky Mountain region, had a lagged inventory coefficient of .97 with a highly significant t-value of 18.39. Returns per ewe, calf price, and hay price variables all had hypothesized signs and were significant at a 10 percent confidence level. Harvested crop acreage again had a positive sign and was significant. The model exhibited positive autocorrelation with a Durbin h statistic of 2.964. Forecast errors for this model ranged from -16.3 to 7.1 percent and the model had a F-value of 592.05.

The model of the West Coast and Southwestern states (Region 7) exhibited the lowest forecast error of all regions. Lagged inventories, however, had a coefficent of .988 with a t-value of 20.63, which is very high for a partial adjustment model. Returns per ewe was the only other variable exhibiting both the hypothesized sign and significance. Calf price had a negative sign but was not significant. Hay price had a negative coefficient but was not significant, while harvested acreage had a positive sign and was significant at the 10 percent level. The model for Region 7 was the only regional model which exhibited a positive sign on the part-time farm variable but it also had an insignificant t-value. As mentioned earlier, the model exhibited the most accurate prediction with a percent error ranging from -1.1 to 12.4 percent with a low of .04 percent. The model had a Durbin h statistic of .147, indicating auto-correlation was not present.

4.3.1 Regional vs. National Models

Regional models exhibited substantial variation in t-values, Durbin h statistics, and in forecast errors. No consistent overestimation or underestimation patterns were observed in forecasts. R^2's and F values were high for all models. Returns per ewe had a positive sign for all regions, though significance was marginal. The calf price variable had the hypothesized sign for all regions and was found to have higher t-values in western regions. The acreage harvested variable generally exhibited a positive rather than negative sign and was usually significant among regional models. This implies that total regional crop acreage is complementary to sheep production. Even though crops may compete with sheep on individual operations, total crop production increases feed availability and lowers feed costs. The positive coefficient on crop acreage harvested is assumed to reflect the effect of increased feed availability on sheep inventories. Hay price had a negative coefficent for all but Region 1. Similar to calf price, hay price exhibited higher t-values in western regions. The percent of part-time farms variable was generally negative and significant except in the model for Region 7, where it exhibited a positive sign.

Correlation matrices for the regional variables exhibited high partial correlation coefficients between the lagged inventory and part-time farm variables and between total returns and crop acreage harvested variables. Correlation was also high between deflated hay price and the percent part-time farm variable. Multicollinearity results in large standard errors but does not bias coefficient estimation. The low t-values for various variables in models with high R^2's along with high correlation coefficients indicates that multicollinearity may be a problem in the regional models, which will create larger confidence intervals.

The model for the United States exhibited more desirable statistical properties than the regional models. Though the possibility of multi-collinearity exists, all variables except crop acreage harvested had hypothesized signs and were significant at the 5 percent level. Similar to the regional models, the coefficient for crop acreage harvested was postive and significant. The model's R^2 was .997 and the Durbin h statistic of .256 failed to reject the hypothesis that autocorrelation was not present. Forecast errors ranged from -15.4 to 3.1 percent.

Regional models were hypothesized to be more accurate predictors of inventory levels because of regionalization of production practices, seasonal conditions, and enterprise competition. Models were re-estimated for the period from 1953 to 1988 and root mean squared errors (RMSE) were calculated over that period to determine if regional or national models should be used for forecasting and elasticity calculations. The RMSE for the sum of regional predicted values versus actual national inventories was 377.65. The RMSE for the national model's predicted values was 401.27. This difference in error of 23.62 thousand head is relatively small. This difference in accuracy cannot justify the added costs and limitations of data collection for regional forecasting, therefore the national model is used for elasticity estimates and inventory projections.

4.4 Elasticity and Inventory Estimates

The national model was re-estimated with data through 1989 to obtain elasticity estimates and make inventory projections through 1993. Coefficient values changed slightly from the previous model, which may result from the industry's movement toward expansion in 1987. In the sample period prior to 1987, the industry had experienced expansion only three times; in 1955, from 1958 to 1960, and from 1979 to 1982. The re-estimated model is:

$$BEI_t = \underset{(.460)}{1416.8} + \underset{(21.087)}{.928}\ BEI_{t-1} + \underset{(3.565)}{24.132}\ DTR_{t-2} - \underset{(-3.387)}{14.125}\ DCP_{t-3}$$

$$- \underset{(-3.452)}{28.42}\ DHP_{t-1} + \underset{(3.043)}{12.357}\ CAH_{t-1} - \underset{(-1.99)}{113.674}\ PPF_{t-1}$$

$R^2 = .996$ $F = 1443.207$ Durbin $h = .8081$

Variable t-values (in parentheses) were similar to the previous model and other statistical properties of the model exhibited inconsequential changes.

4.4.1 Sheep Industry Supply Elasticities

The partial-adjustment model framework used in this modeling effort enables calculation of short and long-run elasticities. Short-run, five year, and long-run elasticity estimates are presented in Table 4.2. Short-run response to all factors is relatively inelastic which is consistent with survey results and elasticity estimates from prior studies (Gardner, Whipple and Menkhaus). The short-run elasticity of breeding inventories with respect to returns per head of .126 indicates only a small response to increased returns. The five year elasticity is lower than Whipple and Menkhaus' estimate of stock sheep inventory elasticity with respect to lamb price (five year) of 1.38, but is similar in magnitude to their wool price elasticity of .59. Long-run elasticity with respect to returns is 1.74, much lower than Whipple and Menkhaus' 30 year lamb price and wool price elasticities. The overall low elasticity of breeding inventories with respect to returns has strong implications for industry groups attempting to stimulate production. Higher returns will not result in large increases in inventories in the short or long run.

Inventory response to changes in calf prices is the lowest of all factors with a long-run elasticity of -.939. A low elasticity of breeding inventories with respect to calf price suggests that competition from beef cattle may be a long term stimulus for change in sheep inventories. Since

Table 4.2 Stock Elasticity Estimates for the U.S. Sheep Industry

Elasticity of Breeding Inventory w.r.t.	Time Horizon		
	Short-run	5 Years	Long-run
Total Returns	0.126	0.546	1.754
Calf Price	-0.067	-0.290	-0.939
Hay Price	-0.132	-0.572	-1.839
Part-time Farms	-0.200	-0.866	-2.788
Crop Acreage	0.234	1.014	3.256

sheep and cattle are both faced with genetic limitations which hamper rapid changes in production, a low cross elasticity of sheep inventories with respect to calf prices is not suprising.

The elasticity of sheep inventories with respect to hay price is similar in magnitude to that of total returns. On a national level, the elasticity of inventories to hay price is hypothesized to more nearly reflect the input cost of hay than changes in seasonal conditions. The variation in hay price significance in regional models suggests that elasticities for hay price in the national model cannot reflect the actual changes in seasonal conditions on national inventories. Furthermore, variation in pasture conditions between major sheep producing areas may be so localized that it has no significant effect on national hay prices.

Sheep inventories exhibit the most elastic response to changes in the proportion of part-time farms and to changes in harvested crop acreage. The long-run elasticity of sheep inventories with respect to the proportion of part-time farms is -2.788. Changes in resource contraints portrayed by this variable should have a large short and long-run effect on flock size under the hypothesized fixed asset in reverse supply function. Consideration should be given, however, to the possibility of a more inelastic response to a decrease in the proportion of part-time farms. Under the fixed asset in reverse framework developed in section 4.1.5, resources can be more easily shifted out of sheep production than they can be brought back into the industry. This suggests the possibility of a lower elasticity for the part-time farm variable during periods of decline in the proportion of part-time farms.

Crop acreage harvested exhibits the highest elasticity and is positive, which does not follow the hypothesized sign or the expected magnitude of influence compared to other variables. In the surveys discussed in Chapter 3, crops were the secondary competitive enterprise for sheep producers, therefore a high (negative) elasticity was not expected. The assumption that the crop acreage harvested variable reflects changes in feed availability rather than competition for resources is further supported by its high positive elasticity. The high elasticity of sheep inventories with respect to crop acreage harvested indicates a relatively large response by sheep producers to changes in feed availability and costs.

Elasticity estimates for sheep inventory response have many implications for the industry. Estimates are smaller than those of Whipple and Menkhaus but agree with the inelastic response of the hypothesized suppply function. Any industry strategy must take into account the inelastic response of sheep producers and the resource constraints present in the industry.

4.4.2 Inventory Projections

The sheep industry, like most agricultural industries, is affected by many unpredictable factors. Seasonal conditions, domestic and foreign policy, fashion trends, and changes in competitive products all play a role in determining producer returns and ultimately breeding inventories. The combination of these factors makes long term industry projections difficult and subject to error.

Industry projections using the national model developed from the surveys all indicate a general and long-term decline in inventories. World sheep inventories reached record highs in 1989 of 1.15 billion head. U.S. breeding inventories have increased from 7.87 million head in 1986 to 8.51 million in 1989. Total U.S. lamb and mutton production is projected at 340 million pounds for 1989, its highest level since 1985. Deflated total returns per head (1982-84 base) for 1988 as estimated for the national model of inventories are $83.92 per head, $14.14 below 1987 levels. Estimates based on preliminary prices and production for 1989 indicate a further decrease in total returns to approximately $77 per head (deflated). Calf prices have trended up since 1986 and cattle inventories have shown signs of expansion for 1990. Harvested crop acreage estimates based on plantings show a 12 million acre increase of harvested acreage to 302.1 million acres for 1989. Hay price for 1989 is expected to decrease by 2.5 percent from 1988. The proportion of part-time farms is expected to follow its current trend and increase by .5 percent. Based on this preliminary information, breeding inventories are predicted to decrease by 420 thousand head to 8.09 million head in 1990. Annual patterns in breeding inventories and in total lamb and mutton production since 1979 support model results. Expansion in 1990 would be the fourth consecutive increase in breeding inventories, while previous expansion periods have lasted only 1 to 3 years. Increased calf prices and decreases in actual and deflated total returns for 1988 and 1989 further support a decrease in breeding inventories in 1990.

Projections for 1991 through 1993 indicate a continued decline in the national breeding flock. Projections are run under several different scenarios. For all scenarios the proportion of part-time farms is assumed to continue its current trend. Lamb weights and lambing rates are maintained at their five year averages, and fleece weights remain the same. The consumer price index is assumed to increase at an inflation rate of five percent through the period. Table 4.3 contains the projection from each scenario used.

Scenario 1 projects inventories under the assumption that current annual nominal price levels for lambs and calves remain constant through the projected period. Nominal hay price and harvested acreage are maintained at their respective 5-year average levels. The wool incentive price is adjusted down 1 cent per pound per year based on the current trend. Under these assumptions, breeding inventories are projected to be 7.89, 7.67, and 7.49 million head for 1991, 1992, and 1993, respectively.

Scenario 2 assumes that prices keep pace with inflation which is assumed to continue at 5 percent per year. Hay price is maintained at its 5-year average real level, and lamb and calf prices are kept at current real levels. Wool incentive price and harvested acreage remain the same as in of the first scenario. Though deflated returns are higher for sheep in scenario 2, higher deflated calf and hay prices resulted in inventories falling to 7.01 million head by 1993.

Though many changes can occur over the next four years, projections for Scenario 3 are made using current trends and expected changes in variables affecting the sheep industry. Increasing lamb and mutton supplies through 1991 from higher domestic production and ewe slaughter are expected to place downward pressure on lamb prices with actual nominal annual prices

Table 4.3: U.S. Breeding Ewe Inventory Projections, 1990 - 1993

	1990	1991	1992	1993
Scenario 1:				
Deflated Total Returns@	$83.92	$79.15	$75.32	$71.67
Deflated Hay Price	$68.40	$55.05	$52.43	$49.93
Deflated Calf Price	$69.08	$75.40	$74.80	$71.22
Crop Acreage Harvested	302.1	304.8	304.8	304.88
Percent Part-time Farms	35.8	35.9	36.1	36.2
Projected Inventory (mill. hd.)	8.09	7.89	7.67	7.49
Scenario 2:				
Deflated Total Returns	$83.92	$82.49	$81.85	$81.24
Deflated Hay Price	$68.40	$63.25	$63.25	$63.25
Deflated Calf Price	$69.08	$75.40	$75.40	$75.40
Crop Acreage Harvested	302.1	304.8	304.8	304.88
Percent Part-time Farms	35.8	35.9	36.1	36.2
Projected Inventory (mill. hd.)	8.09	7.73	7.37	7.01
Scenario 3:				
Deflated Total Returns	$83.92	$76.16	$72.47	$73.43
Deflated Hay Price	$68.40	$63.25	$63.25	$63.25
Deflated Calf Price	$69.08	$75.40	$75.40	$75.40
Crop Acreage Harvested	302.1	315.0	304.8	304.8
Percent Part-time Farms	35.8	35.9	36.1	36.2
Projected Inventory (mill. hd.)	8.09	7.71	7.12	6.55

@ Values for independent variables are actual lagged values used in calculating each year's projected inventory.

falling to approximately $.65 per pound. A continued trend of increasing lamb and mutton imports may also add to downward pressure on lamb prices. Demand for lamb is assumed to remain relatively stable. The wool incentive price is assumed to continue declining slowly to $1.75 per pound by 1991 based on current USDA policy. Though long term trends in lambing rates indicate an annual increase of .01 lambs per ewe, lambing rates are again held stable due to the high annual fluctuations and limited short-run affect on total returns. Lamb weights are expected to remain stable at 117 pounds due to increased industry pressure to reduce sales of overweight lambs. Real returns per ewe fall substantially under these assumptions since wool price and lamb price are projected to decrease in real terms.

The beef cattle industry is considered to be entering an expansionary phase, therefore calf prices are assumed to increase at or above the assumed 5 percent inflation rate through 1990 due to decreased heifer and cow slaughter (USDA). Decreased grain stocks and higher prices in 1988 and 1989 are expected to increase harvested acreage in 1990 to around 315 million acres (USDA). Acreage harvested is then assumed to return to its 5-year average of 305 million acres. Hay price is assumed to remain at its 5-year average real level, and the proportion of part-time farms is assumed to increase at its current rate. Under these assumptions, January 1st inventories of ewes and ewe lambs are projected to fall to 6.55 million head by 1993. A decrease in imports due to higher domestic production and lower retail prices may help bolster returns per ewe. Increased lambing rates and resulting higher returns could also reduce inventory liquidation.

Survey results of producers plans through 1990 indicated that inventories should continue to expand (Chapt. 3). These decisions, made in 1988, will most likely change since returns for sheep have declined in 1988 and 1989 and since calf prices have shown significant increases over the same time period. Without substantial increases in returns, which are unlikely with world sheep numbers at an all-time high and decreasing government support, the sheep enterprise will be unable to compete with rising beef cattle inventories for producer resources. Breeding sheep inventories will decline and more resources will be lost from the industry. Though model projection indicate inventories as low as 6.5 million head by 1993, allowance for error and consideration of survey results suggest breeding inventories may fall to between 7.2 and 7.4 million head in the next four years.

Chapter 5

Conclusions and Implications

5.1 Implications for the Sheep Industry

The U.S. sheep industry faces many challenges over the next several years. Results of this study indicate that the industry is more prone to contraction than expansion and that breeding inventories should fall below 7.4 million head by 1993. Lamb and mutton will face continued competition with other red meats, fish, and poultry for consumer market share. Domestic wool will face continued competition with synthetic fibers and foreign textiles. Increased returns for beef cattle in the U.S. will lure more resources out of sheep production. Competition from record large world sheep inventories and decreased government support will place downward pressure on lamb and wool prices and on the U.S. sheep industry.

Based on these conditions and survey results, any industry strategy to increase or at least maintain industry production should center on three main goals:

1. Maintaining producer returns,
2. Increasing producer preference, and
3. Maintaining market share.

Though elasticities of inventories with respect to total returns are low, lower prices for lamb and wool from increased world production and decreased government support will have a negative effect on inventories.

Producer returns are more responsive to changes in lambing rates than to any other output factor. Lambing rates also show the most potential for improvement and are more controllable than lamb price. Import restrictions have been shown to increase lamb prices and inventories (Whipple and Menkhaus), but they would also lead to decreased product availability and possible loss of market share. Research towards developing economical increases in lambing rates and dissemination of this information is one primary way to maintain returns. Increased wool quality and resulting increases in value is another way to bolster returns per head. Survey results indicate the need for a consistent wool grading system and for incentives to increase wool cleanliness and quality. Both of these alternatives would help maintain producer returns during periods of declining inflation-adjusted selling prices.

The second area of concern that an industry strategy should address is producer attitudes and preferences. A more positive perception of sheep by current and future producers will help keep resources in the industry. Survey results indicated that most growth in sheep numbers in recent years has occurred among mid-sized, diversified farmers in the Midwestern and Northern Plains states. With increasing returns for beef cattle, keeping resources in sheep production may depend on these and other producers being made more aware of the advantages of combined grazing and of the more stable income that sheep can provide. Also, research to reduce the labor requirements of sheep and to reduce predator losses would help change producer perceptions. Another factor influencing producer attitudes is increased seasonal variations in lamb price, which was evident in the survey and in historical monthly prices. Increases in price variation directly increase producers' risks. Consideration should be given to strategies which would help stabilize prices throughout the year.

The third area on which an industry strategy should concentrate is on maintaining market shares (and therefore prices) for lamb and wool. Consumers ultimately decide the demand for both lamb and wool, but lamb is more directly subject to consumer preferences since it involves less further processing. Problems with overfat and overweight lambs, as experienced in the spring of 1988, need to be addressed before they substantially affect consumer demand. Respondents to the surveys also indicated confusion over what type of lambs were desired. Most concerns revolved around discounts for heavy lambs that were not overly fat. Industry standards and incentives for acceptable carcass size, quality, and yield based on consumer demands would help clear up this confusion and reduce waste. Finally, the effects of product promotion on both lamb and wool consumption should be evaluated and product advertisement pursued if it proves cost effective.

The strategies suggested may still not be enough to bolster returns over the next few years and maintain inventory and resource levels. Consideration of these and other possibilities should be incorporated into the development of any industry programs. Though the results presented in Chapter 4 are not the final word on sheep supply response, they do provide insight into the current industry situation and prospects for the future.

5.2 Implications for Future Research

Several problems still exist with the supply models presented in Chapter 4. Multicollinearity, especially in regional models, may need to be corrected in order to obtain smaller confidence intervals and to increase forecast accuracy. Further research and more sophisticated modeling of the hypothesized supply function may also increase regional and national model accuracy. The use of weighted regional values rather than those of representative states may increase variable significance and regional model accuracy. More accurate measures of seasonal conditions and forage availability may also prove beneficial. More observations, particularly observations outside of the downward trend in inventories, might increase the accuracy of the estimated models.

In any case, future modeling efforts must include some measure of the change in resources that has occurred within the industry and account for the technological changes that have occurred in lambing rates and lamb weights. Consideration must also be given to the actual proportion of income received from lamb and wool outputs and its change over time. Future models must also include some measure of the profitability of cattle, and of forage or pasture availability and cost.

Controlled experimentation could be used to determine the elasticity of the short run supply function and the magnitude of the increase in profit incentives that would be required to stimulate production. The follow-up survey indicated that, on average, lamb prices would have to increase by $18 per hundred pounds before producers would expand. A representative set of sheep producers, placed in a controlled setting, could be presented with alternative scenarios to determine when expansion would occur. If the hypothetical resource constraints are so severe that a lamb price increase of 20 to 30 percent or a similar increase in returns per ewe would be required to bring in additional capital investment and labor, the industry faces a severe barrier to growth. Controlled experiments to elicit producer responses would help to determine the magnitude of the needed incentives, and provide guidance to strategies for industry groups.

On a final note, changes in government policy, including import restrictions or suspension of the wool incentive program, may result in significant changes in the projected inventories and in the supply models presented in this study. Further work to estimate the net impact of the wool incentive program during a period of downward trending inventories is needed.

References

American Sheep Producers' Council, Inc.. Situation Outlook Report: 88-89. Denver, Co.: ASPC, 1989.

Burton, Robert O., and J. W. Wollo. "Adjustments in a Beef/Sheep Farm in Response to the Cattle Cycle: The Potential for Increased and More Stable Income," Northeastern J. of Agr. Econ., Vol. 15 (April 1986), pp. 45-52.

Chavas, J. P. and R. M. Klemme. "Aggregate Milk Supply and Investment Behavior on U.S. Dairy Farms," Amer. J. of Agr. Econ.. 67(1985):55-66.

Epplin, Francis M., D. G. Doye, and C. E. Ward. A Comparison of Costs and Returns from Sheep for Alternative Management Systems, Lambing Times, and Flock Sizes. Oklahoma Agr. Exp. Sta. Research Report No. P-842, Oklahoma State Univ., Sept. 1983.

Frary, Robert B. "A Brief Guide to Questionaire Development," Learning Resource Center, VPI & SU.

Gardner, Bruce. Effects of U.S. Wool Policy, Washington, D.C.: GAO-CED 82-86CR, June 1982.

Gee, C. Kerry. Enterprise Budgets for Western Commercial Sheep Businesses, 1974. Washington, D.C.: USDA ERS No. 659, March 1977.

Gee, C. Kerry and R. S. Magleby. Characteristics of Sheep Production in the Western United States. Washington, D.C.: USDA ERS Ag. Econ. Rep. No. 345, 1976.

Gee, C. Kerry, R. S. Magleby, W. R. Bailey, R. S. Gum, and L. M. Arthur. Sheep and Lamb Losses to Predators and Other Causes in the Western United States. Washington, D.C.: USDA ERS Ag. Econ. Rep. No. 369, April 1977.

Gee, C. Kerry, R. S. Magleby, D. B. Nielsen, and D. M. Stevens. Factors in the Decline of the Western Sheep Industry. Washington, D.C.: USDA ERS Ag. Econ. Rep. No. 377, Aug. 1977.

Gray, James R., J. M. Fowler, and M. Jones. Economic Characteristics of Sheep and Cattle Ranches in Southeastern New Mexico, 1978. N. Mex. Ag. Exp. Sta. Research Report No. 438, New Mexico State Univ., April 1981.

Gujarati, Damodar N.. Basic Econometrics, 2nd. ed. New York, N.Y.: McGraw-Hill, Inc., 1988.

Jordan, R. M.. Economic and Management Considerations for Lamb Production Through the 1980's. Minnesota Ag. Extension Serv. AG-FO-0730, University of Minn., 1985.

Jordan, R. M.. Starting or Expanding Your Sheep Flock. Minnesota Ag. Extension Serv. AG-FO-0608, University of Minn., 1985.

Kruse, Jamie L., C. K. Gee, and A. G. Madsen. Farm Flock Management Systems. Colorado Ag. Exp. Sta. Bull. No. 589S, Colorado State Univ., March 1984.

Martin, Larry J. and R. Haack. "Beef Supply Response in North America," Canadian J. of Ag. Econ.. Vol 25, No. 3 (1977): pp. 29-47.

Parker, C. F. and A. L. Pope. "The U.S. Sheep Industry: Changes and Challenges," Journal of Anim. Science. Vol 57, Suppl. 2 (July 1983): pp. 75-99.

Pindyck, Robert S. and D. L. Rubinfeld. Econometric Models and Forecasts, 2nd. ed. New York, N.Y.: McGraw-Hill, Inc., 1981.

Purcell, Wayne D. Analysis of Demand for Beef, Pork, Lamb and Broilers: Implications for the Future. Blacksburg, Va.: Research Institute on Livestock Pricing Research Bulletin 1-89, July 1989.

Reeves, Jeffery G., Warren P. Preston, and Wayne D. Purcell. "Subjective Dimensions of Producer Behaviour: Analytical Implications for Sheep Supply Response." Paper presented at the annual meeting of the Amer. Ag. Econ. Ass., Baton Rouge, La., July 28-Aug. 2, 1989.

Regan, Eugene. The Sheep Market: Problems and Prospects. Paris: OECD, 1980.

Reynolds, R. G. and B. Gardiner. "Supply Response in the Australian Sheep Industry: A Case for Disaggregation and Dynamics," Australian J. of Ag. Econ.. Vol 24 (Dec. 1980): pp. 196-209.

SAS* Users' Guide: Basics, 5th. ed. Cary, N.C.: SAS Institute, Inc., 1985.

Schwager, Jack O.. A Complete Guide to the Futures Markets. New York, N.Y.: John Wiley & Sons, 1984.

Sheep Industry Development Program, Inc. Sheep Production Handbook. Denver, Co.: Double Quick Printing, 1987.

Shelton, Maurice and R. M. Lewis. Ram Performance Testing (in Texas): A Review and Evaluation. Texas Agr. Exp. Sta. No. PR-   , 1986.

Stillman, Richard, Terry Crawford, and Lorna Aldrich. Report on the U.S. Sheep Industry. Washington, D.C.: USDA, March 1989.

U.S. Department of Agriculture. Agricultural Statistics. Washington, D.C., 1950-87.

U.S. Department of Agriculture. Agricultural Prices: 1988 Summary. Washington, D.C.: USDA NASS, June 1989.

U.S. Department of Agriculture. Costs and Returns, Migratory Sheep Ranches, Utah-Nevada. Washington, D.C.: USDA ERS Farm Prod. Economics Division, 1969-71.

U.S. Department of Agriculture. Costs and Returns, Northwest Cattle Ranches. Washington, D.C.: USDA ERS Farm Prod. Economics Division, 1969-70.

U.S. Department of Agriculture. Costs and Returns, Southwest Cattle Ranches. Washington, D.C.: USDA ERS Farm Prod. Economics Division, 1969-71.

U.S. Department of Agriculture. Costs and Returns, Western Livestock Ranches. Washington, D.C.: USDA ERS Farm Prod. Economics Division, 1961-68.

U.S. Department of Agriculture. Cotton and Wool: Situation and Outlook Report. Washington, D.C.: USDA ERS, May 1989.

U.S. Department of Agriculture. Crop Production: 1988 Summary. Washington, D.C.: USDA NASS, January 1989.

U.S. Department of Agriculture. Domestic Wool Requirements and Sources of Supply. Washington, D.C.: USDA Bureau of Ag. Econ., June 1950.

U.S. Department of Agriculture. Economic Indicators of the Farm Sector: Costs of Production. Washington, D.C.: USDA ERS, 1980-86.

U.S. Department of Agriculture. Sheep, Lambs, and Goats: Final Estimates. Washington, D.C.: USDA Statistical Reporting Service, 1972-81.

U.S. Department of Agriculture. Slaughter Lamb Marketing: A Study of the Lamb Industry. Washington, D.C.: USDA Packers and Stockyards Admin., January 1987.

U.S. Department of Agriculture. Wool and Mohair: Background for 1985 Farm Legistlation. Washington, D.C.: USDA ERS Ag. Info. Bull. 466, September 1984.

U.S. Department of Agriculture. Wool Statistics and Related Data: 1930-69. Washington, D.C.: USDA ERS Statistical Bulletin No. 455, Aug. 1970.

U.S. Department of Agriculture and U.S. Dept. of the Interior. Grazing Fee Review and Evaluation. Washington, D.C.: Forest Service, Bureau of Land Management, February 1986.

U.S. Department of Commerce, Bureau of the Census. Census of Agriculture: General Report. Washington, D.C.: Vol. 2, 1952-68.

U.S. Department of Commerce, Bureau of the Census. 1970 Census of Agriculture: Area Reports. Washington, D.C.: Vol. 1, Pt. 1-50, 1972.

U.S. Department of Commerce, Bureau of the Census. 1987 Census of Agriculture: Area Reports. Washington, D.C.: Vol. 1, Pt. 1-50, 1989.

U.S. Department of Commerce, Bureau of the Census. Census of Agriculture: Summary and State Data. Washington, D.C.: Vol. 1, Pt. 51, 1977-84.

Whipple, Glen D. and D. J. Menkhaus. "The Impact of Lamb Import Quotas on U.S. Lamb and Wool Markets," Paper presented at the annual meeting of the Amer. Ag. Econ. Ass., Baton Rouge, La., July 28-Aug. 2, 1989.

Whipple, Glen D. and D. J. Menkhaus. "Supply Response in the U.S. Sheep Industry," Amer. J. of Ag. Econ.. 71(1989): 126-135.

Winrock International. Possible Changes in the National Wool Act and Related Issues with Effects on Sheep Producers. March 1985.

Appendix I. **SURVEYS**

PLEASE REMEMBER, ALL ANSWERS ARE STRICTLY CONFIDENTIAL

Circle the appropriate answer, please, or answer as directed.

1. How many years have you been in the sheep business?

    a. 1-5 years
    b. 6-10 years
    c. 11-20 years
    d. Greater than 20 years

2. How do you consider your farming operation?

    a. Full-time (major source of household income)
    b. Part-time

3. What percent of your total farm receipts come from your sheep enterprise?

    a. Less than 10%
    b. 10-25%
    c. 26-50%
    d. 51-75%
    e. Greater than 75%

4. Please indicate all of the other enterprises other than sheep that accounted for more than 10% of your total farm receipts in 1987.

    _____ Beef Cattle
    _____ Dairy Cattle
    _____ Other Livestock (hogs, poultry, horses, goats, etc.)
    _____ Cash Crops (grain, hay, vegetables, Christmas trees, etc.)

5. Do you hire labor for the daily operation of your sheep enterprise?

    a. Yes b. No

6. How many breeding sheep were in your operation as of Jan. 1, 1988?

    a. None, I operate a feedlot
    b. 1-50 Head
    c. 51-299 Head
    d. 300-599 Head
    e. 600-999 Head
    f. 1,000-2,499 Head
    g. Greater than 2,500 Head

IF YOU ANSWERED NONE, PLEASE SKIP TO QUESTION #11.

7. When are your lambs born? (Circle all that apply)

    a. Winter b. Spring
    c. Summer d. Fall

8. Where are most of your lambs born? (Circle one)

    a. In barn or shed
    b. On range
    c. On pasture

19. Compa‥d to 1988, how many sheep do you expect to have (check one answer on each line):

	Greater than 10% More	1-10% More	Same	1-10% Fewer	Greater than 10% Fewer	None
Next year	O	O	O	O	O	O
In 5 years	O	O	O	O	O	O

20. Do you have more sheep than you had five years ago?

a. Yes b. No

IF NO, PLEASE GO TO QUESTION #22

21. To what extent have each of the following factors influenced your decision to expand your sheep flock?

	Influence			
	Strong	Moderate	Weak	None
Had excess labor available	1	2	3	4
Amount of predation decreased	1	2	3	4
Had unused facilities available	1	2	3	4
New lamb markets developed	1	2	3	4
Had underutilized range/pasture	1	2	3	4
More profitable than other enterprise	1	2	3	4
Wanted to stabilize income	1	2	3	4
Had available capital to invest	1	2	3	4
Able to obtain financing	1	2	3	4
Added partner to operation	1	2	3	4
Personal preference for sheep	1	2	3	4

IF YOU ANSWERED QUESTION #21, PLEASE SKIP QUESTION #22

22. To what extent have each of the following factors influenced your decision to not expand your sheep flock?

	Influence			
	Strong	Moderate	Weak	None
Lack of suitable fencing	1	2	3	4
Lack of quality labor	1	2	3	4
Increased predation	1	2	3	4
Increased grazing fees	1	2	3	4
Limited range/pasture acreage	1	2	3	4
Limited number of lamb markets	1	2	3	4
Limited number of wool markets	1	2	3	4
Nearing retirement	1	2	3	4
Drought conditions	1	2	3	4
Excessive debt load	1	2	3	4
Shortage of replacement ewes	1	2	3	4
High death loss from disease	1	2	3	4
Requires too much capital investment	1	2	3	4
Other enterprises more profitable	1	2	3	4
Personal preference for other enterprise	1	2	3	4

23. Over the long term, do you think sheep are more, less, or equally as profitable as cattle?

a. More Profitable
b. Equally Profitable
c. Less Profitable
d. Don't Know

SURVEY ON LABOR ISSUES IN SHEEP PRODUCTION

1. Was the last change in the size (5% or more) of your sheep operation during the 1970s or 1980s a reduction ?

   Yes________ No________

   If yes, was labor (costs or availability) of labor the primary reason for that reduction?

   Yes________ No________

   If labor was not the primary reason, list the top 3 reasons in order of importance including labor if it was one of the top 3.

   a. ____
   b. ____
   c. ____

2. Have you changed from full-time to part-time farming during the 1970s or 1980s?

   Yes________ No________

   If yes, was labor (costs or availability) in your sheep program the most important reason?

   Yes________ No________

   If labor was not the most important reason, list the top 3 reasons in order of importance, including labor if it was one of the top 3 reasons.

   a. ____
   b. ____
   c. ____

3. Was the last change in the size (5% or more) of your sheep program during the 1970s and 1980s an expansion of the size of your sheep program?

   Yes________ No__________

   If yes, was labor (costs or availability) the primary constraint that stopped the expansion at a certain level?

   Yes________ No__________

   If labor was not the primary constraint, list the top 3 reasons in order of importance, including labor if it was one of the top 3 reasons.

   a. ____
   b. ____
   c. ____

4. During the 1970s or 1980s, did you consider expanding your sheep program and then decide not to?

   Yes________ No__________

   If yes, was labor (costs or availability) the primary factor that stopped you from expanding?

   Yes________ No__________

   If labor was not the primary reason for not expanding, list the 3 top reasons you decided not to expand, including labor if it was one of the top 3 reasons.

   a. ____
   b. ____
   c. ____

Appendix II.

American Sheep Producer Council Regions

REGION 1 EAST COAST & SOUTHEAST
- Alabama
- Arkansas
- Conneticut
- Deleware
- Florida
- Georgia
- Kentucky
- Louisiana
- Maine
- Maryland
- Massachusetts
- Mississippi
- New Hampshire
- New Jersey
- New York
- North Carolina
- Pennsylvania
- Rhode Island
- South Carolina
- Tennessee
- Vermont
- Virginia
- West Virginia

REGION 2 OHIO VALLEY & GREAT LAKES
- Illinois
- Indiana
- Michigan
- Ohio
- Wisconsin

REGION 3 MIDWESTERN PLAINS
- Iowa
- Kansas
- Minnesota
- Missouri
- Nebraska
- North Dakota
- Oklahoma

REGION 4 NORTHERN PLAINS
- Montana
- South Dakota
- Wyoming

REGION 5 TEXAS
- Texas

REGION 6 ROCKY MOUNTAINS
- Colorado
- Idaho
- Utah

REGION 7 WEST COAST & SOUTHWEST
- Alaska
- Arizona
- California
- Hawaii
- Nevada
- New Mexico
- Oregon
- Washington

Appendix III. RESPONSE RATES FOR SURVEY #1

Total Responses - 530 Response Rate 59.8%

REGION 1:	Mailed -	73
	Usable Responses -	43
	Uncompleted -	4
	Improper Address -	0
	Refusals -	1
	Response Rate -	64.4%
REGION 2:	Mailed -	78
	Usable Responses -	39
	Uncompleted -	9
	Improper Address -	2
	Refusals -	0
	Response Rate -	63.2%
REGION 3:	Mailed -	103
	Usable Responses -	62
	Uncompleted -	5
	Improper Address -	2
	Refusals -	0
	Response Rate -	66.3%
REGION 4:	Mailed -	166
	Usable Responses -	93
	Uncompleted -	8
	Improper Address -	1
	Refusals -	0
	Response Rate -	61.2%
REGION 5:	Mailed -	152
	Usable Responses -	76
	Uncompleted -	9
	Improper Address -	2
	Refusals -	2
	Response Rate -	56.3%
REGION 6:	Mailed -	137
	Usable Responses -	75
	Uncompleted -	10
	Improper Address -	2
	Refusals -	1
	Response Rate -	63.0%
REGION 1:	Mailed -	291
	Usable Responses -	142
	Uncompleted -	11
	Improper Address -	10
	Refusals -	2
	Response Rate -	54.4%

Appendix IV. RESPONSE RATES FOR SURVEY #2

Total Responses - 121 Response Rate 24.0%

REGION 1:	Mailed -	47
	Usable Responses -	11
	Uncompleted -	2
	Improper Address -	0
	Refusals -	0
	Response Rate -	27.7%
REGION 2:	Mailed -	48
	Usable Responses -	12
	Uncompleted -	2
	Improper Address -	0
	Refusals -	0
	Response Rate -	29.2%
REGION 3:	Mailed -	67
	Usable Responses -	14
	Uncompleted -	0
	Improper Address -	0
	Refusals -	0
	Response Rate -	20.9%
REGION 4:	Mailed -	101
	Usable Responses -	22
	Uncompleted -	1
	Improper Address -	0
	Refusals -	0
	Response Rate -	22.8%
REGION 5:	Mailed -	85
	Usable Responses -	15
	Uncompleted -	3
	Improper Address -	1
	Refusals -	0
	Response Rate -	17.9%
REGION 6:	Mailed -	85
	Usable Responses -	19
	Uncompleted -	6
	Improper Address -	1
	Refusals -	0
	Response Rate -	29.8%
REGION 1:	Mailed -	151
	Usable Responses -	28
	Uncompleted -	4
	Improper Address -	3
	Refusals -	0
	Response Rate -	21.6%