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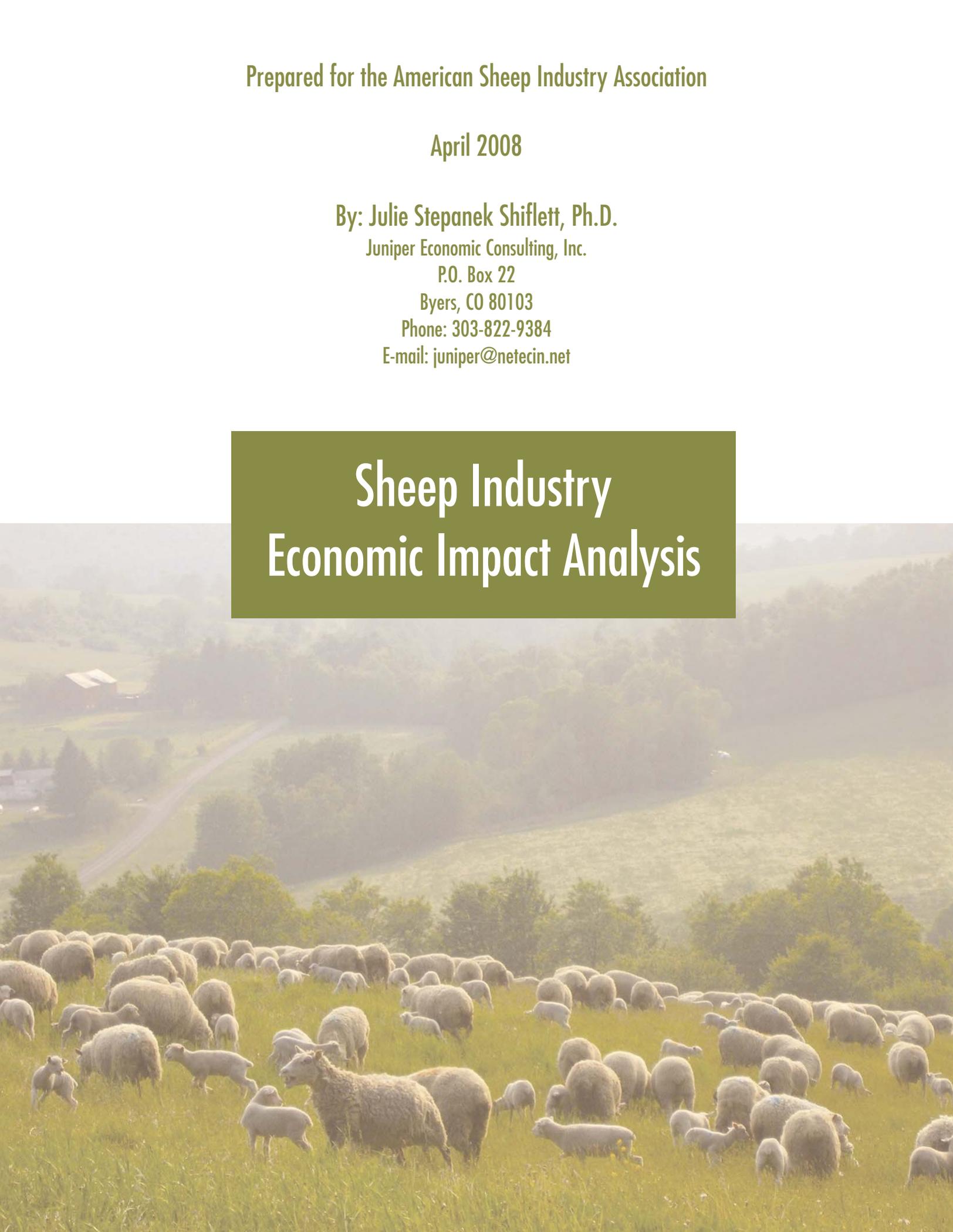
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Sheep Industry Economic Impact Analysis

Abstract

Sheep industry production spurs a ripple effect throughout the economy, generating additional economic activity that was estimated using the IMPLAN modeling software and dataset. An estimated \$509 million in lamb, mutton, wool, sheep milk production, and breeding stock at the producer level supports an additional \$1.3 billion in economic activity for a total of \$1.8 billion. The sheep industry supports backward-linked industries that supply sheep production. It also supports local businesses through expenditures of sheep-industry generated income on goods and services. This study estimated a second model in order to quantify the value added to sheep products that were not captured in the first model. The sheep industry produces many and varied products from lamb chops served in fine dining restaurants to lanolin. Estimates of retail lamb and wool, wholesale pelts, variety meats, meal, tallow, and retail sheep cheese sales revealed that \$768 million in production generates an additional \$1.4 billion in multiplier effects, summing to a total economic impact of \$2.2 billion. When the interactions and effects of including the government and investment – and not just households – in the model, the total output effect increases to \$3.2 billion at the farmgate and \$4.5 billion at the wholesale and retail level.

I. Introduction

The sheep industry is an important economic component of our economy, but how important? Although sheep producers are found in every state, we don't know how significant their efforts are to our economy. From the lamb chops at Chéz Luis to wool blankets and hand lotion, the sheep industry produces a variety of products. To add to this, the sheep industry generates business for input supply companies, such as feed and sheep health supplies. In addition, sheep-industry generated income supports businesses of goods and services purchased. What is the total effect of the sheep industry, including these ripple effects?

The sheep industry has a long-standing history in the United States with sheep representing an integral part of rural communities and lamb showing up on dinner tables in every state of the nation. Although much has changed over the years, the sheep industry continues to provide a livelihood for many and contributes to the economic value of a myriad of agricultural and industrial products.

The U.S. sheep inventory is concentrated in the West, while sheep operators, with smaller flocks, are concentrated in the Midwest and Northeast. In general, the larger range flocks are found in the West, but flocks are scattered throughout the Northeast, Mid-Atlantic and Midwest. Texas, California, Wyoming, Colorado, and South Dakota represent the top five most populous states for total numbers of sheep and lambs.

Most sheep producers have relatively small flocks. Ninety-two percent of the total sheep operations have fewer than 100 head of sheep and lambs. In 2007, there were 70,590 sheep and lamb operations across the United States. Texas, Iowa, and Pennsylvania represented the top three most populous states in terms of sheep producers. The Northeast collectively followed as number four.

The largest lamb processing plants are found in the West – specifically in Colorado and California. The location of processing coincides with states with large sheep inventories and feeding operations.

The lamb and wool industry is an approximately \$542 million dollar industry (farmgate receipts). About 2 percent of sheep operations account for one-half of sheep and lamb production in the United States.

II. Objective

The objective of this study is to estimate the economic impact of the U.S. sheep industry. The economic impact is a measure, a number, of how important the sheep industry is to our economy by capturing all the multiplier effects from producer expenditures on feed to income spent by lamb fabricators.

Thus, the initial production, the “direct” effect of production of lamb, mutton, wool, and the many byproducts, has an “indirect” or “multiplier” effect that echoes throughout the national economy. For every \$1 of lamb produced, there is an amount that is used to support backward-linked industries such as pharmaceuticals and there is some amount that is spent on groceries and movies. This direct and indirect effect (or multiplier effect) sum to the total effect and is estimated using an input-output modeling technique and software called IMPLAN.

III. Previous Studies

There is no known study estimating the economic impact of the sheep industry in the United States. That is, there is no known study capturing the multiplier effect of the industry on the U.S. economy. There are estimates of the total production value of the sheep and goat industries combined. There are also estimates of the value of production of lamb, mutton, and wool production. This study is unique in that it will identify and quantify the total multiplier effect of the sheep industry.

Total farm cash receipts from livestock were estimated to have surpassed \$120 billion annually since 2003, with beef, dairy, poultry, and pork representing well over 90 percent of this value.¹

The value of beef production (including cull cows and steer calves from dairy herds) accounted for the largest share of livestock production. Dairy products represented the second largest animal-product sector. The third-largest sector was comprised of the poultry industry, including broiler, turkey, and egg production. Receipts from hog production represented the fourth-largest sector.

Other livestock and animal products — including sheep and lamb, wool, goats and mohair, and aquaculture products — produced farm cash receipts representing about 5 percent of the total value of animal products, or roughly \$6 billion. Within this sum, a 2002 study found that the value of the sheep, goats, and their products was \$541.7 million.²

The U.S. Department of Agriculture's National Statistics Service computes the gross income to sheep producers for lamb and wool annually. Gross income includes the value of home consumption as well as the cash receipts from marketed production. Cash receipts from lamb and mutton production totaled \$368 million in 2006 while the value of home consumption was \$11 million. Colorado was the highest-ranking state for sheep and lamb cash receipts with \$118 million, followed by California (\$44 million) and then Texas (\$43 million).

IV. Method and Data

This analysis employed the use of the computer software and database package called IMPLAN. The IMPLAN economic impact modeling system, available from the Minnesota IMPLAN Group, Inc. (MIG), is the acronym for *Impact Analyses and Planning*.

IMPLAN is an input-output model. Within each industry, such as lamb production, there are sectors defining the stage of production such as carcass fabrication. Then, for a one-year production period, a transactions table reflects the value of goods and services exchanged between sectors of the economy.

The economic data for IMPLAN comes from the system of national accounts for the United States based on actual data collected by the U. S. Department of Commerce, the U.S. Bureau of Labor Statistics, and other federal and state government agencies. Data are collected for distinct producing industry sectors of the national economy corresponding to the Standard Industrial Categories (SICs).

The model estimates the economic importance of the sheep industry by quantifying the linkages between input supply industries of the targeted industry as well as linkages between the incomes received in the targeted industry and expenditures on goods and services purchased. The model can quantify the direct effect, indirect effect, and induced effect from \$1 value of production in any given sector. The direct effect, indirect effect, and induced effect sum to the total effect.

The direct effect shows how output changes with a given change in final demand. For example, if lamb demand increases, the direct effect will show how lamb production is affected.

The indirect effects are the inter-industry purchases as they respond to the demands of the directly affected industries. Sheep production generates business for many contributing industries. From fencing to pharmaceuticals to feed, lamb production helps to support these backward linked industries.

The induced effects reflect spending from households from the income received from the targeted industry. Lamb producers most likely spend most of their income in their local economy on goods and services from new jeans to haircuts. The induced effect represents the impacts on all local industries caused by the expenditures of household income generated by sheep and wool production. That is, the induced effect captures all spending on goods and services by those contributing to sheep and wool production.

The induced effect includes spending by sheep producers as well as spending by all employees of all input-related industries contributing to sheep production. This may include employees of pharmaceutical companies, guard dog breeders, feedlot hands, shepherds, and part-time wool shearers.

¹U.S. Department of Agriculture, Economic Research Service. Accessed at <http://www.ers.usda.gov/Briefing/AnimalProducts/questions.htm>

²U. S. Department of Agriculture, Bureau of the Census, 2002.

This model used IMPLAN Sector 13 representing the average makeup of all non-cattle and non-poultry livestock and within which the sheep industry falls. The sector was defined to capture livestock industries that were found to have similar production functions. This means that the ratio of inputs to outputs is the same. Production functions show where an industry spends and in what proportion to generate each dollar of output. The production function generates the multipliers. For each sheep byproduct such as sheep cheese, the cheese manufacturing sector was used.

A multiplier is a single number that summarizes the total economic benefits resulting from production of a given industry. Multipliers measure the strength of ripple effects that can occur in an economy from \$1 of production. Multipliers typically range between 1 and 3. The more inputs purchased locally and the more consumers shop at local shops, the higher the multiplier.

In order to estimate the impact from the sheep industry, the value of sheep products must be known. The model provides the multipliers that can compute the linkages and resulting indirect and induced effects, but it doesn't provide the initial direct effect of production. IMPLAN estimates the value of sector 13 (non-cattle, non-poultry livestock), but not of the sheep industry individually.

The multipliers for the sheep industry were obtained through IMPLAN (Table 1). The output multiplier has a direct effect of 1.0, an indirect effect of 1.8, and an induced effect of 0.84, for a total effect of 3.65. This means that every \$1 of lamb produced by a producer will yield \$1.80 in extra product in backward linked industries such as at a local feed store, and \$0.84 in extra spending in the local economy, perhaps for a haircut.

Table 1. Sector 13 multipliers

	Direct Effect	Indirect Effect	Induced Effect	Total Effect
Output Multipliers	1.0	1.80	0.84	3.65
Employment Multiplier	25.2	10.3	6.2	41.7

The employment multiplier tells us that for every 25 jobs created in the sheep industry, 10 jobs will be created in backward-linked industries, and 6 jobs will be created as a result of increased consumer spending by sheep-industry related persons (Table 1).

The multipliers were estimated a second time, but this time all interactions in the economy including those between the sheep industry and state and federal government and investment are included (Table 2). The impact will be a lot larger if all institutions are internalized; therefore for every change in the economy, not only households are stimulated, but government and investment as well. Thus, not only does this model include interactions between industries, factors of production, and households, but it also includes the effect of social security, the income tax leakage, and savings. The model now also accounts for inter-institutional transfers.

Policy makers typically only want to know the impact of a particular industry on households, thus government and financial institutions are omitted from impact studies. Although the government and investment effects are important, they are not directly related to the backward and forward linkages of household spending from lamb production.

The output multiplier has a direct effect of 1.0, an indirect effect of 1.80, and an induced effect of 3.54, for a total effect of 6.34 (Table 2). This means that every \$1 of lamb produced by a producer will yield \$1.80 in extra product in backward linked industries such as at a local feed store and \$3.54 in extra spending in the local economy.

Table 2. Sector 13 multipliers including government and investment

	Direct Effect	Indirect Effect	Induced Effect	Total Effect
Output Multipliers	1.0	1.80	3.54	6.34
Employment Multiplier	25.2	10.3	26.3	61.8

The employment multiplier tells us that for every 25 jobs created in the sheep industry, 10 jobs will be created in backward-linked industries, and 26 jobs will be created as a result of increased consumer spending by sheep-industry related persons (Table 2).

Two models were estimated in this analysis. The first model captured the value of the sheep industry at the farmgate, or the producer level. The second model captured the value added in the industry. For example, lamb sales at the farmgate were about \$379 million in 2007; however, retail and foodservice lamb sales were close to \$568 million, \$188 million more. The additional 50 percent in value was paid to transporters, meat cutters, lamb packers, grocers, and restaurant owners in order to turn the live animal into retail-ready lamb chops. There is a cost to adding value to products. The first model would miss the positive ripple effect throughout the economy of a fabricator's expenditures.

The effects of lamb, mutton, wool, purebred production, and sheep milk production were first estimated. This gives us the direct effect (gross value to sheep producers), the indirect effect (the economic boost to backward linked industries), and the induced effect (the expenditure of sheep-related incomes). The second model incorporated products such as lanolin and retail sales to capture value added in the industry.

The sheep industry's products and byproducts are far reaching, showing up in everyday products from baseballs, medications, hot dogs, to fine china. Estimating the value of all byproducts is a challenge because in many cases, the portion of production, such as the sheep intestines used for hot dog casings, is small. This analysis used publicly available data and estimates from many in the industry to cover as much industry production and value added as possible.

V. Model 1, Economic Impact of Producer Production

The IMPLAN model provided multipliers as well as the resulting indirect and induced effects of production. However, to arrive at the total effect of the sheep industry, production values had to be estimated and inputted into the model. To capture value added, the value of sheep products and the various stages of production were inputted into the model in order to estimate the total economic impact of the sheep industry. The values used are delineated in Table 3. Details on how the figures below were estimated are available in Appendix A.

The first model estimated the economic impact of lamb, mutton, wool, sheep milk, and purebred production at the farmgate.

Lamb and Mutton Production. The value of the sheep industry for meat production at the farmgate was estimated at \$453 million in 2007 (Table 3). Lamb and mutton production captures lamb slaughtered in federally inspected plants, non-federally inspected plants, the ethnic market, as well as on-farm slaughter.

Table 3. Direct effects of farmgate production

Product	Estimated Value
1. Lamb Production (Including the ethnic market)	\$449,519,504
2. Mutton Production	\$3,327,064
3. Wool Production	\$38,543,720
4. Sheep Milk Production	\$2,868,775
5. Purebred Sheep Production	\$14,933,504
Total	\$509,192,567

Slaughter lambs are sold through public auctions as well as through private, direct trade with packers. Marketing methods employ different pricing mechanisms and as a result, different average prices emerge. Prices may be a function of the weight of the animal, the quality, the time of year, or simply a function of the relationship between packer and producer. A weighted-average price was thus used to value slaughter lambs. Producer lamb production accounts for an estimated 89 percent of lamb, mutton, wool, and sheep milk sales. In 2007, the U.S. exported 116,579 head of live sheep, valued at \$8 million.³

Fabricated lamb and mutton and variety meats are also exported. Exports are primarily to Mexico, but also to Canada and the Caribbean. Most of the exports to Mexico were slaughter ewes sold live and therefore not captured in the lamb and mutton value calculated above which was based on numbers slaughtered here in the United States. Therefore, \$8 million is added to the value at the farmgate of sheep and lamb production.

The value of mutton production was estimated by taking the non-lamb portion of federally inspected slaughter and multiplying it by the slaughter ewe average price.

Ethnic Lamb Market. The ethnic lamb market is a significant and growing component of the sheep industry that mostly falls outside the mainstream, commercial market, yet it is not well documented. Lamb is common in the diets of many people of ethnic origins, particularly from the Middle East, Africa, the Mediterranean region, Latin America, Caribbean, and Asia. In addition, lamb is popular in religious observations for many ethnic groups. As will be explained, assumptions regarding how ethnic lamb is marketed led to an estimate of \$72 million for the ethnic market in 2007.

The ethnic lamb market is defined here as relatively lightweight lambs less than 100 pounds compared to the average live weight at slaughter of 140 pounds in the commercial market. For example, milk-fed 40- to 55-pound lambs are in demand for the celebration of the Eastern, or Greek, Easter. Heavier, 60- to 80-pound lambs are in demand for the Moslem observation of Ramadan, a month of fasting.⁴

It is hypothesized that the ethnic market raises the returns to slaughter-lamb production because of the price premiums offered by many ethnic consumers. For example, there is a holiday market for milk-fed lambs as light as 18 pounds. Price premiums are received for these lambs because they are rare, many must be produced by out-of-season breeding in May for October births.⁵

³U.S. Department of Agriculture, U.S. Census Bureau, Foreign Trade Statistics.

⁴Larson, A. and E. Thompson. No date. "Direct Marketing Lamb to Niche and Ethnic Markets," University of Illinois Extension.

⁵www.sheepgoatmarketing.com, joint project between University of Maryland and Cornell University, Accessed 2/19/08.

The volume of lamb going into the ethnic market is not known, so an estimate is in order to value the market. An estimated 1,075,165 head were sold into the ethnic trade in 2007. This estimate was based upon the assumption that most lamb slaughter in the ethnic market occurs outside of the federally inspected “commercial” market. Slaughter may occur in non-federally inspected, or state plants, or even in slaughtering facilities that are not captured in national databases.

For this report, it was assumed that 10 percent of the volume of state-slaughtered lamb is comprised of the ethnic trade. There is also a volume of lamb that “falls through the cracks” and is not captured by national slaughter statistics. This is assumed because the lamb crop, less losses and replacements, exceeds commercial slaughter.⁶ Thus, the entire lamb crop is not captured by national statistics.

Prices at two auctions, San Angelo, Texas, and New Holland, Penn., were used to value live lambs in the ethnic market. San Angelo was chosen because it is one of the largest sheep auctions in the United States, but also because it is believed that many lambs transported from Texas to the Northeast are geared for ethnic markets. New Holland is a very popular auction in the Northeast and it is assumed that most of the lightweight slaughter-lamb sales go directly into the ethnic market. The average price of these two markets for lightweight lambs was \$103.48/cwt. in 2007. More details explaining how the ethnic market was calculated can be found in the Appendix A.

Wool Industry. The U.S. wool clip was valued at \$38.5 million in 2007 at the farmgate. This is the gross income received by sheep producers for U.S. wool production. The U.S. wool industry produces wool across each micron category, the average diameter of wool fibers. However, the exact quantity of each micron produced is unknown. Thus, a simple average price was used to value the wool clip, not a weighted average.

U.S. wool is characterized from the very fine to the coarsest wool. Roughly 28 percent of the wool clip is 22 micron and finer. About half of wool production is the mid-micron wools from 22 micron to 31 microns, with the remaining 4 percent being the coarsest wool. “This makes American wool suitable for a wide variety of products including fine worsted suiting, knitwear, woolen velours and coatings, upholstery, bedding materials for futons, mattresses and comforters, and industrial products.”⁷

In the U.S. wool industry, about 28 percent of the 22 micron wool is used in the worsted textile industry for suit fabric. About half of the 22 micron wool goes into the woolen textile industry for products such as sweaters.

Dairy Sheep. The sheep dairy industry is a small, but growing segment of the sheep industry. Sheep milk at the farmgate was estimated at \$2.9 million in 2007. Dairy sheep production is primarily found in the northeastern United States (Vermont and New York) and in the Midwest (Wisconsin and Minnesota). Dairy sheep are neither typical U.S. meat nor wool breeds, but East Friesian and Lacaune sheep.

There were an estimated 6,500 dairy ewes in 2003. This figure increases to 7,800 dairy sheep if rams, non-milked young replacement ewes in a milking flock, and dairy sheep in flocks that don’t milk but which produce dairy stock are included.⁸ The total dairy breeding sheep population was about 7,800 head in 2003 and is estimated at 10,000 head today.⁹

The sheep dairy industry faces stiff competition from imports, but this is a good sign there is solid demand to support the expanding domestic industry. Imported prices are generally lower and volumes imported far surpass domestic production. A sheep milk cooperative in Wisconsin reported, “With current estimates for U.S. imports of sheep milk products at more than 72 million pounds annually (equivalent to 360 million pounds of milk), there is a great deal of room for cooperative growth between producers and processors.”¹⁰

The demand for sheep dairy products, particularly cheese and yogurt, has grown tremendously. The price of milk varies between \$0.75/lb. to \$1/lb. out of the farm. Sheep milk cheese can retail for \$16/lb. and \$20/lb.

⁶A 5% loss rate was assumed. Replacements and lamb crop figures came from the USDA National Agricultural Statistics Service.

⁷American Sheep Industry Association. www.sheepusa.org accessed 1/2008.

⁸Thomas, Dave. 2004. Overview of the Dairy Sheep Sector in Canada and the United States.

⁹Thomas, Dave. L. Department of Animal Sciences, University of Wisconsin-Madison, Wisconsin, E-mail correspondence, Jan. 15, 2008.

¹⁰Wisconsin Sheep Dairy Coop Accessed on 10/26/07 at <http://www.sheepmilk.biz/about.html>.

Domestic sheep cheese prices are generally higher than for imported sheep milk cheeses that are worth about \$6/lb. when arriving in the United States and retail for \$10/lb. to \$12/lb. Therefore, domestic sheep milk cheeses must maintain high quality and capitalize on the “buy local/domestically” movement in order to compete with the approximately 70 million pounds of sheep milk cheese that is imported annually.¹¹

Breeding Stock. Another important segment of the sheep industry that generally isn’t accounted for by lamb or cull lamb sales is sheep breeding stock. There are 47 breeds and types of sheep in the United States from the common Suffolk or Dorset, to the popular Katahdin hair sheep, to the rare Coopworth. Purebred sheep are represented by at least 33 official registry associations.¹² Purebred sales occur throughout the year, often at county and state fairs and not at livestock auctions.

The Banner — the nation’s largest all-breeds sheep magazine — covers all major sheep sales and produces sale reports of registered purebreds. Most purebred sheep are registered, but they do not have to be registered by law. Breeding stock and show sheep may sell for \$150 per head to \$2,800 per head, with the premium given to show sheep.¹³ In 2007, the weighted-average price was \$451.55 per head for the sale of purebred sheep. In 2007, *The Banner* tracked 33,072 head marketed.¹⁴ Thus, the total value of purebred sheep sales in the United States in 2007 was \$14,933,504.

The American Livestock Breeds Conservancy also tracks rare sheep breeds and is currently updating a sheep census conducted in 1994. Its primary focus is to conserve rare breeds and genetic diversity in livestock, but in doing so it also keeps count of sheep inventory by breed. This is important because many breeds may not necessarily show up in national commercial lamb or wool production figures.

Model 1 Results. Impacts are usually measured in terms of gross output (sales), income, employment, and value added. Output is the value of production, or sales, in a given year. Employment includes full-time and part-time wage, salaried, and self-employed jobs.

The value-added impact encompasses employee compensation, proprietor income, other property income, and indirect business tax. Employee compensation includes wages, but also health and life insurance, and retirement payments. Proprietary income is income by self-employed individuals. Other proprietary income includes payment from interest, rents, and dividends. Lastly, indirect business tax is tax paid by individuals to businesses.

The direct effect of lamb, mutton, and wool production at the farmgate, or the value to the producers was \$503 million in 2007 (Table 4). The value that this production produces in backward-linked industries such as feed was \$888 million. The value that this production created in the United States on consumables, goods and services, was \$436 million. The total effect of lamb, mutton, and wool production was \$1.8 billion in 2007 at the producer level.

The value-added effect summed to \$654 million. The value-added indirect effect accounted for \$350 million and the induced effect accounted for \$238 million. The direct effect was \$66 million. The direct effect may be low relative to the value-added impact from the indirect and induced effects because there are relatively few hired hands in sheep production relative to other enterprises.

¹¹Thomas, Dave. L. Department of Animal Sciences, University of Wisconsin-Madison, Wisconsin, E-mail correspondence, Jan. 15, 2008.

¹²The Banner Sheep Magazine. www.bannersheepmagazine.com accessed 3/11/08.

¹³American Livestock Breeds Conservancy. www.albc-usa.org accessed 8/11/08.

¹⁴The Banner Sheep Magazine, www.bannersheepmagazine.com accessed 3/11/08.

Table 4. Effects of lamb, mutton, and wool production at the farmgate

	Direct Effect	Indirect Effect	Induced Effect	Total Effect
Total Output Effect	\$502,926,995*	\$887,656,267	\$435,532,808	\$1,826,116,068
Value-Added Impact	\$66,019,154	\$350,153,427	\$237,684,447	\$653,857,030
Employment Impact	12,811	5,062	3,187	21,059

**Some of the direct effect is lost in the modeling effort from converting 2007 values to the model's 2006 base and back again.*

The total employment effect was 21,059 jobs. This figure is added to the current number of 70,590 sheep and lamb producers for a total 91,649 jobs. For every 12,811 jobs created in the sheep industry there are 5,062 jobs created in backward-linked industries and 3,187 jobs created as a result of sheep-industry produced income related expenditures.

The model was estimated a second time to capture all interactions in the economy, including those by the government and investment. Typically, the government does not respond to every change in a local economy so the government is excluded from impact analyses, but the government is linked to the industry in general so it is worthwhile to calculate its effect.

The direct effect of lamb, mutton, and wool production at the farmgate, or the value to the producers was \$494 million in 2007 (Table 5). The value that this production creates in backward-linked industries such as feed was \$902 million. The value that this production created in the United States on consumables, goods and services, was \$1.8 billion. The total effect of lamb, mutton, and wool production was \$3.2 billion in 2007 at the producer level.

The value-added effect summed to \$1.4 billion. The value-added indirect effect accounted for \$355 million and the induced effect accounted for \$977 million. The direct effect was \$56 million. The direct effect may be low relative to the value-added impact from the indirect and induced effects because there are relatively few hired hands in sheep production relative to other enterprises.

The total employment effect was 30,200 jobs. This figure is added to the current number of 70,590 sheep and lamb producers for a total 100,790 jobs. For every 12,323 jobs created in the sheep industry there are 5,022 jobs created in backward-linked industries and 12,856 jobs created as a result of sheep-industry produced income related expenditures.

Table 5. Effects of lamb, mutton, and wool production at the farmgate, including government and investment effects

	Direct Effect	Indirect Effect	Induced Effect	Total Effect
Total Output Effect	\$494,258,944*	\$901,951,304	\$1,766,819,493	\$3,163,029,699
Value-Added Impact	\$56,277,808	\$355,129,916	\$976,589,609	\$1,387,997,322
Employment Impact	12,323	5,022	12,856	30,200

**Some of the direct effect is lost in the modeling effort from converting 2007 values to the model's 2006 base and back again.*

VI. Model 2, Value Added in the Sheep Industry

The economic impact of the sheep industry was also estimated at the wholesale and retail levels, where possible, to capture value added in the industry. When estimating impacts at the wholesale and retail level, it is important to split the retail price into the appropriate producer values. For example, a portion of the value of a lamb chop at a fine dining restaurant will be given to the restaurateur, but a portion will also be allocated to the producers, packers, and transporters. IMPLAN can thus capture all linkages along a supply chain.

The added value of the sheep industry is estimated at \$768 million compared to \$509 at the farmgate, at least an additional \$259 million. This is only an estimate and does not capture all lamb and wool byproduct sales at the wholesale and retail levels.

Pelt Market. Once a sheep or lamb is slaughtered, the pelt is removed and sold. The U.S. pelt market was valued at \$16 million in 2007 (Table 6). The U.S. sheep industry produces pelts of varying quality and thus prices. The U.S. Department of Agriculture records pelt prices and volumes sold under formula, negotiated and contract trades — about 44 percent of the commercial market — but not pelts sold from lambs and sheep purchased at auctions. Therefore, the entire pelt market was valued based upon an extrapolation of the value breakdown from known, recorded prices and quality.

Wooled pelts, which comprised 64 percent of total pelts in 2007, were valued at \$10.6 million, No. 1 pelts were valued at \$5.3 million (34 percent of total), and the remaining \$262,741 was attributed to No. 2s, No. 3s, and No. 4s.

Table 6. Value added direct effects of model 2

Product	Estimated Value
1. Wholesale Pelts	\$16,100,174
2. Wholesale Variety Meats & Rendered Products	\$21,968,453
3. Retail Lamb Sales	\$311,800,000
4. Food Service Lamb Production	\$255,967,600
5. Retail Sheep Cheese	\$9,796,457
6. Retail Wool: Military Purchases of Wool Products	\$147,299,355
7. Wholesale Lanolin	\$4,586,740
Total	\$767,518,708

Variety Meats and Rendered Products. The U.S. sheep industry produces sheep and lamb variety meats and rendered products, which was valued at \$22 million in 2007. After the lamb or mutton is marketed, the other edibles, such as livers, are considered a delicacy and often marketed to ethnic markets, while other edibles and non-edibles are marketed into the rendering process as feed ingredients for items such as pet food and tallow. Roughly 74 percent of the value from sheep byproducts comes from marketed edible products while the remainder comes from rendered products.

Lamb processors market variety meats, cheek meat, kidneys, brains, livers and hearts, to ethnic grocers domestically and overseas. In 2007, \$2.4 million in offal, entrails and internal organs, were exported with an average annual value of \$1.8 million between 2002 and 2007.¹⁵ According to lamb packers, sheep and lamb variety meats are generally valued at approximately \$2.50 per head. Thus, the value of variety meats is an estimated \$6.7 million.

¹⁵U.S. Department of Commerce, U.S. Census Bureau, Foreign Trade Statistics. Data accessed 2/18/08.

The major packers in the sheep industry also market whole frozen sheep heads for up to \$3.50 each. Sheep heads are primarily exported to Mexico, but ethnic markets also exist in Los Angeles, the San Francisco Bay Area and Texas. The estimated value of heads was \$9.4 million in 2007.¹⁶

Hooves are discarded at some plants but not all; bones are sometimes sold or otherwise rendered. Sheep and lamb blood also has value. Dried blood is used in blood meals for fertilizers for plants or applied directly to roses. Blood is sometimes sold as a separate item, but often sold with other rendered products.

The ability and portion of lamb byproducts sold as consumables or rendered differs widely by plant. Plants that don't have good markets for some variety meats sell them to rendering. Typically, all non-edibles would be sold to rendering — bones, stomachs, some intestines (except natural casings), lungs, fat, etc. Not all packers are able to sell rendered products from sheep; some small plants have to pay to have products that would otherwise be marketed for rendering discarded.

The rendering process typically produces lamb meal and tallow. It was estimated that about 37 percent of a live sheep is sent to rendering, roughly 65 percent of this volume is water, and the remainder is half tallow and half meal.¹⁷

A common use of lamb meal is for pet food, such as Iams "Lamb & Rice" dog food brand. As Iams reported, "Lamb meal is rendered lamb tissues such as skeletal muscle, some bone and internal organs that have been dried and ground. Skeletal muscle and internal organs are sources of high-quality protein and fats. Bone, in small amounts, is an excellent source of minerals such as calcium."¹⁸ The value of the lamb meal market in 2007 was estimated at \$3.4 million.

Another byproduct of sheep production is tallow. Lamb and mutton fat, or suet, is extracted from lamb offals and rendered into tallow. Rendering suet involves the repeated process of melting, simmering, straining, and cooling. Tallow may be edible or inedible. Edible tallow is often used in baked goods such as packaged cookies and crackers, ready-made pie crusts, or in fried goods. Inedible tallow was originally used to make candles, but is now used in a myriad of industrial uses from animal feed to art supplies. The value of tallow produced by the sheep industry at the rendering level was estimated at \$2.5 million in 2007.

Retail and Foodservice Sales. Much of the value added in the lamb industry stems from transforming live animals into lamb cuts. Lamb packers and meat cutters, transporters, and grocer butchers all may play a role making lamb cuts ready to set out in a supermarket meat case.

It was estimated that 37 percent of lamb sold at retail is actually sold in the food service sector.¹⁹ Hotels and restaurants are increasingly placing lamb on the menu and fetching a premium price to do so. It was estimated that the unit price of lamb in the food service sector was \$7.91/lb. in 2007 while the retail average was \$5.66/lb. The total value of lamb sold at retail was an estimated \$312 million while the value in the foodservice sector was \$256 million.

Military Wool Purchases. A portion of U.S. wool is processed into wool top and wool textiles while the remainder is exported as raw wool. The further processing that occurs in the United States includes textiles such as wool yarn, thread and fabric, wool apparel, wool home furnishings, and wool floor coverings.

Many retail products are produced using 100-percent wool; however, many of the products are blended with other natural and non-natural fibers so it is difficult to value total wool retail sales. The U.S. military is an important purchaser of wool and wool-blended products. This enables us to capture part of the value of wool retail sales.

Annual military purchases of wool products equal approximately \$147 million.²⁰ Ninety-eight percent of this value is wool and wool-blended clothing. The military also purchases wool blankets worth about \$24 million annually. All branches of the military, and both enlisted men and women as well as officers wear wool.

¹⁶Estimated at 2,670,588 sheep and lamb slaughter in 2007.

¹⁷Dr. David Meeker, National Renderers Association, phone conversation 3/25/08.

¹⁸IAMS report accessed at us.iams.com on 3/11/08.

¹⁹American Lamb Board. January 2007. *Analysis of Lamb Demand in the United States*.

²⁰Driggers, Mitch. ASI Wool Consultant, E-mail correspondence, 1/2008.

Lanolin Market. Lanolin is a wool byproduct. Wool grease, the precursor to lanolin, is a yellow substance extracted from wool. Wool grease is obtained by squeezing wool between rollers. The water-repellent properties of lanolin means its uses are varied and widespread. Common commercial uses include cosmetics, lubricants, and rust-preventative coatings.

Lanolin is increasingly popular in the cosmetic and pharmaceutical industries for it provides moisture and therefore prevents skin from drying and chapping. Common uses range from lipsticks to sunscreen to band-aids. The lanolin market is increasingly producing higher purity products such as Medilan (medical-grade lanolin). Price premiums are received as the purity of lanolin increases. U.S. lanolin supplies are tightening and prices are rising as the sheep and lamb inventory contracts.

Current figures on the value and production of the U.S. lanolin market were difficult to obtain. A U.S. lanolin manufacturer, FannCor of the Fanning Corporation, declined to comment on production and value, most likely because it is the sole manufacturer. Some calculating can provide a good estimate, however. The finer wool clips produce about 4.5 kg. of wool grease per 100 kg. of clean wool while the coarser wools may produce about 2 kg.²¹ Wool grease sells for about \$1.50/kg. to \$2/kg. with an average \$1.75/kg., or \$3.86/lb.²² It was assumed that some volume is lost in processing wool grease into lanolin. An estimated price of \$4/lb. was used for wholesale lanolin sales. This brings the value of lanolin at wholesale to \$4.6 million. (See Appendix A for further explanation of calculation.)

Model 2 Results. The economic effects presented in the first model only captured the total impact of the sheep industry at the farmgate. They represent the total effect to the economy triggered by live sheep and lamb sales and wool and sheep milk sales by producers. They don't capture value added to sheep products. The model results presented below estimated the economic effect of adding value to products estimated in the first model.

The total effect of the sheep industry is estimated at \$2.2 billion (Table 7). The direct effect of production, or sales, is \$768 million, the indirect effect of supporting backward-linked industries is \$548 million and the induced effect of household spending is \$861 million.

The value-added impact totaled \$1.2 billion with \$255 million attributed to the indirect effect and \$469 million attributed to the induced effect. The direct value added effect from the sale of sheep products and byproducts totaled \$474 million.

The total employment effect from additional lamb, wool, or sheep byproduct sales at the retail level is up to 21,179 jobs created. Adding this number to the total number of sheep producers in 2007 yields 91,524 jobs. For every 11,744 jobs created in the sheep industry, there are 3,270 jobs created in backward-linked industries and 6,165 jobs created as a result of sheep-industry produced income-related expenditures.

Table 7. Total effects of byproduct production and wholesale/retail sales

	Direct Effect	Indirect Effect	Induced Effect	Total Effect
Total Output Effect	\$767,518,265*	\$547,667,265	\$860,947,261	\$2,176,132,795
Value-Added Impact	\$473,852,170	\$255,016,400	\$469,280,529	\$1,198,149,106
Employment Impact	11,744	3,270	6,165	21,179

**Some of the direct effect is lost in the modeling effort from converting 2007 values to the model's 2006 base and back again.*

²¹Paullier, Diego. Chargeurs Wool USA. Phone conversation 1/30/08.

²²Paullier, Diego. Chargeurs Wool USA. Phone conversation 1/30/08.

When the model was estimated a second time to capture the effect of stimulated government and investment, induced and total effects increase dramatically. The total effect of the sheep industry is estimated at \$4.5 billion (Table 7). The direct effect of production, or sales, is \$768 million, the indirect effect of supporting backward-linked industries is \$548 million and the induced effect of household spending is \$3.2 billion.

The value-added impact totaled \$2.5 billion with \$255 million attributed to the indirect effect and \$1.8 million attributed to the induced effect. The direct value-added effect from the sale of sheep products and byproducts totaled \$474 million.

Table 8. Total effects of byproduct production and wholesale/retail sales including government and investment effects

	Direct Effect	Indirect Effect	Induced Effect	Total Effect
Total Output Effect	\$767,518,265*	\$547,667,265	\$3,166,641,369	\$4,481,826,877
Value-Added Impact	\$473,852,170	\$255,016,400	\$1,753,827,558	\$2,482,696,147
Employment Impact	11,744	3,270	23,096	38,110

**Some of the direct effect is lost in the modeling effort from converting 2007 values to the model's 2006 base and back again.*

The total employment effect from additional sheep and wool byproduct sales at the retail level is up to 38,110 jobs created. Adding this number to the total number of sheep producers in 2007, 70,590, yields 108,700 jobs. For every 11,744 jobs created in the sheep industry, there are 3,270 jobs created in backward-linked industries and 23,096 jobs created as a result of sheep-industry produced income-related expenditures.

VII. Addendum

Further research into the economic importance of the sheep industry could benefit from estimating values of more byproducts, but also sheep services. When we think of sheep, we typically think of wool and lamb products, but not necessarily services that sheep can provide. Targeted grazing by sheep has been coined the “new livestock-based ecological service.”

Sheep grazing is becoming an economic tool to substitute for costly weed control and maintenance of firebreaks. However, there is little formal documentation of this service. Hudson Glimp, a recent retiree from the University of Nevada, commented, “Invasive species cost \$120 billion a year in lost revenue due to the loss of beneficial uses and habitat and the cost to control.” He added, “We will become an effective tool in plant management. In 10 years, we could have a \$50 million industry if we do it right.”²³ If this potential is realized, the multipliers tell us that the sheep industry could produce \$90 million in indirect effects and \$45 million in induced effects for a total effect of \$182 million.

²³Daines, R. March 2006. “Income Beyond Lamb and Wool for Sheep Producers.” Sheep Industry News. American Sheep Industry Association.

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Appendix A

Model Parameters Notes

In order to estimate the economic value of the sheep industry, estimated values of the primary products and byproducts had to be estimated. This section delineates the assumptions behind the estimates. All the data, unless specified, was obtained from the U.S. Department of Agriculture's (USDA) Agriculture Marketing Service, USDA's National Agricultural Statistics Service (NASS), the Livestock Market Information Service, and the American Sheep Industry Association. All numbers below highlighted in **bold** were entered into the model in order for IMPLAN to produce the indirect and induced effects.

The first model estimated the value of lamb, mutton, wool, breeding stock, and sheep milk at the farmgate, or producer level.

Lamb and Mutton Production

There were 2,691,800 head and 364,996,000 pounds of lamb and mutton produced commercially in federally inspected and non-federally inspected plants in 2007. Ninety-four percent of commercial slaughter was federally inspected slaughter. The slaughter lambs were purchased through different marketing methods and thus at different prices, so a weighted average value of slaughter lambs was estimated. The estimated total value of slaughter-lamb production in 2007 was **\$369,053,730**.

An estimated 41 percent of slaughter lambs were marketed through auctions in 2007 with an average price of \$95.41/cwt. Another 40 percent of lambs were marketed on a carcass-based formula with prices being weighted again for weight. The average of carcass-based formula sales on a live basis was \$98.69/cwt. Lambs were also sold on a live-basis formula with an average price of \$98.73/cwt., but unfortunately the volume was unknown so this submarket was left out. Finally, lambs were marketed through live, negotiated sales with an average price of \$98.41/cwt. The 7 percent of federally inspected slaughter lambs that were packer owned was averaged at the average carcass based formula price. Custom slaughter was valued at the average live auction price.

The value of mutton at the farmgate was obtained by multiplying the average cull ewe price for 2007, \$41.14/cwt., by the volume of mutton produced in 2007, 8,087,175 pounds, which was **\$3,327,064**.

On-farm slaughter by sheep and lamb producers was valued at **\$4,012,990** in 2007. On-farm may or may not be for home consumption. The slaughter of 4 million pounds was assumed to be all lamb and was valued at the average slaughter-lamb price in 2007, \$98/cwt.

Ethnic Lamb Production

The ethnic lamb market was valued at **\$72,317,774** with 1,075,165 head slaughtered at an average \$103.48/cwt. The ethnic lamb market was defined as relatively lightweight lambs less than 100 pounds compared to the average live weight at slaughter of 140 pounds in the commercial market.

An estimated 34,411,500 pounds were produced for the ethnic market that "fell through the cracks." At an average 65 pounds per lamb in the ethnic market and a carcass weight of 32.5 pounds, this comes to an estimated 1,058,815 head in ethnic trade. In addition, 10 percent of state-inspected lamb was assumed to go to the ethnic market, which was 16,350 head in 2007.

Prices at two auctions, San Angelo, Texas, and New Holland, Penn., were used to value live lambs in the ethnic market. San Angelo was chosen because it is one of the largest sheep auctions in the United States, but also because it is believed that many lambs transported from Texas to the Northeast are geared for ethnic markets. New Holland is a very popular auction in the Northeast and it is assumed that most of the lightweight slaughter lamb sales go directly into the ethnic market. The average price for slaughter lambs less than 110 pounds²⁴ in New Holland in 2007 was \$109.06/cwt. and the average in San Angelo was \$97.89/cwt. The average price used was \$103.48/cwt.

²⁴Available prices were published by weight categories and could not be obtained up to 100 lbs.

Wool Production

The estimated value of wool production in 2007 was **\$38,543,720**. Roughly 64 percent of total sheep and lamb inventory is shorn annually. If total sheep and lamb inventory was 7,730,000 head in mid-2007 and the average weight per fleece was 7.35 pounds, then total wool production was 36,362,000 pounds in 2007 at an average price of \$1.06/lb. This figure was obtained by using the USDA/NASS average price of \$0.68/lb. for 2006 and inflating it by the 56 percent to reflect the price increases observed in the clean wool market in 2007.

By comparison, USDA/NASS reported that the value of wool production in 2006 was \$24,414,000, given an average price of \$0.68/lb. and 36 million pounds produced.

Sheep Milk and Cheese

The value of sheep milk was estimated at \$2.9 million in 2007. This figure was estimated from a survey conducted by David Thomas, Ph.D., Department of Animal Sciences, University of Wisconsin-Madison, in 2003 as well as his estimates of current flock numbers. There were an estimated 6,500 dairy ewes in 2003. This figure increases to 7,800 dairy sheep if rams, non-milked young replacement ewes, and dairy sheep in a few flocks that don't milk but which produce dairy stock for sale are included.²⁵

Thomas provided a guess that the number of dairy sheep inventory increased 30 percent between 2003 and 2007, which brings the total inventory to 10,140 head.²⁶ If the dairy ewe population is estimated at 8,450 head (1.3*6,500 head) and given an estimated 176 kg. milk per ewe (388 lbs./ewe), then total milk production in 2007 was estimated at 3,278,600 pounds. Thus, given producer milk prices between \$0.75/lb. and \$1/lb. (\$0.875/lb. average) milk production was valued at **\$2,868,775**.

An estimated 83 percent of all sheep milk is used for cheese production with the remainder going into yogurt, ice cream, and soap and lotion production (derived from Thomas, D., 2004, figures). Thus, an approximate 2,721,238 pounds of milk were used in cheese processing. It takes approximately 5 pounds of sheep milk to produce 1 pound of sheep milk cheese so an estimated 544,248 pounds of cheese were produced. Domestic sheep milk cheeses will wholesale for \$8/lb. to \$10/lb. and retail for \$16/lb. to \$20/lb.²⁷ Given an average retail price of \$18/lb.; the value of sheep cheese at retail was **\$9,796,457** in 2007.

Value Added Model Notes. The second model was estimated in order to capture some of the value added in the sheep industry. The model estimated the value of imported pelts, rendered products, domestic retail and food service sales, and retail sheep cheese. In order to capture some of the value added in the wool market, military wool, and wool blended products were valued as well as the lanolin market. This section outlines how the values were estimated. All numbers below highlighted in **bold** were entered into the model in order for IMPLAN to produce the indirect and induced effects.

Pelt Market

The U.S. pelt market was valued at **\$16.1 million** in 2007. The U.S. sheep industry produces pelts of varying quality and thus price. The pelt market was valued accordingly. In 2007, 64 percent of the market was comprised of woolled pelts and 34 percent were No. 1 pelts. The remaining pelts were No. 2s, No. 3s, and No. 4s. The price of fall clips was used as an estimate of the value of woolled pelts. Average prices in 2007 were as follows: woolled pelts, \$6.16; No. 1, \$5.78; No. 2, \$4.64; No. 3, \$2.39; and No. 4, \$1.64. Woolled pelts were valued at \$10.6 million in 2007 and No. 1 pelts were valued at \$5.3 million.

²⁵Thomas, D. 2004. Overview of the Dairy Sheep Sector in Canada and the United States.

²⁶Thomas, D. E-mail correspondence, Jan. 15, 2008.

²⁷Thomas, D. E-mail correspondence, Jan. 15, 2008.

Variety Meats and Rendered Products

The estimates of variety meats and value added from rendered products relied upon data from packers and the National Renderers Association. Packers vary in the amount of variety meats versus rendered product sold and some packers pay to have offal removed. The numbers calculated here are estimates of the marketing strategy used by the largest lamb packers. Price information is proprietary so rough values are based on conversations with packers and renderers in the industry. Prices for lamb meal and tallow are out of a renderer. Below is a table demonstrating how variety meat, meal, and tallow values were derived.

Volume	Price	Value
2,691,800 commercial head slaughtered		
2,691,800 edible portion (\$2.50/head)	\$2.50	\$6,729,500
69,986,800 lbs. to rendering (about 38%, or 26 lbs.)		
45,491,420 lbs. water (about 65%)		
24,495,380 lbs. remaining after water out		
12,247,690 lbs. fat (1/2 offal is fat)	\$0.20	\$2,449,538
12,247,690 lbs. meal (1/2 offal is meal)		
6,124 tons meal (conversion to tons)	\$550.00	\$3,368,115
2,691,800 sheep heads (\$3.50/head)	\$3.50	\$9,421,300
		\$21,968,453

Domestic Retail and Foodservice Lamb Markets

The quantity and average price of lamb sold through the retail and food service sectors must be estimated due to lack of formal data.

There was 183.1 million pounds of commercial lamb and mutton (federally inspected and non-federally inspected) production in 2007 (USDA/NASS). Of this total, 95.5 percent was lamb, or 174.9 million pounds. Roughly one-half of this volume is sold to retail and foodservice after trimming, cutting, and deboneing takes place, which is equal to 87.45 million pounds. An American Lamb Board study found that 37 percent of total lamb sold to consumers is sold in the foodservice sector, which is 32.36 million pounds (January 2007).

An average price of racks, rib chops, shanks, and legs in the foodservice sector from the same American Lamb Board demand study in 2006 was \$7.69/lb. Inflating this figure to 2007 dollars yielded \$7.91/lb. Thus, when price is multiplied by quantity, the value of the domestic food service sector was **\$255,967,600** in 2007.

The same calculation applies to estimating the value of the domestic retail market. In 2007, 55.09 million pounds of lamb was sold in the retail sector. If the average retail price is inflated from the USDA's Economic Research Service lamb retail price series, the average price in 2007 was \$5.66/lb. This brings the total value to **\$311.8 million** in retail sales.

Value Added Wool Market

The value of military wool purchases was obtained from Mitch Driggers, ASI wool consultant. He estimated that annual military purchases of wool products equal approximately \$147,299,355. Ninety-eight percent of this value is wool and wool-blended clothing for officers and enlisted men with the remainder being blankets.

The value of the lanolin market was estimated at **\$3,440,055**. The value was estimated from a known average of 3.25 kg. per 100 kg. of clean wool. Total wool production in 2006 was 36,019,00 pounds which is 16,335,147 kg. At 3.25 kg. per 100 kg. clean, wool grease production was calculated at 530,892 kg. wool grease or 1,170,087 lbs. wool grease. Wool grease was valued at an average \$1.75/kg. or \$3.86/lb. This means the value of wool grease was \$4.5 million. Assuming 2 percent of volume is lost in further processing, lanolin production was calculated at 1,146,685 pounds. At an assumed \$3/lb. this brings the value to \$3.4 million.



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