Stochastic Simulation of a Small-Scale Meat Packing Plant

Constance L. Falk

A small-scale meat packing plant selling lambs and steers in northern New Mexico was analyzed in three Monte Carlo simulations. The monthly distributions of steer live-weights and prices at the feedlot were fit and the parameters estimated. The distributions were correlated between liveweights and prices each month and between all monthly prices. An annual distribution of lamb liveweights was also fit. The three simulations assumed that retail prices of beef in northern New Mexico were comparable to the national average, minimum and maximum weighted prices. If minimum national beef prices are used, there is a better than 50 percent probability that net profits will be negative every month except June-September. In January-May and November, there is a greater than 90 percent chance that net profits before taxes will be negative. When maximum prices are used there is a slight chance that net profits before taxes will be negative.

Introduction

Sheep production is the third largest livestock enterprise in New Mexico, with 1990 cash receipts of $13.2 million (New Mexico Department of Agriculture). New Mexico's breeding ewe herd is the nation's eighth largest, averaging about 5 percent of the national herd annually (Shapouri). New Mexico's sheep and lamb numbers have steadily declined from 650,000 in 1981 to an estimated 462,000 in 1991 (NMDA). In Rio Arriba County of northern New Mexico, a non-profit economic development organization, Ganados del Valle (Livestock of the Valle), has worked to revive two breeds of sheep and establish local industry based on sheep production. One of the four businesses they have started since 1983 is a lamb marketing business, Pastores Lamb (Sheperds' Lamb).

Like many other small lamb producers in recent years, Pastores Lamb has investigated alternative meat marketing approaches such as direct marketing and organic marketing (Schwartz, 1992; Livestock Weekly, 1992; Deterling, 1987; Missouri Farm, 1987; Traupman, 1990). Between 1989 and 1992, producer groups in 11 states investigated forming cooperatives to market lambs to niche markets, a concept considered to be a significant change in the role of market-

Associate Professor, Department of Agricultural Economics and Agricultural Business, New Mexico State University.

ing cooperatives in the sheep industry (Kazmierczak and Bell). Much of the interest in alternative lamb marketing is related to the drop in U.S. lamb consumption such that lamb is now considered a specialty meat. Lamb consumption peaked at 7.3 lb per capita in 1945 and has dropped to a record low of 1.3 lb in 1987 (Stillman, Crawford, and Aldrich).

Since 1989 Pastores Lamb has marketed direct to consumers and specialty and gourmet restaurants in Taos, Santa Fe, and Albuquerque, NM. The lambs have been slaughtered and packaged under contract by small custom plants in northern New Mexico with uneven results. The enterprise also faced high costs associated with transporting the animals to one site for killing and processing, storing the meat at another site, and transporting it to the customers in three geographical areas in New Mexico. A small-scale slaughter and specialty meat processing plant with freezer and cold storage located near the source of the lambs may reduce these costs and coordination problems and improve the quality of the end product.

Literature on Small-Scale Meat Plant Feasibility

Brasington and Hammons provide a guide for small meat plants based on technical assistance given to 60 small-plant operators needing to comply with the plant requirements established by the 1967 Wholesome Meat Act. In the Brasington and Hammons study, a complete room-by-room description is provided that details space and equipment requirements for small slaughter and non-slaughter plant operations. Using information from a later study by Brasington (1978), Watkins (1983) put together a guide for starting a small meat packing plant. Both Brasington (1978) and Watkins (1983) include utility and labor usage estimates.

Watkins provides a useful feasibility study outline. Estimates of operating costs and a computerized model for larger, specialized beef-packing plants are provided by Duewer and Nelson (1991).

Objectives

The general objective of this project was to determine whether building and operating a small meat packing plant in northern New Mexico would be financially feasible. Such an analysis may be useful to other groups pursuing alternative meat marketing and who wish to investigate the feasibility of small-scale multi-species meat packing enterprises. The uncertain nature of the project necessitated using a risk analysis approach. A secondary objective was to demonstrate an easy method for incorporating stochastic and correlated variables into a Monte Carlo simulation.

Model

Sources of risk in meatpacking may include uncertain wholesale and retail meat prices, livestock live weights, and livestock prices. The impacts of uncertain or stochastic cattle prices and liveweights on a small slaughter plant's net profits before taxes were analyzed in this study. The selection of variables is explained in the data section below.

A LOTUS 123[1]-based spreadsheet template was developed to model the financial outcomes of a small-scale meat plant under risk. Risk was incorporated using @RISK[2], a LOTUS 123 add-in software that conducts Monte Carlo simulations in which estimates of distributions of output variables are based on assumptions of distributions of input variables and the relationships between input variables. The distributions of the input variables were selected using BESTFIT[3], a Windows-based software that fits data series to distributions.

Spearman rank correlation coefficients were estimated for monthly steer prices and liveweights and for steer prices between months. The correlation coefficients were entered into @RISK using the @CORRMAT function, a correlation matrix which is used to maintain relationships between input variables when they are sampled from their respective distributions each iteration of the simulation. This method of correlation is "distribution-free" as any type of distribution may be correlated. The samples drawn for two distributions are correlated, and the integrity of the

original distributions is maintained (@RISK Version 2.01 User's Guide).

Data Sources and Assumptions

Primary data on plant designs and new equipment costs were obtained from Koch Supplies, Inc. a manufacturer of slaughter and fabrication equipment. Additional primary data were obtained from local companies. Managers of small meat plants in New Mexico, Arizona, and Utah were also interviewed to better understand the constraints faced by small facilities.

A weekly minimum of 50 lambs, 10 cows, and 20 hogs year-round were recommended by plant engineering specialists at Koch. These weekly minimums should be able to economically sustain a small-scale plant that primarily focuses on lamb sales, according to company spokespersons. However, in northern New Mexico there are no sources of hogs, and lambs are only available in the fall. A small feedlot for steers is located in Farmington and could supply a slaughterhouse near Los Ojos.

The model constructed for this study assumed year-round availability of steers and fall supply of lambs. The model assumed processing of 50 lambs weekly from August to December, a total of 1,000 lambs. An annual total of 1,050 steers were assumed killed and processed, 18 weekly during the lamb season and 23 weekly the rest of the year.

Monthly steer liveweight and price distributions were fit using daily averages from 1988 to 1993 from feedlots in Nebraska (USDA Market News Service). A monthly distribution was fit based on the daily variability in that month. Spearman rank correlation coefficients were calculated between monthly steer prices and liveweights and between monthly distributions of steer prices. The resulting correlation matrix is shown in Table 1.

Liveweights for lambs were obtained from Ganados del Valle's historical records, and one distribution was fit for all the months, rather than a distinct distribution each month as was done for the steers. The resulting distribution fit for lamb weights was Normal (93.54,8.55), based on 125 observations from the 1990 marketing season. Insufficient data was available to estimate monthly distributions for lamb liveweights.

Although potentially an important source of income in a small plant, custom kill, cut, and wrap operations of livestock and deer and elk were not included in this study. In addition, no income was assumed from the sale of inedible offal, hides, or edible offal, even though these items may provide income for a small plant.

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[1]LOTUS 123 is a trademark of Lotus Development Corporation

[2]@Risk is a trademark of Palisade Corporation.

[3]BESTFIT is a trademark of Palisade Corporation.

	January		February		March		April		May		June		July		August		September		October		November		December	
	PR	WT	PR	WT	PR	WT	PR	WT	PR	WT	PR	WT	PR	WT	PR	WT	PR	WT	PR	WT	PR	WT	PR	WT
Jan PR	1	-0.32	0.927	0	0.870	0	0.744	0	0.688	0	0.761	0	0.797	0	0.8	0	0.792	0	0.758	0	0.776	0	0.805	0
Jan WT		1		0		0		0		0		0		0		0		0		0		0		0
Feb PR			1	-.023	0.953	0	0.847	0	0.827	0	0.835	0	0.881	0	0.847	0	0.847	0	0.875	0	0.900	0	0.893	0
Feb WT				1		0		0		0		0		0		0		0		0		0		0
Mar PR					1	-0.31	0.938	0	0.9	0	0.873	0	0.885	0	0.829	0	0.844	0	0.85	0	0.858	0	0.932	0
Mar WT						1		0		0		0		0		0		0		0		0		0
Apri PR							1	-0.24	0.964	0	0.926	0	0.826	0	0.758	0	0.758	0	0.779	0	0.779	0	0.879	0
Apri WT								1		0		0		0		0		0		0		0		0
May PR									1	-0.17	0.935	0	0.814	0	0.767	0	0.797	0	0.805	0	0.773	0	0.829	0
May WT										1		0		0		0		0		0		0		0
Jun PR											1	-0.16	0.885	0	0.876	0	0.820	0	0.820	0	0.755	0	0.761	0
Jun WT												1		0		0		0		0		0		0
July PR													1	-0.07	0.923	0	0.929	0	0.888	0	0.820	0	0.791	0
July WT														1		0		0		0		0		0
Aug PR															1	-0.24	0.944	0	0.923	0	0.820	0	0.776	0
Aug WT																1		0		0		0		0
Sept PR																	1	0.051	0.970	0	0.879	0	0.820	0
Sept WT																		1		0		0		0
Oct PR																			1	-0.32	0.944	0	0.85	0
Oct WT																				1		0		0
Nov PR																					1	-.05	0.9	0
Nov WT																						1		0
Dec PR																							1	0.16
Dec WT																								1

The USDA Economic Research Service calculates national weighted average retail beef prices, using Bureau of Labor statistics, for specific beef cuts (USDA). National monthly weighted average retail prices were used because no state or regional retail prices are published. Beef averages are based on retail prices of ground chuck and ground beef; chuck, round, and rib roasts; and sirloin, t-bone, and round steaks.

The average, maximum, and minimum monthly national weighted average retail beef prices for the period 1988 to 1992 for each month were calculated. Three simulations were run, one for each of the three assumptions of retail beef prices: average, maximum, and minimum. This procedure was used because it was not possible to correlate retail beef data series with steer prices, since retail price series were national aggregates and steer prices were from specific feedlots. Instead, an analysis to test the sensitivity of the simulations to three levels of retail beef prices was conducted.

Ganados has charged as much as $5.06/lb for their specialty breeds of lamb direct to home consumers. The priced used in this study, $2.97/lb, was the average price charged during fall 1992 to retail customers. Lamb prices were treated as deterministic variables in this study since Ganados has been able to adjust their prices and sell all of their inventory without any problem.

Cost Assumptions

Land, Building, and Equipment Costs. Kill floor and processing equipment was assumed purchased new from Koch. Equipment costs are shown in Table 2. Equipment purchase costs could be reduced by purchasing used and rebuilt equipment instead of new, but that would increase maintenance costs. The refrigeration equipment and facility walls were assumed purchased new from the meat processing supply corporation, although used facility walls and equipment are available throughout the Southwest. Land costs were based on local real estate values in northern New Mexico, and construction estimates were obtained from local contractors. Estimated capital outlays are summarized in Table 3.

Table 2
Equipment Costs for a New Small-Scale Multi-Species Kill Floor and Processing Facility

Item	Price ($)
Meat saw (band)	4,717.00
Meat saw, splitting (splitter)	2,712.00
Saw (brisket splitting)	3,575.00
Sink: double	538.00
Sink: step	598.00
Grinder/Mixer	7,495.00
Tables: utility	2,149.00
Slicer	1,280.00
Cuber	-
Sterilizer: knife	115.00
Sterilizer: splitting saw	529.00
Scales: platform	3,995.00
Scales: overhead track	3,320.11
Scales (utility)	759.00
Stuffer: sausage	1,290.00
Smoker (electric or steam)	8,000.00
Mixer, steam and water	6,490.00
Hoist, 1 - ton (32 ft./min. bleeding)	2,185.00
Rack, head - inspection	716.00
Truck, inspection paunch	1,065.00
Truck, gut inspection	940.00
Spreader, carcass	170.00
Lander, beef	170.00
Cradle, skinning	620.00
Pen, knocking (beef)	2,145.00
Stunner (Magnum 25)	330.00
Rollers (suspend carcasses)	49.00
Heater, hot water	90.00
Beam Bleam	1,942.00
Patty machine	3,995.00
Knife sharpener (electric)	379.00
Miscellaneous (knives, gambrels, hand saws, tubs, lugs.)	4,000.00
TOTAL:	**$66,358.11**

Source: Koch Supplies, Inc.

Table 3
Estimated Capital Outlays for a Small-Scale Multi-Species Kill Floor and Processing Facility

Category of Asset	Cost ($)	
Land		$40,000
Building:		
Main building	185,211.00	
Holding pens	3,500.00	
Retail area	10,000.00	
Storage office, restrooms	15,000.00	
Offal room	10,000.00	
Hide curing room	7,080.00	
Subtotal		$230,791
Equipment:		
Truck to haul livestock	30,000.00	
Processing equipment	66,358.11	
Truck to haul meat	25,500.00	
Office furniture	1,000.00	
Cash register	529.00	
Microcomputer	2,300.00	
Meat display cases	5,000.00	
Subtotal		$130,687
Total		$401,478

Direct Labor. Labor cost estimates were based on the following assumptions:

1. 45 hours/week/person at 52 weeks/year. Overtime hours are paid at the rate of 1.5 times regular wages. Two weeks per year are paid vacation.
2. Average wage of $6.50 /hour. Average entry wage for meat cutters in New Mexico is $5.32/hour, and the average paid is $6.48 according to a 1990 statewide survey (Economic Development Department). Overtime pay before taxes is $9.75.
3. 1.5 beef slaughtered per labor-hour, 2 hogs slaughtered per labor-hour, 2 lambs slaughtered per labor-hour, 80 pounds of meat cut and wrapped per labor-hour.
4. Package meat weights for beef were assumed to be 33 percent of liveweight and for lamb the percentage was 48 percent.

The direct labor assumptions in #3 are based on work done at the New Mexico State University meat lab. Thomas[4] estimated that 2 sheep or 1.5 cows can

be slaughtered per labor-hour and meat can be wrapped 80 lb/hr. Given the volume of livestock and labor-hour productivity assumed, it was estimated that the facility would need seven full-time people: two on the kill floor, three in processing, and two employees in retail. The work week is scheduled for 45 hours, creating one hour of overtime per day for each employee. In addition it was contemplated that a full-time secretary would be employed at $6.00 per hour.

Labor costs include basic wage plus taxes and insurance. In New Mexico, taxes and insurance for meat plant workers are 25.01 percent of the basic wage. For secretaries, the labor burden is 11.12 percent. The worker's compensation insurance rate of 14.66 percent for meat plant workers is the largest share of the labor burden (National Council on Compensation Insurance). Taking into account labor taxes, the average hourly labor cost for packing house workers was estimated to be $8.13 ($6.50 * 1.2501). The hourly rate for the secretary was estimated to be $6.67 ($6 * 1.1112). The estimated average monthly cost of employing one person full-time in the plant would be $1,300 and the estimated monthly salary for a secretary would be $1,067.20.

Utilities. The volumes of water, electricity, and gas to be used in the plant were estimated based on the volume of meat handled in the plant and the average consumption of utilities per head estimated by Brasington. Utility costs were calculated using rates in the Los Ojos area and are shown in Table 4.

Table 4
Utility Consumption Estimates per Head and Cost in a Small-Scale Multi-Species Kill Floor and Processing Facility

Utility	Utility Consumption/Head*	Cost ($)**
Water	241 gal	.0023/gal
Gas	251 cub ft	.001244/cu ft
Electricity	88 kWh	.12/kWh

*Source: Brasington
**Rates in Chama, NM, 1992

Other General and Administrative Expenses and Factory Overhead. Other general expenses besides utility expenses are phone, supplies/laundry, property tax, and promotion. Administrative expenses are the managerial salaries. Factory overhead consists of property and liability insurance and building and equipment maintenance. Table 5 shows the assump-

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[4] Jack Thomas, associate professor of animal science, NMSU, Las Cruces, NM, 1992.

tions made about general, administrative, and over-head expenses.

Table 5
Other General Expenses, Administrative Salaries, and Factory Overhead in a Small-Scale Multi-Species Kill Floor and Processing Facility

Expense Category	Cost per Period ($)
Other general expenses:	
Supplies/laundry	800/month
Property tax	3,200 in Nov.
Promotion	200/month
Truck fuel/maintenance	200/month
Telephone	200/month
Factory overhead:	
Property insurance	2,201/year
Liability insurance	7,500/year
Maintenance	
Building	2,000/year
Equipment	2% of investment/year
Administrative salaries	75,309/year

Telephone and supplies/laundry costs were based on Watkins assessment rates. For the telephone costs, Watkins' estimate was doubled to be conservative. Insurance quotes were provided by Farm Bureau Insurance Co. Liability insurance for a $1,000,000 policy. Property tax expenses were calculated following the procedure given by the Rio Arriba County office.[5]

In this analysis the secretary's pay is included with administrative salaries. This analysis assumes two managers, each earning $25,000 in salary as Ganados del Valle places a $25,000 ceiling on administrative salaries in its organization. The two managers are envisioned to divide up marketing, plant management, and purchasing duties. The 25.01 percent labor burden rate covering unemployment compensation, workers' compensation, and Social Security and Medicare payments used for packing house labor is also used for the two managers. It is possible that if one of the managers were not involved in the packinghouse work

at all, then a lower workers' compensation rate could be obtained, but the highest was used to be conservative.

Packaging Material. Wrapping paper is required for retail sale cuts, and the costs of packaging material were based on the estimated volume of packaged meat weight. The plant is expected to purchase paper 1,100 feet long by 18 inches wide. Such a roll can wrap the meat from 4 beef carcasses that weigh 350 lbs. each or 1,400 lbs, and it costs $27/roll.[6] Thus, the per pound cost of wrapping paper used in the model, $.019285714, was multiplied by the total number of pounds processed each month, a stochastic variable, to arrive at the monthly cost of packaging.

Transportation. Since the closest feedlot to the Los Ojos area is in Farmington, 113 miles to the west, variable transportation costs from the feedlot to the packing house were multiplied each iteration by the number of cwt processed in the plant each month each iteration. The per unit cost is the same as that assumed by the USDA Livestock and Poultry Situation and Outlook Report for 1992 (USDA), $.22/cwt/100 miles. A fixed monthly expense was included in the general and administrative expenses to cover the truck used to haul meat.

Simulation Results

Table 6 shows the probability of profits, before taxes, being negative for each month for each simulation. The probability of net profits, before taxes, dropping below zero was quite low when average national weighted beef prices were used, except in November when there was a 40 percent chance. When maximum national retail beef price averages were used, the probability of net profits, before taxes, being negative were zero every month except November, when there was a 9 percent chance. However, when minimum national beef prices were used, there was a better that 50 percent probability that net profits, before taxes, would be negative every month except June-September. In January-May and November, there was a greater than 90 percent chance that net profits, before taxes, would be negative when minimum national retail beef prices were used.

Summary and Conclusions

In this study, the feasibility of a proposed small-scale multi-species kill floor to be located in northern New Mexico was analyzed in a Monte Carlo simulation. Stochastic variables in the simulation were daily steer prices and live weights (at the feedlot) and lamb live weights. Three simulations were run, one each for minimum, average, and maximum average national

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[5]Sum up the value of land, buildings, and equipment and divide the sum by 3. The resulting figure represents the taxable value. Property tax equals $30 per each $1,000 of taxable value.

[6]Pres Carillo, meat manager, Chama Valley Supermarket, Chama, NM, 1992.

Table 6
Simulation Results for a Small-Scale Multi-Species Kill Floor and Processing Facility

Month	Simulation 1: Monthly average national weighted beef prices		Simulation 2: Monthly maximum national weighted beef prices		Simulation 3: Monthly minimum national weighted beef prices	
	Expected Value of Net Profits Before Taxes ($)	Probability of Net Profits Before Taxes Falling Below Zero	Expected Value of Net Profits Before Taxes ($)	Probability of Net Profits Before Taxes Falling Below Zero	Expected Value of Net Profits Before Taxes ($)	Probability of Net Profits Before Taxes Falling Below Zero
Jan	6,013	2%	17,222	0%	(7,064)	96%
Feb	6,722	0%	16,495	0%	(5,377)	96%
March	4,641	1%	14,239	0%	(6,785)	100%
April	5,562	1%	14,461	0%	(6,451)	100%
May	7,640	1%	15,545	0%	(3,339)	92%
June	12,001	0%	18,245	0%	3,974	4%
July	10,683	0%	15,637	0%	2,578	14%
August	12,189	0%	15,416	0%	6,325	1%
Sept	11,722	0%	14,588	0%	6,655	8%
Oct	4,584	11%	9,160	0%	(189)	52%
Nov	1,132	40%	5,427	9%	(5,272)	91%
Dec	4,747	11%	10,350	0%	(1,482)	65%

weighted retail beef prices. Lamb retail prices were fixed at the level actually charged in 1992 by Ganados del Valle (the client for whom the study was conducted). Cost estimates were obtained from a variety of primary and secondary sources.

The study results showed that the plant is feasible provided retail beef prices do not fall below average national levels. In the simulation using minimum national retail beef prices, the probability of net profits, before taxes, falling below zero were high in ten months of the year. Of course, a feasibility study is only the first step in determining whether a project will be successful. Other factors which could affect the project include whether experienced meat plant managers are hired to oversee animal procurement; product marketing; and technical, human resource, and financial management. In addition, an appropriate financial plan and organizational design is needed. All of these factors will influence whether a small plant can successfully operate in an industry which has seen the closure of small plants across the country.

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