NEW GENERATION COOPERATIVE OR INVESTOR-OWNED FIRM?

A THEORY OF MARKET ORGANIZATION*

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Abstract:

Entry into many markets can be attractive to both member-owned firms (*e.g*. new generation cooperatives) and traditional investor-owned firms (IOF). We present a theory that predicts the circumstances when each type of organization will be most likely to form. Using the ethanol industry as a backdrop, we employ a series of discrete-time, stochastic dynamic programming models to analyze individual agent decisions about investment in a new generation cooperative (NGC). By linking these models we identify the conditions that point toward the formation of two types of NGC – those that trade their shares through an auction mechanism and those that rely on direct member negotiations. We observe that the cooperative's choice of trading mechanism affects not only the NGC's share price but also impacts the likelihood that it will form in the first place. We then compare the "investment thresholds" of the different NGC's to the investment threshold of a similarly situated IOF. We conclude that a member-owned firm is more likely to form than an IOF when the enterprise promises only marginal profitability in the short-term.

I. INTRODUCTION

Entry into many markets can be attractive to both member-owned and investor-oriented firms (IOF). The ethanol industry is a good example, with new generation cooperatives forming in large numbers in some places and IOF's being the predominant form of organization in others.

The differences between new generation cooperatives (NGC) and IOF's can only be understood when the risk of investing in NGC's is taken into account. Ethanol cooperatives can fall victim to high corn prices, low ethanol prices, or both. Tradable shares, often touted as a means of overcoming the free-rider problem of many open membership cooperatives, may also pose significant risks for producers. The delivery obligation associated with NGC shares may prevent producers from selling corn to the highest bidder, the future value of cooperative shares is highly unpredictable, and a producer's ability to trade stock is never guaranteed. Cooperative proponents and policy makers need to consider how the risk inherent in a NGC affects its ability to form and ultimately impacts its long term stability.

In order to address some of these issues, we use dynamic programming methods to model the optimal ethanol plant investment decisions in three distinct market settings. We are particularly concerned with (i) differences in formation thresholds for IOF and NGC organizations and (ii) the impact a cooperative's choice of the mechanism for stock trading has on its ability to attract members and on the distribution of membership in a farm population. Our analysis combines dynamic investment models for heterogeneous agents with market simulations over a ten year horizon.

The first organizational form we consider is a NGC that has achieved a competitive market for trading shares among member and non-member farmers. By a "competitive market" we mean one where there are enough potential buyers and sellers of shares in each time period to make the market for NGC stock perfectly liquid. Each agent can trade as many shares as he wishes at the current market price. In essence, each agent submits a demand schedule for NGC shares, and the market clears at the price at which aggregate demand is equal to zero.

The second organizational form we consider is the case where cooperative shares are traded through a multi-unit, discriminatory auction. This type of stock trading mechanism is common among ethanol cooperatives in Minnesota. In a multi-unit, discriminatory auction, each agent in the market submits an optimal quantity / price pair. The quantity may be positive (a buyer), negative (a seller), or zero. A buyer's price is a bid and a seller's price is a reserve price. After all of the quantity / price pairs are submitted, the "auctioneer" clears the market by first determining which buyers and sellers are successful and then matching successful buyers and sellers. Successful buyers pay their bid price, but the price received by a successful seller depends upon which buyer purchases her shares.

The final organizational form we consider in an IOF. This is the simplest case, since there is a single investor, who does not farm. It is the baseline situation for our analysis.

In the sections that follow, we first describe features of the agent model and market setting that are common to the analysis of all three market organizations. Then for each market setting, we set up and discuss the individual agent problem. Next, we determine corn price / ethanol price combinations that define a formation threshold for the establishment of an ethanol plant. After presenting formation thresholds for all three organizational forms, we present findings for the two NGC forms on the distribution of membership.

We conclude that producers' desire to use NGC's as a risk management tool causes NGC's to form over a broader set of conditions than an IOF would form. However, when a cooperative trades its shares through a discriminatory auction mechanism, investors are more reticent to become members than if the market for cooperative shares were competitive. This implies that a cooperative with a discriminatory auction trading mechanism fails to capture all of the potential welfare gains for its members. We also find that the distribution of membership differs dramatically with the choice of stock trading mechanisms for the two NGC forms.

II. COMMON MODELING ASSUMPTIONS

A. The Agent Model

The investors in each of the three organizational forms have much in common. The goal of each agent is to maximize expected utility of net cash flows over an infinite horizon. An agent's net cash flow in a given year includes net income from the ownership share of the ethanol plant (if it has formed) and from farming (unless the agent is an IOF) as well the expense (revenue) from buying (selling) an interest in the cooperative or ethanol plant. Therefore, net cash flow is a function of the corn price (CP_t), the ethanol price (EP_t), the share price (SP_t), the number of shares owned (SH_t), and the number of shares purchased or sold (X_t) in time period t. The net cash flow function can be specified by $\Pi(CP_t, EP_t, SP_t, SH_t, X_t)$. At the time an agent makes an investment decision, the corn and ethanol prices that will determine the current period's cash flow are unknown. Under the auction market NCG structure, both the share price and share balance are uncertain, since agents are not sure they will make a trade when they submit share quantity / price combinations to the auction. Therefore, in each case the net cash flow (Π) is a random variable. We assume agents' risk preferences can be represented by an additively time-separable utility function with positive, non-increasing marginal utility.

Investment decisions affect not only current net cash flows but also opportunities for future net cash flows. We model the evolution of these opportunities with state equations for the corn price (CP_t), the ethanol price (EP_t), the share price (SP_t), and the number of shares owned (SH_t). In each of the models, the corn price follows the non-stationary process, $CP_t = CP_{t-1} \cdot e_t^C$, with $e_t^C \sim N(0, s_C^2)$. The ethanol price, follows a similar process, $EP_t = EP_{t-1} \cdot e_t^E$ and the error term on the ethanol price is also normally distributed with a mean of zero and a variance of s_E^2. Not surprisingly, the evolution of share prices is modeled quite differently for each market organization. In general, this can be denoted by $SP_t = g(SP_{t-1}, SH_{t-1}, X_t, e_t^S)$, where e_t^S is a random variable and not all arguments necessarily have an impact on share price dynamics. Under the IOF and competitive market NGC structures, the share balance is given by the simple deterministic expression $SH_t = SH_{t-1} + X_t$, where X_t is positive when shares are purchased and negative when they are sold. Under the auction market NGC structure, the share balance is uncertain, since the agent does not know whether the quantity / price pair he submits to the auction market will result in a trade. Therefore, a more general specification for the dynamics of share balance is $SH_t = f(SH_{t-1}, SP_t, X_t, e_t^X)$, where e_t^X is a random variable and not all arguments necessarily have an impact on SH_t.

For all three market organizations, share balances are constrained to be nonnegative, and there is a maximum share balance level for each agent. These constraints, in turn, impose constraints on levels for the number of shares that can be purchased or sold. Taking this into account, the general formulation for the agent's problem with utility function $U[\Pi(CP_t, EP_t, SP_t, SH_t, X_t)]$ is:

$$\max_{X_t} \mathrm{E}\big[U[\Pi(CP_t, EP_t, SP_t, SH_t, X_t]\big] \tag{1}$$

subject to:

$$\begin{aligned}
&CP_t = CP_{t-1} \cdot e_t^C \\
&EP_t = EP_{t-1} \cdot e_t^E \\
&SP_t = g(SP_{t-1}, SH_{t-1}, X_t, e_t^S) \\
&SH_t = f(SH_{t-1}, SP_t, X_t, e_t^X) \\
&0 \le SH_t \le SH_{\max}
\end{aligned}$$

At any time, t, the tradeoff between current returns and future opportunities is represented by the Bellman equation:

$$W(SH', P) = \max_X \left\{ \mathrm{E}\big[U[\Pi(P, SH, X)]\big] + \frac{1}{1+r}\mathrm{E}\big[W(SH', P' + dP)\big] \right\} \tag{2}$$

subject to:

$$\begin{aligned}
&P = (CP', EP', SP) \\
&CP' = CP \cdot e_t^C \\
&EP' = EP \cdot e_t^E \\
&SP' = g(SP', SH', X', e^S) \\
&SH' = f(SH, SP, X, e^X) \\
&0 \le SH \le SH_{\max}
\end{aligned}$$

The first term on the right hand side is the expected utility of net cash flow in the current time period, given the agent's choice of a new share balance, *SH'*. The second term on the right side is the discounted "value" of the agent's decision going forward, assuming he continues to optimize in the future.

With four state variables, some of which are stochastic, this problem cannot be solved analytically. Therefore, we have found numerical solutions to the various agent problems using MATLAB and a revised version of a program initially developed by Heman Lohano (2002). Lohano's model implements methods described in Chapters 8 and 9 of Miranda and Fackler (2002).

B. The Net Cash Flow Function

For the IOF net cash flows come only from the operation of the ethanol plant. Therefore,

$$\Pi^I = SH_t[(EP_t - CP_t - CAC)] - (SP_t)(X_t), \qquad (3)$$

where *CAC* is the constant average cost of ethanol plant operation per bushel of corn.[1] The first term is the ethanol plant's profit and the second term is the net cost of investment or disinvestment.

The net cash flow for agents in the competitive NGC and the auction NGC models are considerably more complex than that for the IOF. Net cash flows from membership in the cooperative are identical to those for the IOF case. They include the agent's share of profits from ethanol plant operation and cash flows associated with the purchase or sale of shares in the ethanol plant. Net cash flows from farming are adjusted

[1] The ethanol price has been converted from $/gallon to $/gallon/bushel of corn.

to reflect that corn delivered to the cooperative cannot be sold in the open market. Therefore, the overall net cash flow function is:

$$\Pi^i = SH_t^i[(EP_t - CP_t - CAC)] - (SP_t^C)(X_t^i)$$

$$+ (CP_t + g^i)SH_t^i + (1 + q)CP_t[Y_t^i(A^i/2) - SH_t^i] - C(A^i/2) \qquad (4)$$

$$+ CP_t[Y_t^i(A^i/2)] - C(A^i/2),$$

where C is the production cost per acre for corn or soybeans. The first line of this expression is the return from the cooperative investment. The second line is the net cash flow from corn production, including payments for corn from the cooperative; and the third line is net cash flow from soybean production.

C. The Investment Setting

To analyze ethanol plant investment decisions, it is first necessary to define both the nature of the ethanol plant and the characteristics of the population of potential investors. Just as the solution to the agent problem depends, in large part, on the parameters chosen for the model so, too, do the outcomes at the market level. To be assured that the parameters are reasonable, we found it desirable to create a hypothetical investment setting that is based on an actual ethanol plant. We have chosen the seven county area including and surrounding Freeborn County, Minnesota in South Central Minnesota as the basis for our investment setting.

Freeborn County is the home of Exol ethanol cooperative. The Exol plant produces 36 million gallons of ethanol per year and requires 13 million bushels of corn. Using Exol as a model, the initial cost of the plant is estimated to be approximately $97 million. Assuming the half the cost of the plant is financed with equity, the initial cost outlay for the IOF is $48.5 million. If the cooperative issues 13 million shares, each representing the right and obligation to deliver one bushel of corn each year, the share price required to raise \$48.5 million is \$3.75.

Under the IOF organizational structure, there is a single investor, who is assumed to be risk neutral. Under the two cooperative organizational structures, the farm population represents a large, diverse pool of potential investors. In 1997, Freeborn County and the six contiguous counties were the home of 4234 farms that grew corn. The average corn yield on these farms was about 140 bushels per acre. Approximately 68 percent of these farms were between 50 and 499 acres in size, 22 percent were 500 to 1000 acres, and 10 percent were greater than 1000 acres. In our model, the population of agents is distributed among small (300 acres), medium (600 acres) and large (1200 acres) producers in approximately these proportions. The number of farms growing corn in the counties surrounding Freeborn County outnumbers the corn farms located in Freeborn County by approximately 4 to 1. Agents in the surrounding counties are designated as "far" agents because they incur a \$0.10 /bushel transaction cost if they deliver corn to the ethanol plant. If this cost is captured by the variable g^i, which is equal to -\$0.10 for "far" agents and zero otherwise, the agent's effective price for delivering corn to the cooperative is $CP_t + g^i$.

In this part of Minnesota, most crop producers grow both corn and soybeans, allocating approximately equal acreage to each crop. For simplicity here, we assume a 50-50 allocation of acreage on all farms and identical net returns for the two crops. We restrict a farmer's NGC share balance to be non-negative and no greater than expected corn production – i.e., $0 \leq SH_t \leq 140(A/2)$, where 140 is expected yield and A is total acreage. Corn yields are stochastic, so it is possible for a farm's corn production to fall below SH_t, the number of bushels that must be delivered to the cooperative. When this happens, the agent incurs a 5 percent transaction cost, designated by q, for purchasing corn on the open market for delivery.

Under the two NGC organization structures, farmer-investors are assumed to be risk averse with a negative exponential utility function, $U(\Pi) = -\exp[-l(\Pi)]$. We assume that half of each type of agent are highly risk averse, half are slightly risk averse, and the coefficients of risk aversion (?) are:

Farm Size	**Highly Risk Averse**	**Slightly Risk Averse**
300 acres	$l = 0.000015$	$l = 0.000004$
600 acres	$l = 0.000008$	$l = 0.000002$
1200 acres	$l = 0.000002$	$l = 0.0000005$

A risk neutral agent would have a certainty equivalent equal to the mean value of a 50/50 lottery. The parameters of our model were chosen so that the slightly risk averse agents had certainty equivalents approximately equal to 90% of the agent's expected return and highly risk averse agents had certainty equivalents approximately equal to 65% of expected returns.

Investment decisions under each organizational structure are simulated over a ten-year period for 100 randomly generated scenarios that are defined by values of all the random variables in the model. This analysis yields detailed information on investment and disinvestments for the IOF structure and on trade volumes, share prices, and the distribution of membership for the two NGC structures. Since a computer simulation with 4200 agents and 13 million shares would be far too large to run in any reasonable length of time, we have scaled back both the number of agents and the number of shares available by a factor of 0.005. We now have twenty-one agents and 65,000 shares available for purchase from the cooperative. Testing has shown that share price dynamics are robust to changes in the scale factor.

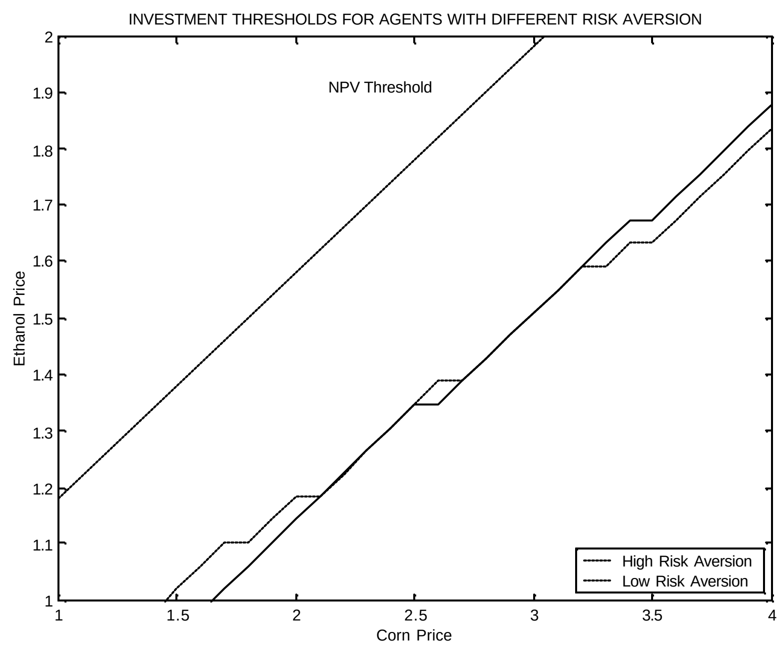
III. INDIVIDUAL AGENT MODELS

A. The Agent In The Competitive Market NGC.

The agent's problem in the competitive market tracks the recursive problem of Equation 2 very closely. The agent's control variable is the change in his share balance, X, and the state variables are the ethanol price, corn price, share price and share balance. In order that agents in our model may have "rational" expectations about the share price dynamics we have estimated the share price, as a function of the corn and ethanol prices, from the simulated stock trading markets. Since the agents' *expectations* of the share price dynamics affect the *actual* share price dynamics we have estimated the share price using an iterative process of estimating the share price, updating expectations, and re-estimating the share price until expectations are consistent with the true share price dynamics.

Using numerical methods to solve Equation 2 for the agent in a competitive market, we are able to estimate the demand for NGC shares for agents with a variety of characteristics. While the primary focus of this paper is on the formation thresholds for the various cooperative structures, those results will be more clear if we briefly discuss some features of the agent's optimal policy.

Figure 1 shows the corn price / ethanol price combinations at which two medium sized agents in a competitive market, who vary only by the level of risk aversion, will initially purchase 5000 shares in a new generation cooperative. The threshold lines represent the states at which it is optimal for each agent to purchase the specified quantity of shares at an initial share price of $3.75. The net present value line represents the set of states where the share price is equal to the expected net present value of the cooperative.



Competitive Market Investment Thresholds
FIGURE 1

The graph illustrates that agents will often be willing to invest in a NGC even if the expected net present value of the cooperative, given the current state, is less than the cost of the shares. Risk averse farmers wish to mitigate corn price uncertainty through diversification by investing in a NGC. The risk reduction benefits offered by the cooperative are large enough that investors are willing to accept negative profits in the near term. This explains why the threshold falls below the NPV line. Decreasing marginal utility means that these benefits begin to decline, however, if the agent becomes over-invested in the NGC. In fact, we find that the threshold increases with the size of the investment. As the level of risk aversion grows, the marginal utility required of each additional share also grows so agents with higher risk aversion generally require more favorable states before they will commit to large purchases.

In addition to the results shown in Figure 1, we find that an agent's optimal policy is typically to dedicate only a fraction of his expected corn production to the cooperative. Only as the NGC becomes more profitable will the agent incrementally purchase a larger number of shares. We also find that the size of the farm and distance from the cooperative affect demand for cooperative shares. A large producer grows more corn and is, therefore, able to deliver more corn to the cooperative. He is also more susceptible to volatility in the corn price, so demands more shares as a consequence of his desire to manage risk. Finally, since the agent's distance from the cooperative affects the agent's net cash flow, agents who are far from the cooperative demand fewer shares than agents who are near the cooperative.

2. The Agent In The Auction Market NGC

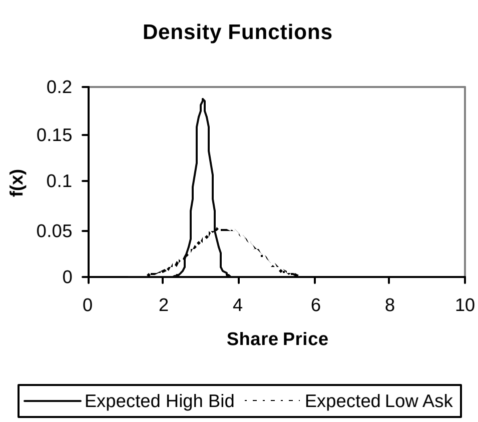
Like the agent in a competitive market, the investor in a NGC that uses a multi-unit discriminatory auction tries to optimize the discounted expected utility of net cash flow (Equation 4). They do so by submitting an optimal quantity / price pair (X_i , SP_i) such that $SP_i \geq 0$ at the beginning of each time period. In other words, there are now two choice variables and the share price is no longer a state variable.

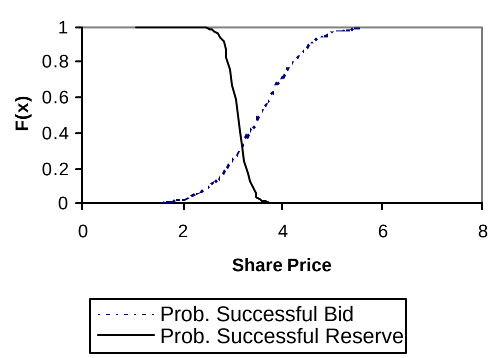
The auction market clears through a hypothetical auctioneer who uses the price / quantity bids to prepare schedules of aggregate supply and demand. The price at which supply and demand are equal is called the "stop-out price" (SOP). If a bid price is higher than or equal to the stop-out price, it is successful and the bidder will pay the amount of his bid. Conversely, if a seller's reservation price is equal to or lower than the stop-out price then she will be successful. This auction mechanism introduces two important strategic elements that are not found in the competitive model.

The first is that over most states there is some probability that a bid will not be successful. This probability is represented by the function:

$$\Phi(EP, CP, SP) = \begin{Bmatrix} \Phi_+ = \Pr(SP \geq SOP) \; if \;\; SH' > SH \\ \Phi_- = \Pr(SP \leq SOP) \; if \;\; SH' < SH \\ 1 \qquad\qquad\qquad\quad if \;\; SH' = SH \end{Bmatrix}$$

This says that the probability of being successful in the auction is a function of the ethanol price, corn price and the bid or reservation price. For example, if the states are such that the cooperative is profitable then many agents will likely be trying to buy and the probability of being successful with a relatively low bid price will be close to zero. A seller, on the other hand, would have a high probability of being able to sell in that environment with even a high reserve price. The key feature of Φ is that it provides the agent with a tradeoff. A more aggressive policy (a high bid or low reserve) improves the odds of success but reduces the agent's potential payoff. A conservative policy improves potential net cash flow but decreases the odds of success.





Density and Probability Functions For Auction Market
FIGURE 2

We have constructed Φ using an iterative method similar to that used to estimate the share price dynamics in the competitive model. We first estimated the high bid price and low reserve price from many simulations and constructed a normal distribution around that expectation (Figure 2). Since the probability of a certain bid price being successful is the probability that it is higher than the lowest reserve price, we recognized that Φ_+ is simply the cumulative of the reserve price density function. Conversely, Φ_- is 1 minus the cumulative of the bid price density function. An example of Φ, as well as the bid and reserve price density functions, for a corn price of \$2.40/bu. and an ethanol price of \$1.50/gal. is shown in Figure 2.

The second implication of the auction market-clearing mechanism is that the actual price received by a successful seller depends upon which buyer purchases her shares. In this model, the matching of buyers and sellers is determined by a "randomized rationing rule," which says that each of the successful sellers has an equal probability of being matched with any one of the successful buyers. This method greatly simplifies the model[2] but, fortunately, since the range of successful bid and reservation prices in our simulations is relatively narrow the choice of matching rule does not significantly alter the results.

However, since the share price a seller actually receives depends on the buyer to whom she is matched, she must hold an expectation of the price which is a function of

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[2] Consider an auction where the lowest reserve price is matched with the highest bid. In this case, the sellers have an incentive to lower their reserves in order to increase the expected price they will receive. This greatly complicates the model and may be impossible to solve in this setting. (Casson, 1993)

her reserve price. In our model, each seller does this by first forming an expectation of the highest bid price (see Figure 2). This distribution is then truncated from below by the seller's reserve price (since she cannot receive any price below her reserve price) and an expectation is calculated.

The Bellman equation in the auction problem reflects the impact of Φ and the uncertainty over a seller's share price. In the auction model, the payoff is a weighted average of the value of a successful bid and an unsuccessful bid:

$$W(SH', SP, P) = \max_{SH',SP} \quad \Phi\left\{ \mathrm{E}\left[U(\Pi)\right] + \frac{1}{1+r}\mathrm{E}\left[W(SH', SP, P+dP)\right]\right\} + (1-\Phi)\left\{ \mathrm{E}\left[U(\Pi_{SH'=SH})\right] + \frac{1}{1+r}\mathrm{E}\left[W(SH, P+dP)\right]\right\}$$

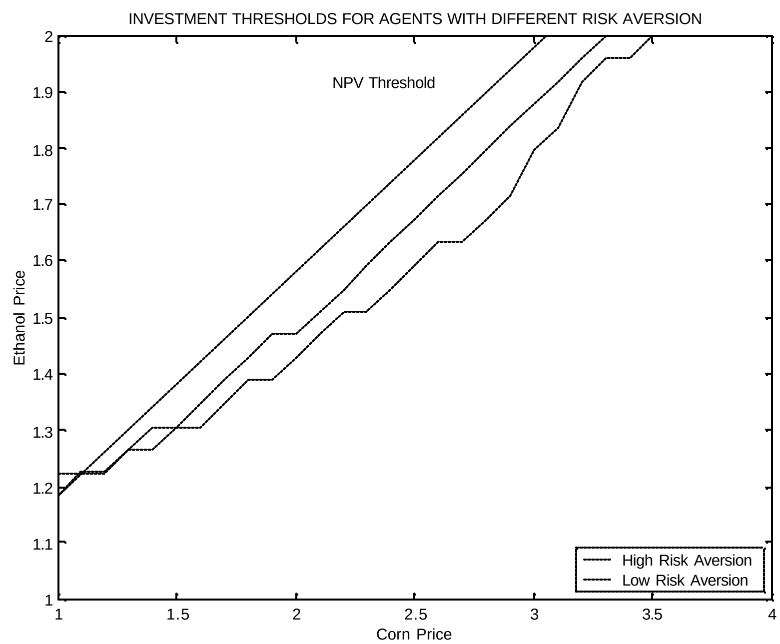
The auction problem is further complicated in the years prior to the cooperative's formation because the share price is set by the cooperative rather than chosen by the agent. In that situation, the agents solve:

$$\max_{SH'} \left\{ \mathrm{E}\left[U(\Pi_{SP=\overline{SP}})\right] + \frac{1}{1+r}\mathrm{E}\left[W(SH', SP, P+dP)\right]\right\}$$

subject to the constraints of Equation 2

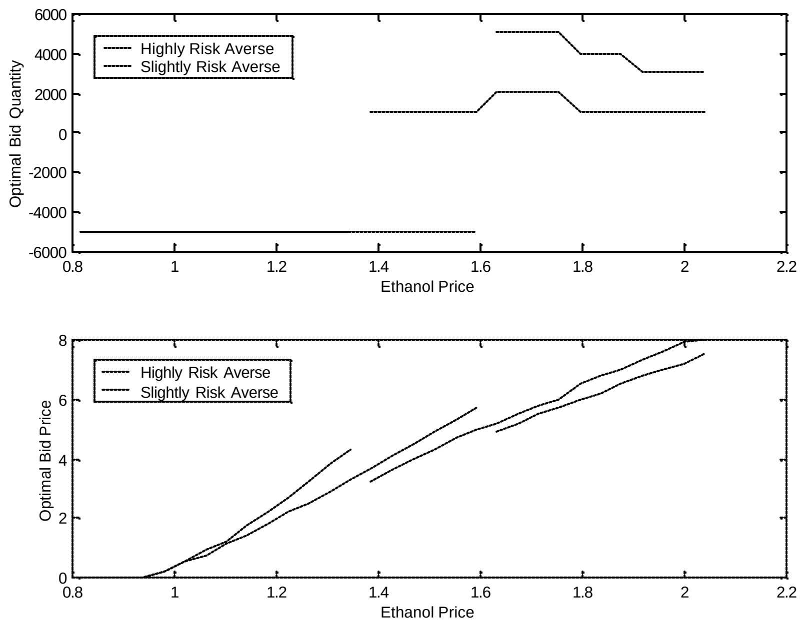
The net cash flow in the current year is determined by the number of shares the agent decides to purchase, the expected state, and the share price that the cooperative has set, $\overline{SP}$. The continuation value is the discounted value function determined by solving the Bellman equation. In other words, the agent splices together a dynamic programming problem of two control variables with a maximization problem of a single control variable.

Again, a brief discussion of the agent's optimal policy is helpful. Figure 3, the counterpart to Figure 1, shows the investment thresholds for two medium sized investors in an auction market who vary only by their level of risk aversion. Just as in the competitive market, there are many states (although fewer than in the competitive model) where the agent's optimal policy is to invest in an unprofitable cooperative. However, in the auction setting the agent with a higher level of risk aversion nearly always has a lower investment threshold than the less risk averse agent.



Auction Market Investment Thresholds
FIGURE 3

Figure 4 plots the optimal policy of the same two agents, but instead of an investment threshold it shows the optimal quantities and share prices that would be submitted to the auctioneer over a range of ethanol prices. This figure shows that the optimal price, whether a bid or a reserve price, is increasing in the ethanol price when the corn price is fixed. As the ethanol price increases it forces a buyer to bid a higher price in order to improve his chances of success. Higher ethanol prices also allow a seller to submit a higher reserve price to improve her expected net cash flow without compromising her chances of success. Figure 4 also shows that a highly risk averse buyer will offset his need to submit a higher bid price by bidding for fewer shares than his less risk averse counterpart.



Optimal Prices and Quantities In The Auction Market
FIGURE 4

Perhaps more importantly, Figure 4 illustrates one of the problems posed by trading with an auction mechanism. It shows that over the range of ethanol prices from about $1.40 to $1.60, the highly risk averse agent is a buyer and the slightly risk averse agent is a seller. However, no trade will occur because the seller's reserve price is always higher than the buyer's bid price. In fact, we have found that for every type of agent there is a discontinuity between the bid price function and the reserve price function, with the reserve price function being higher on its right hand endpoint than the bid price function is at its left hand endpoint. This makes it difficult to find compatible buyers and sellers, and as a result it is possible to have both buyers and sellers in the market but no trading.

This problem results in a significant reduction in trading volume and illustrates the very real possibility that an agent will be unable to execute an optimal trade. The fear that a member will eventually be unable to sell his shares is important because it has the effect of stifling the initial demand for NGC stock. A risk-averse investor, who is unsure whether he will be able to resell his shares, will compensate for this possibility by purchasing fewer shares to begin with. When all investors act this way, aggregate demand for the NGC stock is reduced. In the next section, this issue will be made more concrete.

C. The Problem When The Agent Is An IOF

The problem of the investor-oriented firm is very much like that of an agent in a competitive-type cooperative. The IOF, which we assume to be risk-neutral, maximizes the discounted sum of expected net cash flow (Equation 3) over an infinite planning horizon by choosing the optimal level of investment, *SH'*. We assume the IOF is myopic and ignores the possibility of a NGC preemptively building an ethanol plant. As a result, the IOF's "share price" is non-stochastic and equal to the cost, per bushel of corn processed, of building the plant. We assume that if the IOF wants to divest itself from the plant it could sell the building and equipment for approximately 15% of its original value. Finally, for purposes of comparison with the cooperative formation thresholds, we assume that processing costs (*CAC*) are the same for both the IOF and the cooperative.

With these modifications, the IOF's optimal policy is found by using numerical methods to solve the general recursive problem (Equation 2). The control variable in the IOF's problem is binary so that $SH' = total\, bushels\ of\ corn\ processed$ if the IOF chooses to invest and $SH' = 0$ if it does not. However, since we have assumed risk neutrality, the

IOF's optimal policy would be to either invest as much as possible or invest nothing even if we did not impose this constraint.

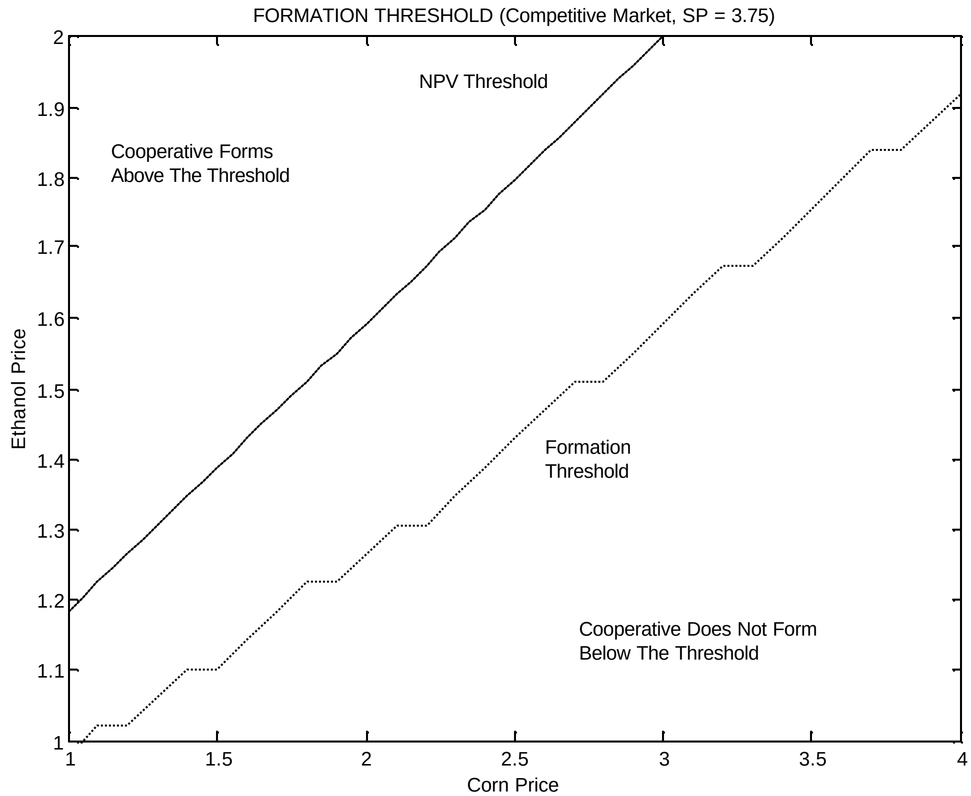
IV. MARKET SIMULATION MODELS

A. Competitive Market

After identifying an investor population and ethanol plant capacity, we were able to calculate the cooperative's formation threshold by evaluating the demand for shares at various ethanol price / corn price combinations for each agent in the investor population. At each state, we concluded that the cooperative would form if the aggregate demand for shares was greater than or equal to 65,000 (13 million times 0.005). The investment threshold for a cooperative which trades its shares in a competitive manner is shown in Figure 5.

The most striking result is that the cooperative will form even when the traditional net present value rule suggests investment would be unwise. The area above the formation threshold and below the net present value line represent ethanol price / corn price combinations where the expected net present value of a cooperative share is less than the $3.75 share price. In fact, most of this area represents states that result in a single period loss for the cooperative but which are favorable for cooperative formation, nonetheless.

The reason the cooperative's investment threshold is below the NPV threshold should be apparent from our earlier discussion of the agent's problem. Figure 1 tells us that each potential investor demands shares in the cooperative as a risk



Investment Threshold – Competitive Market NGC
FIGURE 5

management tool even if immediate losses are expected. Since total demand for cooperative shares is merely an aggregate of the demand of individual investor demand, it is not surprising that the cooperative could conceivably form over a broad range of seemingly unfavorable states.

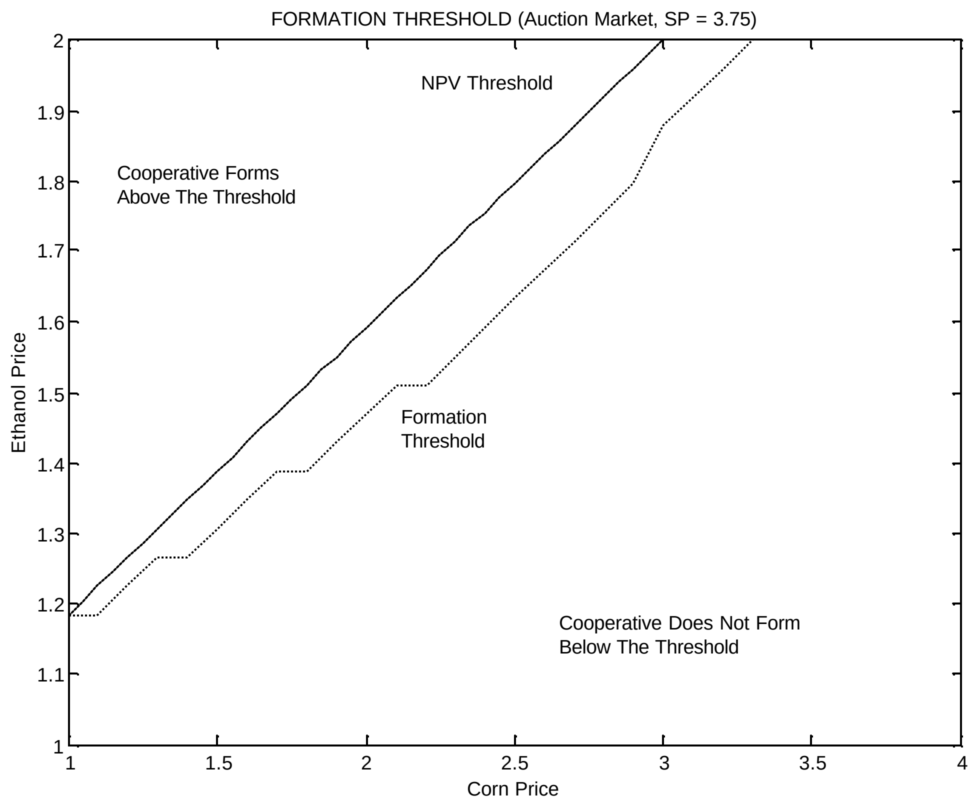
As a practical matter, for a cooperative's shares to be traded in a competitive manner there would need to be a large, heterogeneous membership and an efficient mechanism for members to learn and share information. This is unlikely to be a realistic assumption. However, there are still very good reasons for studying the competitive case.

First, the cooperative's formation threshold has implications for producer welfare. Our model of investment in a competitive-type cooperative assumes agents are able to exercise their optimal policy. Therefore, each state above the threshold is one where the existence of a cooperative improves the utility of its members. The presence of a NGC may also increase local corn prices (Zeuli, 1998) and improve the welfare of non-members. Even if a NGC has a neutral impact on the welfare of non-members, forming a cooperative at states above the threshold results in a Pareto improvement for the population of investors. Using this concept of welfare, rather than cooperative profitability, as a measure of cooperative success suggests that NGC's may have more value to producers than what is revealed on a balance sheet. Specifically, these results show that it is entirely rational for producers to form a NGC even when the cooperative promises immediate losses or if the application of the NPV rule suggests investment would be unwise.

Second, this model provides a baseline upon which to judge cooperatives that use other market mechanisms. If a cooperative using a discriminatory auction stock trading mechanism, for example, forms over a different range of states we can conclude that form of cooperative either fails to capture potential welfare gains (if it forms over a more limited range of states) or that it causes members to suffer welfare losses (if it forms over a broader range of states). We will discuss this welfare comparison in more detail in the final section of this paper.

B. Auction Market

To determine the formation threshold for a cooperative using an auction trading mechanism, we used the same population of hypothetical producers and the same parameters for the ethanol plant as we did in the competitive market example. Figure 6 shows the threshold as a function of the ethanol and corn prices. Again, we find that a cooperative using an auction trading mechanism can form even when the NPV rule suggests it should not.



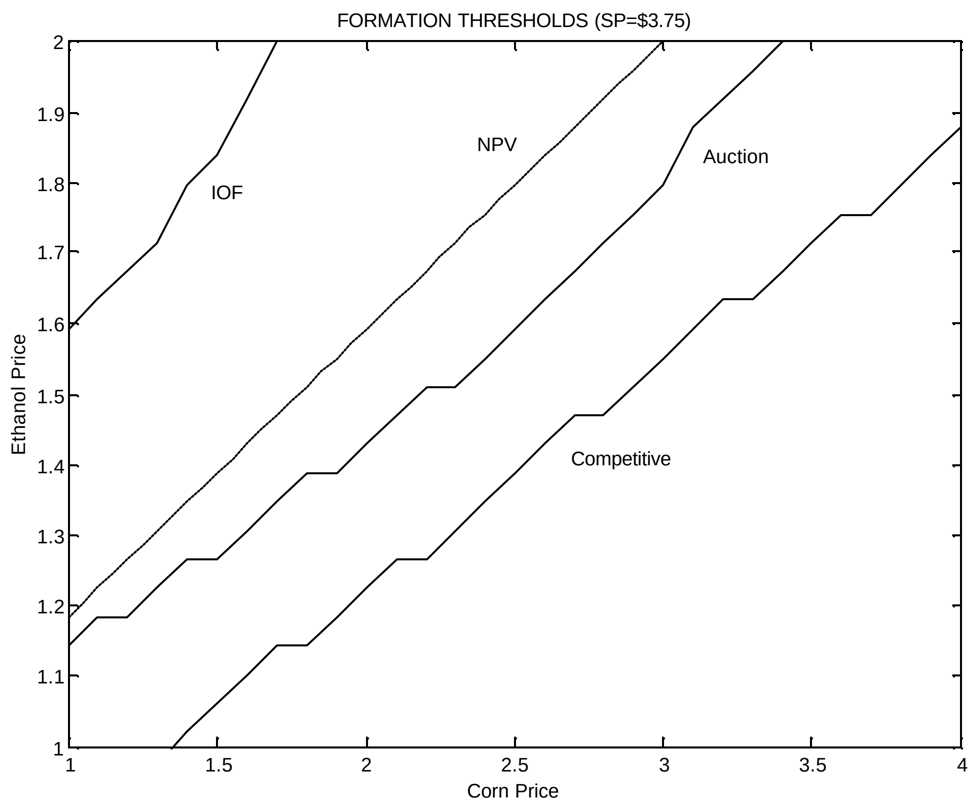
Formation Threshold – Auction Market NGC
FIGURE 6

C. Comparison of Organizational Structures

There are a number of reasons why a comparison of formation thresholds is important. Comparing cooperative thresholds is a useful measure of how effective a certain type of cooperative is at capturing the potential welfare gains promised by a processing cooperative. Our model can, therefore, be a useful tool in designing efficient cooperative trading mechanisms. In addition, a comparison of formation thresholds can have practical application for policymakers. A "low" investment threshold implies more opportunities for cooperatives to organize. Understanding the conditions that change investment thresholds can be useful when cooperative advocates suggest policies to promote cooperative development.

Figure 7 shows the investment thresholds for the competitive-type cooperative, the auction-type cooperative, and the investor-owned firm. We find that the threshold for the auction-type NGC is higher than the threshold for the competitive-type cooperative. In addition, the investment threshold for the IOF is significantly higher than both of the cooperative thresholds. There are sound reasons why this should be the case.

A helpful way of analyzing these thresholds is to examine their relationship to the NPV line. The net present value rule says that investment should occur when the discounted expected value of the investment exceeds its cost. Dixit and Pindyck (1994) show that under normal circumstances the threshold for a risk-neutral investor should be higher than the NPV line because there is a positive value associated with waiting for uncertainty to be resolved. By investing, an agent gives up the option of waiting. In order to compensate for the loss of the option to wait an agent will demand that the investment be more valuable than if the option of waiting did not exist. We see that the IOF's investment threshold conforms to this rule. The reason the cooperative thresholds are below the NPV line is because the cooperative's benefit to its members as a risk management tool outweighs the value of waiting. Since the IOF in our model does not care about risk management but is concerned only about its expected profit, its threshold will never fall below the NPV line.



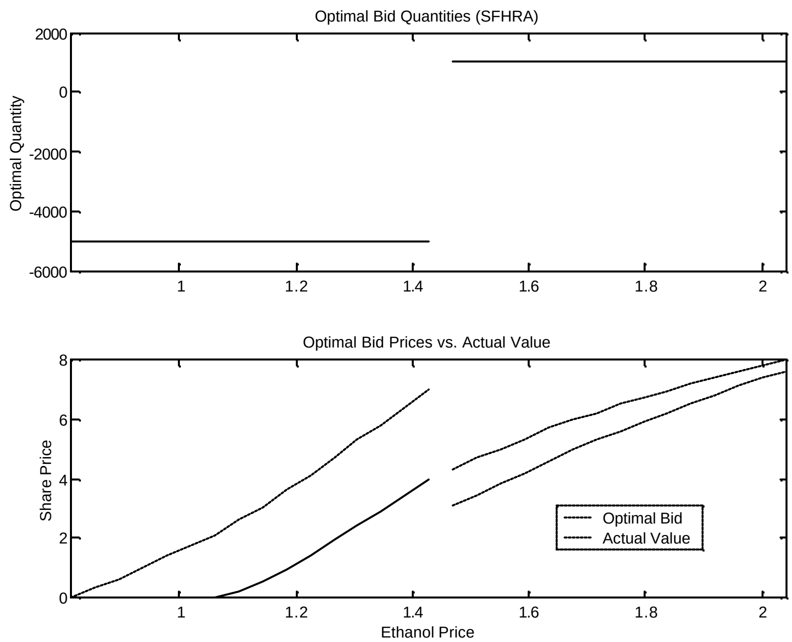
Investment Threshold Comparison
FIGURE 7

A cooperative's value as a risk management tool does not imply that its investment threshold will always fall below the NPV line, or even that it will always fall below the IOF's threshold. The thresholds of individual agents rise as the level of their investment rises. In our model, the number of agents relative to the number of cooperative shares available is sufficiently large to permit agents to invest small amounts. Consequently, they are willing to purchase shares under less favorable conditions. However, if the number of potential investors were small relative to the number of shares outstanding, the individual thresholds would rise and the cooperative threshold would subsequently rise. The magnitude of the shift in the investment threshold would depend on how the change in plant size affected the price dynamics and probability functions.

Another reason the IOF's threshold is higher is because the gap between the IOF's cost of construction and the salvage value adds an element of irreversibility to the IOF's problem that is not present in the cooperative's problem. Since we reasonably assume an IOF cannot sell an active plant but must instead sell its equipment for the salvage value, the IOF has an incentive to wait and invest only when the prospects of long term profitability are good. While the decision to shut down a member-owned ethanol plant is equally expensive, this fact tends to be lost at the individual level. If a member chooses to disinvest in the cooperative he cannot, by himself, cause the plant to close. Instead, he sells his shares to another producer. Therefore, a cooperative member's disinvestment decision is based upon his expectation of the share price he will receive under the relevant trading mechanism and not the plant's salvage value. This difference tends to make cooperative members perceive their investment decision as more reversible than an investor-owned firm would.

Thus far, we have not explained why the auction threshold is higher than the competitive market threshold. Our findings reveal two reasons why this is the case. First, agents fear that they may have a difficult time reselling shares in the auction setting and this causes them to scale back the size of their initial investments. As we explained earlier, a risk-averse investor realizes he may ultimately need to submit a relatively low reserve price in order to improve his odds of successfully selling his shares. It is optimal for him to compensate for this possibility by holding fewer shares. Therefore, in order to lure investors to buy enough shares for the cooperative to form, the cooperative must promise greater profitability that it would if the stock's liquidity were more secure.

A second reason an auction-type cooperative has a higher investment threshold is because discriminatory auctions create incentives for agents to "shade" their bids. (Nautz (1995), and Nautz and Wolfstetter (1997)). Figure 8 illustrates this point. It shows the



Bid Shading In The Auction Market
Figure 8

optimal quantity and price for a small agent in an auction setting who owns 5000 shares in the cooperative. The solid line in the bottom graph shows the agent's optimal bid price and the dotted line shows the price the same agent would be willing to pay for his optimal quantity in a competitive market. We see that it is optimal for the agent to understate his true willingness to pay for shares at every state represented in the graph. Intuitively, bid shading occurs because a buyer's optimal action is to bid as low as possible without slipping below the stop-out price. A bid above the stop-out price, while it may be closer to the agent's true value, only increases the cost of acquiring shares. When agents bid below their true value, however, it is possible that shares will not be sold to investors who, in truth, would have been willing to pay for them. This creates an inefficiency in the market that prevents gains from trade from being realized.

The fact that the auction-type cooperative's threshold is higher than that of the competitive-type cooperative suggests that a cooperative using an auction mechanism to trade its shares fails to capture all of the potential welfare gains for its members. The area above the competitive threshold and below the auction threshold represents a set of states where an auction-type cooperative, if it had a more efficient trading mechanism, could be improving member welfare. However, due to bid-shading and the fear of stock illiquidity the auction-type cooperative does not form and investors are left without a potentially valuable risk management tool.

D. Membership Distribution

While we have concentrated on the formation thresholds for the three different types of organization, our market simulations also allow us to examine the long-run distribution of shares in the two types of cooperatives. The following table summarizes the average share holdings for a 65,000 share cooperative organized by agent characteristic and cooperative type. These averages where obtained from the results of ten different ten-year simulations.

We have found substantial differences in the distribution of shares in the two types of cooperatives. Both types of cooperatives end up with a disproportionately high percentage of large agents, but the competitive-type cooperative much more so than the auction-type cooperative. The competitive-type cooperative strongly favors agents who are near the ethanol plant, but the auction-type cooperative ends up with members who are geographically distributed much more like the general population. Finally, the competitive-type cooperative is likely to have members with low levels of risk aversion

Agent Type	Overall Percentage In The Population	Percentage In A NGC Using A Competitive Trading Mechanism	Percentage In A NGC Using An Auction Trading Mechanism
Large	9	44	19
Medium	24	37	24
Small	67	19	57
Near	24	61	31
Far	76	39	69
Highly Risk Averse	50	27	69
Slightly Risk Averse	50	73	31

Distribution Of Cooperative Members
Table 1

while the auction-type cooperative is likely to have members with high levels of risk aversion. Despite these differences, the type of agent who is likely to be the biggest shareholder in both types of cooperative at the end of a ten year period is a large, near, slightly risk-averse agent.

The distribution of shareholders in the competitive-type cooperative is predictable. The agent characteristics that result in the greatest demand for shares are large size, nearness to the cooperative, and a low level of risk aversion. In fact, the shareholders in the competitive cooperative are distributed in exactly this manner.

However, the distribution in the auction-type cooperative is less intuitive. This is because an agent's risk aversion is the factor driving his success or failure in the auction setting. As we showed in Figure 4, a highly risk averse agent tends to submit a more aggressive bid price when he is a buyer but a less aggressive reserve price when he is a seller. The other characteristics, farm size and distance from the cooperative, impact only the *quantity* submitted to the auctioneer. These characteristics tend not to be good predictors of who will own shares because an agent's success in an auction is determined solely by the *price* submitted. As a result, the shareholders in an auction-type cooperative are disproportionately highly risk averse while the other characteristics of the cooperative's membership track more closely with the investor population as a whole.

IV. CONCLUSIONS

We have found that using a dynamic, agent-based model of a member-owned business can help explain differences in behavior between member-owned and investor-owned firms. Using a new generation ethanol cooperative as an example, we find:

- Member owned firms will form in conditions where an investor owned firm would not.
- Over a range of corn price / ethanol price combinations, including many that would result in a NGC realizing a negative profit, the existence of a cooperative improves the utility of investors.
- A NGC that chooses to trade its shares through an auction mechanism will face a higher investment threshold than if a competitive market for the shares existed. This suggests that employing a discriminatory auction trading mechanism causes a cooperative to miss out on opportunities to improve member welfare.
- A NGC that uses a competitive trading mechanism is likely to end up with a membership dominated by large agents with low levels of risk aversion who are

located near the ethanol plant. NGC's using a discriminatory auction mechanism, however, are likely to be dominated by highly risk-averse investors.

While the relative entry thresholds of the investor-owned firm and member-owned firms in our paper are important, there are other equally important issues that need to be examined. Cooperatives can use trading mechanisms other than auctions. They may also use different types of auctions, such as competitive auctions. We intend to explore some of these other structures to determine if entry thresholds change significantly and to compare the welfare implications of the structural choices made by cooperative management. In addition, we are currently working on finding the exit thresholds for IOF's and cooperatives with the hope that this will shed light on the issue of takeovers of ethanol plants.

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