FINANCIAL ANALYSIS OF ON-FARM GRAIN DRYING

Clyde Kiker and Mark Lieblich

Abstract

Artificial drying of corn in the Southeastern Coastal Plain was shown to be financially feasible for average annual per farm production levels of greater than 10,000 bushels. Net present values for four types of drying systems were evaluated using simulation modeling in which weather conditions, yield levels, and prices were entered as stochastic variables. Scale of production and irrigation substantially influenced crop drying potential. Stochastic efficiency analysis was used to evaluate the riskiness of the investment.

Key words: crop drying, risk, simulation, financial analysis.

The hot, humid climate of the Southeastern Coastal Plain (SCP) creates conditions at harvest time that differ substantially from those of the Corn Belt. Field drying of corn exposes the crop to damage from weather, diseases, and insects. Also, to benefit from a higher, early-season price, the corn must be harvested at high moisture and artificially dried to prevent in-storage spoilage. With an early harvest, the farmer either has to have drying equipment available or sell relatively wet corn immediately after harvesting at a discounted price. The price discount for selling wet corn can be severe and from a practical perspective, the farmer will either continue field drying or use on-farm artificial drying.[1] The question facing the corn farmer is, "under what conditions is it reasonable to invest in drying equipment and thereby expand the alternative strategies available at harvest time?"

Numerous studies have addressed the evaluation of drying equipment purchases. Bridges et al. (1979a and b) utilized nonstochastic simulation models to aid in the selection of least cost drying systems. Loewer et al. (1979 and 1980) developed a simulation model (also nonstochastic) and approximated the optimal selection of drying facilities for static physical and economic settings. Penson and McCarl included stochastic elements such as weather conditions and harvest time in their analysis of midwestern country grain elevators, but these had much greater capacity (1.0 and 1.5 million bushels per year were dried) than the production of typical SCP farms. Klemme in an analysis of midwestern on-farm grain handling facilities found a positive gain. Hewitt and Schwart and Hill have provided publications detailing equipment, fixed, and operating costs for a variety of drying and storage systems. While previous studies in other regions are useful in appraising the potential of on-farm crop drying, they do not provide the specific quantitative information needed to assist SCP corn producers in the decision to invest in artificial drying equipment or continue field drying.

The purpose of this paper is to evaluate the profitability and risk of investment in on-farm drying systems under conditions that occur in association with corn production in the SCP. Allowing for the diversity of conditions under which the uncertain investment may occur permits examination of technical economies of scale and the influence of irrigation.

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[1] The typical moisture discount in North Florida and South Georgia is based on a reduction of 2 percent of total weight per percent of moisture content dry basis. For $3.00 per bushel corn (15.5 percent dry basis), the price discount is approximately 4 cents per bushel per percent moisture content dry basis. Marketing 26 percent corn immediately after harvesting would result in a 40 cent per bushel reduction in price.

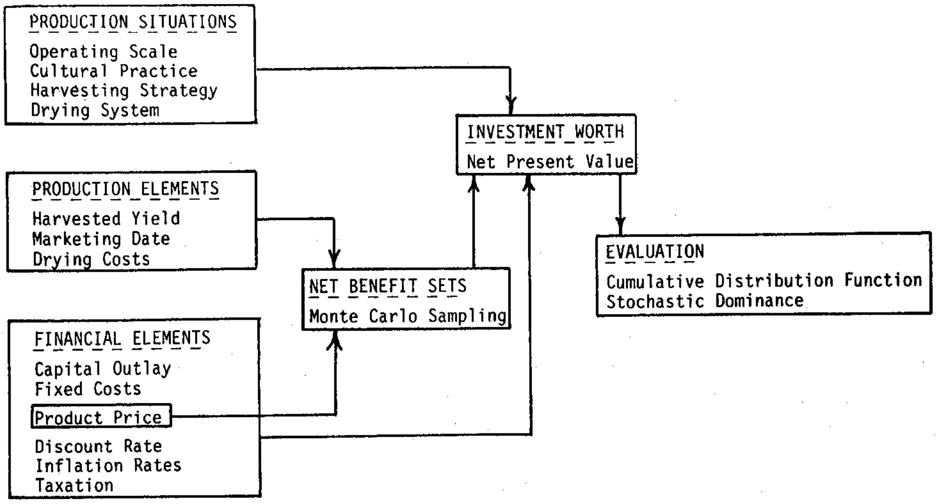

Figure 1. Components of the Simulation Model Used to Appraise the Financial Potential of Corn Drying Systems.

METHODOLOGY

A field corn producer who wishes to evaluate the investment potential of drying equipment needs to consider certain aspects of the production operation. Scale of the operation and certain cultural practices (especially irrigation in the SCP) will have substantial influence on the profitability of the investment. The operating scale is important because certain types of drying equipment are available in only discrete capacities. That is, a small scale operation may have to use equipment with a capacity more suited to larger scale operations. The result is a higher investment outlay per bushel of production.

Irrigation enters the consideration by bringing about increased expected yields with decreased variability among years and thus, better utilization of drying equipment. In addition to the effects on yields, irrigation allows an expanded range of possible planting dates compared to dryland production. Earlier planting, in conjunction with earlier harvesting made possible by drying equipment, allows marketing earlier in the season when prices are likely to be higher.

The problem is essentially one of capital budgeting. Artificial drying gives the corn producer an opportunity to increase net revenue by lowering field losses, selling at higher earlier season prices, and avoiding discounts due to moisture content above the standard. However, to have the advantages of artificial drying, capital must be invested. Formulating the problem in a manner which allows determination of net present value (NPV) serves to provide a measure of the investment's worth and permits comparisons of investment alternatives. A partial budgeting procedure is used in which the present values "with" and "without" the drying system investment were used in calculating the NPV.

The NPV of an artificial drying system, however, is influenced by variable weather conditions and prices. Weather conditions translate into yield and harvest date variability while corn prices vary between and within years. The result is introduction of uncertainty. A Monte Carlo simulation methodology was used in conjuntion with stochastic efficiency analysis to deal with the uncertainty.

MODEL

Simulation methodology was used to evaluate the worth of the investment under various influences occurring in North Florida which are typical of much of the SCP (Figure 1 is a diagram of the model used.). Incorporated into the analysis are four factors identified by Morey et al. as having a major impact on the corn harvesting strategy: (1) recoverable yield which decreases with time once maturity is reached; (2) average moisture content which generally decreases after maturity; (3) weather conditions which are stochastic; and (4) price of corn which varies over the harvesting period and across years. North Florida weather is such that plant growth and field drying conditions cause yields to vary within and between years. Similarly, prices vary within and between years. Influences of recoverable yield, drying conditions, and crop prices were incorporated through probability distributions for weather and prices. Cash flows were determined and used to calculate net present values once various financial parameters were specified. The results were sets of NPVs for each potential investment which were arranged as cumulative distribution functions (CDFs). With the CDFs, stochastic dominance was used to evaluate the riskiness of the investment (Anderson et al.).

Calculations involved determining incremental cash flows for each year of the investment's economic life. The NPV for the investment was determined by contrasting the present value of the artificial drying system (within which harvesting occurs at 26 percent moisture dry basis) with the present value of the currently used field drying system (within which harvesting occurs at 15.5 percent moisture dry basis). The specific expression used was:

$$(1)\ NPV = -(IO) + \frac{(IC)}{(1+R)\bullet(1+H)} + \sum_{t=1}^{5} \frac{(MT)\bullet(D_t)}{(1+R)^t \bullet (1+H)^t} + \sum_{t=1}^{10} \frac{(1-MT)\bullet(S_t)}{(1+R)^t \bullet (1+H)^t} - \frac{(I5)}{(1+R)^5} + \frac{(1-MT)\bullet(SV)}{(1+R)^{10}},$$

where:

NPV = net present value of the investment in dollars;

IO = net initial investment outlay in dollars;

IC = investment tax credit received in year 1 in dollars;

R = real discount rate;

H = general inflation rate;

MT = marginal tax rate;

D_t = depreciation for tax purposes in nominal dollars;

I5 = investment outlay for replacement of moisture testing equipment in year 5 in real dollars;[2]

SV = salvage of the equipment in year 10 in real dollars; and

S_t = pretax incremental cashflow in year t resulting from the drying equipment investment expressed in nominal dollars.

The pretax incremental cashflow in nominal dollars for each year, S_t, was represented as:

$$(2)\ S_t = [(PE_t)\bullet(1+PI)^t \bullet (QE_t)] - [(CA_t)\bullet(1+H)^t] - [(PL_t)\bullet(1+PI)^t\bullet(QL_t)],$$

where:

PE_t = price of corn in dollars per bushel when harvested early in year t, a stochastic variable;

PI = nominal product price inflator;

QE_t = total marketable yield obtained under the early harvesting and artificial drying strategy at a 15.5 percent moisture equivalent for year t, in bushels, a stochastic variable;

PL_t = price of corn in dollars per bushel when harvested late in year t, a stochastic variable;

QL_t = total marketable yield obtained under the field drying and late harvesting strategy at a 15.5 percent moisture equivalent for year t, a stochastic variable; and

CA_t = cost of artificial drying in real dollars for year t.

The cost of drying each year was represented as:

$$(3)\ CA_t = [(IR)\bullet(IO)] + [(SU)\bullet(WG)] + \left[\frac{(WG)\bullet(HO)\bullet(QE_t)}{(BU)}\right] + [(LP)\bullet(GU)\bullet(QE_t)] + [(EL)\bullet(EU)\bullet QE_t)],$$

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[2] It is possible under future tax law that the replacement moisture meter will still qualify for a tax credit and depreciation allowance. This case was not included in the NPV calculation because (a) it is not clear what the tax law will be at the time of replacement and (b) including it adds more complexity in the calculations without a gain of information useful in the decision analysis (the present value of the tax credit and depreciation is less than $100 and does not change the investment decision).

where:

IR = yearly charge for insurance and repairs as a percent of the initial investment outlay;
SU = fixed amount of labor for drying equipment start-up each year in hours;
WG = hourly wage rate;
HO = daily hours of labor required to operate the drying equipment;
BU = number of bushels harvested per day;
LP = cost of liquified petroleum gas;
GU = gallons of liquified petroleum gas required to remove 10 percentage points of moisture from a bushel of corn;
EL = cost of electricity; and
EU = number of kilowatt hours used by the system to remove 10 percentage points of moisture from a bushel of corn.

MODEL USE

In using the model (equation (1), (2), and (3)), a series of factors related to SCP production situations was specified. In addition to the necessary financial parameters, the scale of the corn operation was given. Scale was specified by approximate average annual production levels of 5, 10, 20, and 60 thousand bushels.[3] Dryland and irrigated production were analyzed. The planting date, specific annual yield level, and date at which the corn became marketable differed between irrigated and dryland production.[4]

As is seen in equation (2), the annual pretax incremental cashflow is a function of stochastic corn yields and prices. These were obtained in the following way. A corn growth simulation model developed by Duncan was used to generate the stochastic yield levels and the dates of harvest under dryland and irrigation production practices and for field drying and artificial drying operations. The harvest date was the date at which the grain moisture content in the field reached 26 percent for the artificial drying operation and 15.5 percent for the field drying operation. The dates thus established reflect any delay in harvest caused by weather conditions. Given these harvesting criteria, there is a 14-week interval within which the corn will be harvested and marketed. The harvest dates from the simulations were used to establish the week of marketing.

The corn growth rate, rate of drying in the field, and date of harvest are functions of weather conditions. Yield and harvest dates for a 17-year period were established using Duncan's model and 17 years (1955 to 1971) of weather conditions (daily rainfall, solar radiation, and high and low temperatures) recorded at Chipley, Florida.[5] Field, harvest, and dry matter losses were calculated following Loewer et al. (1982) and Hall (p. 204). The corn price at harvest time was established by using the date of harvest and the weekly price series for the Atlanta cash market for No. 2 field corn. Weekly corn prices for the 14-week interval within which harvest would take place were collected for the period 1975 through 1983 from the publication *Feedstuffs* . Atlanta prices were assumed to be similar to the SCP prices. The prices were adjusted to 1983 dollars through use of the GNP deflator for nondurable goods.

To reflect the effects of stochastic corn yields on the potential of investment in a drying system, a corn yield and harvest date was randomly drawn from the set of outcomes generated by the Duncan model. To reflect the effects of stochastic corn prices on the investment potential, a price-year was randomly drawn from the 10-price years and the previously determined harvest date was then used to establish the appropriate weekly price within the price-year. Yield values and prices were used in equation (2) to obtain the pretax cashflow for the crop-year. The random draw procedure was used repeatedly to

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[3] The scales were defined by potential output levels because this allowed ready specification of the drying equipment. Two primary sources of information were used to select the operating scales. Information regarding the adoption of drying equipment by farms of various scales was collected from research and extension personnel in nine SCP states. Information on comparative costs of drying corn was obtained from Schwart and Hill.

[4] Irrigated field corn production is represented by a strategy with a planting date of March 1, a planting density of 29,000 plants per acre, and an irrigation schedule of applying one acre-inch of water when the soil moisture content falls below 65 percent of its moisture-holding capacity. Dryland field corn production is represented by a strategy with a planting date of April 15 and a planting density of 15,000 plants per acre.

[5] The data were from HISARS. The time period, data, and Duncan's model were the same as used by Boggess and Amerling in the appraisal of irrigation investments on SCP farms. Tew also used Duncan's model in a study of irrigation scheduling in the Georgia Plain, but used a different data set. Studies in Kentucky have also used Duncan's model (Barfield et al.; Palmer et al., 1981 and 1982).

establish 100 10-year sets of pretax incremental cashflows associated with the two drying strategies.

Talbot and Hewitt have identified the four most popular types of drying systems for use on Florida farms: batch-in-bin, batch-in-bin with a stirring auger, automatic batch, and continuous flow. The drying system design and its costs include all equipment required to upgrade the holding and handling system used with field drying to a system incorporating artificial drying. The designs and costs are modifications of those presented by Schwart and Hill. Table 1 lists equipment and costs (IO) for the systems. Equipment assumed available from the field drying option is the difference between the equipment listed by Schwart and Hill and that listed in Table 1.

A 6 percent real discount rate (R) was used along with an overall inflation rate (H) of 3.4 percent (U. S. Bureau of Economic Analysis) giving a nominal discount rate equivalent to 9.604 percent. A marginal tax rate (MT) of 30 percent was levied upon each year's net revenues. The investment tax credit (IC) in the first year was calculated at 10 percent of the initial outlay. The salvage value of the equipment (SV) at the end of the economic life, in real dollars, was calculated at 10 percent of the initial outlay. Depreciation was calculated using the straight line method over a 5-year period (i.e., $D_t = 0.95(IO)/5$; IRS, *Farmers Tax Guide*). Following Schwart and Hill, an economic life of 10 years was chosen for the investment analysis. Some moisture drying equipment (I5), costing $381, was replaced after 5 years. Overall insurance and repairs were set at 3.3 percent of initial equipment costs (Schwart and Hill).

While fluctuations in corn prices over time were reflected using the random draw procedure, it was desirable to reflect the effects of inflation resulting from broad economic influences. To do this, the corn prices expressed in 1983 dollars were inflated at 3.6 percent per year (PI), a value based upon a 9-year (1973-1982) rate of change in farm product prices (U. S. Bureau of the Census). Prices of $0.887 per gallon for LP gas and $0.07023 per kwh of electricity, which are typical in the region, were used. The charge for labor was $4.50 per hour.

With the exception of corn prices, all prices increased at the overall inflation rate for the economy. The discounting procedure results in NPVs in current dollars.

The final results for the Monte Carlo simulations were sets of 100 NPVs for various investment possibilities. The drawing sequences used to obtain 100 10-year sets of pretax cashflows used in calculating the NPVs was held constant for all of the investment possibilities.

TABLE 1. CAPITAL OUTLAYS FOR DRYING SYSTEMS DESIGNED FOR FOUR SCALES OF CORN PRODUCTION, NORTH FLORIDA

	Production scale			
Equipment	5,000 bu.	10,000 bu.	20,000 bu.	60,000 bu.
	dollars			
Batch-in-bin system:				
Bins and unloading equipment	8,951	8,951	12,318	30,100
Erection cost	1,075	1,075	1,327	3,242
Concrete work	1,692	1,692	2,258	5,964
Fans, heater, and vaporizer	3,880	3,880	5,303	10,606
Augers	0	2,394	3,318	7,980
Moisture meter	381	381	381	381
Sampling equipment	118	118	118	118
Outlay	16,097	18,491	25,023	58,391
Stirring batch-in-bin system:				
Bins and unloading equipment	8,211	8,211	8,211	12,999
Erection cost	974	974	974	1,378
Concrete work	1,378	1,378	1,378	2,258
Fans, heater, and vaporizer	3,445	3,445	3,445	
Stirring equipment	3,184	3,184	3,184	4,667
Moisture meter	381	381	381	381
Sampling equipment	118	118	118	118
Outlay	17,691	20,085	21,009	31,094
Continuous flow system:				
Dryer	22,305	22,305	22,305	32,150
Moisture meter	381	381	381	381
Sampling equipment	118	118	118	118
Outlay	22,804	22,804	22,804	32,649
Automatic batch system:				
Dryer	16,551	16,551	16,551	33,855
Augers	2,394	2,394	2,394	2,394
Moisture meter	381	381	381	381
Sampling equipment	118	118	118	118
Outlay	19,444	19,444	19,444	36,748

Sources: Schwart, 1982; Schwart and Hill, 1977.

TABLE 2. VALUE OF THE PHYSICAL PARAMETERS OF THE FOUR CORN DRYING SYSTEMS

Physical parameter[a]	Drying system Batch-in-bin	Stirring batch-in-bin	Automatic batch	Continuous flow
LP gas requirement, GU	0.165	0.165	0.21	0.165
Electrical energy requirement, EU	0.15	0.106	0.113	0.106
Start-up labor requirement, SU	10.0	10.0	3.0	3.0
Daily labor requirement, HO	3.0	3.0	13.0	13.0
Insurance-repair cost factor, IR	0.033	0.033	0.033	0.033
Harvest rate, BU	1,460	1,460	1,460	4,380

[a] See the list of variables in the text for a more complete specification of units.
Sources: Schwart, 1982; Schwart and Hill, 1977.

Decision Rule

Stochastic efficiency was the criterion used to determine the feasibility of the investment under the various scales and cultural practices. Following Anderson et al., the 100 NPVs were plotted as cumulative probability distributions (CDFs). The CDFs illustrate the range of NPVs for each investment and the cumulative probability associated with the NPV. The rule for determining the efficient investment choice is the first degree stochastic dominance rule and is predicated upon the idea that the decisionmaker prefers more to less profit. The rule provides that the probability of receiving a NPV greater than or equal to a given value will always be higher for the dominating investment (Anderson et al.).[6]

RESULTS

Results of the Monte Carlo simulations are presented in figures 2 to 4 and Table 3 for the various operating scales and cultural practices. The curves present the probabilistic worth, in present value terms, of the purchase and use of drying equipment with an early harvest strategy, as opposed to continued field drying and late harvest, during a projected 10-year period. The results provide no information regarding the overall profitability of producing corn. Results are presented for the profitability and risk of the investment in four types of drying systems within three dryland and four irrigated operating scales.

Figure 2 contains the CDFs for investment by the dryland operation for the 5, 10, and 20 thousand bushel per year operating scales.[7]

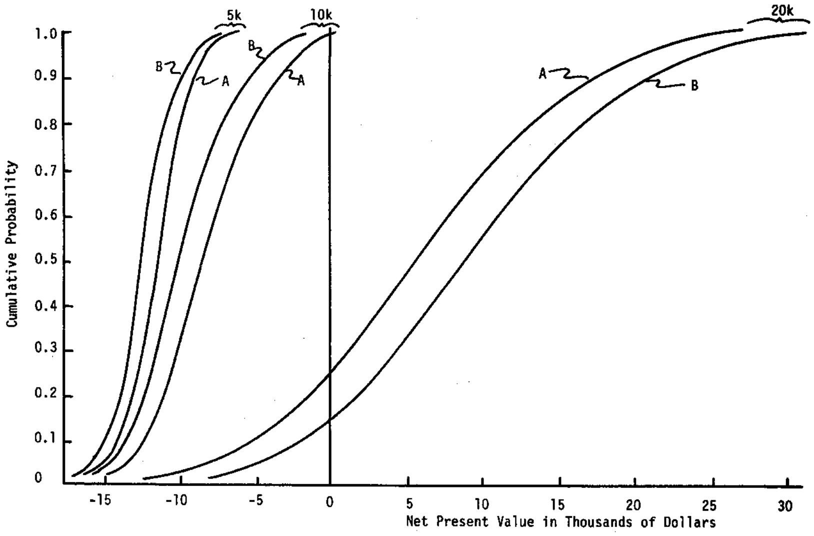

Figure 2. Net Present Value of Investment Expressed as Cumulative Probability Distributions for Batch-in-Bin (A) and Stirred Batch-in-Bin (B) Drying Systems on Farms Using Dryland Cultural Practices and Having Average Annual Operating Scales of 5, 10 and 20 Thousand Bushels.

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[6] A first degree stochastically dominant CDF must lie nowhere to the left of a dominated curve (Anderson et al., p. 282).

[7] The 60,000 bushel per year operating scale was not analyzed for the dryland cultural practices because the implied farm size would be extraordinary for the SCP.

Only the batch-in-bin (A curves) and batch-in-bin with stirring (B curves) are presented since these systems always dominated the automatic batch and continuous flow systems. For the 5 and 10 thousand bushel operating scale, each of the four investments in drying systems result in a net loss for the dryland operation, Table 3. The probability of the investment providing a NPV greater than that for continued field drying and late harvesting is essentially zero.

The third dryland operating scale, producing an average of 20,000 bushels, showed some potential for profitable investments. The stirring batch-in-bin system investment now dominates the others by the first-degree rule and has a median NPV of $8,400, while the batch-in-bin system has a median NPV of $5,500. For this scale, all four drying systems have a probability of a positive NPV greater than 70 percent, Table 3.

Figure 3 contains the CDFs of the investment in drying systems for the 5, 10, 20, and 60 thousand bushel irrigated operations. Only the CDFs for the two batch-in-systems are given for the 5, 10, and 20 thousand bushel scales since these systems dominate the other two. At the 60,000 bushel scale, the continuous flow system is no longer dominated by the batch-in-system.

The 5,000 bushel irrigated operation shows little probability of being profitable, as did the dryland operation at the same scale. Similarly, artificial drying on the 10,000 bushel scale shows little likelihood of paying off the capital outlay. At this scale, the batch-in-bin system is best but has only a 13 percent probability of a positive NPV.

For the irrigated production operation which produces an average of 20,000 bushels, each of the four systems provides an opportunity for a profitable investment. The batch-in-bin and stirring batch-in-bin systems dominate the other two systems, but not dramatically. Table 3 shows the median NPVs to be $20,800, $17,000, $14,800, and $13,900 for the stirring batch-in-bin, the batch-in-bin, the continuous flow, and the automatic batch systems, respectively.

The irrigated operation which produces an average of 60,000 bushels provides opportunities for drying system investments which are very profitable and have minimal risk, Figure 3 and Table 3. Investment in the stirring batch-in-bin systems dominates the others by the first-degree rule and has a medium NPV of $96,000. The continuous flow drying system is now comparable to the stirring batch-in-bin system investment since it has a median NPV that is $6,000 less. The batch-

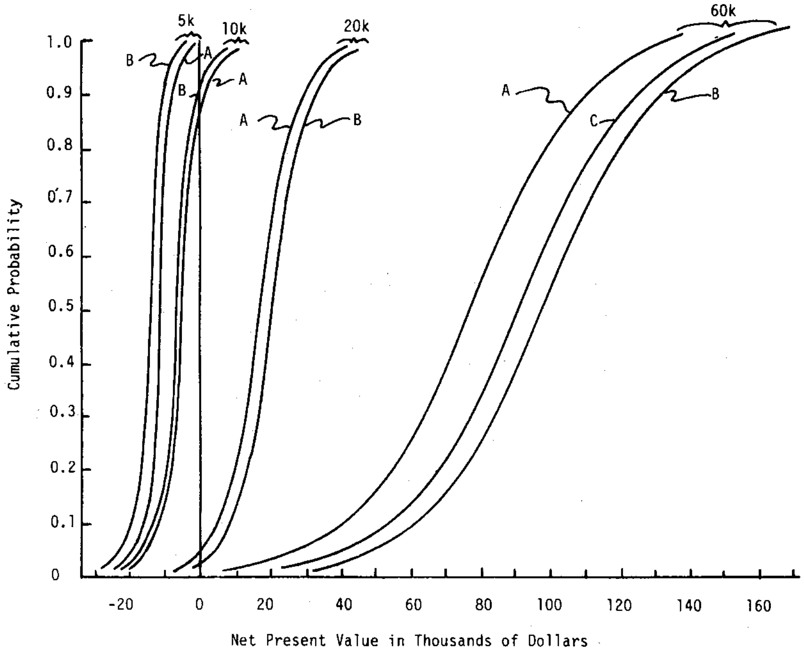

Figure 3. Net Present Value of Investment Expressed as Cumulative Probability Distributions for Batch-in-Bin (A), Stirred Batch-in-Bin (B), and Continuous Flow (C) Drying Systems on Farms Using Irrigation Cultural Practices and Having Average Annual Operating Scales of 5, 10, 20, and 60 Thousand Bushels.

TABLE 3. MEDIAN NET PRESENT VALUE AND THE PROBABILITY OF A POSITIVE NET PRESENT VALUE FOR DRYING SYSTEMS FOR ALTERNATIVE PRODUCTION SCALES FOR CORN, NORTH FLORIDA

	Production scale							
	5,000 bu.		10,000 bu.		20,000 bu.		60,000 bu.	
Drying system	Median NPV	P(NPV≥0)	Median NPV	P(NPV≥0)	Median NPV	P(NPV≥0)	Median NPV	P(NPV≥0)
	dollars	percent	dollars	percent	dollars	percent	dollars	percent
Dryland operation:								
Batch-in-bin	−11,200	0	− 8,600	2	5,500	76	N/A[a]	N/A
Stirring batch-in-bin	−12,600	0	−10,200	0	8,400	85	N/A	N/A
Automatic batch	−17,000	0	−14,000	0	3,300	72	N/A	N/A
Continuous flow	−18,000	0	−15,000	0	3,800	75	N/A	N/A
Irrigated operation:								
Batch-in-bin	−10,600	0	− 4,800	13	17,100	96	75,800	100
Stirring batch-in-bin	−12,700	0	− 6,000	9	20,800	98	96,000	100
Automatic batch	−17,000	0	−10,000	3	13,900	93	76,000	100
Continuous flow	−19,000	0	−11,200	5	14,800	95	90,000	100

[a] The 60,000 bushel per year operating scale was not analyzed for dryland cultural practices because the implied farm size would be extraordinary for the SCP.

in-bin and automatic batch drying systems clearly provide the poorer investment opportunities for the large scale operation.

Figures 2 and 3 show the effect of scale on the overall profitability of the drying system investment and the change in the system that is dominant. At the 5 and 10 thousand bushel average production levels, no drying system dominates the field drying strategy. Thus, using the first-degree rule, the decision is not to invest. At the 20,000 bushel scale, the stirring batch-in-bin system is the dominant system, although all systems show some potential. When the 60,000 bushel irrigated scale is considered, the stirred batch-in-bin is clearly dominant, although the continuous flow system is a strong second. Generally, as the production scale increases, the capital outlay is spread over a greater expected yield with the results being higher NPV.

The effect on the investment potential of using irrigation cultural practices is seen in Figure 4. At an operating scale of 5,000 bushels, there is little difference; the investment is unwise. The same is true for the 10,000 bushel production level. Investment in a drying system is profitable for both irrigation and dryland practices at the 20,000 bushel average production scale. Using irrigation and obtaining the earlier prices results in a median NPV more than twice as high as for the dryland practice. There is, however, a probability of a negative NPV, approximately 25 percent for the dryland operation and 5 percent for the irrigated operation.

CONCLUSIONS

Investment in artificial drying equipment, along with the concommitant change in harvesting strategy, has the potential to be a profitable and somewhat certain venture for some Southeastern Coastal Plain corn producers. Uncertain production and marketing conditions which may occur during the life of the investment can have a strong influence upon the value of the investment. In general, those corn operations which have average production of 10,000 bushels per year or less may find an investment in grain drying equipment difficult to justify. The capital outlay seems too great to be offset by the net revenue increases which are generated by obtaining a higher early season price and by reduced crop losses. If the components for the dominant batch-in-bin system could be obtained at a lower cost, the investment could be more favorable for the smaller operations.

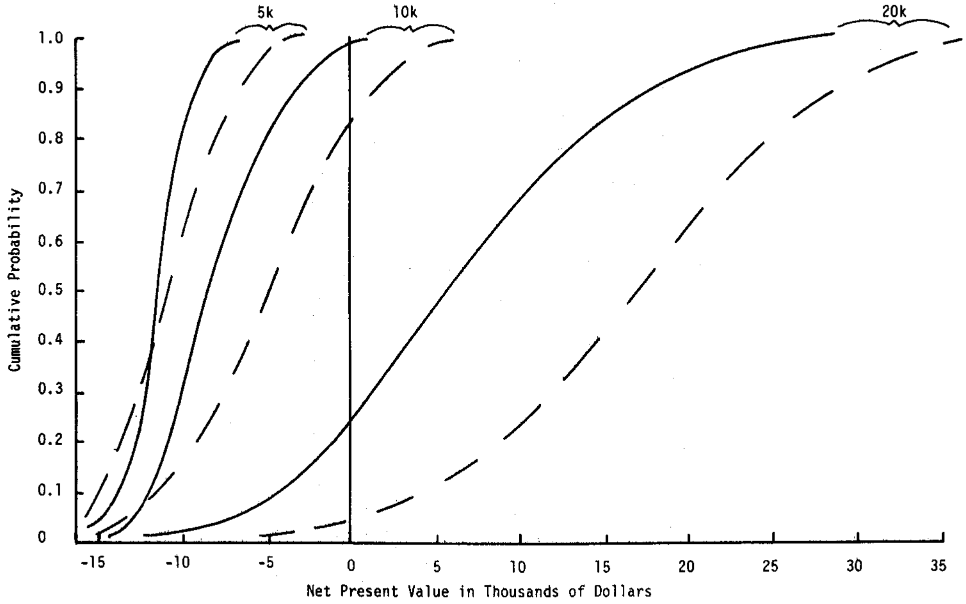

Figure 4. Net Present Value of Investment Expressed as Cumulative Probability Distributions for Batch-in-Bin Drying Systems on Farms Using Dryland (———) and Irrigation (— —) Cultural Practices and Having Average Annual Operating Scales of 5, 10, and 20 Thousand Bushels.

There is also the possibility that several farmers could join together in a cooperative arrangement and thereby use the drying equipment more effectively.

For those corn operations which have an average production of more than 10,000 bushels, the investment shows some promise of being profitable. Simulation results show the investment to have a high probability of being profitable for operations producting 20,000 or more bushels. Investment in drying systems for larger scale operations appears to provide strong returns with little risk. This is especially true for irrigated operations that can take advantage of higher early season prices.

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