A Method for Determining Ranch Profit Probabilities When Livestock Yields Are Normally Distributed

Martin Blake and James R. Gray

Data on net turnoff for small, medium-size and large cow-calf and small and large size yearling ranches were tested for normality using the Shapiro - Wilk test. The yield data examined were accepted as normally distributed at the $\alpha = .10$ level. The probability of profit for each type of ranch was assessed using normal curve techniques for nine different cost-price alternatives and weather conditions. Yearling cattle ranches had higher profit probabilities than cow-calf ranches. Prices received had more influence on profit probabilities than weather conditions.

Western ranchers have a limited number of choices for selecting alternative livestock enterprises. In making these choices, they need to take into account price and cost information and also possible variations in livestock yields. The object of this paper is to demonstrate a simple and yet powerful technique for evaluating such information when yields are normally distributed.

Problem Situation

In recent years, increasing numbers of ranchers have shifted from cow-calf to stocker yearling cattle enterprises. The stocker yearling cattle enterprise involves buying calves in the fall at 320 to 400 pounds, or short yearlings[1] in the spring at 400 to 500 pounds, grazing them on their ranches through the winter and/or spring and summer, and selling them as yearlings in the late summer or fall as feeder animals of 600 to 780 pounds. Both steers and heifers can be included in the stocker yearling program.

On balance, both cow-calf and yearling enterprises may result in widely varying incomes. Cow-calf ranchers operate much the same, year after year, and accept variations because of their low ranch operating costs. Meanwhile, operators of yearling enterprises try to outguess the future to avoid losing their high investments of risk capital.

In these situations, ranchers and others are uncertain as to which enterprise to choose. The choice tends to be irreversible in the short-run, if not the long-run, because building a quality cow-calf herd requires several years of cow and bull selections. Needed is a method that would permit profit comparisons in a local area of the two kinds of enterprises in low and high cattle price years in combination with below and above average producing conditions.

Objectives

The major objective of this paper is to demonstrate a technique for determining profit probabilities of cattle ranch enterprises when livestock yields are normally distributed. As an example of this technique, the profit probabilities of cow-calf and yearling cattle enterprises in northeastern New Mex-

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[1]Short yearlings are animals that are 12 to 15 months old.

ico are calculated for various combinations of prices received and cost levels.

Procedures

Approach

Ranch organizations, costs and returns were obtained through personal interview surveys of ranchers in the study area in 1966 and 1973. A wide variety of secondary data, published mostly by state and federal agencies, were used to project ranch budget data from 1965 and 1972 to 1978. Ranch budgets were constructed for each year from 1965 through 1978, using techniques developed in prior ranch cost and return studies [Gray and Goodsell]. Only the 1965 and 1978 budgets have been published [Gray, 1969 and Gray, 1980].

Ranch sizes and types included in the study were based on lists of ranchers obtained from county extension agents and office managers of the Soil Conservation Service and the Farmers Home Administration, all located in the study area. These local officials classified the ranches by type (either cow-calf or yearling) and size (small, medium, and large). Too few ranchers had units that were classified as cow-yearling to permit study of this type in the study area. However, ranches classified as large yearling ranches typically had small cow-calf enterprises. Calves on these ranches were mostly sold as yearlings.

Major elements of the 1978 organizations, costs, returns, and efficiency factors for the ranch budgets used as a part of the data base for the analysis, are shown in Table 1.

The Shapiro-Wilk test was used to test the hypothesized normality of livestock yields in northeastern New Mexico [Shapiro and Wilk]. The measure of yield used in this study was the net hundredweight of turnoff[2] per ranch (Table 2). This test was performed on yields for small, medium and large cow-calf enterprises and small and large yearling enterprises for the period 1965-1978.

The Shapiro-Wilk test statistic, W, is obtained by dividing the square of an appropriate linear combination of the sample order statistics by the estimated variance. W is responsive to the nature of the overall configuration of the sample as compared with the configuration of expected values of normal order statistics. The W statistic is scale and origin invariant and thus supplies a test of the composite null hypothesis of normality. The Shapiro-Wilk test is quite sensitive against a wide spectrum of non-normal alternatives, even for small samples ($n < 20$) [Shapiro and Wilk].

The W statistics for small, medium and large cow-calf ranches and small and large yearling ranches are 0.96, 0.98, 0.96, 0.95, and 0.94, respectively, where 1.00 represents a distribution that is exactly normal. Thus, at the $\alpha = .10$ significance level, the null hypothesis of normality is not rejected; there is no evidence of non-normality of the yield data based on the Shapiro-Wilk test.[3]

The impacts of weather, disease, forage availability, and other factors affecting yield were indirectly evaluated by this approach to the extent they influenced observed yields.

Analysis

A normal distribution is completely specified by two parameters of the distribution, the mean and the standard deviation. The means of the yield distributions for small, medium and large cow-calf and small and large yearling ranches are 241.9, 860.0, 1693.6, 722.3 and 1991.6 hundredweight with standard deviations of 83.5, 304.8,

[2]Net turnoff is total weight sold, plus total weight consumed, less total weight purchased, plus or minus total inventory weight gains or losses. Net turnoff is usually reported per ranch (in hundredweight) or per cow (in pounds).

[3]If the distributions of livestock yields had proved to be non-normal, the problem could still be solved in a similar fashion using the empirical distribution function for each series of yields. The use of a normal distribution, which is completely specified by the mean and standard deviation, avoids some of the tedious mechanics of using the empirical distribution function.

TABLE 1. Average Organization, Costs, Returns and Efficiency Factors per Ranch by Ranch Size and Type in Northeastern New Mexico, 1978

Item	Unit	Cow-Calf Ranches			Yearling Ranches	
		Small	Medium Size	Large	Small	Large
Organization:						
Rangeland	Acres	2,825	7,880	22,680	4,410	18,390
Cropland	Acres	20	0	0	10	0
Total cattle	Numbers	73	256	533	280	962
Avg. animal units	AUs	63	232	497	133	494
Receipts and costs:						
Total receipts	Dol.	10,254	39,353	80,980	82,282	221,287
Total costs	Dol.	12,944	30,871	54,265	64,242	168,429
Fixed[a]	Dol.	4,948	8,690	17,039	8,004	26,681
Variable:						
Feed	Dol.	3,368	8,879	17,987	4,567	11,106
All other	Dol.	4,628	13,302	19,239	51,671[b]	130,642[b]
Total variable	Dol.	7,996	22,181	37,226	56,238	141,748
Net returns[c]	Dol.	−2,690	8,482	26,715	18,040	52,858
Efficiency factors:						
Calf crop[d]	Pct.	79.6	76.6	71.7	--	76.3
Death loss[e]	Pct.	4.1	3.5	3.7	5.0	4.0
Rangeland per AU[f]	Acres	51.4	35.5	47.8	32.7	34.1
Beef production per acre[g]	Lbs.	3.63	4.99	3.57	18.66	12.03

[a]Includes long-term lease fees, insurance, property taxes and depreciation.

[b]Includes $45,060 and $107,562 for purchase of stocker animals on small and large yearling ranches, respectively.

[c]Net returns to operator labor, management, and all capital used on ranch.

[d]Calves surviving to fall divided by cows and yearlng heifers in the herd January 1.

[e]All cattle died during the year divided by all cattle in the herd January 1.

[f]All rangeland divided by number of AUs adjusted for amounted of roughages fed during year.

[g]Adjustments made for feed fed.

Source: [Gray, 1980]

569.6, 221.5 and 676.9 hundredweight, respectively (Table 2). The normal distributions of yields were transformed to normal distributions of returns by multiplying the means and standard deviations by price.[4]

Once the normal distribution of yields has been transformed to a normal distribution of returns, various cost figures were used to evaluate the probability of making a profit.

[4]Profit variability is affected by both yields and prices. It might be argued that yield variability alone may overstate the variability of profit as prices might increase in a low yield year and decrease in a high yield year, thus, offsetting some impacts in yield variability. Correlation coefficients between cow-calf yield and calf prices and between yearling yield and yearling prices were calculated to see if this was the case. The correlation coefficients between small, medium and large ranch cow-calf yields and calf price were 0.25, 0.49, and 0.16, respectively. The correlation coefficients between small and large ranch yearling yields were −0.17 and −0.09, respectively. None of these were significantly different from zero at the $\alpha = .05$ level. This would indicate that, in this case, yield and price variations are uncorrelated and, thus, can be analyzed separately. This is not surprising since the area being analyed contributes such a small portion of the total U.S. cattle supply.

TABLE 2. Net Turnoff per Ranch in Northeastern New Mexico, 1965-78

Year	Cow-Calf			Yearling	
	Small	Medium	Large	Small	Large
	hundredweight				
1965	240.9	811.1	1728.1	965.7	2466.6
1966	179.8	589.6	1225.0	816.7	1716.5
1967	326.9	1074.9	2413.4	370.2	2472.1
1968	181.0	593.1	1302.3	789.6	1692.1
1969	269.8	982.5	2121.5	673.6	2116.4
1970	332.6	1051.8	2295.1	1040.7	2313.8
1971	197.2	691.0	1455.9	691.4	1414.0
1972	320.1	1247.9	1939.9	1038.5	2434.0
1973	395.3	1432.1	2582.2	941.7	3616.7
1974	71.9	253.6	456.7	475.6	918.8
1975	264.9	947.6	1937.1	562.5	2237.6
1976	183.4	614.4	1244.7	447.4	1567.2
1977	226.1	774.7	1581.7	737.9	1663.1
1978	196.1	976.1	1426.9	561.2	1253.6
Mean	241.9	860.0	1693.6	722.3	1991.6
Standard deviation	83.5	304.8	569.6	221.5	676.9

The three prices used in this study were a high price, typical of a rising cattle cycle or herd build-up phase, an average price, typical at a peak or trough in the cattle cycle, and a low price, typical of a falling cattle cycle or herd liquidation phase. The three series of costs used in this paper were typical of those experienced in an above average forage condition year, an average forage condition year, and a below average forage condition or drought year. Costs per ranch were estimated for each type and size of enterprise.

Application

The method used in this study to assess the probability of making a profit from a given ranching enterprise can best be explained through use of an example for a medium cow-calf ranch. Figure 1-a represents the normal distribution of yields for a medium cow-calf ranch. The mean yield is 860.0 hundredweight and the standard deviation is 304.8 hundredweight per ranch. One standard deviation above and below the mean is depicted in Figure 1-a, where σ is the symbol for one standard deviation.

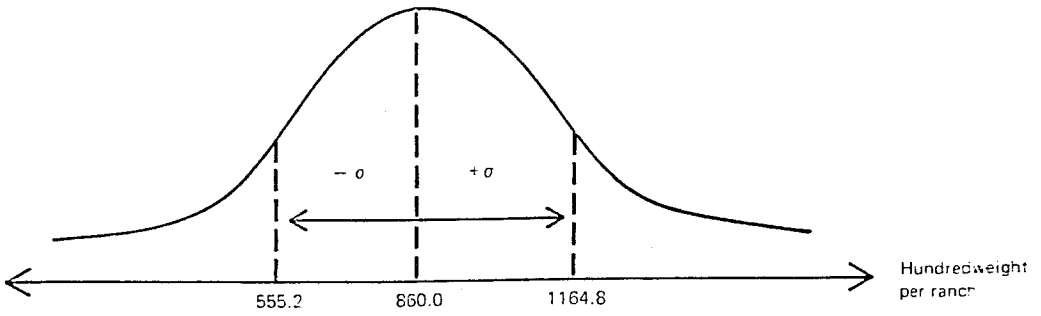
This normal distribution of yields was transformed into a normal distribution of returns per ranch by multiplying the mean and standard deviation by price. The price used to transform the normal distribution of yields in Figure 1-a into the normal distribution of returns per acre shown in Figure 1-b was the high price of $77.52 per hundredweight (Table 3). The mean and standard deviation of this normal distribution of returns per medium cow-calf ranch were $66,667.20 and $23,628.10, respectively.

The cost used in this example was the average cost of operating a medium cow-calf ranch, $35,325 (Table 4). The probability of getting a return greater than this cost is represented by the shaded area in Figure 1-c. The standard z score is calculated as:

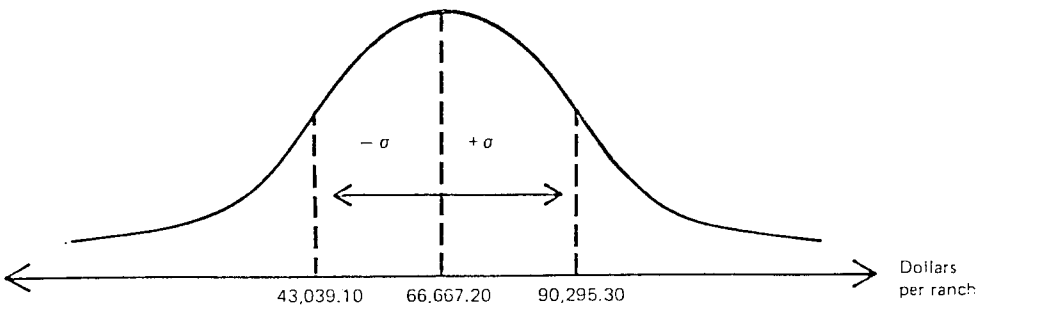
$$Z = \frac{35{,}325.00 - 66{,}667.20}{23{,}628.10}$$

$$= \frac{-31{,}342.2}{23{,}628.1} = -1.326$$

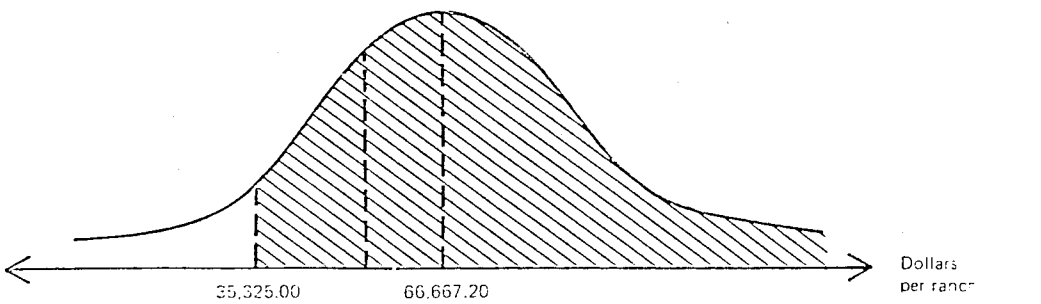
From a normal curve table, it was found that this corresponded to an area under the normal curve of .9075 (90.75 percent of the area under the normal curve).



a. Average yield per ranch ± one standard deviation



b. Average returns per ranch ± one standard deviation



c. Profit per ranch

Figure 1. Profitability of a Medium-Size Cow-Calf Ranch in New Mexico.

TABLE 3. Prices Received per Cwt. of Net Turnoff on Cow-Calf and Yearling Ranches by Price Periods

Price period	Price received per cwt. on: Cow-calf ranches	Yearling ranches
	(dollars/cwt.)	
High prices (Rising cattle cycle)	77.52	78.00
Average prices (Peak or trough in cycle)	35.21	44.50
Low prices (Falling cattle cycle)	22.29	21.98

Thus, with a price of $77.52 per hundredweight and costs of $35,325 per ranch, the probability of making a profit on a medium cow-calf ranch in New Mexico was 90.75 percent. The probabilities of making a profit for various price-cost combinations were calculated in a similar manner for each size and type of ranch.

Discussion

For purposes of discussion, the characteristics of cow-calf versus yearling enterprises display the dimensions of the choice confronting ranchers.

1. Cow-calf enterprises of sizes comparable to yearling enterprises require much less operating capital. The operator of a yearling enterprise must purchase his herd each year as well as maintain it until the herd is sold. This creates major cash flow and inventory adjustment problems. The cow-calf operator maintains his basic herd from year-to-year and sells only the increase.
2. Cow-calf enterprises typically produce about 300 pounds of animals per unit (with a unit being a cow). On yearling enterprises, production is at least 30 percent more, mainly because all weight gains appear in sales. Cows lose all or part of their summer gains during the winter. Weight sales on cow-calf ranches vary less than on yearling ranches. When droughts occur, yearling cattle may make only modest gains of about 100 pounds from winter to the following fall, while calves will weigh at least 250-300 pounds.
3. Cow-calf operations are less flexible than yearling operations. If drought has occurred, operators of yearling enterprises may delay purchasing animals until the drought is over. If animals were puchased before the drought, yearlings may be sold in the summer or early fall to feedlot operators. Cow-calf ranchers usually attempt to maintain the breeding herd despite drought. If the coming year appears to be favorable (non-drought), ranchers with yearling enterprises again have more flexibility than cow-calf ranchers. The yearling ranch operator has two options not normally available to cow-calf ranchers. He can both increase herd size rapidly by buying calves, and he can rent pasturage, paying either a monthly animal unit rent, or an end-of-season rent per pound of gain. Both options are difficult for cow-calf ranchers because a) purchased calves may not eventually develop into cows with desirable breeding characteristics, b) a period of two to three years is needed to find out about breeding qualities, and c) those with pasturage to rent prefer renting to operators of yearling en-

TABLE 4. Estimated Costs[a] per Ranch, Including Depreciation in Above Average, Average, and Drought Years at Deflated Prices

Ranch size and type	Above Average			Average			Drought		
	Net turnoff per ranch	Cost per cwt.	Cost per ranch	Net turnoff per ranch	Cost per cwt.	Cost per ranch	Net turnoff per ranch	Cost per cwt.	Cost per ranch
	cwt.	------- $	-------	cwt.	------- $	-------	cwt.	------- $	-------
Small cow-calf	284.71	39.99	11,386	326.30	41.58	13,568	260.41	60.36	15,718
Medium cow-calf	962.62	32.11	30,910	678.94	52.03	35,325	709.25	57.27	40,619
Large cow-calf	1,196.58	52.17	62,426	1,043.57	60.98	63,637	1,053.44	65.19	68,674
Small yearling	673.60	33.58	22,619	691.40	41.83	28,921	475.60	51.01	24,260
Large yearling	2,116.40	38.41	81,291	1,414.00	63.42	89.676	918.80	86.60	79.568

[a]Costs deflated to 1978 prices with 1978 = 207 of the 1969 base year.

terprises. Yearling cattle have higher gains per acre and there are fewer management problems with yearlings than with cows, which may be calving and lactating as well as being bred during the pasturage season.

4. To some degree, the same situation occurs during periods of unfavorable prices. If prices appear to be unfavorable (high purchase price for calves and low selling price for yearlings) ranchers with yearling enterprises may delay stocking with calves. On the other hand, the consequences of a wrong guess are more serious on yearling ranches because of the larger amounts of capital involved. Further, the operator of a yearling enterprise has to contend with two prices, the price he pays for calves and the price he receives for yearlings, both of which may vary widely from year to year. The price risk is probably much higher for the yearling than for the cow-calf enterprises.

Tables 5 and 6 contain the results of the analysis. In general, probabilities of profit[5] among cow-calf ranches were largest on large cow-calf ranches and smallest on small cow-calf ranches, regardless of price or producing conditions. Even with low prices in a drought situation, the probability of profit, albeit small, existed on large ranches. On the other hand, there was almost no probability of profit on small ranches during low price periods, regardless of conditions. Probabilities of profit were very high on large cow-calf ranches if prices were high, regardless of producing conditions, and probabilities were very low on these ranches with low prices, also regardless of producing conditions. Differences between large and medium-size ranches were minor except for the condition of average prices during average and drought situations. Profit probabilities were high on small cow-calf ranches only when high prices

[5]Profit was defined as receipts exceeding production costs. Production costs were the sum of operating expenses and depreciation.

TABLE 5. Percent Probabilities of Profit on Small, Medium, and Large Cow-Calf Ranches in New Mexico

Price Situation		Small Cow-Calf		
		Production Cost With Conditions:		
		Above average	Average	Drought
Condition	Price per hundredweight	$11,386	$13,568	$15,718
		(Percentage probability of profit)		
High prices	$77.52	87.24	78.84	68.04
Average prices	$35.21	16.46	4.29	0.72
Low prices	$22.29	0.06	0	0
		Medium Cow-Calf		
Price Situation		Production Cost With Conditions:		
		Above average	Average	Drought
Condition	Price per hundredweight	$30,910	$35,325	$40,619
		(Percentage probability of profit)		
High prices	$77.52	93.49	90.77	86.49
Average prices	$35.21	47.66	31.92	16.77
Low prices	$22.29	4.20	0.87	0.08
		Large Cow-Calf		
Price Situation		Production Cost With Conditions:		
		Above average	Average	Drought
Condition	Price per hundredweight	$62,426	$63,637	$68,674
		(Percentage probability of profit)		
High prices	$77.52	94.06	93.73	92.19
Average prices	$35.21	44.46	42.09	32.60
Low prices	$22.29	2.60	2.07	0.74

were received and producing conditions were above average or at least average. During drought the chances of receipts exceeding production costs, even with high prices, were only about two out of three (68 percent probability).

On ranches with yearling cattle enterprises, profit probabilities were higher on small ranches than on large ranches. This occurred because ranches with large yearling enterprises tended to have secondary cow-calf enterprises. At any rate, profit probabilities were very high on both sizes of ranches with yearling enterprises when prices received were high. One feature of yearling enterprise profitabilities is the tendency for the percentage to be lower for average producing conditions than for drought conditions. Two situations are responsible for this tendency. Ranchers with yearling enterprises normally reduce numbers and production costs during drought. Avoiding a loss is as important a feature in profitability as making a gain. Secondly, during drought periods, larger numbers of calves are marketed, usually at lower than normal prices. As buyers, operators of yearling enterprises are in a position to buy low and sell at average or above average prices. They usually have more favorable price margins in drought periods than in average periods.

Neither size of yearling enterprises had

TABLE 6. Profitability of Small and Large Yearling Ranches in New Mexico

Price Situation		Small Yearling		
		Production Cost With Conditions:		
Condition	Price per hundredweight	Above average	Average	Drought
		$22,619	$28,921	$24,260
		(Percentage probability of profit)		
High prices	$78.00	97.45	94.37	96.83
Average prices	$44.50	83.30	62.81	78.81
Low prices	$21.98	8.30	0.37	4.25
		Large Yearling		
Price Situation		Production Cost With Conditions:		
Condition	Price per hundredweight	Above average	Average	Drought
		$81,291	$89,676	$79,568
		(Percentage probability of profit)		
High prices	$78.00	91.96	89.32	92.44
Average prices	$44.50	59.62	48.61	61.82
Low prices	$21.98	0.58	0.10	0.81

percent probabilities of profit that were much above zero when prices received were low, regardless of producing conditions. This was the case except for small enterprises during above average conditions. At average prices, chances of profit were about 50-50 on ranches with large enterprises and average conditions. For small enterprises it was about 60-40.

When cow-calf enterprises were compared to yearling cattle enterprises, percent probabilities of profit were much higher on small yearling enterprises than either small or medium-size cow-calf enterprises when prices received were average or higher. There was not much difference in percent profit probabilities for large enterprises except during the condition of average prices during drought. Percentages were almost twice as high on ranches with yearling enterprises.

Conclusions

Yearling enterprises had higher profit probabilities than cow-calf ranches in northeastern New Mexico, based on data for the 1965-78 period.

Prices received per hundredweight of animals sold had more influence on profit probabilities than drought, average and above average producing conditions.

Based on the Shapiro-Wilk test, there is no evidence of non-normality in the yield data. Once the yield data have been shown to be normally distributed, the normal curve techniques demonstrated in this paper offer a relatively quick and easy procedure to determine percentage probabilities for alternative cattle enterprises, prices and weather conditions.

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