LARGE SCALE CLOSED COOPERATIVE SWINE PRODUCTION UNDER UNCERTAINTY

Presented at the 1997 AAEA National Conference in

Toronto, ON Canada

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ABSTRACT

We evaluate returns from establishing closed (defined membership) cooperatives owned by grain producers to produce hogs in Iowa. Using a computer simulated production model incorporating biological factors and statistical techniques we model uncertainty of production and market environment. Using a MOTAD model, an efficient Expected Income-Mean Absolute Income Deviation (E-A) frontier is developed for the proposed closed swine production cooperatives.

[1] We would like to thank the following people for their valuable input, which without, this paper would not have possible: Dr. John Lawrence, Carl Watson, TEAM Pork, Alan Vontalge, ISU Extension, Dr. Gary Dial and the Pig Champs staff. We would also like to thank the U.S.D.A. Rural Business Cooperative Services, Cooperative Foundation, and the N.C.R.C.R.D for their support of this research. The authors maintain the responsibility for any errors within.

CLOSED VS. OPEN COOPERATIVES

Open membership cooperatives have been used extensively by producers in the marketing of farm products and the purchase of farm production inputs. The open membership form has proven to be well adapted to these activities. However open membership cooperatives have not been as widely employed in production or processing cooperatives. Differences in the way the two types of cooperatives are capitalized and the way financial benefits are distributed may be an important factor in the use of the closed cooperative form in these activities.

In most open cooperatives there is no fixed level of capitalization required and the real financial value returned to the member is a function of the percentage of the patronage refund returned in cash and the length of time between the issue of the deferred portion of the patronage refund and the time when the deferred portion is redeemed in cash (Junge and Ginder, 1986). Members usually join open cooperatives for a variety of reasons other than the strict financial benefits returned. Other cooperative benefits may in fact outweigh the financial benefits received.

Open cooperatives have not been as widely used for production and further processing as the closed (or defined membership) cooperatives. The closed form is particularly well suited for activities where members desire more direct and immediate return of financial benefits and where they are willing to commit capital and business volume to the cooperative at the time they join.

In order to return the financial benefits promptly as cash, the closed cooperative is organized and operated much differently then the open cooperative. Membership is strictly defined by the capacity of the cooperative plant in the closed cooperative. Unlike the open cooperative structure each member is required to make a defined volume commitment for each share owned. The closed cooperative does not face uncertainty in acquiring raw products from its members.

The closed cooperative model was used in this study to pass back net margins generated in hog markets. It was assumed that the cooperative was capitalized by grain producers who desire to add value to corn delivered to the cooperative by feeding it through hogs. The equity capital required (at the assumed level of leverage) was divided by the quantity of corn consumed by the hogs in the production facility annually to arrive at an equity requirement per bushel. Shares were denominated in 5,000 bushel units to arrive at the up front capital requirement per share. Net margins were distributed in proportion to the number of bushels delivered.

PROBLEM STATEMENT

To determine whether closed cooperatives are viable alternatives to farmers in Iowa, this paper assessed the feasibility of establishing closed cooperatives in Iowa for the purpose of producing hogs on a large scale, 2400 sow operations. In this paper, twelve specific hog production operations were defined for analysis. The farms were set up as follows:

Table 1. Closed Cooperative Operations Analyzed

	Low Equity	Medium Equity	High Equity
Farrow to Finish	FTF.O.L	FTF.O.M	FTF.O.H
Farrow to Finish as a Multiplier Herd	FTFMH.O.L	FTFMH.O.M	FTFMH.O.H
Farrow to Wean with Contract Finishing	FTW.C.L	FTW.C.M	FTW.C.H
Farrow to Wean with Contract Finishing as a Multiplier Herd	FTWMH.C.L	FTWMH.C.M	FTWMH.C.H

See Appendix A for further specification of individual farm setup. The equity levels for the farrow to finish operations were based on a percentage of total construction costs, breeding herd cost, and cash to pay for three months operation at full capacity. The equity structures were based upon current banking requirements for minimum equity contribution percentages required for operations of this type. After consulting with TEAM Pork of Iowa State University (ISU)

Extension, it was determined that lenders for this kind of operation typically require a minimum equity contribution for total construction costs of 30%. As indicated in Table 2 the minimum equity contribution for the breeding herd is 40% to 50%, and the minimum equity contribution for operating cash is 65% to 85% of 3 months operating cash requirement. Table 2 shows the equity required for farrow-to-finish operations. The equity structure used is shown in percentage terms for construction, then breeding herd, and three months operating cash respectively in column one. The cash requirements associated with each equity structure are shown in the remaining columns to the right with the total equity, in dollars per bushel, required in the last column on the right.

Table 2. Equity Positions and Requirements for Farrow to Finish Operations

Equity Structure	Construction	Breeding Herd	3 mths oper.	Total Equity	Total Equity per Bushel
30-40-65	$1,922,029	$321,360	$809,250	$3,052,639	$5.02
30-45-75	$1,922,029	$361,530	$933,750	$3,217,309	$5.29
30-50-85	$1,922,029	$401,700	$1,058,250	$3,381,979	$5.56

The farrow-to-wean with contract finishing operations were handled differently. There was not a large fixed cost in this operation when compared to the farrow-to-finish operations, but there were substantially higher variable costs associated with paying contract finishing fees. The farrow-to-wean with contract finishing operation's equity structure typically had a higher equity contribution requirement for the three months operating cash contribution.

Table 3 shows the equity structure used and the cash requirements for each of the farrow-to-wean with contract finishing operations. As in Table 2 the first column shows the equity requirement as a percent of total equity required for construction, breeding herd, and 3 months operating cash respectively. The remaining columns show the dollar amount required for construction, breeding herd, and three months operating cash for each of the three equity structures analyzed. The total dollars, in dollars per bushel, associated with each structure are shown in the far right column. The farm operations that utilize contract finishing pay $32.00 per nursery space per year and $34.00 per nursery space per year. The cooperative must supply the needed dietary and health inputs required for the finishing stage.

Table 3. Equity Positions and Requirements for Farrow to Wean Operations

Equity Structure	Construction	Breeding Herd	3 mths oper.	Total Equity	Total Equity per Bushel
30-40-100	$692,460	$321,360	$1,450,302	$2,425,602	$3.99
30-45-117	$692,460	$361,530	$1,696,853	$2,712,323	$4.46
30-50-133	$692,460	$401,700	$1,928,902	$2,984,542	$4.90

The farm operations supplying multiplier herd animals select gilts at the end of the finishing stage. The only difference was that there was a premium paid for the select gilts sold as multiplier herd animals. The select gilts consumed the normal amounts of feed, care, and medication throughout all stages of production.

To effectively evaluate the performance of a cooperative hog production operation a swine production model incorporating financial and biological parameters developed by Iowa State University Extension's TEAM Pork was employed. The key stochastic variables in the model were: farrowing rate, pigs weaned per liter, nursery mortality, finisher mortality, and feed efficiency. Using a large swine production database (PigChamps) maintained by University of Minnesota, each variable was modeled and estimation techniques were used to determine the production from each farm analyzed.

METHODOLOGY

Empirically evaluating the performance of the proposed hog production operations was performed using the following procedure. Biological data was collected from the PigChamps database and price data was collected from ISU Extension. A computer software program called

BESTFIT®[2] was used to analyze the data and determine distribution's parameters. The results from BESTFIT® were used in @RISK®[3] to perform a Monte Carlo data simulation. The simulated data was used in the Swine Feasibility Analysis (SFA) model to generate returns for each of the proposed hog production operations. The returns from the SFA were used in a Minimization of Total Absolute Deviations (MOTAD) model to estimate an efficient E-A frontier for the proposed hog production operations.

DATA COLLECTION

PigChamps tracks various farms across the Midwest and identifies the results by size and location. The biological variables used in this study were the farrowing rate, pigs weaned per litter, nursery mortality, and finisher mortality. Biological variables used in this study were based on longitudinal data from a single operation rather than cross sectional across several farms. This more effectively captured the true nature of production. With cross-sectional data, it was not impossible to assure that the same farm would be included in each sample. The PigChamps database was screened for farms in the upper Midwest (Iowa, Minnesota, and Illinois) with more than 600-sows. There were thirteen farms that met this selection criterion. Each of the thirteen farms had four years of monthly data on file. The uncertain price variables in the model were: corn, soybean meal (44%), sows, barrows, gilts, feeder pigs. See Appendix A for a detailed description of the price data.

STATISTICAL DISTRIBUTION ANALYSIS AND DATA GENERATION

To incorporate uncertainty into the production model, the statistical distributions for the

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[2] BESTFIT® is a registered trademark of the Palisades Corporation. BESTFIT® is distribution fitting software that finds statistical distribution function that best fits a data set.

[3] @RISK® is a registered trademark of the Palisades Corporation. @RISK® is risk analysis and modeling software that is designed to be used in conjunction with BESTFIT®.

price and biological variables used were calculated. The price variables were assumed to be distributed log normal. In Osborne(1959) it was shown that stock market prices are distributed log normal, we extended the results to commodity prices. The biological variables were modeled using the beta distribution because of it's flexibility. That is the probability density could take on a great variety of different shapes (Freund, 1992).

BESTFIT® was used to analyze the production and price data. Among other functions BESTFIT® can be used to estimate the parameters of specified distribution given data[4]. The final results can be used as inputs to @RISK® to generate samples from the specified distribution. A key feature of @RISK® is that it permits the correlation structure among variables to be estimated and used in the data generation process. After approximating the correlation among the monthly price and biological data, this correlation structure was used as input for data generation in @RISK®.

After the distributions for the uncertain production and price variables were identified by BESTFIT®, @RISK® was used to generate five years of input data, on a monthly basis, for the SFA model. Each set of draws was used as input data for an iteration of the SFA model and the results were stored. This process was repeated 100 times.

SWINE FEASIBILTY ANALYSIS MODEL

The computer simulated production model used was developed by ISU Extension to model production, pig flows, cash flows, and provide financial statements. Using the SFA model,

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[4] Five steps are used to determine the parameters that best fits the data set. Taken from the User's Manual: 1. Data is converted to the density distribution, 2. Maximum Likelihood Estimators are computed and used as a first guess at the parameters of the distribution, 3. The parameters are optimized using the Marquardt-Levenberg algorithm, 4. The goodness of fit is measured for the optimized function, 5. All results are then compared and the one with the lowest goodness of fit value is considered the best fit.

the costs of production were easy to compute, along with detailed pig flows, for given assumptions about the hog's diet and the facility set-up. The SFA model depends largely on the user inputs. This allows the model to be used by many different types of swine farms. There are six main sections in the SFA model: l. Data Input, 2. Growth Curve Analysis, 3. Pig Flow calculations, 4. Financial Analysis, 5. System Sensitivity Analysis, and 6. Statistical Comparisons to Database Records.

The Data Input section requires user information in four main categories: StartUp Costs, Diet Inputs, Production Inputs, and Financial Inputs. The Growth Curve for the SFA model is computed based on the average daily gain of the barrows and gilts. It assumes the weight of weaned hogs is twelve pounds and of market hogs is 265 pounds. The model computes the average daily gain for each diet based on the ingredients the user inputs. The model also incorporates the effects of diets at different stages in the life cycle of the animal based on calculated growth curves. The weight gained on each diet is computed using the average daily gain of the diet and the length of time on the diet. From these calculations the SFA model computes: days in the swine facility, consumption per day, feed cost per day, total cost, the cost per pound of gain, weight exiting the diet, and total gain on the diet. The SFA model computes Pig Flows while maintaining constant pig flow or constant sow herd size. In determining pig flows the model factors in deaths in the nursery and finisher, and the farrowing rate the user entered. The model specifies the required boars and gilts needed after the effects of culling in the breeding herd. In the Start-Up Budget, the model assumes the Land, Building, and Equipment will be paid for by equity first, and then long term loans, ten to twenty five years, and that the cost for the Breeding Herd is covered by short term loans, three to ten years. The Cash Flows have three main categories: Revenue/Income, Expenditures/Costs, and Net Cash Flow. When there is a negative

Net Cash Flow for any month, the Line of Credit (LOC) will be automatically assessed for the amount of negative cash flow, unless there is enough in the Cash Balance account to cover the amount of the negative Net Cash Flow. The Profit Margin and Return on Investment are computed based on the Net Cash Flows and the value of future cash flows are discounted at the assumed inflation rate, 6%, 8%, and 10%. The Payback Period and the Internal Rate of Return are also computed.

The output used from SFA model was the cash accumulated after five years of operation. The cash accumulation after 5 years was used as the estimate for total net margins that could be passed back to the farmer-members. Additional results from iterating the SFA model provided information on profitability, production, and costs under uncertain biological and price conditions.

MINIMIZATION OF TOTAL ABSOLUTE DEVIATIONS (MOTAD)

Linear programming models have been developed which take into account net revenues as a stochastic variable (Anderson, Dillion, and Hardaker, 1977). One of these models uses the mean absolute deviations in place of variance as a measure of risk (Hazell 1971). Hazell (1971) introduced MOTAD as an alternative model that closely parallels the quadratics programming approach, but without the need for a non-linear programming algorithm (Anderson, Dillion, and Hardaker, 1977). The linear programming model can be stated as a minimization of n variables subject to technological constraints and a parametric constraint on expected net returns (Anderson, Dillion, and Hardaker, 1977).

Hazell (1971) demonstrated that an equivalent but possibly more direct approach might be to use the mean absolute value of negative deviations about the mean. Hazell (1971) also demonstrated that the MOTAD model may have considerable potential as an alternative computational procedure to quadratic programming in deriving the efficient E-V farm plans, when quadratic programming code is lengthy and difficult or not available.

Using MOTAD to find the optimal portfolio combination, the model is of the following form: $Max\ E = \sum_{i=1}^{n} x_i u_i$

subject to :

1. $\sum_{i=1}^{n} a_{ki} x_i \le b_k$ for k = 1, 2, …, m
2. $\sum_{i=1}^{n} \mu_{ri} x_i + y_r \ge 0$ for r = 1, 2, …, s
3. $\sum_{r=1}^{s} y_r \le \lambda$ for r = 1, 2, …, s
4. $x_i, y_r \ge 0$ for all i = 1,2,...,n and r = 1,2,...,s

where a is the technical requirement of activity *i* for resource or constraint *k*, *m* is the number of constraints and resource equations, *b* is the level of resources or constraint *k*, *s* is the number of states of nature or observations, *y* is the absolute income deviations, λ is the maximum allowable deviations from the mean income. The development of this model closely follows those developed in Anderson, Dillion, and Hardaker (1977), Hazell (1971), and Tauer (1983). The model will provide an efficient E-A frontier with the choices for the specified levels of absolute deviations.

The results from the SFA model were then used as input for a General Algebraic Modeling System (GAMS) program that solved the constrained minimization problem of the MOTAD model. This was done for all twelve proposed closed cooperative hog production farms.

MODEL SPECIFICATIONS AND RESULTS

INITIAL COOPERATIVE MODEL

The initial run of the cooperative MOTAD model was constrained by a maximum number of activities in the portfolio of only one hog production operation. The theoretical implication of this restriction implies that over all activities, the MOTAD model might not be able to achieve an optimal solution because it cannot combine investments into a portfolio with more than one hog production operation. In this paper, the hog production operations were treated as mutually exclusive investments. Restricting the model to select one and only one hog production operation results in the selection of the activity that minimizes negative variations from mean expected income levels, while providing the highest expected income.

Operationally, having each hog production operation as a mutually exclusive event may coincide with the setup of the hog production operations. This would not allow the farmer-members to be invested in more than one type of hog production operation specified in this paper. Farmers would typically not have multiple opportunities to join a number of closed hog production cooperatives. Currently there are a limited number of projects already in existence which in many cases have recently been formed and would not have a large number of shares available for purchase from existing shareholders. In other cases the closed cooperative for hog production has not been formed and it is unlikely that a producer would participate in organizing more than one cooperative.

Another constraint in the model limits the number of pigs input into the finishing buildings to less than or equal to the number of pigs produced. This constraint ensures that contract finishing buildings are exclusively dedicated to pigs from the cooperative who produced them. This constraint was imposed to assure the cooperative all the pigs in the finishing buildings would be single sourced, significantly reducing the potential for the introduction diseases into the finishing buildings, and that there was no co-mingling of genetics from other suppliers in the finishing buildings.

The initial MOTAD model was setup to determine which farm operations would be optimal at different levels of risk, and to determine the expected cash accumulation after five years of operation. Figure 1 shows the estimated efficient frontier from parametrically running the model with respect to λ, the expected deviations from mean income. Table 4 shows the corresponding levels of risk and expected income for Figure 1. The model did not select a hog production operation until the $200,000 expected deviation level (λ) was reached. At $203,776 expected deviations, the model selected the FTWMH.C.M. Then, by allowing a slight increase in λ ($204,011), the model selected FTFMH.O.M. And at the higher levels of λ, above $204,011, the model selected the FTFMH.O.H operation. All the hog production operations selected were those that had either medium or high levels of equity. This implied that the farm operations with access to greater amounts of capital could meet financial obligations without worrying about the uncertainties in cash generation by hog production.

Figure 1. Initial MOTAD Frontier, constrained to select only one operation

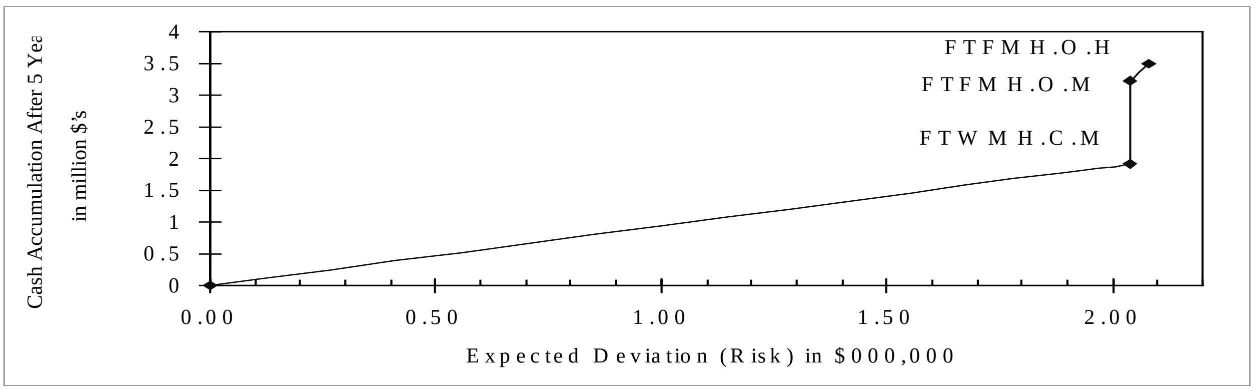


Table 4. Initial cooperative model estimated frontier

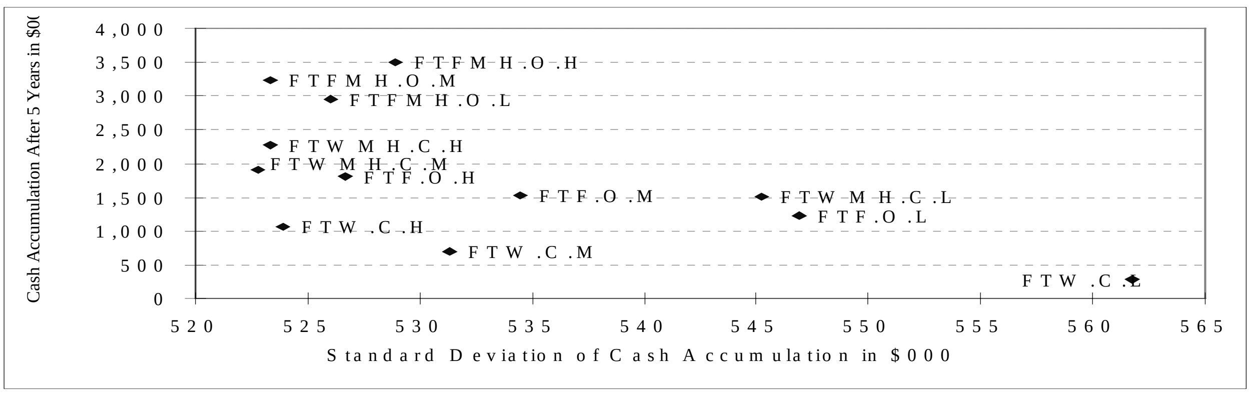
Farm Operation	Expected Deviations from Mean Income (Risk)	Expected Cash Accumulation after 5 years of operation
FTWMH.C.M	$203,776	$1,908,280
FTFMH.O.M	$204,011	$3,228,830
FTFMH.O.H	$208,115	$3,506,029

The cooperative MOTAD model solved for the efficient frontier given the restrictions.

Comparing the MOTAD analysis, negative deviations from mean expected income, with mean-variance analysis shows similar results.

Figure 2 shows the mean-variance graph of the initial cooperative model. The graph also shows the relative risk-reward tradeoffs of the proposed hog production operations. The same three hog production operations, FTWMH.C.M, FTFMH.O.M, and FTFMH.O.H, that form the initial cooperative model efficient frontier also form the efficient on the mean-variance graph in Figure 2. This supports Hazell's (1971) position that the mean absolute value of negative deviations from the mean are an alternative measure of risk to using a variance based risk measure.

Figure 2. Cash Accumulation vs. Standard Deviation of Cash Accumulation for all farm operations



SECOND COOPERATIVE MODEL

The initial cooperative MOTAD model was run a second time to analyze how selection of a hog production operation would change when a limit was placed on the amount of capital investment that could be made. An additional financing constraint was imposed, limiting the amount of investment capital available to three levels : $3 million, $3.125 million, and $3.25 million. All of the first model's constraints were also included in the second cooperative run.

Figures 3 through 5 show the plotted estimated frontiers for the second cooperative model and Table 5 summarizes the estimated efficient frontiers.

Figure 3. MOTAD model with financial constraint of $3 million available for equity

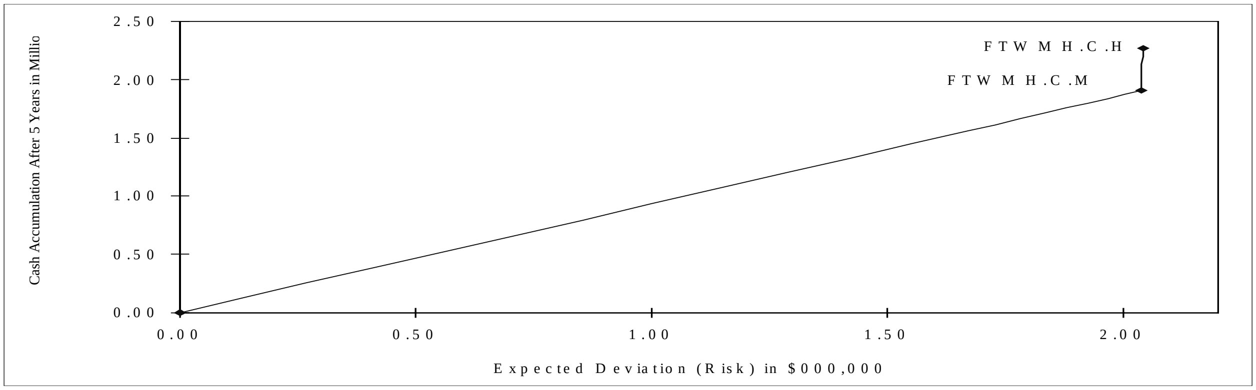


Figure 4. MOTAD model with financial constraint of $3.125 million available for equity

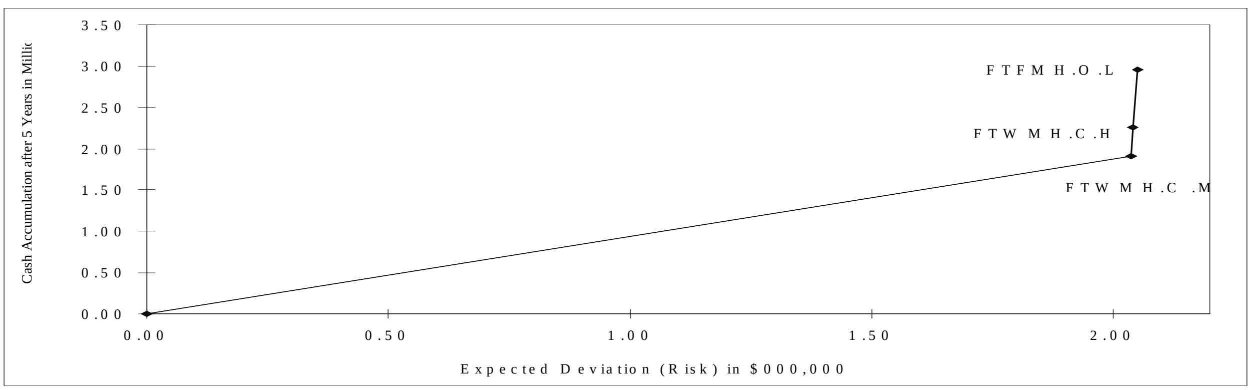
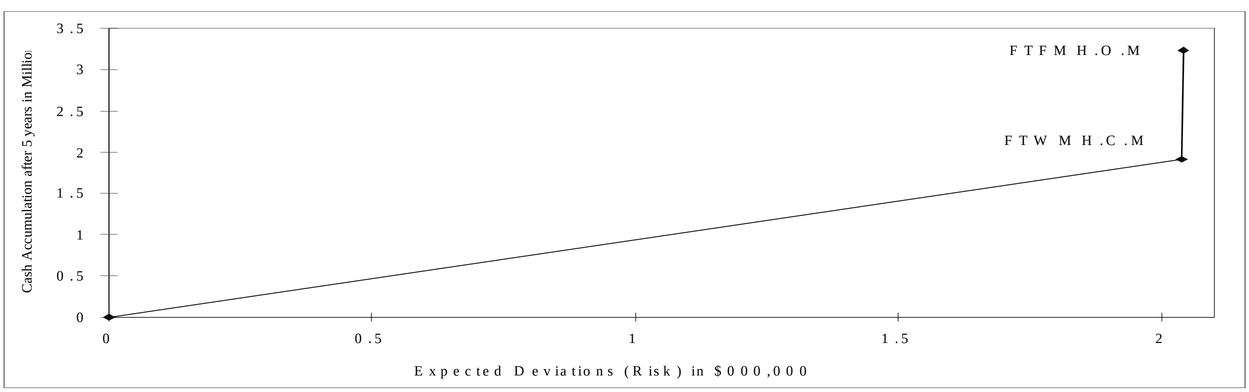


Figure 5. MOTAD model with financial constraint of $3.25 million available for equity



In all three financially constrained models the first farm operation selected by the model is the FTWMH.C.M. When investment capital is constrained to $3 million, the FTWMH.C.M had comparable levels of deviations to other operations, but had a lower expected income when compared to the FTWMH.C.H operation. The expected income could be increased by $350,000

Table 5 Second Cooperative Model Estimated Frontier with Financial Constraints of $3.0, $3.125, and $3.25 Million Available for Equity

Financial Constraint	Farm Operation	Expected Deviations from Mean Income (Risk)	Expected Cash Accumulation after 5 years of operation
$3.0 million	FTWMH.C.M	$203,776	$1,908,280
$3.0 million	FTWMH.C.H	$204,105	$2,267,277
$3.125 million	FTWMH.C.M	$203,776	$1,908,280
$3.125 million	FTWMH.C.H	$204,105	$2,267,277
$3.125 million	FTFMH.O.L	$205,176	$2,952,275
$3.25 million	FTWMH.C.M	$203,776	$1,908,280
$3.25 million	FTFMH.O.M	$204,011	$3,228,830

with only a small increase in risk, approximately $330, when moving from the FTWMH.C.M operation to the FTWMH.C.H operation. When the investment capital constraint is relaxed to $3.125 million, the FTFMH.O.L provides the opportunity to increase expected income by more than $1 million for increasing risk $1400, when compared to the FTWMH.C.M. When the investment capital constraint is further relaxed to $3.25 million, the FTFMH.O.M increases expected income by $1.3 million for a $235 increase in risk, when compared to the FTWMH.O.M. There are greater benefits to the hog production operations that have the ability to obtain more capital. In Table 5 if the hog production operation can increase investment capital available from $3 million to $3.25 million then expected income increases by $1 million, while risk is decreased.

In all three cases when financial constraints were imposed, the potential to generate income became constrained by the limited equity capital available. The choice of operations was expanded when the model moved from $3 million to $3.125 million available equity and also when the equity constraint was relaxed to $3.25 million. When more investment capital was available a more efficient hog production operation, FTFMH.O.M, became feasible. Under prior constraints this operation was unfeasible.

The main difference between the initial and second cooperative models is the level of expected income that could be obtained and the amount of risk that could be tolerated. In the initial model, the FTFMH.O.H operation was feasible and provided an expected cash accumulation of $3.5 million for $208,115 expected risk. At higher levels of λ the initial member model, financially unconstrained, offered greater expected income than any of the financially constrained models without significantly increasing the hog production operation's exposure to risk.

COOPERATIVE MODEL CONCLUSIONS

From the above results, two main points are apparent. First, for relatively small equity constraints, $3 million, expected income can be increased by more than $300,000 if an additional $329 is taken on as risk. Similarly, when equity is constrained to $3.125 million, expected income can be increased by $685,000 if an additional $1071 is taken on as risk. When equity is limited to $3.25 million, the expected income potential is increased by an additional $1.32 million for $235 more in risk. It appears that disproportionately high rewards are offered for modest levels of risk in all models.

Second, the addition of a multiplier herd appears to provide substantial benefits to the hog production operation. The hog production operations that included a multiplier herd exhibited a reduction in expected risk levels by an average of about $3,000, while offering an increase in expected income on the average of $1.46 million. This implies that the inclusion of a multiplier herd provides superior returns. The results indicate that saving gilts to replace culled sows reduces the sow replacement costs and generates cash flows with substantially less negative variation from mean expected income.

INITIAL MEMBER MODEL

The choice of how many shares each farmer-member would purchase was also analyzed. The cooperative MOTAD model's inputs were replaced with inputs that were on a farmer-member scale. The model was altered to determine the level of farmer-member participation in the selected models. This initial model was constrained to limit the number of shares an individual farmer-member could purchase at 18. This was based on Iowa Cooperative laws that limits an individual member's ownership at 15% of a closed production cooperative. Each hog production operation had an average of 120, 5,000 bushel, shares determined by the annual corn required. The same hog finishing constraint from the first model was also included in the member MOTAD model.

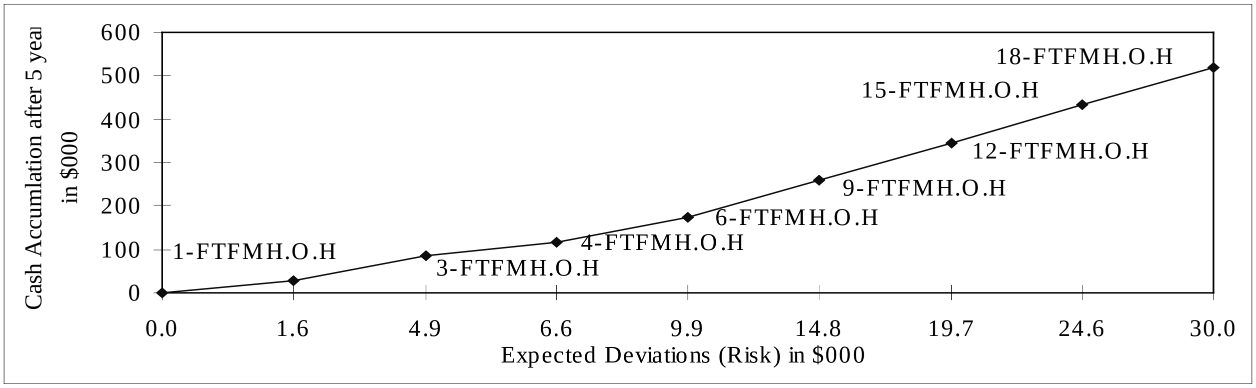
The member model was used to determine an optimal level of participation by the farmer-members of the farm operations. Figure 6 shows the estimated frontier from the initial member model, and the values for expected risk and expected cash accumulation after five years are in Table 6.

The model's results are intuitive having the prior knowledge of the initial cooperative model's results. In the initial member model, the level of risk was the only binding constraint. The initial member model continued until the constraint on the maximum number of shares became binding.

SECOND MEMBER MODEL

The member MOTAD model was also run a second time with a financing constraint to see how the farm operation selection would change when limits were placed on the investment capital farmer-members units could purchase. The constraint limits the amount of money each farmer-

Figure 6. Initial member MOTAD model



member can use to purchase shares in the cooperative. The three levels of investment capital available used were: $50,000, $100,000, and $250,000. While both member models allowed for multiple shares in a cooperative to be owned by one farmer-member, once again neither allowed a farmer-member to own shares in different cooperatives.

Table 6. Initial member model estimated frontier

Farm Operation	Expected Cash Accumulation after 5 years of operation	Expected Deviations from Mean Income (Risk)
1-FTFMH.O.H	$28,781	$1,643
3-FTFMH.O.H	$86,343	$4,930
4-FTFMH.O.H	$115,124	$6,573
6-FTFMH.O.H	$172,686	$9,860
9-FTFMH.O.H	$259,025	$14,787
12-FTFMH.O.H	$345,373	$19,716
15-FTFMH.O.H	$431,716	$24,645
18-FTFMH.O.H	$518,059	$29,574

It would not be likely that any single farmer-member would have the financial ability to purchase all 120 shares of any single cooperative, nor would any cooperative allow a member to own a majority of the existing shares. The second member model was run similar to the second cooperative model, with a constraint on the financing available to farmer-members. In the second member model the three levels of farmer-member financing used were: $50,000, $100,000, and $250,000. Figures 7 through 9 show the plots of the estimated efficient frontiers, and Table 7 shows the values from the plots.

In the financially constrained member models, the limitation on investment capital becomes a binding constraint. The FTFMH.O.H operation, one of the operations with the highest equity requirement, was able to provide it's farmer-members with more expected income at all levels of risk and for all financial restrictions. The second member models are all contained in the initial member model. As each financial restriction is loosened, the frontier looked increasingly similar to the initial model's frontier.

Figure 7. Member MOTAD model with financial constraint of $50,000 available per member

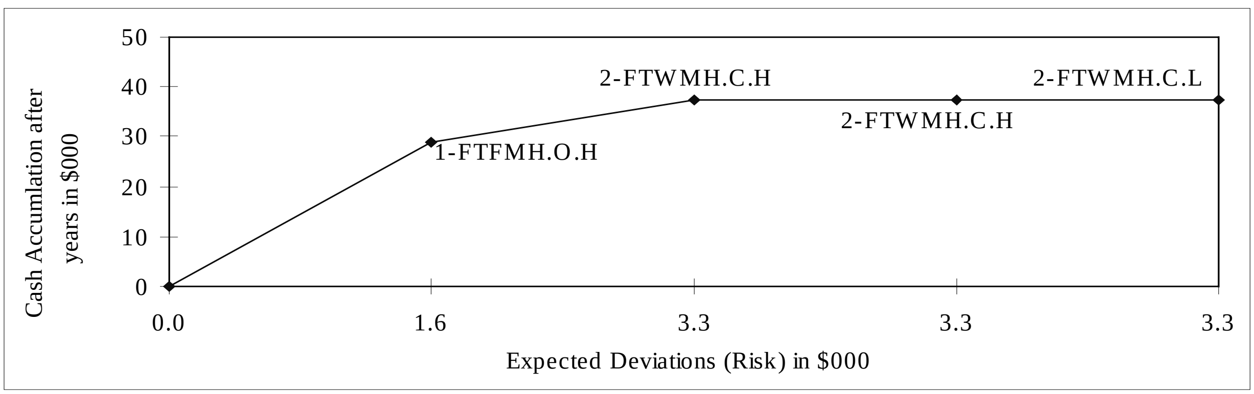


Figure 8. Member MOTAD model with financial constraint of $100,000 per member

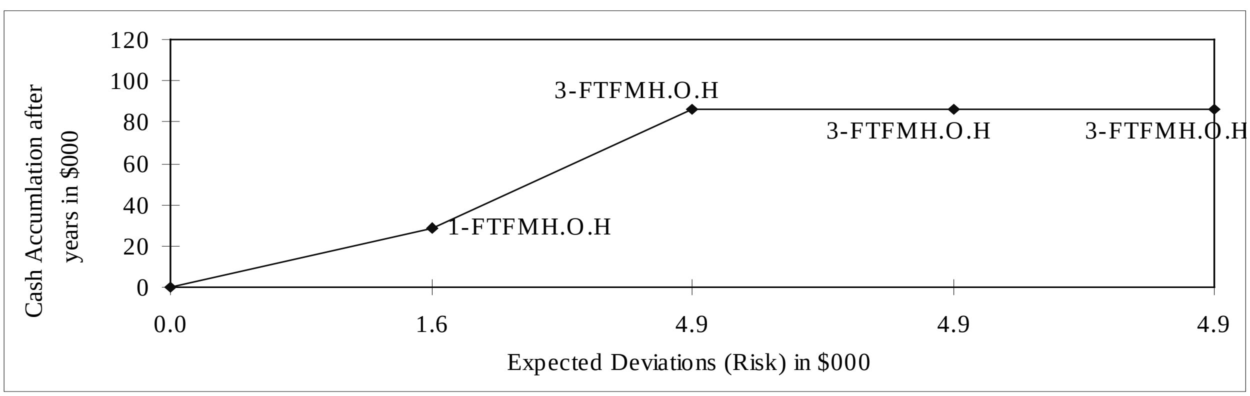


Figure 9. Member MOTAD model with financial constraint of $250,000 per member

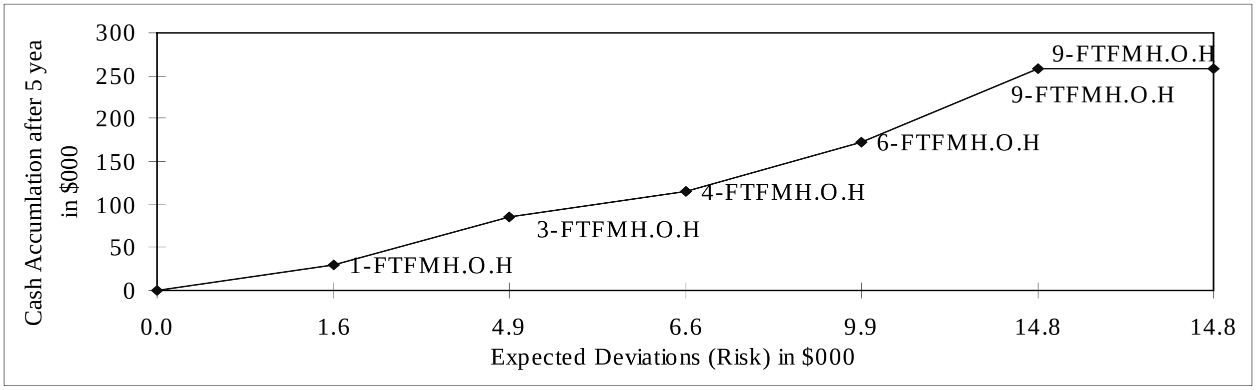


Table 7. Estimated frontiers for member model with financial constraints

Financial Constraint	Number of shares and Farm Operation	Expected Cash Accumulation after 5 years of operation	Expected Deviations from Mean Income (Risk)
$50,000	1-FTFMH.O.H	$28,781	$1,643
$50,000	2-FTWMH.C.H	$37,206	$3,267
$50,000	2-FTWMH.C.H	$37,206	$3,267
$50,000	2-FTWMH.C.H	$37,206	$3,267
$100,000	1-FTFMH.O.H	$28,781	$1,643
$100,000	3-FTFMH.O.H	$86,343	$4,930
$100,000	3-FTFMH.O.H	$86,343	$4,930
$100,000	3-FTFMH.O.H	$86,343	$4,930
$250,000	1-FTFMH.O.H	$28,781	$1,643
$250,000	3-FTFMH.O.H	$86,343	$4,930
$250,000	4-FTFMH.O.H	$115,124	$6,572
$250,000	6-FTFMH.O.H	$172,686	$9,858
$250,000	9-FTFMH.O.H	$259,029	$14,787
$250,000	9-FTFMH.O.H	$259,029	$14,787

ADDING VALUE

The main objective of the closed cooperative was to provide an additional corn marketing opportunity for grain farmers. The farmer-members are paid Posted County Price[5] (PCP), $1.74 per bushel, when they deliver corn to the cooperative. At the end of each quarter, the hog production operation makes a second advance payment, Quarterly Corn Payment, based on the average corn price at the principal market for corn. A final value-added payment is made at the end of the year. This value-added payment is based on accumulated cash at the end of the year after all expenses, including long term and intermediate term loans, and line of credit payments have been made. This final payment incorporates the extra value gained from feeding the corn through livestock.

In Table 8 the average annual payments to the members are the per bushel payment for

[5] PCP for Iowa northwest crop reporting district.

total delivery of a five year contract, where the per year delivery requirement is 5,000 bushel per year, or 25,000 bushels over five years. The Total Payment per Member column is the average annual payment the member can expect for each of the five years in dollars per bushel delivered to the cooperative. Compared to the Iowa average corn price for 1990 to 1995 of $2.24 per bushel, all operations provided the grain farmer with a means to add value to a portion of their corn marketed through the livestock production operation. Table 9 shows the payments on a per share basis.

The Quarterly Corn Payments are identical for all operations because they face identical market conditions, the difference between the posted county price and the market price are always the same regardless of the closed cooperative setup and production methods, but the value added payments differ significantly.

DISTRIBUTION OF PAYMENTS

The member payments were sorted and distributions for each type of payment under each operation were constructed. The four operations that are included in this paper are FTF.O.M, FTW.C.L, FTFMH.O.H. What is not possible to control is economic agents that form these cooperatives. There may be circumstances that don't fit into our models that would make a farmer prefer an operation with a low level of expected income and a high level of risk over an operation with a higher expected income and a lower level of risk. For example, referring to Figure 2, the possibility of a farmer choosing to form a FTW.C.L operation over a FTFMH.O.H operation. It is important to note that all of the proposed hog production cooperatives are established so that any payments made to farmer-members were not made from the depreciation

Table 8. Average Annual Member Payments by Source for 5 Year Period ($/bu), Standard Deviations in Paraenthesis

Operation	Posted County Price Paid	Quarterly Corn Payment	Value-Added Payment	Total Payment per Member
FTF.O.L	$1.74	$0.47	$0.40 (0.1767)	$2.62 (0.1571)
FTF.O.M	$1.74	$0.47	$0.50 (0.1721)	$2.71 (0.1526)
FTF.O.H	$1.74	$0.47	$0.59 (0.1690)	$2.81 (0.1495)
FTFMH.O.L	$1.74	$0.47	$0.97 (0.1667)	$3.18 (0.1470)
FTFMH.O.M	$1.74	$0.47	$1.06 (0.1653)	$3.27 (0.1456)
FTFMH.O.H	$1.74	$0.47	$1.15 (0.1647)	$3.37 (0.1450)
FTW.C.L	$1.74	$0.47	$0.09 (0.1835)	$2.31 (0.1638)
FTW.C.M	$1.74	$0.47	$0.23 (0.1727)	$2.44 (0.1532)
FTW.C.H	$1.74	$0.47	$0.35 (0.1695)	$2.56 (0.1500)
FTWMH.C.L	$1.74	$0.47	$0.50 (0.1758)	$2.71 (0.1570)
FTWMH.C.M	$1.74	$0.47	$0.63 (0.1676)	$2.84 (0.1479)
FTWMH.C.H	$1.74	$0.47	$0.74 (0.1671)	$2.96 (0.1473)

Table 9. Member Payments in dollars per share for 5 years of delivery (25,000 bu.)

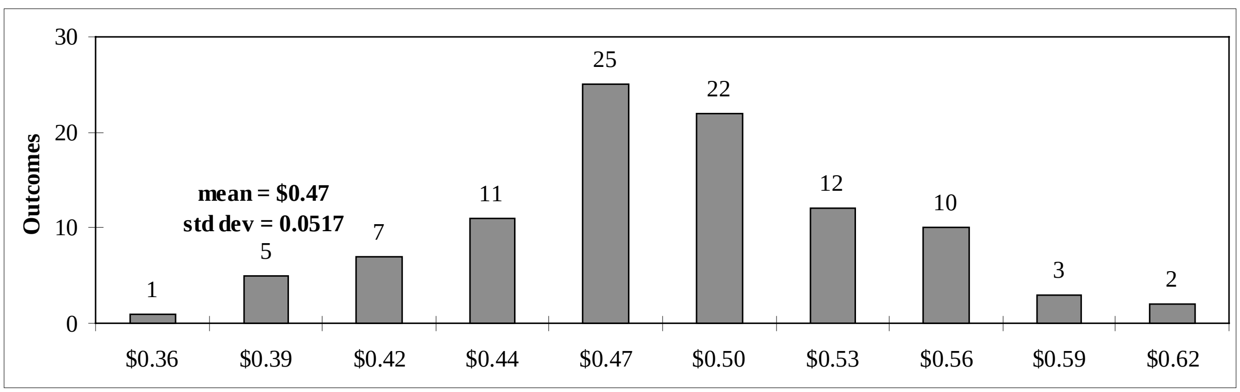
Operation	Posted County Price Paid	Quarterly Corn Payment	Value-Added Payment	Total Payment per Member
FTF.O.L	$43,500	$11,750	$10,000	$62,250
FTF.O.M	$43,500	$11,750	$12,500	$67,750
FTF.O.H	$43,500	$11,750	$14,750	$70,000
FTFMH.O.L	$43,500	$11,750	$24,250	$79,500
FTFMH.O.M	$43,500	$11,750	$26,500	$81,750
FTFMH.O.H	$43,500	$11,750	$28,750	$84,000
FTW.C.L	$43,500	$11,750	$2,250	$57,500
FTW.C.M	$43,500	$11,750	$5,750	$61,000
FTW.C.H	$43,500	$11,750	$8,750	$64,000
FTWMH.C.L	$43,500	$11,750	$12,500	$67,750
FTWMH.C.M	$43,500	$11,750	$15,750	$71,000
FTWMH.C.H	$43,500	$11,750	$18,500	$73,750

assets. This was included so that all of the hog production cooperatives are not able to make farmer-member payments unless the hog production operation is successful. The farmer-members will see further benefit from not using their assets for payments should they be interested in selling their shares. By not making payments from depreciation, the hog production cooperative will maintain long term assets.

QUARTERLY CORN PAYMENTS

The member-patrons received the current market price for their corn upon delivery. At the end of each quarter, the cooperative made a payment to each member based upon the PCP price in the cooperative formation contract. The Quarterly Corn payment made was the difference between the PCP and the average Tu.-Th. close at the local elevator for that quarter. There was a maximum set for the Corn Quarterly payment of $1.50 per bushel. In this analysis all operations faced identical feed input circumstances, prices and biological performance inputs, resulting in identical Quarterly Corn payments for all operations.

Figure 10. Average Quarterly Corn payments per year ($/bu.)



In Figure 10, the Quarterly Corn payments look roughly normal, and the average payment each member received was $0.47 per bushel. The Quarterly Corn payment can also be viewed as a risk management tool. The farmer-members won't lose out on high cash market corn prices, because a larger Quarterly Corn payment will be made when corn prices rise. This will come at the expense of the value-added payment. The cap placed on the Quarterly Corn payment was used to provide the cooperative has some protection if cash market corn prices rise extremely high, as was the case in 1996 for example. In this case, the farmer members could have sold their corn for more at the cash market, but must remember that they are committed to a value-added activity, which may not add value at all times. This is a similar situation to the one they face in livestock enterprises on their own farms. However, since the hog production cooperative is an independent entity with independent financing it must meet its own cash requirements. If they were to take a Quarterly Corn payment larger than $1.50, there is a potential for the hog production operation to become unprofitable because the cooperative lacks operating cash.

VALUE ADDED PAYMENTS

Each farmer-member was eligible for a Value-Added payment based on the cooperatives performance for the fiscal year. This payment was calculated based upon the accumulation of cash at the end of five years. This was the total amount available to be used for the Value Added payments. If the analysis were done with the cash accumulation after each year, the Value Added payments will have the benefit of the time value of money and accumulate interest. Figures 11 through 13 show the distributions of Value-Added payment. The distribution of Value-Added payments varies among the different hog production operations looked at. In all hog production operations the Value-Added payments are distributed fairly normal with tendency to one end of the payment scale. The standard deviation of the payment distributions decreases as more equity was added and the finishing facilities were owned by the cooperative.

Figure 11. Annual Average FTW.C.L Value-Added Payment ($/bu.)

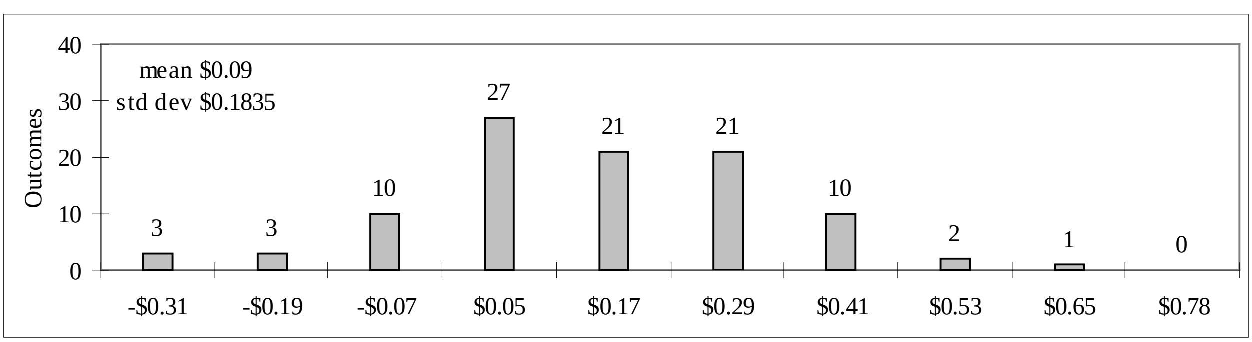


Figure 12. Annual Average FTF.O.M Value-Added Payment ($/bu.)

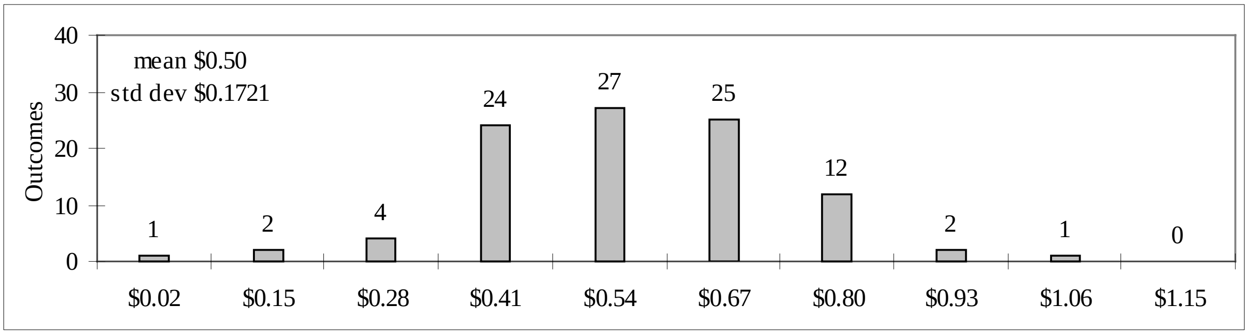
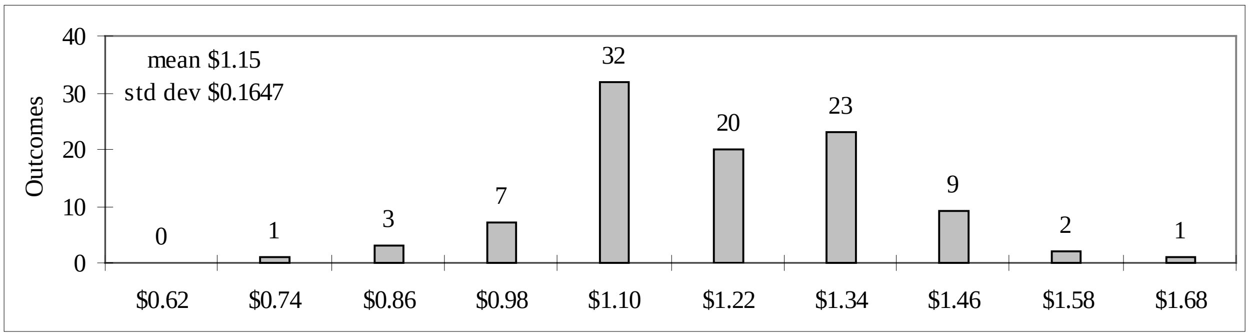


Figure 13. Annual Average FTFMH.O.H Value-Added Payment ($/bu.)



TOTAL PAYMENTS

The average annual Total payment to the farmer-members over five years was based on total bushels of corn delivered. All of the cooperative hog production operations had a 5 year iron clad delivery contract associated with membership. Figures 14 through 16 show the distribution of total payments. The Total Payment distributions also appear to be roughly normal in their shape, but there are significant differences in their mean total payment amounts. The FTFMH.O.H also exhibited characteristics of looking normally distributed, but it is important to point out that the FTFMH.O.H's payments were greater than the payments of the FTW.C.L. 98% of the time. In the FTFMH.O.H, 98% of the time the total payment to the member was greater than $3.12 a bushel. Not only did the FTFMH.O.H increase the payment to the member, but the certainty of that payment was also reduced. The FTFMH.O.H had a standard deviation that was

11% less than the FTW.C.L.

Figure 14. Average FTW.C.L Total Payment ($/bu.)

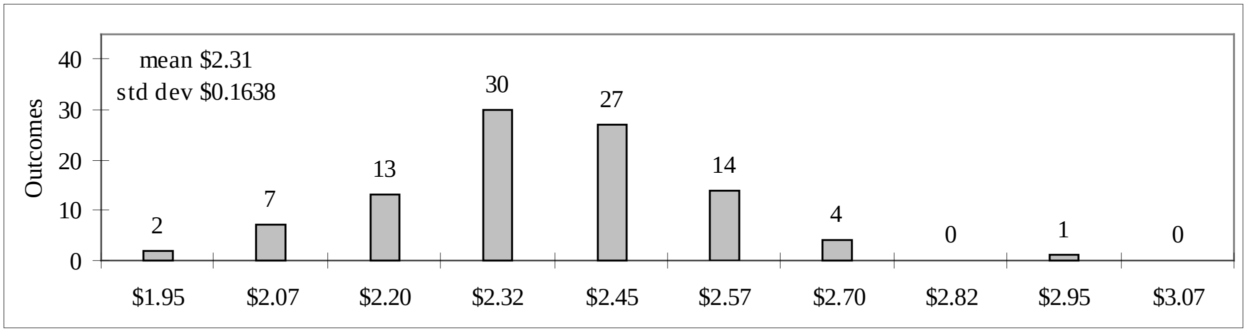


Figure 15. Average FTF.O.M Total Payments ($/bu.)

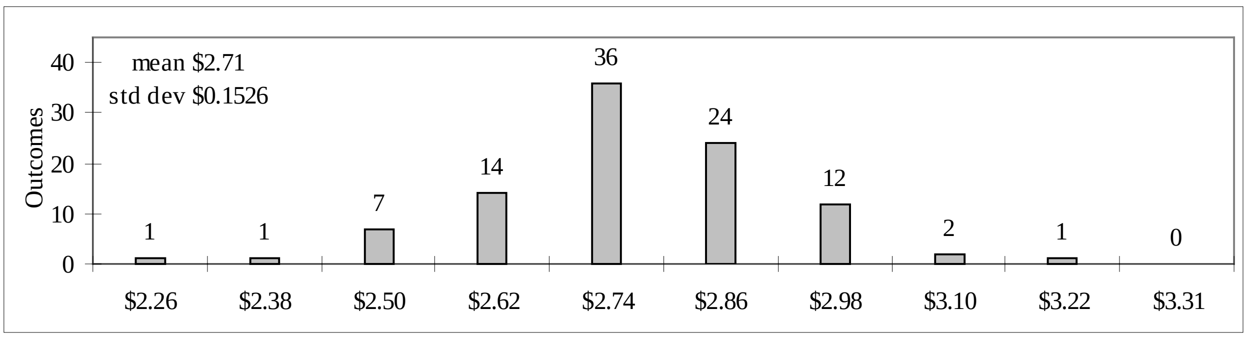
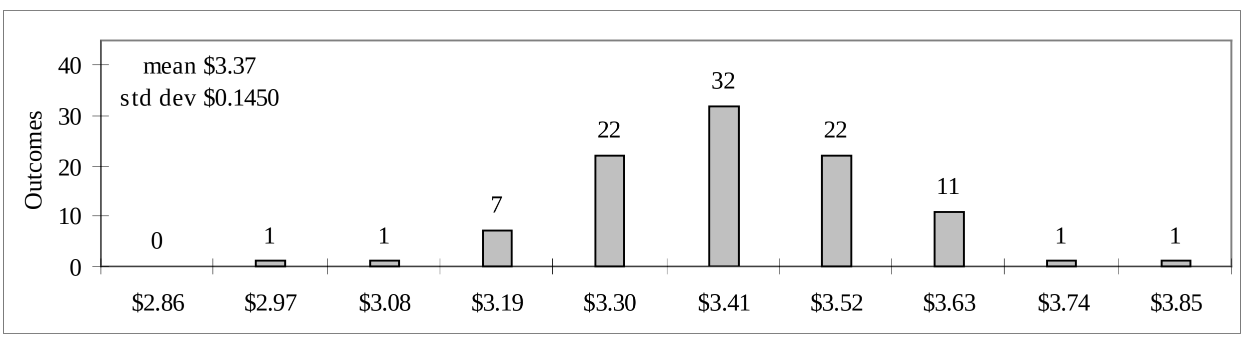


Figure 16. Average FTFMH.O.H Total Payment ($/bu.)



SUMMARY AND CONCLUSIONS

Closed value added swine cooperatives appear to be a viable alternative for Iowa grain producers as a means for adding value to grain production. Analysis of four swine production systems indicated that cumulative performance over a 5 year period (including startup periods) resulted in positive cash flow and net income. This was true under three different financial leverage positions.

The cooperative MOTAD analysis indicated that the performance of operations with high or medium equity levels were generally superior to those with lower equity levels for all four production systems - generating better returns for the risk levels analyzed. Similar results tothose from MOTAD were obtained when mean variance analysis was used.

The cooperative MOTAD analysis also indicated that constraints on the amount of equity capital available affected the efficient frontier. The most stringent equity constraint of $3.0 million available for equity selected a farrow-to-wean operation (FTWMH.C.H) with lower expected income. Relaxation of the constraint 5% permitted expected income to increase markedly by allowing a low equity farrow-to-finish operation with owned-finishers and a multiplier herd (FTFMH.O.L) to enter. Relaxation of the equity constraint by an additional 5% permitted a better capitalized farrow-to-finish operation with owned-finishers and multiplier herd (FTFMH.O.M) to enter with an additional income of $300,000.

The member MOTAD analysis indicated that constraints on the amount of equity capital available also affected the efficient frontier. The most stringent equity constraint of $50,000 available for equity per member indicated that a single member would maximize their expected cash accumulation after five years at $37,206 by owning 2 shares of the high equity farrow-to-wean with contract finishing operation (FTWMH.C.H). Relaxation of the constraint to $100,000 per member for equity, increased the expected cash accumulation per member markedly to $86,343, by allowing for 3 shares of a high equity farrow-to-finish operation with owned-finishers and a multiplier herd (FTFMH.O.H) to be purchased. Relaxation of the equity constraint to $250,000 per member for equity showed that purchasing additional shares of the high equity farrow-to-finish operation with owned-finishers and multiplier herd (FTFMH.O.M) was the only way to increase expected cash accumulation while keeping risk at a minimal level.

All efficient frontier selections resulted in significant added value for producers joining the cooperative. The low equity farrow-to-wean with contract finishing operation (FTW.C.L) generated an average of $0.09/bushel to the value of all corn provided to the cooperative by its members each year. The medium equity farrow-to-finish operation with owned finishers (FTF.O.M) provided an average of $0.50/bushel and the farrow-to-finish with multiplier herd and owned finishers (FTFMH.O.H) provided an average of $1.15/bushel each year. These value added prices represent much better alternatives than selling grain in the open market.

Several conclusions can be drawn from these results which may be useful to groups who are considering forming cooperatives

1. A multiplier herd approach to replacement females provided a significant cost savings which permits higher returns. Production systems without multiplier herds were universally inferior to those without them.
2. Using owned finishing facilities provided higher returns than contract finishing.
3. Severe constraints on equity capital can significantly reduce income and value added payments. Relaxation of the equity constraint by as little as 10% permitted value added payments to increase nearly three fold.
4. Risk exposure did not increase significantly when the medium equity farrow-to-finish multiplier herd operation (FTFMH.O.M) was selected over the farrow to wean with contract finishing (FTW.C.M). A relatively small increase in risk allowed value added returns to increase markedly.
5. In the member models, increasing equity contributions from $50,000 to $250,000

(an increase of $200,000) provided an increase in expected cash accumulation after 5 years from $37,206 to $259,029, an increase of over $220,000.

6. By using additional equity, the high equity farrow-to-finish with owned finishers operation (FTFMH.O.H) was able to add an additional $1.06/bushel each year over the low equity farrow-to-wean with contract finishing operation (FTW.C.L).

APPENDIX A. Production and Economic Assumptions for all Operations

	Farrow to Finish	Farrow to Finish with Multiplier Herd	Farrow to Wean	Farrow to Wean with Multiplier Herd
BUILDING COSTS				
Building Site Prep	$24,000	$24,000	$12,000	$12,000
Manure Management System	$144,000	$144,000	$48,000	$48,000
Water Supply System	$36,000	$36,000	$19,200	$19,200
Electric Lines/Generator	$72,000	$72,000	$72,000	$72,000
LP Tanks	$7,200	$7,200	$3,600	$3,600
Acres of Land Needed	240	240	80	80
Average Price per Acre[6]	$2,071	$2,071	$2,071	$2,071
Community Acceptance and Legal Start-Up Fees	$50,000	$50,000	$50,000	$50,000
Total Costs for Building and Equipment				
Breeding and Gestation	$1,026,000	$1,026,000	$1,026,000	$1,026,000
Farrowing	$768,000	$768,000	$768,000	$768,000
Nursery	$1,039,584	$1,039,584	N/A	N/A
Grow-Finisher	$3,058,980	$3,058,980	N/A	N/A
Isolation Building	$96,000	$96,000	$96,000	$96,000
Managers Home	$85,000	$85,000	$85,000	$85,000
Cost per Pig Space for Bldg. and Equip.				
Breeding and Gestation	$450	$450	$450	$450
Farrowing	$2,000	$2,000	$2,000	$2,000
Nursery	$130	$130	N/A	N/A
Grow-Finisher	$170	$170	N/A	N/A
Isolation Building	$160	$160	$160	$160
Production Data Inputs				
Sow-Boar Ratio	20:1	20:1	20:1	20:1
Total Number of Boars	120	120	120	120
Litters per Sow per Year	2.16	2.16	2.16	2.16
Market Hogs per Litter	8.53	8.53	8.53	8.53
Breeding Herd Cull Weight	400 lb.	400 lb.	400 lb.	400 lb.

[6] 1996 average dollar value per acre of farmland in the northwest crop reporting district (Duffy and Lillywhite, 1996).

Breed and Gestation sq. ft/space	11.0	11.0	11.0	11.0
Farrowing sq. ft/space	35.0	35.0	35.0	35.0
Nursery sq. ft/space	3.0	3.0	N/A	N/A
Grow-Fin sq. ft/space	8.0	8.0	N/A	N/A
Capacity of Nursery	8,000	8,000	N/A	N/A
Capacity of Gro-Finisher	18,000	18,000	N/A	N/A
Farrowing - rooms/crates	4/96	4/96	4/96	4/96
Total Number of Crates	384	384	384	384
Labor (F.T.E.'s)	14.63	14.63	14.63	14.63
Nursery Contract Fee	N/A	N/A	$32.00	$32.00
Finisher Contract Fee	N/A	N/A	$34.00	$34.00
Posted County Price[7]	$1.78	$1.78	$1.78	$1.78
Select Breeding Stock Premium	N/A	$25.00	N/A	$25.00
Avg. Number of Selects/Litter	N/A	2.2	N/A	2.2
ECONOMIC INPUTS				
Corn	$\bar{x}$ = \$2.21/bu, s = 0.4653, Iowa cash price, dollars per bushel, monthly averages, Iowa Dept. of Ag. and Land Stewardship, Ag. Mkt. Div., Des Moines, IA.			
Soybean Meal	$\bar{x}$ = \$181.49/MT, s = 32.12, 44% protein, FOB Decatur, monthly average, Iowa Dept. of Ag. and Land Stewardship, Ag. Mkt. Div., Des Moines, IA.			
Sows	$\bar{x}$ = \$39.73/cwt, s = 7.14, Prices quoted at 5 Midwest markets : Omaha, Sioux City, St. Joseph, St. Paul, and Sioux Falls, monthly averages, USDA.			
Barrows and Gilts	$\bar{x}$ = \$46.48/cwt, s = 6.91, Prices quoted at Iowa-Southern Minnesota cash market for US#1-2's, 210 to 240 pounds, monthly averages, USDA.			
Feeder Pigs	$\bar{x}$ = \$39.71/cwt, s = 9.68, Iowa average feeder pig price for US#1-2's, 40 pounds, monthly average, USDA.			

[7] Iowa 1996 average corn loan rate for Northwest Crop Reporting District for U.S. #2 or better.

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