An Improved Procedure for Evaluating
Alternative Farm Sizes*

by

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Abstract

The methodology used in existing farm size studies fails to explicitly consider such factors as time, uncertianty, alternative financial arrangements, income taxes, changing land prices, increasing input costs and year-to-year net cash flows. A procedure that incorporates these factors is described and demonstrated in this paper.

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Questions concerning optimum farm size have received attention from agricultural economists for many years. Heady, Johnson and Hardin held a conference in the late 1950's on "Resource Productivity, Returns to Scale, and Farm Size," to review the state of the art in farm size studies. This conference spawned several studies pertaining to farm size during the 1960's and in 1971 Ball and Heady sponsored a second conference on farm size. Much of the recent interest regarding farm size by agricultural economists has been prompted by the controversy surrounding enforcement of the 160 acre limitation in the Reclamation Act of 1902 (e.g., Hall and LeVeen, Luft and Guenthner, USDA, and Hall and Young).

The methodology used in farm size studies has not changed appreciably over the years despite advances in the areas of farm management and quantitative analysis. The cost of production generally is obtained through surveys, or generated using engineering and/or census data. These costs are then used to develop static long-run average or unit cost curves. From these curves, inferences are made regarding optimal farm size with respect to costs and efficiency of resource use.

One of the major problems with the cost curve methodology is that it ignores the dynamic problems of operating a farm. In addition to being static, the methodology fails to incorporate uncertainty. As a result, the studies have been unable to address the key question concerning farm size, namely, "Which farm size is most likely to survive and which size is most likely to fail?" (Raup 1969). The need to incorporate uncertainty in farm size studies has been pointed out by several researchers

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Several farm simulation models are currently available that could be modified and used to analyze alternative farm sizes. The simulation model used in the analysis below is a modified version of the Capital Investment Simulation Model.[1/] This particular farm simulation model was selected because it is capable of simulating the annual production, marketing and financial activities of a farm over a multiple year planning horizon.

To incorporate the uncertainty a farmer faces in his production acctivities, the model draws random values for stochastic variables, such as crop yields and water allotments. Uncertainties associated with the marketing activities of a farm can be incorporated by drawing random values for crop prices and other stochastic variables affecting the marketing process. The simualtion model calculates annual values for the financial accounts of a farm, including income taxes.

Annual net cash flow shortages are met by drawing on the farm's cash reserves and if necessary by obtaining a second mortgage on the farm's assets. A farm is declared insolvent if it is unable to meet annual net cash flow deficits by borrowing against its equity in land and machinery. The credit worthiness of a farm is determined each year of the analysis, based on the calculated ratio of equity to assets (or equity ratio). If a farm has a long term equity ratio less than 20 percent it is considered unworthy for additional credit and declared insolvent.

The second step of the procedure calls for developing an annual crop plan generator. The problem is to determine the levels of the enterprises for the next year of the planning horizon, based on expected prices and yields. A linear programming (LP) model was used to select annual crop plans for the analyses below; however, other methods can be used (e.g., a system of supply response equations). The LP model used for this analysis determines acreage levels annually, based on revised price and yield expectations in a Nerlove adaptive expectations framework. The procedure has been used previously by Fisher and Tanner, and Condra.

The third step in the procedure is the application of the simulation model. Input data for the model can be obtained from farmer surveys, engineering studies and secondary data. The length of the planning horizon used in the analysis depends upon the type of farm to be analyzed. (Ten years may be sufficient for a crop farm, while a cow-calf operation may need to be analyzed over a 15 year period.) The number of iterations required for the analysis can range from 100 to 500, depending upon how many stochastic variables are in the model.

The final step in the procedure is evaluation of the simulation results. On an annual basis the procedure generates data necessary to calculate experimental probability density functions (pdf's) for the endogenous variables in the model, such as: cash receipts, production costs, income taxes, interest paid, depreciation, ending year net cash flows, assets, liabilities, net worth, equity ratio and cropping patterns. The probable profitability of the different farm sizes can be compared for each year of the planning horizon using the pdf's.

In addition to providing information for estimating the annual pdf's, the model provides several summary statistics for each farm size. One of which is a cumulative probability distribution (cpd) showing the probability of a given farm remaining solvent or surviving. In general, as the planning horizon progresses from year 1 to, say, year 10 the probability of survival decreases. By comparing the cpd for different farm sizes one can determine which farm has the best chance of survival over a given planning horizon. A second summary statistic is net present value. By comparing the net present value cdf's across different farm sizes, one can determine which farm size offers a reasonable chance of returning the owner a rate of return at least equal to the discount rate.

After identifying those farm sizes that are likely to survive and provide a reasonable chance of returning a minimum of return to owner equity, the researcher can determine which farm size is most efficient. Efficiency can be measured in terms of expected output over a multiple year planning horizon per unit of input (acres, man hours, etc.). In addition, the expected long-run average cost curve can be estimated from the simulation results.

An Application of the Procedure

Four alternative farm sizes are evaluated to demonstrate the procedure described above.[2/] The farm sizes evaluated are: 160 acres, 320 acres, 640 acres and 960 acres. Data to describe the representative farms were developed from both primary and secondary sources. Farmers in El Paso County, Texas were surveyed to obtain (a) typical machinery complements, (c) market values of farmland and buildings, and (c) values of other depreciable assets. Farm survey data also were used with engineering data to verify production costs in published budgets for the area.[3/] Additional data were developed from interviews with the Bureau of Reclamation, the Texas Department of Water Resources, local lenders, and Extension specialists.

The simulation model described above was used to analyze each of the four farm sizes over a 10 year planning horizon. The model was replicated 100 times. Uncertainty facing farmers in the study area was incorporated by drawing stochastic values for crop prices and yields, and water allotments. Water allotments were selected at random from an empirical distribution of historical water allotments. Crop prices and yields were drawn at random from empirical distributions developed from current average yields and prices and deviations from trend over the 1965-1977 period.

The probable economic success or failure of the four different farm sizes, assuming an owner/operator form of land tenure and a beginning equity level of 50 percent is presented here. The results of the analysis for a representative 160 acre farm in El Paso County suggest that the farm would not produce sufficient net income to maintain a family, without substantial off-farm income. Simulated values for net cash income after taxes indicate that the farm would have an average annual net cash flow of about -$44,000 in the first two years, and significantly larger deficits in the remaining years (Table 1). The farm's average net worth would decrease each year of the planning horizon, from $193,000 in year 1 to about $30,000 in year 10, due to the need to meet annual net cash flow deficits by refinancing the farm's assets. An indication of the farm's increasing debt load, is the change in the debt to asset ratio, for the 160 acre farm; on the average, it increases from 0.54 in year 1 to 0.96 in year 10.

Average annual net cash flow deficits, ranging from -$79,000 to -$140,000, indicate that a 320 acre farm would have to depend upon outside financing to meet its average annual cash expenses and family living expenses (Table 1). As a result, the firm's average debt to asset ratio increases from 0.53 in year 1 to 0.83 in year 10.

The results for a representative 640 acre farm suggest that the farm also would have annual net cash flow deficits (-$129,000 to -$202,000) on the average. However, the farm's beginning net worth is sufficiently large to prevent the farm from being declared insolvent. The average debt to asset ratio for the 640 acre farm is 0.52 in year 1 and 0.67 in year 10. The simulation results for a representative 960 acre farm indicate that on the average, the farm would experience annual net cash flow deficits of about -$165,000. Like the 640 acre farm, the 960 acre farm's need for outside capital does not jeopardize the farm's solvency, since the annual appreciation of its assets exceeds its average deficits in most all years. The average ratio of debts to equity is less than 0.53 in all 10 years of the analysis so the farm does not face insolvency.

Table I. Simulated Annual Net Cash Income After Taxes for Four Representative Farm Sizes in El Paso County, Texas, Assuming an Initial Equity of 50 Percent and Full Ownership.

Year	Average Net Cash Income After Taxes			
	160 acre	320 acre	640 acre	960 acre
	(Nominal $)			
Year 1	-44,149.	-79,792.	-129,120.	-167,123.
Year 2	-44,850.	-79,898.	-127,054.	-147,512.
Year 3	-52,158.	-93,127.	-149,401.	-170,508.
Year 4	-59,964.	-107,261.	-170,487.	-187,888.
Year 5	-68,454.	-122,686.	-194,866.	-211,367.
Year 6	-62,814.	-106,156.	-156,775.	-146,240.
Year 7	-69,352.	-116,351.	-170,326.	-151,919.
Year 8	-75,659.	-125,613.	-181,531.	-158,609.
Year 9	-85,436.	-141,327.	-202,256.	-171,209.
Year 10	-87,622.	-141,338.	-199,727.	-151,080.

Probabilities of economic survival (solvency) for the representative farms were calculated based on the simulation results. These probabilites are summarized in Table 2. The probability that a 160 acre farm would survive (i.e., remain solvent) for 4 years is about 57 percent; however, the same farm has only a 5 percent chance of surviving for 7 years, and only a 1 percent chance of surviving for 10 years. On the other hand, a 640 acre farm with the same level of beginning equity has a 100 percent chance of surviving for 5 years and an 88 percent chance of surviving for 10 years.

Figure 1 presents a graph of the cummulative distributions of net present value for each of the four representative farms. The vertical axis in Figure 1 is the probability associated with a given level of net present value, for example the probability of observing a net present value of -$560,000 or less on a 640 acre farm is about 20 percent. If a net present value is less than zero it implies that the investment is not an economic success, i.e., it does not provide the investor a rate of return at least equal to the discount rate (7.5 percent). The results indicate that the 960 acre farm is the only farm size that provides a chance of being economically successful. The study indicates that the 960 acre farm offers only about a 44 percent chance.

The results of this study indicate that the 640 acre and 960 acre farms are the only farm sizes that will have a reasonable chance of surviving over the next 10 years. The 960 acre farm is the only farm size that offers a chance of returning at least a 7.5 percent return on equity to the owner/operator. The smaller farms (160 and 320 acres) in the study

Table 2. Probability of Economic Survival for a Given Number of Years, for Alternative Representative Owner/Operator Farms with a Beginning Equity Level of 50 Percent, in El Paso County, Texas.

Years	Farm Sizes in Acres			
	160	320	640	960
3	1.00	1.00	1.00	1.00
4	.57	0.93	1.00	1.00
5	.18	0.71	1.00	1.00
6	.17	0.53	.99	1.00
7	.05	0.32	.98	1.00
8	0.02	0.20	.94	1.00
9	0.01	0.17	.90	1.00
10	0.01	0.14	.88	1.00

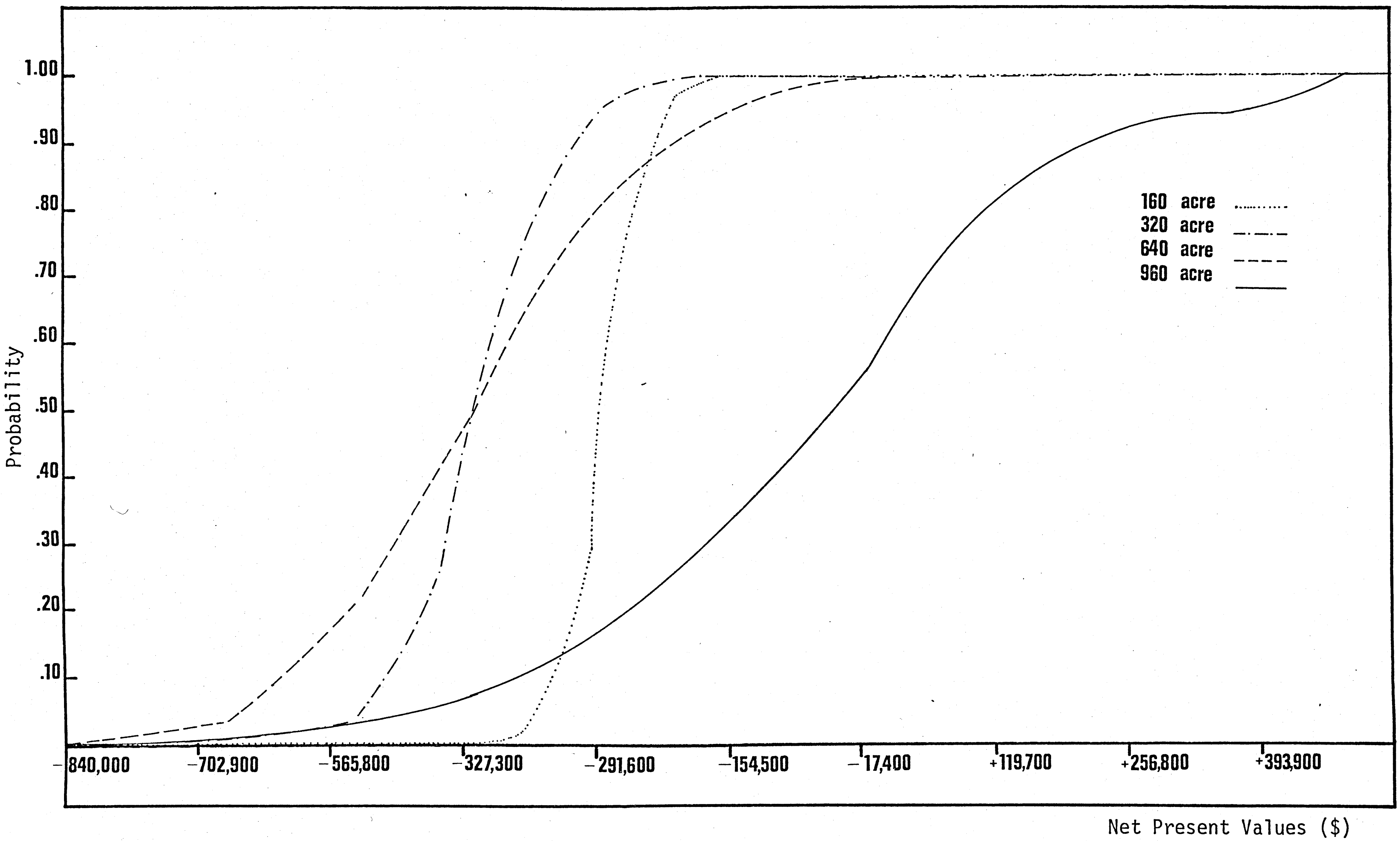

Figure 1. Cummulative Distributions of Net Present Values for Alternative Farm Sizes.

area will have to depend on off-farm income or accept a lower rate of return to land and management than assumed for this study, if they are to survive in the future. (Additional analysis showed that small farms of 160 and 320 acres in the study area will have a reasonable chance of remaining solvent if their current equity levels are 100 percent.)

The study indicates that the 640 acre and 960 acre farms provide a good chance of surviving despite high levels of net cash flow deficits for these farm sizes. The reason being that these farm sizes are able to meet their annual deficits by refinancing the farmland since annual increases in the value of farmland exceed annual net cash flow deficits. The smaller farm sizes (160 and 320 acres) are not able to take full advantage of this because their annual deficits exceed the annual increases in land values.

An average unit cost curve was developed for the four farm sizes analyzed in this paper. The annual average cash receipts for each farm size were divided by annual average costs for the respective farm size, using the simulation results for years 1 and 2. The resulting average unit cost curves indicated that the 960 acre farm was the most efficient farm size in the study area; however, the average unit cost for this farm size was greater than one. These results would suggest that the most efficient farm size in the study area is larger than 960 acres.

FOOTNOTES

1/ The farm simulation model used for this study was developed at Oklahoma State University by Hardin for evaluation of alternative financial investments under conditions of uncertainty. Modifications to the model were made by the authors to impliment the procedure presented in this paper.

2/ For a more detailed description of the results and input data used here see Richardson, et al.

3/ Data needs for the model and a copy of the input data for the analysis presented here is available from the authors.

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