A feasibility study of swine producer management cooperatives

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A feasibility study of
swine producer management cooperatives
by
Alan L. Vontalge
A Thesis Submitted to the
Graduate Faculty in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE

Department: Economics
Major: Agricultural Economics

Iowa State University
Ames, Iowa
1991
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CHAPTER I.
INTRODUCTION

The swine industry is of significant importance to Iowa's economy. Iowa produces approximately 25% of the total U.S. hog production (USDA, Meat Animals: Production, Disposition and Income). It was estimated that in 1987 there were 68,100 jobs in Iowa related to the pork industry (Otto, 1987). Cash receipts from hogs marketed in Iowa total over $2.7 billion annually (Iowa Agricultural Statistics, 1988).

These figures show the relative importance of the swine industry to Iowa. However, the future of this industry needs to be evaluated if Iowa is going to maintain its dominant position in the production of pork.

Recent studies have shown that only the top Iowa producers compete with large-scale swine producers in other regions and that the majority of Iowa swine production lacks in efficiency and performance. This concern has led agricultural researchers to search for ways to improve and maintain Iowa's competitive position in the production of pork. One effective method of increasing Iowa swine producers' performance is through increased management. This study investigates the feasibility of a cooperative that provides management services to Iowa swine producers.
Structural Changes in the Swine Industry

The swine industry in the United States has been experiencing a period of dramatic structural change. Although the number of farms producing hogs has been declining since the beginning of this century, the loss in swine farmers has accelerated sharply over the past 30 years. The number of swine farms declined over 75% from 1959 to the present (USDA, Hogs and Pigs; Rhodes, 1990a). This reduction in actual numbers of farms with hogs has been offset by an increase in the average swine farm size. Even more interesting is that while the number of farms producing hogs has declined, the number of large farms selling over 1,000 hogs per year has actually increased from 1,500 farms in 1959 to 23,900 in 1987 (USDA, Hogs and Pigs). The swine industry has evolved from an industry characterized by many small farms dispersed across the United States to fewer, larger, highly specialized swine farms concentrated in the Midwest and Midsouth.

A related structural change in the swine industry is the growth of multiunits. A multiple unit consists of several farms or production units managed by a single entity. A typical multiunit operates one or two farms in addition to the homeplace (Rhodes, 1990a). In 1987 the number of multiunits was almost 20% of the total number of operators producing hogs and almost one-half of the marketings from multiunits came from operations marketing 5,000+ hogs per year (Rhodes, 1990a). This shows the impact on the hog industry that
multiple units have on the numbers of hogs produced and marketed.

Another change in the swine industry has been the increase in contracting activity over the previous twenty years. A contract is an agreement between a contractor and a grower. Growers typically provide labor and the care of animals in their own facilities. The contractor furnishes feed and typically provides and owns the animals. Growers are paid fees which generally reflect the level of production that they are able to achieve with the contractor's hogs. Between 8% and 12% of the hogs in the United States are produced under contract (McDaniel et al., 1988; Rhodes, 1990b).

These structural changes in the swine industry have been combined with a shift in the regional production of hogs. North Carolina has increased their share of U.S. hog production from 1.8% in 1955 to 4.5% in 1987 (USDA, Meat Animals: Production, Disposition and Income). This shift in production has been caused by the formation of large farms in the Southeast. In 1987, 58% of the hog farms in North Carolina marketed over 5,000 hogs annually. In Iowa, fewer than 10% of all swine farms were that large (Rhodes, 1990a). These large farms in the Southeast are potentially Iowa's greatest competitor in the production of pork due to their scale and efficiency.
Relation to cattle feeding industry

These structural changes show that there is a reorganization occurring in the swine industry. These changes resemble those that previously occurred in the broiler and cattle feeding industries (Rhodes, 1990a; Hillburn, 1988).

Prior to 1960, cattle feeding was dominated by small farmer-feeders which were mainly located in the Corn Belt. The industry was characterized by large numbers of small farmers with diversified operations. Cattle feeding then started to shift to large, specialized commercial feedlots in the Southern Plains and Western States. Over the period between 1955 and 1978, cattle marketings in the Corn Belt decreased from 39% to 20% of total U.S. marketings. Over the same time period cattle marketings in the Southern Plains increased from 14% to 45% (Reimund et al., 1981).

Structural change within an industry can be broken down into four identifiable steps: (Reimund et al., 1981)

1. New innovations and technologies are developed for an industry.
2. Production shifts to new areas more amenable to the new methods as opposed to the traditional methods.
3. New areas of production grow and develop possibly causing overproduction.
4. Industrialization occurs in the industry which results in vertical coordination and contracting
which shifts the control of product flows from producers to the processing and marketing stages.

The growth of large-scale, specialized hog production operations using new technologies that are being developed outside of traditional hog producing regions tends to suggest that the swine industry is following in the footsteps of the cattle feeding industry. Producers in the emerging areas, such as North Carolina, are new entrants in hog production with operations of substantial size. With contracting activities there is also some vertical integration occurring with the input supply or output processing activities related to swine production. This information tends to suggest that the swine industry is in the second, or "shift in location of production", stage of the structural change process (Reimund et al., 1981). However, the majority of hog production is still located in the Corn Belt (USDA, Meat Animals: Production, Disposition and Income).

Other swine industry concerns

In addition to these structural changes occurring in the swine industry there are also other pressures influencing the industry. Consumers are demanding a leaner product as health concerns have led them to reduce the level of fat in their diet. Regulations and penalties regarding disposal of waste products from swine farms have received much interest. Animal rights activists are constantly challenging swine producers
and their building designs. There has also been an increase in the number of larger swine farms with extensive management in Iowa, as well as other areas of the United States, which has brought on the concern that the Iowa swine industry needs to become more efficient and productive if it is going to continue to survive and grow against this competition (Hillburn, 1988).

**Effects of Structural Changes on Iowa Producers**

A study conducted by the Iowa State University Swine Task Force addresses the subject of management in pork production (Kliebenstein, et al., 1988). Iowa has been producing approximately 25% of the total U.S. hog production for the past three decades (USDA, Meat Animals: Production, Disposition and Income). In recent years it has been shown that it is not necessary to produce hogs in a region where feedstuffs are abundant to have a competitive advantage (Kliebenstein et al., 1988). The study compared Iowa swine producers with "intensively managed" operations. These "intensively managed" operations were located primarily in the Atlantic coastal region and Midsouth, but would include Iowa producers also. These swine operations with specialized management are usually the only enterprise in the farm unit, rather than being part of a diversified farming operation. They hire labor which has been trained to one specific area of swine production and tend to substitute assets for labor.
The study showed that only about the top 20-25% of Iowa swine producers are on a comparable basis to the "intensively managed" operations. This information is summarized in Table 1.1 (Kliebenstein et al., 1988).

<table>
<thead>
<tr>
<th>Iowa Producers</th>
<th>Intensively Managed Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Top 10%</td>
</tr>
<tr>
<td>Feed cost/cwt.</td>
<td>$18.77</td>
</tr>
<tr>
<td>Fixed cost/cwt.</td>
<td>$4.05</td>
</tr>
<tr>
<td>Diet cost/cwt.</td>
<td>$5.22</td>
</tr>
<tr>
<td>Total cost/cwt.</td>
<td>$29.30</td>
</tr>
<tr>
<td>Feed efficiency</td>
<td>3.61</td>
</tr>
<tr>
<td>Avg hd mkt/yr</td>
<td>1036</td>
</tr>
<tr>
<td>Pigs/sow/yr</td>
<td>1.76</td>
</tr>
<tr>
<td>Pigs weaned/lit</td>
<td>13.95</td>
</tr>
<tr>
<td>Death loss, %</td>
<td>15.02</td>
</tr>
</tbody>
</table>

The intensively managed operations are larger in size than the average Iowa swine producer. However, their advantage comes from their production efficiency, rather than the scope of their operation. For example, over the period 1983-1986 the "intensively managed" operation's total cost per hundred lb. of pork produced was $4.06 lower than the top one-third of Iowa producers, which is illustrated in Table 1.2. The results of this study conclude that "management intensity is the key to remaining competitive in pork production" (Kliebenstein et al., 1988, p. 62).
Table 1.2  Comparison of Iowa producers with competition, (1983-1986)

<table>
<thead>
<tr>
<th></th>
<th>Iowa Producers</th>
<th>Intensively Managed Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Top One-Third</td>
<td>Low One-Third</td>
</tr>
<tr>
<td>Feed cost/cwt.</td>
<td>$23.76</td>
<td>$28.27</td>
</tr>
<tr>
<td>Fixed cost/cwt.</td>
<td>$6.77</td>
<td>$9.76</td>
</tr>
<tr>
<td>Total cost/cwt.</td>
<td>$38.20</td>
<td>$48.40</td>
</tr>
<tr>
<td>Pigs/sow/yr</td>
<td>15.01</td>
<td>13.72</td>
</tr>
<tr>
<td>Feed efficiency</td>
<td>3.72</td>
<td>4.09</td>
</tr>
<tr>
<td>Avg hd mkt/yr</td>
<td>1422</td>
<td>1171</td>
</tr>
</tbody>
</table>

*a Assumes an average corn price of $2.50/bushel. Competition feed cost is adjusted according to diet cost relationship between Iowa average and competition shown in Table 1.1.*

While these specialized farms located outside the Corn Belt are superior in their performance as compared to average Iowa swine producers, the loss of the pork industry from Iowa is not a foregone conclusion. Producers in the Corn Belt have the intrinsic advantage of being located close to a supply of feedstuffs and processing plants for their products. Smaller swine operations located in Iowa can compete and survive, but to do so they are going to need increased management.

Problem Statement

The Iowa State University Swine Task Force study which showed only the top 20% to 25% of Iowa swine producers are competitive against "intensively managed" operations combined with the beginning of a shift in the regional production of pork identifies the need to develop and strengthen Iowa's
competitive advantage in swine production. Iowa producers need to become more competitive and efficient in their production of pork if they are going to survive in this ever-changing industry. One of the best ways to accomplish this task is through increased management levels. One viable solution for providing these additional management services could be through the creation of management cooperatives to assist farmers in reaching this goal. The objective of this thesis is to study the feasibility of a cooperative providing these key management services to Iowa swine producers.

Management Cooperatives

Description of a management cooperative

A cooperative is defined as a user-owned and controlled business that distributes benefits on the basis of use (Cobia, 1989). The fundamental purpose of an agricultural cooperative is to improve the economic well-being of farmers, whether financially or with other measures. This purpose is accomplished through the provision of goods and services, access to markets, reduction of costs, sharing of risks, and increased farmer influence in the marketplace (USDA, 1987). The management cooperative will provide and fulfill all of these requirements of a cooperative.

Traditionally cooperatives have provided feed, fertilizer, or supplies to farmers or provided a market for their product. The management cooperative may still provide
feed and supplies to swine farmers, but in addition it will provide management services. Some examples of management services could include, but are not limited to record keeping, nutrition analysis, ration formulation, supplying of superior genetics, on-farm consultation, veterinary and health programs, facility design, financing for the livestock and/or buildings, and assisting in the originating and marketing of swine.

There are some basic assumptions which need to be made in determining and explaining how the swine management cooperative would work. The cooperative will need to provide more than just an advisory service. Advisory or educational organizations cannot create the needed incentive for the farmer to actually change his or her production practices. A stronger relationship between the farmer-member and the cooperative must be created. For this reason, it is probably essential that the farmer and the cooperative enter into a legally binding contract. If there was no contract between these two participants there would be no assurance that the farmer or the cooperative would perform as intended. Participation in the management cooperative can be thought of as simply raising hogs under contract where the contractor is a cooperative, as opposed to another swine producer or a corporation.
Review of contracting

Contract production of hogs has existed for over 30 years. Prior to the 1980's there was very little contract hog production in the Corn Belt. However, contracting began to grow in the 1980's in response to the financial crisis (Futrell, 1989; Rhodes, 1990b). Currently between 8 and 10 percent of hogs are produced under contract (McDaniel et al., 1988). V. James Rhodes (1990b) suggests an upper limit of approximately 12 percent of the total U.S. slaughter is produced under contract in his report on contract hog production. A survey by Iowa State University and the Iowa Pork Producers Association showed that only 3.2% of Iowa farmers raise hogs under contract (Ginder, 1990). This tends to suggest heavier contracting activity in other parts of the U.S. and that there is great potential for the expansion of hog contracting in Iowa.

Financial reasons appear to be the major incentive for contract hog production. Some other possible influences include: (1) inability to finance hog production either through internally generated equity or through credit, (2) unwillingness to assume the risk involved, (3) the need to utilize under-used resources, either physical facilities or labor, (4) the flexibility of being able to get in or out of hog production quickly, (5) the desire to reduce managerial expertise needed, (6) the high cost of capital and the desire to reduce capital input, and (7) the opportunity to be
guaranteed a minimum return (Futrell, 1989; McDaniel et al., 1988).

The swine management cooperative engaged in contracting could be attractive to the financially troubled farmer. In the mid-1980's farmland asset values plummeted which caused a serious decline in the net worth of many farmers. This reduction in net worth reduced the farmers' borrowing capacity. Lenders became more stringent in their lending practices and farmers also became less willing to take on debt to finance expansion or continue with their present size of operation. Some producers downsized the scope of their operation and others were even forced into bankruptcy.

"Those who wish to maintain the current independent producer centered structure must recognize that contracting provides what may be the only viable opportunity for skilled producers in financial difficulty or without adequate risk (equity) capital to use their skills" (Ginder, 1989, p. 10). The swine management cooperative could provide financially-troubled producers with access to contracting and permit them to remain in swine production and at the same time they will have an opportunity to share in the profits generated.

Contracting may also be an effective method of expanding a producer's operation without assuming much additional risk (McDaniel et al., 1988). Miyazaki (1984) expands on this idea and argues that cooperatives are often established as a way of restructuring a financially weak or bankruptcy-prone
entrepreneurial firm. The management cooperative will be appealing to financially troubled farmers for two distinct reasons. First, by joining a cooperative the farmer-members will still have some control in decision making and second, the contracting aspect will reduce the farmer-member's exposure to risk.

Contracting with the management cooperative may allow farmers to substitute managerial services for labor. If a producer is limited in the size of his swine operation by a labor constraint, then the additional management provided by the cooperative may allow the farmer to expand his operation. Similarly, if a producer desires to maintain the size of his operation but reduce the amount of labor which he has to provide, the cooperative may be the answer.

Contracting is often not viewed favorably by farmers. With contracting farmers usually lose some degree of control over the decision making for their operation. Some critics of contracting argue that farmers on contract simply become hired hands on their own land for large corporations. Contracting with the management cooperative will tend to alleviate this problem associated with contracting. Since a cooperative is a user-owned and controlled business, farmers contracting with the cooperative will have some voice in the decision making for the cooperative. Farmers will be required to perform as the contract specifies but they will also have some policy control through their ability to vote and elect a board of
directors who, in turn, determine how the cooperative is operated.

Another major criticism of contracting is that farmers do not receive enough return to cover their labor costs and building expenses (Robbins, 1988). Contracting with the cooperative will also tend to eliminate this problem. The management cooperative may use the same contract form as others used in the industry, but because it is a cooperative farmers are entitled to a share of the cooperative's profits through patronage refunds. If a farmer contracts with a large corporation any profits that are realized by the corporation may leave the community and go to the corporate shareholders or they may be invested by the corporation in other areas outside of swine production. If that same farmer contracts with a cooperative and the cooperative realizes profits then either the profits will be returned to the farmer or they will be retained by the cooperative which will serve to benefit the local community.

While there are some criticisms against contracting, farmers who are actively involved in contracting generally have a positive attitude towards it. In V. James Rhodes' study (1990b) growers rated their satisfaction with contracting at an average of 4.5 on a 6 point scale (6 = extremely satisfied and 1 = not satisfied at all). In that same study independents who were not involved in contracting had a more negative view of contracting. Of those
dependents not involved in contracting only 1% were considering the idea and only another 20% said they might consider it sometime (Rhodes, 1990b). This indicates that farmers are generally opposed to contracting until they actually produce hogs under contract and recognize its advantages.

**Cooperative objectives**

The swine management cooperative's objective is more than just to supply management services to swine producers. The primary objective for the formation of this type of cooperative is to increase the performance and efficiency of Iowa swine producers so that Iowa can maintain its competitive advantage in the production of pork. Some specific objectives or goals for the formation of swine management cooperatives include:

1. To improve the utility or well-being (income) of a farmer who desires to be involved in swine production. This is the fundamental purpose of a cooperative (Cobia, 1989).

2. To provide farmers or other individuals with additional labor and/or resources available with the opportunity to diversify their present operation to make a profit in the swine industry without requiring extensive knowledge or managerial experience. The cooperative will also allow
producers to expand their operation due to the reduced time required to perform managerial obligations.

3. To provide the managerial services listed above to swine farmers that otherwise would not be available. Some of these services, such as a consulting veterinarian, would be available without the cooperative but may be prohibitively expensive for the individual producer to purchase this service on his or her own.

4. To coordinate the sale of market hogs to obtain a higher price than individual farmers would be able to. In addition, the cooperative could provide inputs such as feed or veterinary supplies to the farmer-members at lower input prices than individual farmers might be able to obtain on their own.

5. To increase the efficiency of markets through improved coordination between producers and consumers such as encouraging the production of a certain type or quality of hog.

6. To encourage the construction and utilization of standardized facilities for profitable and efficient swine production. Through the development of standardized building designs the cooperative will be more able to identify the cause of problems in an individual building by comparing it to other
basically identical buildings.

7. To reduce and share producer risk by offering the farmers a guaranteed return under contracting. The producer still faces some production risks. However, the price and production risk for the individual farmer-members are pooled and accepted by the cooperative.

8. To provide financing to swine farmers for buildings and equipment if they are unable to obtain financing elsewhere.

9. To serve as a production standard and provide a measure of how a profitable and efficient swine operation should perform for comparison to other forms of swine operations.

10. Establish a competitive contract market for contract provisions. The cooperative could affect payment schedules, incentive structures, and other practices thereby preventing potential abuse. This is known as the "competitive yardstick" role of cooperatives (Cobia, 1989).

Objectives

The objective of this research is to study the feasibility of a cooperative providing management services to Iowa swine producers. This question will be analyzed in terms of the cooperative's return, farmer-members' returns, and risk
levels. This thesis will focus on the following five objectives:

1. Determine the optimal membership structure for the cooperative. Some specific questions include: What is the optimal membership size for the cooperative? Should membership be composed of specialized swine producers or swine producers with diversified swine and crop farms or some combination of the two? What mix of farrow-to-finish, feeder pig finishing, and feeder pig production is best for the cooperative? Should the cooperative be composed of small, medium, or large-sized swine farms or some mixture of all three?

2. Determine the effect increased levels of management has on swine performance measures such as litters/sow/year, pigs weaned/litter, death loss, feed efficiency, and labor requirements. Do different levels of management produce different results?

3. Determine the effects on membership, cooperative returns, member returns, and risk levels that various contract styles might have. Are there some contract structures which are better suited to the cooperative?

4. Determine if there are advantages to the cooperative in providing financing to farmer-members for
facilities or whether members should obtain their own financing.

5. Determine how the cooperative's earnings might be distributed to members.

Overview of the Thesis

This thesis is organized as follows. Chapter II provides a review of the theory related to cooperatives and similar business forms and shows how the theory relates to the problem being addressed. Chapter III includes an explanation of the model and the analytical procedures used. Chapter IV presents and interprets the results from the model. Chapter V includes a summary, conclusions, and suggestions for further research.
CHAPTER II.
THEORETICAL MODEL

There is an abundance of material that has been written on the subject of agricultural cooperatives. However, most of it has been described as descriptive, eulogistic, and lacking in theoretical content (LeVay, 1983). Cooperative theory that addresses management cooperatives is virtually nonexistent. The cooperative form of business resembles other business forms such as participatory and labor-managed firms. The inclusion of this theoretical literature has contributed to the development of a complete and comprehensive theoretical model for the management cooperative used in this research study.

Definitions

Cooperatives

Cooperatives have traditionally been defined as businesses that are owned by their patrons and follow the Rochdale principles (Staatz, 1987b). The Rochdale principles include: (1) net margins distributed according to patronage; (2) democratic control—one-member, one-vote; (3) limited return on stock; (4) limitation on the number of shares owned; (5) open membership; (6) trading on a cash basis; (7) membership education in the cooperative way of doing business; (8) political and religious neutrality; (9) no unusual risk assumption; and (10) goods sold at regular retail prices, with
net margins rebated to members, rather than discounted retail prices.

After reviewing these principles it becomes obvious that no cooperative in the 1990's will follow all of them. Variations in practices make a concise definition extremely difficult to state. However, due to the modern legal and tax structure and the standards which have been set forth in the Capper-Volstead Act, agricultural cooperatives tend to be limited in the practices they follow. Perhaps the best definition of a cooperative is "a user-owned and controlled business from which benefits are derived and distributed equitably on the basis of use" (USDA, 1987, p. ii).

A review of the literature on cooperative theory shows that cooperatives are related to participatory and labor-managed firms. While these other two business forms are not exactly the same as cooperatives, they do show many similarities which can be applied to the theory of cooperatives.

**Participatory firm**

A participatory firm is a firm where decision making is not done on an individual basis, but where decision making is done in groups. The reason for the development of a business form where different groups jointly determine company policy is that employee participation in management increases worker productivity. The workers feel that the success of the
company depends on their decisions (Svejnar, 1982). The ownership of assets in a participatory firm is usually the same as in a profit-maximizing firm (PMF) where the stockholders or owners own and control the assets. Workers in a participatory firm enjoy the usufruct of the assets but do not own them. Usufruct rights are the rights to use and benefit from an asset (Minkler, 1989). The participatory firm is related to a cooperative because the employees of the firm are actively involved in the decision making process and in an agricultural cooperative the members can influence decision making through their vote of who serves on the board of directors.

**Labor-managed firm**

A labor-managed firm (LMF) also closely resembles a cooperative. A LMF is a firm where all laborers participate in decision making (Vanek, 1970). Members of a LMF are also able to enjoy the usufruct of the assets. The LMF goes one step farther than the participatory firm in that members of the LMF share in the residual income (Minkler, 1989). This is a similar practice that is followed in a cooperative business where the members share in any residual income through the distribution of retained earnings. Ownership of assets in a LMF can be by its workers or by outside investors.
Relationship of firms

These three business forms are related to each other and can be depicted as on a continuum (Fusfeld, 1983). On one end of the continuum is the capitalist firm or PMF. In a PMF the authority to make decisions is exercised exclusively by the owners. The next stage on the continuum is the participatory firm. In the participatory firm workers are given some of the decision making authority and they take on some of the functions and responsibilities of management. Participatory firms can usually be identified as having either "quality circles" or employee stock ownership plans (Fusfeld, 1983). The final firm on the continuum is the LMF where workers control decision making throughout the entire managerial hierarchy. The cooperative form of business most closely resembles the LMF. Sexton (1984) argues that LMFs are closely analogous to agricultural cooperatives. LMF theorists have developed models that are very closely comparable to the models developed by farm cooperative theorists. Meade (1972) also refers to LMFs as cooperatives.

In the rest of this chapter, LMFs, participatory firms, and cooperatives will be viewed as identical business forms.

Objective of the Cooperative

The issue of defining the objective of a cooperative form of business has received much attention and has been addressed by several theorists. There is no overall general consensus
on what the objective of a cooperative should be. However, the most commonly found objective in cooperative literature is that of maximization of income per member or per laborer (Ward, 1958; Vanek, 1970; Ladd, 1982). The rationale behind this objective is simple - everyone engaged in a cooperative or collective effort is naturally interested in receiving, subject to some predetermined rules for income sharing, the maximum reward for his efforts (Vanek, 1970). This objective is expanded by Kahana and Nitzan (1989) to include some other less quantifiable variables such as the level of unemployment, participation in community affairs, intangible income, perceptions of the manager's performance, and the employment stability for the members. In an empirical test of a plywood cooperative Berman and Berman (1989) concluded that there are no deductive reasons for a cooperative to act differently from a PMF if it maximizes income per member. Kahana (1989) also comes to the conclusion that a LMF with a fixed number of members will maximize profit, the same as that of a PMF.

There have been several other objectives for cooperatives that have evolved from efforts to more precisely understand how the cooperative association works. Ireland (1987) argues that the utility of the members is maximized when the return per hour worked is maximized. This is a comparable objective to the one proposed by Ward, Vanek, and Ladd except that it is based on return per hour worked, instead of return per laborer. Another less quantifiable objective suggested by
Stephen (1982) is that the cooperative objective is to maximize member utility. He includes dividend payment, number of laborers, and total hours worked in his definition of member utility. Maximization of laborer utility subject to some minimum revenue constraint is another objective that has been analyzed (Neary, 1988).

The objective which has received the most analysis and has been accepted by the most theorists is the maximization of income per member. This objective is easily quantified and causes the behavior of cooperatives to be similar to a PMF.

**Equilibrium and Resource Allocation**

**Equilibrium**

Since a cooperative is owned by its user-members, a key issue in determining if a cooperative is a viable business form is whether or not it is efficient in its resource use and allocation. Vanek (1969), Furubotn (1976), and Ireland and Law (1982) support the hypothesis that a cooperative will behave in the same manner as a PMF and will produce the maximum output possible from a given set of resources as well as maximum social satisfaction from a predetermined distribution of income. This holds in the short-run as well as the long-run where both a cooperative and a PMF will lead to the same Pareto-optimal equilibrium solutions (Meade, 1972). It is crucial that a cooperative be as efficient as any other business form if it is to attract members and
provide additional benefits not available elsewhere to those members.

**Cooperative firm is smaller**

One difference between the cooperative firm and its capitalist counterpart is that the cooperative will tend to have lower employment and output (Ward, 1958). The reason behind this is that the cooperative behaves just like a PMF and uses labor up to the point where the value of marginal product of labor equals the wage rate. However, the wage rate of cooperative laborers in a worker cooperative will be higher because of the distribution of profits through patronage refunds to the members, assuming that profits are greater than zero. With a declining marginal product of labor this causes the cooperative to employ less labor and produce a lower output than a PMF (Ben-Ner, 1984a). Bonin and Putterman (1986) also come to the same result that cooperatives will be smaller than capitalist firms when profits are positive.

Another reason for the cooperative being smaller than a similar PMF is because of the subsidiarity principle. The subsidiarity principle states that decision making is done best in small groups (Vanek, 1970). Since all members of the cooperative participate in the decision making process it will be advantageous for the cooperative to be smaller than a PMF.

There are, however, exceptions to the cooperative being smaller in size. Kahana and Nitzan (1989) found that a
cooperative with an objective of maximization of income per member subject to a constraint on the number of members, or an objective of maximum employment subject to a profit per member constraint, would actually hire more labor than a traditional cooperative and possibly more than a PMF. It is also possible under price uncertainty and inflation that a cooperative will produce more than a PMF (Paroush and Kahana, 1980).

The argument for the cooperative being smaller than its capitalist counterpart may not apply to this analysis. In the swine management cooperative the laborers will tend to be paid the same as laborers in similar PMFs and, since the members receive the patronage refunds and not the laborers, the cooperative will tend to produce a similar level of output as other firms in the industry. The level of output for the swine management cooperative will also depend on whether or not it has a limit on the maximum number of farmer-members.

**Capital intensity**

Another significant difference between cooperatives and PMFs is their use of capital. If there was a cooperative with a level of capital equal to a PMF, the cooperative would have a higher capital/member ratio than the PMF, because a cooperative will tend to employ fewer members than the PMF (Steinherr, 1978). In their empirical test of plywood cooperatives Berman and Berman (1989) found that cooperatives do tend to have higher capital/member ratios. This tends to
suggest that the swine management cooperative will be more attracted towards highly capital intensive swine operations.

**Resource allocation**

Resource allocation is another issue which needs to be addressed in comparing the efficiency of cooperatives and PMFs. If there are multiple firms within an industry with different technologies between firms, then inefficiencies in resource allocation will occur because the marginal value products of inputs among firms will not be equal (Vanek, 1970). Despite the inequality of marginal value products, the cooperative firm will still operate at a point of maximum factor productivities (Vanek, 1969). Even though an industry may not be efficient in its resource allocation, the cooperative firms within that industry will use their resources efficiently. Furubotn (1976) argues that with uncertainty resource allocation may not be Pareto-optimal. The empirical test conducted by Berman and Berman (1989) showed no misallocation of labor. Most evidence indicates that cooperatives are efficient in their allocation of resources.

**Financing Cooperatives**

Financing is another important issue in determining the success of a cooperative. Improper financing can affect the way members perceive and use the cooperative. There are three
methods which a cooperative can use to finance its assets and operations: external financing, renting or leasing, or through internal financing.

The original argument presented by Vanek (1977) supported the use of external financing for cooperatives. His reasoning was that external financing would reduce the likelihood that the members would get into disagreements while they were making financing decisions. Also, external financing would prevent the current members from dissolving the firm to obtain quick money for themselves. There is one major disadvantage with external financing. Since this is a cooperative, the external creditors have limited control over the management of the firm. Therefore, it is difficult and costly for cooperatives to encourage outside investors to fully finance a cooperative (Putterman, 1984).

Jensen and Meckling (1979) proposed that for Pareto-optimality the cooperative should be a pure-rental firm. The one major flaw of a pure-rental firm is that intangible assets, such as research and development, cannot be rented. If intangible assets are to be obtained they have to be financed either through personal contributions of workers or through a bond or stock issue (Putterman, 1984).

The final method of financing is through internal financing. Apart from the fact that with internal financing members can dissolve and eliminate the firm, internal financing does represent the members commitment and belief
that the cooperative will succeed. However, it is irrational to think that members can provide all of the money to operate a cooperative business.

Uvalic (1986) showed that when a loan repayment period is shorter than or equal to the workers' time horizon, any investment must be seen as a combination of internal and external financing. This is obvious because if an asset will pay for itself before the average member stops patronizing the cooperative, then the members will be willing to invest in the asset. However, members should not invest 100 percent of the money because this would lead members to try to get the most out of their money at any expense to the cooperative. McBride (1986, p. 147) gives a rule of thumb measurement that the "amount of initial capital that should be provided by members is 50 percent of the amount needed to finance fixed assets and for the first year's operating requirements." The best financing strategy for a cooperative is a mixture of internal and external financing.

Cooperative Advantages and Benefits

Farmers have chosen to organize and patronize agricultural cooperatives in the United States for over 200 years even though there are proprietorships, partnerships, and corporate forms of business that provide the same service as cooperatives (Cobia, 1989). The primary motivation for farmer participation in cooperatives is to improve their well-being
or income (Cobia, 1989). The source of the reasoning behind this motivation is all the advantages that cooperatives have to offer their members. There are several advantages of a cooperative providing management services and engaged in contracting with farmers verses a PMF engaged in contracting with the farmer.

**Broader scope for optimization**

One advantage a cooperative has over an investor-owned firm (IOF) in providing management-type services is that the cooperative will tend to have a potentially broader scope for optimization (Staatz, 1987b). The cooperative and the farmer are vertically integrated due to the legal contract between them. The farmer-members are going to be interested in maximizing the performance of the combination of the farm and the cooperative, not in treating them as separate entities because the farmer-members benefit when the cooperative is prosperous.

The broader scope for optimization of the cooperative is supported due to the cooperative's view of the asset fixity of the farmer-members. In order for the farmer to become involved with the cooperative a set of buildings, equipment, and machinery are needed. Regardless of whether these items are financed by a bank or the cooperative, they represent a fixed cost to the farmer. An IOF is not going to be concerned about these fixed costs. This is evidenced in V. James Rhodes
(1990b) paper on contract hog production where 89% of the producers raising hog under contract said they could maintain their buildings but only 36% said they were receiving enough to replace their buildings. However, a cooperative, due to its integrated structure, will take into account the farmer-members' fixed costs when making decisions and setting payments to farmers. For an IOF these fixed costs become variable costs in that an IOF views the contract payment to a farmer as a variable cost, not as a payment to the farmer for his investment in fixed assets (Staatz, 1987b).

An IOF is not concerned if it deals with a particular farmer on a year-to-year basis. In contrast, the cooperative would be interested in a longer-term commitment with its members. The cooperative will put more emphasis on providing a farmer-member with a market for his labor and effort because the cooperative takes into account the member's need to amortize their fixed investments (Staatz, 1987b).

For the cooperative to take advantage of its broader scope for optimization it is necessary that the activities of the farmer-member and the cooperative are coordinated as closely as possible. Coordination may be difficult or reduced if the membership is highly heterogeneous (Staatz, 1987b). The membership of the management cooperative will tend to be of a homogeneous nature. The membership is homogeneous in that all the members who patronize the cooperative are going to be swine producers who are interested in capitalizing on
the increased management provided by the cooperative. The management cooperative should be able to capitalize on the advantages of its broader scope for optimization because the membership will tend to be more homogeneous than a cooperative that services more than just swine farmers.

**Gain from coordination**

Another advantage of this cooperative will be in its gain from coordination in input and output markets. If, as is usual in contracting situations, the cooperative owns the hogs and if there are several farmers who are contracting with the cooperative, it will have to purchase either breeding stock or feeder animals. Because the cooperative will be dealing with such large quantities of hogs, it will be able to bargain to get volume discounts which will lead to more profits for the cooperative and subsequently its farmer-members. The cooperative will also have this bargaining power if it is supplying feed, veterinary supplies, and other supplies to the individual operations. The cooperative will be able to coordinate the sale of animals as well. It will be able to combine animals for sale of similar kind and quality to receive higher prices at slaughtering plants. There will be additional benefits from coordination if some of the cooperative's patrons are feeder pig producers and others are feeder pig finishers.

Cooperatives generally have not exploited the potential
that can be realized from the coordination of farmers' and cooperatives' actions (Cobia, 1989). This has been due to the decrease in decision making that the farmer must accept if the gains from coordination are to be captured by the cooperative. It will be necessary for the management cooperative to provide the farmer with an attractive offer to induce him to join and patronize if these benefits from coordination are going to be profited upon.

By coordinating the activities of several farmers, the management cooperative will be able to realize efficiencies that otherwise would be unavailable to the members. These efficiencies are represented in game-theoretic terms by superadditivity of the characteristic function and subadditivity of the cost function (Staatz, 1987a).

**Superadditivity and subadditivity**

Superadditivity of the characteristic function implies that the cooperative, as a group of farmer-members, will receive a higher level of payoff than can the summation of disjoint subgroups of two or more farmer-members that in total include all of the farmer-members in the cooperative (Staatz, 1987a). This doesn't ensure that the farmer-members and the cooperative will work together, however. For these two groups to work together their individual returns must be greater than either one could achieve independently. If the cooperative keeps all the additional profits received from superadditivity
to itself, then the members have no incentive to remain with the cooperative.

Subadditivity of the cost function implies that it is cheaper for the cooperative to provide services to multiple groups of members than to provide the service to each group individually. Subadditivity is not synonymous with economies of scale. Subadditivity of the cost function makes providing the service to all cooperative members less expensive than providing the service to individual groups (Staatz, 1987a).

The subadditive cost function can be illustrated with an example based on the swine management cooperative being discussed. The membership will be somewhat heterogeneous in that there are feeder pig producers, feeder pig finishers, and farrow-to-finish stage of production groups. If the cooperative would provide services to one of these groups only, there would be gains realized due to coordination regardless of which group would be choosen. If the cooperative was composed of two groups, such as feeder pig finishers and farrow-to-finish operators, then there would be additional gains and cost efficiencies from the sale of the market hogs because the two groups could market their hogs together. There would also be cost efficiencies from the purchasing of inputs for both groups combined. In this instance the cost of providing services to both groups would be less than the sum if the two groups were operated independently. This same analogy would apply if the
cooperative would have producers from all three stages of production groups where there would be joint benefits and gains from having all three groups in a single management cooperative.

This analysis also brings up the subject of cost allocation. Subadditivity due to having all three production stage groups in the cooperative doesn't necessarily mean that costs should be distributed equally to each group. If this were done, it may be possible for the feeder pig producers and the feeder pig finishers to separate from the cooperative and form their own coalition at a lower cost, for example. If the cooperative is going to achieve the benefits from subadditivity it must allocate costs such that there are no incentives for any group or combination of groups to leave the cooperative (Staatz, 1987a). It is vital that there are benefits for all groups of members to stay with the cooperative.

**Risk pooling**

Risk pooling is one of the objectives for forming cooperatives. Risk pooling and risk sharing are inherent in cooperatives because of the sharing of profits through patronage refunds (Cobia, 1989). Kimball (1988) demonstrated that cooperatives can provide substantial risk insurance to its members even when the cooperative itself has a low level of risk aversion.
The swine management cooperative will provide risk reduction to the farmer-members from the contract, in addition to risk pooling and sharing. By contracting with the cooperative individual producers will be able to reduce their price risks and will only have production risks to face.

**Economic performance of cooperatives**

Cooperative businesses potentially have an economic advantage over PMFs or IOFs because the members are the owners and they participate in the decision making. Steinherr (1977) found that a firm with a given set of resources and a given number of laborers attains the highest output possible when the workers participate in decision making and when there are profit-sharing plans. His results don't show complete laborer participation or profit-sharing, only that some positive level of participation and profit-sharing are optimal. Worker cooperatives have laborer participation in decision making and profit-sharing through patronage refunds. Estrin et al. (1987) also agrees that some worker participation has positive effects on productivity. Conte and Svejnar (1988) found that firms with worker participation in decision making are approximately 46 percent more productive than firms without such schemes, ceteris paribus. Workers are exposed to additional information about the company if they are actively involved in decision making and this results in increased worker utility and profit (Manning, 1989).
Viable alternative for family farmers

The cooperative may also be able to address the issue of the declining number of family farms in recent years. Trends in the past twenty years show that the number of farms in the United States has been decreasing which has been offset by an increase in average farm size. This has been coupled with the fact that a greater share of gross farm income has been going to larger farms (U.S. General Accounting Office, 1979). A 1979 report to the Congress of the United States says "...independent family farmers need the right to act together through cooperatives if many are to survive in today's highly concentrated agricultural structure" (U.S. General Accounting Office, 1979, p. 4). Cooperatives are a viable alternative available for family farmers in helping them survive as agriculture becomes more competitive. Cooperatives will be able to help the survival of the family farm by offering healthy competition to profit-type corporations (Roy, 1976).

Cooperatives have been repositioning themselves in recessionary times by instituting additional practices to reinforce operations (Swanson, 1987). Two of the adapted or modified practices listed by Swanson (1987) will be provided by the swine management cooperative: providing financial assistance or financial consulting to members and providing record keeping services for members. Dunn et al. (1988, p. 10) also argues that "cooperatives remain the single most effective way farmers can improve their economic circumstances
and will continue to play a significant role in the U.S. food and fiber sector."

**Additional benefits**

In a cooperative business there is no separation between those who control the cooperative and those who earn the profits (Vanek, 1971). This reduces conflicts which frequently occur in business between managers and workers. This also increases productivity because there is no conflict of interest between manager and worker goals (Fusfeld, 1983).

Members of a cooperative have incentives to work harder because any additional profit generated by increased effort accrues to the firm as a whole and then to the individual members (Meade, 1972). Members have a genuine, not imposed, motivation to work more productively and efficiently which leads to better quality and quality control (Vanek, 1971). However, some members in a cooperative may be motivated to shirk and cheat rather than to work harder. These problems deal with moral hazard and are addressed later in this chapter.

The members' involvement in decision making through their ability to vote gives them a greater degree of internal unity with their cooperative involvement which affects the day-to-day operations (Ireland and Law, 1988). Members are less alienated due to their involvement in decision making. Minkler (1989) pointed out that this involvement in decision
making is a benefit to the members because they set their own level of monitoring and incentives to work.

The involvement of members in decision making leads to better flows of information which leads to innovation at the point of production because members have more information than employers or managers (Ireland, 1987). Cooperatives are highly efficient organizations for communication and are able to utilize knowledge about production that is generally not available in PMFs or IOFs.

Cooperatives are also more apt to invest in the training and education of their members because the benefits of additional training accrue to the cooperative (Vanek, 1970).

Due to their organizational form, cooperatives may also be able to get certain tax exemptions and have access to loans at below-market rates of interest (Porter, 1987).

**Cooperative Disadvantages and Problems**

Just as there are many advantages of cooperatives that attract members to them there are also many disadvantages. Cooperative business forms have imperfections because of the way they are organized, as do other business forms.

**Lack of cooperatives**

The purpose of organizing a cooperative is to benefit its members. Although there are many advantages to belonging to a cooperative, there are still many farmers who don't patronize
them. In 1985 farmers purchased only 26% of their farm supplies and marketed only 28% of their products through agricultural cooperatives (Cobia, 1989). This suggests that the apparent advantages of cooperatives are not well understood or explored by farmers. This observation is supported by Rooney (1988) who found in a study of employee-owned firms that there was very little participation in decision making in those firms.

Jensen and Meckling (1979) determined that members don't value security or participation in management at more than the cost of providing them. There are costs of having the members participate in decision making but the benefits of increased performance outweigh the costs. Members don't value these benefits as much as the costs and consequently participation is not readily observed (Jensen and Meckling, 1979).

Underinvestment is given as a reason for the lack of cooperatives by Vanek (1977). Meade (1972) proposes two reasons why the cooperative organization is not more common. The first is that the cooperative organization may not have the discipline to ensure efficient operation if the cooperative is comprised of a very large number of members. The second reason is that property owners can diversify their risks by investing in many assets but workers in a producer cooperative cannot put small amounts of effort into differing jobs and hence, they cannot diversify their risks. This is one of the reasons why capital hires labor rather than labor.
hires capital because labor cannot diversify its risk into many different jobs.

While there may appear to be a lack of cooperatives in agriculture today, they do in fact provide a significant share of the total business to farmers.

More diffuse scope for optimization

A cooperative has a more diffuse scope for optimization which comes from decisions regarding the pricing of its goods and services and on allocating costs (Staatz, 1987b). This characteristic is similar to the cooperative's broader scope for optimization, but also serves as a disadvantage. Optimization in a cooperative is more diffuse because the returns are distributed according to patronage and the cooperative has a separate locus for profit maximization for each member (Staatz, 1987b). As a result, price setting tends to be more costly in a cooperative as compared to an IOF due to the members involvement in decision making and the difficulty in reaching a consensus. Each and every member has a different view on how the cooperative should be operated as compared to the management which is working for a common purpose. This is the reason why most decisions in a cooperative are left up to the board of directors and the managers. In an IOF decisions on pricing are usually left up to management and not decided upon by the stockholders or members.
Vanek (1971) also points out that collective decision making results in slower decision making. Another reason for difficult decision making is that members in a cooperative often lack the appropriate expertise for decision making in areas such as finance, marketing, and research (Estrin et al., 1987).

**Expansion into new markets**

A cooperative's ability to expand into new markets or increase market share in existing markets is limited by its cost allocation procedures. In order to enter a new market or gain market share it is often necessary to reduce prices below costs. Since a cooperative operates at cost (including normal profits) reducing prices will result in subsidization of the new or expanding market by the existing market (Staatz, 1987b). These subsidies must be financed for the new members at the expense of the existing members. The existing members will likely object to proposals to enter into new areas or gain additional market share in existing areas. It may also explain why cooperatives generally have a more narrow focus of activities as compared to an IOF (Staatz, 1987b).

**Lack of a market for cooperative stock**

When members join a cooperative, they are required to provide equity in the form of cooperative stock. Unlike an IOF in which a stockholder has a residual claim on the
earnings of the firm as long as the person owns the stock, a cooperative stockholder only receives these residual claims to the earnings if he or she continues to patronize the cooperative. After a farmer-member discontinues patronizing the firm, he or she no longer has a residual claim on the earnings and, depending on the cooperative's equity redemption program, may receive his or her original investment paid back in nominal value over a period of years (Staatz, 1987b).

Another difference between the stock of a cooperative and an IOF, is that the value of the cooperative members' stock does not change with changes in the expected present value of the firm's future earnings. This is caused by an absence of a secondary market for cooperative stock which prevents farmer-members from realizing the full value of the expected present value of the future earnings stream (Staatz, 1987b).

The lack of a secondary market for cooperative stock poses some other problems also. In organizations with tradeable stock, the market price of the stock serves to monitor the performance of the managers in the organization (Jensen and Meckling, 1979). The nonmarketable feature of cooperative stock also means that members are unable to diversify their portfolios across different firms and different assets (Jensen and Meckling, 1979).

**Horizon problem**

Because members' residual claims on earnings are only
available if the member patronizes the cooperative and because of the absence of a secondary market for the stock, cooperative farmer-members receive almost all of their benefits of ownership through current patronage. This causes members to pressure the cooperative to place a higher value on current earnings, as opposed to future earnings. Members would rather receive current earnings from patronage than to have the cooperative make long-term investments which will produce benefits after the current members have retired. This tendency to emphasize current cash flow at the expense of future earnings has been labeled the "horizon problem" (Jensen and Meckling, 1979).

The horizon problem may be more serious if a cooperative has any of the following characteristics: (1) large per-member capital investment, (2) closed membership, (3) few legally incorporated member firms, (4) prohibition of the intergenerational transfer of membership, or (5) a large, diverse membership (Staatz, 1987b).

A large investment by a member may increase the tendency to get a high current return. If a cooperative has a closed membership, then there are no benefits for the farmer-member to be concerned about the long-run viability of the cooperative because his cooperative membership can't be transferred to the next generation or capitalized into the value of his farm if he would sell. A legal corporate member will put more emphasis on the future earning ability of the
cooperative because the membership automatically stays with the corporation even though its owners may change over the years. This same analogy holds for the transfer of memberships between family generations. A cooperative with a large, diverse membership may have more difficulties with the horizon problem than a small cooperative with strong ties between its members.

The swine management cooperative may be able to attenuate the horizon problem by avoiding some of the above characteristics. The cooperative would easily be able to do this by allowing open membership and the transfer of membership between generations. The cooperative will have a fairly homogenous membership. The number of corporate members patronizing the cooperative and the per-member capital investment may provide problems but these should easily be reduced to a manageable level through the use of debt financing.

Horizon problems are not restricted to cooperatives. The investment decisions of PMFs are also affected by problems related to limited time horizons for two reasons (Ireland, 1987). The first reason is that market uncertainty may cause a firm to use a short pay-back criteria when evaluating investment possibilities when actually a project may have large far-off returns. Secondly, firms that have short-term wage contracts may be in a poor bargaining position with unions if they are locked into long-term investment projects.
These two factors show that cooperatives are no more disadvantaged due to the horizon problem, when compared to PMFs (Ireland, 1987).

One way in which the horizon problem can be reduced is for the cooperative to pursue goals of growth and expansion (Staatz, 1987b). In this way the management helps to protect the cooperative's long-run potential.

**Principal-agent problems**

An agency relationship is defined as a "contract under which one or more persons (the principals) engage another person (the agent) to perform some service on their behalf which involves delegating some decision making authority to the agent" (Jensen and Meckling, 1976, p. 308). In the management cooperative the agent can be thought of as the manager of the cooperative or the cooperative itself and the principals are the farmer-members. The manager of the cooperative works for the farmer-members because they own the cooperative. The manager is also responsible for the developing of the contract which determines how and what amount the farmer-members receive for their contributions of labor and effort to the cooperative. Agency theory problems develop because the agent may not always act in the best interest of the utility-maximizing principals.

An organization can be thought of as a connected group of contracts which specify relationships among individuals
(Jensen and Meckling, 1976). With other business forms, including cooperatives, when principals and agents enter into contract agreements any gain achieved by the agent in developing the contract is done at the expense of the principal. These gains are kept with the agent and distributed to the stockholders or owners depending on the form of the business. With the cooperative the situation is the same in that any gains attained by the agent (cooperative) are done at the expense of the principals (farmer-members). Because this is a cooperative form of business the farmer-members own the cooperative and any profits produced by the cooperative are paid back to the members in the form of patronage refunds or else reinvested back into the cooperative which indirectly benefits its members. This is not meant to suggest that agency problems will be nonexistent in the management cooperative, only that they may be of less significance than with other business forms engaged in contracting.

Agency problems are still going to be present because the contracts between the farmer-members and the cooperative will not be costless to write and enforce (Fama and Jensen, 1983). There is going to be friction in writing the contract between the manager of the cooperative and the farmer-members. In order for the management cooperative to be successful in reaching its goals, the contracts must be specific. The contract will need to clearly state the cooperative's
responsibility for such items as developing rations, supplying pigs and other inputs, veterinary programs, payments and incentive payments to the farmer. The contract must also specify the farmer-member's responsibility for production practices and the expected efficiency levels. In addition to developing the contract, there will also be agency problems with enforcing it. The contract will need to include specific penalties to ensure enforcement of the agreements between the principal and agent. It is essential that there is a method of enforcement for both the farmer-member and the cooperative.

Agency costs reflect the costs of writing and enforcing the contracts. These agency costs include monitoring costs of the principal, the contracting costs of the agent, and the residual loss (Jensen and Meckling, 1976). Since the manager and the farmer-members are both utility maximizers there is a good chance that the manager will not do what is in the best interest of the farmer-members. Consequently, they need to provide incentives to the manager and monitor his or her activities. One very effective way that the farmer-members can indirectly monitor and provide incentives to the manager is through the cooperative principle of one-man, one-vote, where they can easily vote to replace an ineffective manager. The manager will incur costs in developing the contracts so that the farmer-members will do what is expected of them and to ensure that the farmer-members will be compensated if the manager attempts to injure them. Residual loss is a cost
incurred because the costs of full enforcement of contracts exceeds the benefits. Even after the monitoring and the contracting activities, the manager will still not make decisions that would maximize the farmer-members utility. This reduction in welfare experienced by the members is also a residual loss (Jensen and Meckling, 1976).

The theory of agency also addresses problems of residual claims. A residual claim is the difference between the variable inflows and promised payments to the principals (farmer-members). Organizations have contract structures which limit the risks taken by the principals by specifying fixed payoffs or incentive payoffs tied to specific measures of performance (Fama and Jensen, 1983a). This was cited earlier as one of the reasons farmer-members engage in contracting activities, to pool and reduce individual risk.

For most corporations the stockholders are the residual claimants who bear the risk faced by the corporation. They accept this risk in exchange for the rights to net cash flows. With a cooperative organizational structure this situation is somewhat different. In the management cooperative the farmer-members with whom the cooperative is contracting are also the residual claimants. The farmer-members receive the fixed payments and/or the payments tied to measures of performance from the contract. They also have the rights to any residual earnings of the cooperative because they are the stockholders. These residual claims are different from those of
corporations, as discussed before, because the farmer-member is only eligible for these as long as he or she continues to patronize the cooperative.

**Separation of ownership and control**

The problem of agency relationships where the farmer-member hires the cooperative to provide managerial services leads to another important issue in the theory of cooperatives, the separation of ownership and control. This problem deals with survival of organizations in which important decision makers do not bear a substantial share of the wealth effects of their decisions (Fama and Jensen, 1983b). The farmer-members and others (debt holders) own the cooperative and bear all the risk faced by the cooperative whereas the manager is left to make the important decisions.

In "Separation of Ownership and Control" by Fama and Jensen (1983b, p. 308), they argue that "organizations control the agency problems that result from separation of decision management from residual risk bearing by separating the management (initiation and implementation) and control (ratification and monitoring) of decisions."

They divide the decision process into four steps: (1) initiation or the generation of proposals, (2) ratification or the choice of decisions to be implemented, (3) implementation or execution of ratified decisions, and (4) monitoring or the measurement of performance and implementation of rewards.
There are two main ideas which serve to support this hypothesis to control agency problems: (1) specific knowledge and diffusing of decisions, and (2) delegation of decision control (Fama and Jensen, 1983b).

In most organizations, information needed for decision control is generally dispersed among several agents. Efficient decision control requires delegating decision control to whoever has the relevant information and allowing someone else to manage these decisions. For example, if the cooperative contracts with a veterinarian to oversee the health of all the farmer-members' operations, then the veterinarian will have the relevant information to make a decision if a health problem arises. The manager of the cooperative, in this case, only needs to monitor the decisions that were made.

Separation and specialization of decision control and residual risk bearing is necessary where there are numerous residual claimants who are not qualified for roles in the decision process and thus delegate their decision control to others. This is a main reason why farmers would join the cooperative. Farmers who wish to increase the performance of their operation may find that their knowledge is too limited to do so. These farmers will join the cooperative so that others can make critical decisions for them. The separation of risk bearing and decision making allows specialized people to perform each job rather a single person where an
entrepreneur is both a decision maker and a residual risk bearer. With several farmers in the cooperative the benefits of separation of decision functions from residual risk bearing would be expected to be greater than the agency costs generated, including the costs of separating the management and control of decisions (Fama and Jensen, 1983b).

In an earlier paper Fama (1980) also argues that the survival of an organization which is characterized by separation of ownership and control is possible with the full revision of managerial wages based on past performance. When a manager is under contract to perform a specific job and if there is no incentive or monitoring, then the manager has an incentive to cheat or shirk. Basing a manager's future wage on his past performance is an effective monitoring instrument and ensures that managerial decisions are made in the best interest of the organization's security holders (Fama, 1980).

From this analysis it seems to suggest that the swine management cooperative with its contracting structure should experience fewer difficulties associated with agency problems and the separation of ownership and control.

**Moral hazard**

Moral hazard is a problem that arise when individuals engage in risk sharing and when full observation of actions is impossible (Holmstrom, 1979). Based on this definition moral hazard could easily occur in the swine management cooperative.
An example of moral hazard is a swine producer who joins the cooperative and knows that he will receive a share of the cooperative's profits through patronage refunds. The producer might become lax in his production methods because of the assurance of the patronage refund and the fact that one producer's production contributes little to total cooperative profits. If that same producer would become very efficient and increase his effort level he would only be able to retain a portion of the additional profit generated by his increased effort (Meade, 1972). These examples show the effects moral hazard could have on productivity for the management cooperative. Estrin et al. (1987) adds to this by arguing as the number of members in the cooperative increases, each individual producer will have a stronger incentive to shirk.

A remedy to the moral hazard problem is to develop methods to monitor the actions of individuals and put members under contract (Holmstrom, 1979). By putting cooperative members under contract and enforcing penalties if they fail to achieve some specified level of performance the problems with moral hazard are reduced.

**Tendency to underfinance the cooperative**

There is a tendency in cooperative businesses for them to be underfinanced (Vanek, 1977). There are two reasons why cooperatives may be underfinanced.

The first reason is that members of a cooperative will
try to increase patronage relative to their investment in a cooperative (Staatz, 1987b). When members join a cooperative they are required to provide equity capital in order to obtain the right to patronize a cooperative. Since a cooperative will only return the nominal amount of equity capital invested by a member after he discontinues patronage, the only return the member receives on his invested money is patronage refunds which are based on how much he uses the cooperative. Therefore, members of a cooperative will try to patronize the business as much as possible based on their investment which will tend to cause the cooperative to be underfinanced.

Another reason for the tendency to underfinance cooperatives is the difficulty in raising capital. Capital acquisition may be difficult because of the nonrecuperability of equity invested in a cooperative (Ellerman, 1986). Members who invest in a cooperative will at most get some patronage refunds and their initial investment returned to them. In addition to this, assets depreciate and need to be replaced which further increases the need for capital. The horizon problem increases difficulties in raising capital because members are reluctant to invest their earnings from cooperative profits in long-term investments. Another reason for the difficulty in raising capital is due to the common property problem whereby new members acquire the same claims on cash flows as those members already in a cooperative (Jensen and Meckling, 1979; Minkler, 1989). The common
property problem causes a disincentive to undertake projects with future benefits because those benefits have to be shared with new members who didn't initially contribute to the project. One solution to this problem might be that new members are only allowed into a cooperative based on approval from the existing members or board of directors.

**Other disadvantages**

There are two other disadvantages which need to be included in this section. The first one is a control problem. It is always assumed that members in a cooperative are working towards a common objective. However, problems can occur if the members are not all interested in pursuing a single objective (Jensen and Meckling, 1979). Another problem is that cooperatives are excellent for having "small" incentive and innovative activity but lack in "medium size" innovation due to the lack of funds for research and development (Vanek, 1977).

**Conclusion**

This chapter has reviewed several theoretical lines of thought for cooperatives. Several implications can be drawn from this theory for the development of a model for the swine management cooperative.

One of the first issues which needs to be addressed is defining an acceptable, concise objective for the swine
management cooperative. The most common objective from the literature is the maximization of income per member. For the mathematical model which is developed in the next chapter, an objective of maximization of cooperative surplus is used. Cooperative surplus is defined as: (cooperative income from swine operations) - (contract payments to farmer-members) - (variable costs of supplying managerial services) - (fixed costs).

This objective is essentially the same as maximization of income per member because all or part of any cooperative surplus will be distributed back to the members. Each individual farmer-member's income will consist of contract payments plus a percentage of the cooperative surplus that is generated. Consequently, the maximization of cooperative surplus maximizes per member income. This objective serves a dual purpose because it parallels objectives which have been developed by cooperative theorists and also allows the cooperative to be treated the same as any PMF where the objective is simply to maximize profits.

The theory also establishes the need for determining contract structures offered by the cooperative. To avoid most moral hazard problems it is essential that the cooperative and its farmer-members enter into enforceable legally binding contracts. The contracts offered by the cooperative should be the same as those offered by other business forms engaged in contracting. This is consistent with the Rochdale principle
which states: "goods sold at regular retail prices, with net margins rebated to members, rather than discounted retail prices." By offering the same terms to farmers as other available contracts in the industry, the swine management cooperative will be able to contend competitively against other contractors and will also be able to attract members due to the cooperative principle of distributing earnings to its members through patronage refunds which, in effect, increases the value of the terms offered in the cooperative's contract.

The theory also addresses several other issues which affect the day-to-day operations of the cooperative. Farmer-members who join the cooperative need to purchase stock to show their belief and long-term commitment to the cooperative and also to provide equity capital for the cooperative.

The cooperative should be able to avoid problems with agency relationships and the separation of ownership and control by having some separation between the making and monitoring of decisions. Persons who have specific information about record keeping or ration formulation or health programs need to have the authority to make decisions and those decisions need only to be monitored by the cooperative manager. For the separation of decision making to be effective in controlling agency problems it is also essential that the decisions made are coordinated with one another. The contracting nature of the cooperative also helps to eliminate these problems.
The comprehensive theoretical literature review on cooperatives has provided insight into several implications on the development of a model for the swine management cooperative. The next chapter details the development of the mathematical model.
CHAPTER III.
MATHEMATICAL MODEL AND DATA

A firm-level mathematical model is used to examine the feasibility of a cooperative providing management services to swine producers and contracting with its farmer-members. The model described in this chapter combines a farm-level spreadsheet model with a linear programming model of the cooperative. The spreadsheet model is linked with a random number generator program to introduce price and production risk into the analysis. Figure 3.1 is a schematic diagram of the model described in this chapter for the swine management cooperative.

The feasibility of the swine management cooperative is in part determined by its need to have several members who are willing to enter into a contract and produce hogs with the cooperative. There are numerous swine farm types with which the cooperative might contract. An analysis of these farm types will determine the activities that are included in the cooperative model.

Swine Farm Activities

Casual observation of swine farms across the state of Iowa will show that no two swine farms are exactly alike. They differ by size, stage of production, facility design and numerous other characteristics. For this analysis it is necessary to limit the swine farm types considered to a number
Random Number Generator incorporates risk analysis into spreadsheet model

Firm-level spreadsheet model for a swine farm producing hogs under contract

Return to Cooperative
Return to Farmer-Member

Linear Programming Cooperative Model

Optimal Membership Structure
Total Cooperative Surplus
Risk Levels

Figure 3.1 Schematic diagram for the cooperative model
that can be easily be incorporated into the linear programming model.

**Building designs**

Swine farm building and equipment designs will generally range from capital intensive confinement units to pasture-type buildings and equipment. The advantage of one building design over another is due to tradeoffs between capital and labor, rather than differences in production efficiencies (Curtis, 1983). Confinement buildings are very capital intensive and require the least amount of labor. On the other end of the spectrum are pasture buildings and equipment which are relatively inexpensive but require larger amounts of labor to raise the same number of hogs. Confinement buildings and equipment are the most common type in Iowa.

Some contractors require farmers to modify their building designs or build new buildings as a provision of the contract. In V. James Rhodes' (1990b) paper on contract hog production in the United States, 34 percent of the growers engaged in contracting reported that they were required to build or change their buildings and equipment in order to obtain a contract. The swine management cooperative engaged in contracting with its farmer-members will also require the modification or the building of new facilities to reach its objective of a standardized-type facility. By having all farmer-members raising hogs in a standardized building design
the cooperative will be more able to identify and resolve problems, such as ventilation, in an individual building by comparing it to a building standard.

For the present analysis it is assumed that the swine management cooperative will require its farmer-members to all have confinement facilities. Since the cooperative will require the modification or construction of new buildings it would be most practical and beneficial for it to choose the most efficient and common design. The limitation to one building design for the cooperative also allows for a more detailed analysis of the results because data on the differences in labor requirements, performance measures, and other measurements between building designs are limited.

**Production stages**

There are three production stages included in the cooperative model: feeder pig production (FPP), feeder pig finishing (FPF), and farrow-to-finish production (FTF). Breeding stock producers have not been included in the model. It is assumed that breeding stock is purchased from existing commercial sources.

**Size**

Swine farms in Iowa also vary widely by size. Four different sizes of swine operations have been included in the model. The operation sizes are defined in Table 3.1 below.
Table 3.1 Swine farm sizes used in the cooperative model

<table>
<thead>
<tr>
<th>operation sizes</th>
<th>symbol</th>
<th>no. sows</th>
<th>no. pigs finished/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>very small</td>
<td>V</td>
<td>50</td>
<td>900</td>
</tr>
<tr>
<td>small</td>
<td>S</td>
<td>100</td>
<td>1800</td>
</tr>
<tr>
<td>medium</td>
<td>M</td>
<td>250</td>
<td>4500</td>
</tr>
<tr>
<td>large</td>
<td>L</td>
<td>500</td>
<td>9000</td>
</tr>
</tbody>
</table>

The three sizes cover a range that includes most Iowa swine producers. One of the specific problems faced by the cooperative is to choose an optimal mix of enterprise sizes and types.

Contracts

Example contracts used in the development of the cooperative model have been taken from specific contracts currently used in the industry. In Chapter 2 it was determined that the swine management cooperative should use contracts that are similar to others used in the swine industry. The cooperative’s advantage and attractiveness to its members comes from the distribution of any cooperative surplus in the form of patronage refunds rather than offering more favorable contracts.

One possible advantage for a farmer-member who joins the cooperative is the increase in production performance that is attained as a result of the management services supplied by the cooperative. In addition to improved performance caused
by management services, there may also be further increases in
performance if the farmer-members are placed under an
incentive-based contract where the payment they receive
depends on the production level they are able to achieve.

Two specific contracts that have been included in the
model for each of the three production stages. An attempt has
been made to find incentive-based and fixed payment contracts
which are representative of contracts currently used in the
industry. Within each production stage there are two
contracts: (1) contract F, a fixed payment contract, and (2)
contract I, an incentive-based contract. The contract
specifics are as follows:

1. Feeder pig production contracts

   Contract F:
   conditions:
   
   Farmer-member supplies facilities and labor.
   Cooperative supplies breeding herd and replacements,
   veterinary supplies, utilities, feed, drugs,
   managerial services, and retains ownership of all
   pigs.
   
   payment:
   $10.00 per month for each sow and gilt in inventory
   $12.00 per 40 lb. feeder pig produced

   Contract I:
   conditions:
   
   Farmer-member supplies facilities and labor.
Cooperative furnishes breeding stock, medication, feed, managerial services, utilities, and owns pigs.

payment:

payment is based entirely on weaned average per sow

<table>
<thead>
<tr>
<th>No. weaned</th>
<th>Dollars/ pig</th>
<th>No. weaned</th>
<th>Dollars/ pig</th>
<th>No. weaned</th>
<th>Dollars/ pig</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;7.6</td>
<td>13.40</td>
<td>8.5</td>
<td>16.25</td>
<td>9.5</td>
<td>17.87</td>
</tr>
<tr>
<td>7.6</td>
<td>13.80</td>
<td>8.6</td>
<td>16.50</td>
<td>9.6</td>
<td>18.06</td>
</tr>
<tr>
<td>7.7</td>
<td>14.10</td>
<td>8.7</td>
<td>16.75</td>
<td>9.7</td>
<td>18.25</td>
</tr>
<tr>
<td>7.8</td>
<td>14.40</td>
<td>8.8</td>
<td>16.93</td>
<td>9.8</td>
<td>18.33</td>
</tr>
<tr>
<td>7.9</td>
<td>14.70</td>
<td>8.9</td>
<td>17.10</td>
<td>9.9</td>
<td>18.41</td>
</tr>
<tr>
<td>8.0</td>
<td>15.00</td>
<td>9.0</td>
<td>17.23</td>
<td>10.0</td>
<td>18.50</td>
</tr>
<tr>
<td>8.1</td>
<td>15.25</td>
<td>9.1</td>
<td>17.36</td>
<td>10.1</td>
<td>18.62</td>
</tr>
<tr>
<td>8.2</td>
<td>15.50</td>
<td>9.2</td>
<td>17.50</td>
<td>10.2</td>
<td>18.75</td>
</tr>
<tr>
<td>8.3</td>
<td>15.75</td>
<td>9.3</td>
<td>17.62</td>
<td>10.3</td>
<td>18.90</td>
</tr>
<tr>
<td>8.4</td>
<td>16.00</td>
<td>9.4</td>
<td>17.75</td>
<td>10.4</td>
<td>19.00</td>
</tr>
<tr>
<td>&gt;10.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>19.10</td>
</tr>
</tbody>
</table>

2. Feeder pig finishing contracts

Contract F:

conditions:

Farmer-member provides and maintains facilities and provides labor.

Cooperative provides feed, pigs, transportation, veterinary supplies, medicine, utilities, and managerial services.

payment:

$.08 per day per pig

Contract I:

conditions:

Farmer-member provides labor and provides and
maintains facilities and equipment.

Cooperative provides feed, pigs, transportation, veterinary supplies, utilities, and managerial services.

payment:

based on the average of two performance measures

<table>
<thead>
<tr>
<th>Feed efficiency</th>
<th>$/day/pig</th>
<th>Death loss %</th>
<th>$/day/pig</th>
</tr>
</thead>
<tbody>
<tr>
<td>lbs. feed/lb. gain</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;3.2</td>
<td>.22</td>
<td>&lt;1</td>
<td>.085</td>
</tr>
<tr>
<td>3.2</td>
<td>.20</td>
<td>1 to 1.99</td>
<td>.08</td>
</tr>
<tr>
<td>3.3</td>
<td>.18</td>
<td>2 to 2.49</td>
<td>.075</td>
</tr>
<tr>
<td>3.4</td>
<td>.16</td>
<td>2.5 to 3.49</td>
<td>.07</td>
</tr>
<tr>
<td>3.5</td>
<td>.14</td>
<td>3.5 to 4.49</td>
<td>.065</td>
</tr>
<tr>
<td>3.6</td>
<td>.13</td>
<td>4.5 to 5.49</td>
<td>.06</td>
</tr>
<tr>
<td>3.7</td>
<td>.12</td>
<td>5.5 to 6.99</td>
<td>.055</td>
</tr>
<tr>
<td>3.8</td>
<td>.11</td>
<td>7 to 9.99</td>
<td>.05</td>
</tr>
<tr>
<td>3.9</td>
<td>.10</td>
<td>&gt;10</td>
<td>.00</td>
</tr>
<tr>
<td>&gt;3.9</td>
<td>.09</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

payment per day per pig = \( \frac{\text{feed efficiency} + \text{death loss} \%}{2} \)

3. Farrow to finish contracts

Contract F:

conditions:

Farmer-member owns and maintains facilities and supplies labor.

Cooperative supplies feed, medication, veterinary supplies, managerial services, pays transportation costs, and owns the hogs.

payment:

$14.00 per head out of nursery

$15.00 per head out of nursery if more than 9.2 pigs
per litter are produced.
$5.00 per head into finisher
$5.00 per head out of finisher

Contract I:

conditions:
Farmer-member owns and maintains facilities and
supplies labor and all other non-feed inputs.
Cooperative supplies feed, managerial services, and
owns the hogs.

payment:
$17.00 per cwt produced to cover all non-feed costs
plus $5.00 per cwt produced guaranteed profit.

By combining the three production stages, four swine
operation sizes, and two contract structures there are 24
(3x4x2) different swine farm activities which can comprise the
membership in the swine management cooperative. One of the
next questions to be answered by the cooperative is what
combination of activities is optimal for a given risk/return
tradeoff. This cooperative decision deals with portfolio
theory.

**Portfolio Theory**

From the above discussion it is apparent that one of the
management problems for the cooperative is to choose an
optimal combination of activities. There is a range of
expected returns and risk levels the 24 activities. The
The choice of activities made by the cooperative will determine its surplus and the risk that it faces. Portfolio theory is a method that the cooperative can use to make this risk/return decision.

The aim of portfolio analysis is to allocate resources across an array of risky assets that maximizes the decision maker's utility (Anderson, Dillon, and Hardaker, 1977). For the swine management cooperative, portfolio analysis will determine what portfolio or combination of swine farm activities will maximize its utility.

One of the earliest studies of portfolio selection was by Markowitz (1959). Markowitz (1959) derived an expected net return-variance frontier and argued that points along this frontier maximize expected utility. The efficient frontier is defined by Markowitz (1959) as combinations of investments that provide the highest return for a certain level of risk or the lowest risk for a certain expected return level. Risk is measured by the variance of the returns in the portfolio. The efficient set is defined by combinations of assets that have the maximum expected return (E) for a given level of variance (V), or the minimum V for a given level of E. The efficient set is also known as the E-V frontier. Analysis of the E-V frontier shows that portfolios with high returns have high risk and those with low returns have lower risk.
Diversification in portfolio theory

Diversification plays an important role in portfolio theory. If asset returns are not perfectly correlated it is possible to combine different assets to get a lower variance with the same expected return as a single asset. The selection of a diversified portfolio reduces risks because the returns from the assets don't fluctuate in unison. Portfolios which are located on the E-V frontier as defined by Markowitz (1959) are combinations of assets which have been diversified to reduce risk.

Diversification plays a role in portfolio analysis for the swine management cooperative, but not in the traditional sense. Traditionally diversification is used to refer to combinations of assets whose returns fluctuate independently or inversely to each other. In the cooperative each of the swine farm activities is subjected to the same input and output prices at any one time. However, production variables are assumed to be independent and identically distributed. Consequently, the correlation of activity returns will be strongly influenced by the relative importance of price on production risk. The benefits of diversification for the cooperative will come from differences in the magnitude of risk associated with the different sizes and types of swine enterprises. The returns from the smaller operations will tend to fluctuate less in absolute terms than the returns from the larger operations. By selecting portfolios of various
sizing of swine operations the cooperative will be able to select a particular risk/return combination, even though the returns from all assets tend to fluctuate together.

**MOTAD**

A convenient quantitative method for portfolio analysis is MOTAD (minimizing of total absolute deviations). Hazell (1971) developed a linear programming method as an alternative to quadratic E-V (expected income-variance) decision criteria to avoid difficulties in computation. One of the drawbacks of quadratic programming in deriving an E-V frontier is the data requirement of the variances and covariances among all activities. These values are generally unknown and are usually only estimated from time series or cross-sectional data on observed gross margins. The linear programming method introduced by Hazell (1971) avoided this data requirement. Linear programming models also have advantages in computational ease over quadratic risk programming models (Hazell, 1971).

Hazell's (1971) linear programming method minimizes total absolute deviations around a mean level of income. The risk efficient frontier is derived from expected income-absolute deviations (E-A) portfolios. An E-A portfolio is defined as having minimum mean absolute income deviations (A) for a given expected income level (E). An E-A frontier is developed by parametrically running the linear programming model with
respect to mean income and minimizing deviations from mean income (Watts et al., 1984). Hazell (1971) demonstrated through a numerical example that the MOTAD model is justified as an alternative computational method for deriving efficient E-A portfolios as compared to a quadratic E-V model.

The MOTAD model has the following form:

(1) Maximize \( rx \)

Subject to:

(2) \( Ax \leq b \)

(3) \( Rx + Iy \geq 0 \)

(4) \( vy \leq L \)

(5) \( x, y \geq 0 \)

where

- \( r, \) is a \( 1 \times N \) vector of expected income for each of the \( N \) activities,
- \( x, \) is an \( N \times 1 \) vector of activity levels,
- \( A, \) is an \( M \times N \) matrix of resource or technical coefficients, where \( M \) is the number of limiting resources or constraints,
- \( b, \) is an \( M \times 1 \) vector of resource or technical levels,
- \( R, \) is an \( S \times N \) matrix of the differences between actual annual income and the average annual income for each of the \( N \) activities, where \( S \) is the number of observations (years or states of nature) considered,
- \( I, \) is an \( S \times S \) identity matrix,
- \( y, \) is an \( S \times 1 \) vector of absolute income deviations for
each observation, 

\[ 0, \] is an \( S \times 1 \) vector of 0's, 

\[ v, \] is a \( 1 \times S \) vector of 1's, and 

\[ L, \] is the maximum allowable deviations from the mean income.

This MOTAD model is similar in construction to the models used by Anderson, Dillon, and Hardaker (1977); and Watts et al. (1984).

The actual annual returns to the cooperative for each activity in the model are derived from a LOTUS 1-2-3 spreadsheet which has been linked to a random number generator. Results from the spreadsheet models on the value of the cooperative surplus for each of the 24 swine farm activities for 100 years of observations or states of nature are input into the MOTAD model. The model is then run by parametrically changing \( L \) to see how the composition of the swine management cooperative changes with increasing levels of allowable risk. Each change in the basis which is caused by changing \( L \) results in a different combination of swine farm activities for the cooperative. By plotting the different risk/return levels an efficient E-A frontier can be depicted for the cooperative.

The software package utilized to solve the MOTAD model is the General Algebraic Modelling System GAMS (Brooke, Kendrick, and Meeraus, 1988). MINOS was used as the solution algorithm. GAMS is designed to make the construction and solution of
large, complex mathematical programming models more straightforward and easier to understand by users of models from other disciplines.

**Spreadsheet Models**

A spreadsheet model of a swine operation for each of the 24 different swine farm activities was developed on LOTUS 1-2-3. The spreadsheet models were originally derived from microcomputer worksheets developed by Iowa State University (Miller et al., 1984, 1985a, and 1985b) and then modified to fit the present analysis. Spreadsheet models were constructed for feeder pig production and feeder pig finishing. The farrow-to-finish spreadsheet is basically a combination of the feeder pig production and feeder pig finishing spreadsheets.

The spreadsheet model allows the user to input all the prices, building costs, feed costs, performance measures and other inputs used in calculating a budget for a model of a swine farm. Examples of some of the variables which are inputted into the model include: size of operation (number of sows or pigs finished), litters/sow/year, pigs weaned/litter, death rate, feed efficiency, average labor hours/pig, average pig selling weight, daily sow and boar feed intake, useful boar life, average weight for cull sows and boars, and number of boars on hand. In addition, the model incorporates the following costs and prices: labor cost, utilities and fuel cost/litter, veterinary supplies cost/litter, marketing
cost/pig, miscellaneous operating costs, corn and supplement prices, price for purchased gilts and boars, price for cull sows and boars, market hog price, feeder pig price, total dollar investment in buildings and equipment, annual depreciation for buildings and equipment, and taxes and insurance.

The spreadsheet models produce budgets for the 24 swine farm activities. Some outputs from the model include: total revenue, total variable cost, total fixed cost, and profit. The model also outputs some performance measures such as: return to capital, labor, and management; hourly return to labor; return/$100 feed fed; and breakeven selling price.

The spreadsheet models are modified to include contract provisions which divide the income from the swine operation between the farmer-member and the cooperative.

**Feed rations**

In the spreadsheet models the feed rations and the amounts fed to breeding stock and feeder pigs are fixed so they are constant across all 24 different swine farm activities. The spreadsheet allows the input for the amount of feed consumed per day by sows and boars, but the ration is fixed at 14% protein. Each feeder pig is assumed to consume 26 pounds of starter feed from weaning to 30 pounds. From 30 to 100 pounds the pigs consume a 16% ration and then a 14% ration after 100 pounds to market weight. All rations consist
of corn-soybean meal mixes where the soybean meal includes additives for vitamins and minerals.

**Building costs**

Building costs for swine facilities were obtained from Dwaine Bundy (1990). The building costs used in the spreadsheets are:

- breeding = $300.00 per sow
- farrowing = $2350.00 per crate
- nursery = $90.00 per pig
- grower = $120.00 per pig
- finisher = $180.00 per pig.

There are some implications due to the assumption of constant unit building costs for the cooperative model. Building costs are not adjusted as the size of the swine operation is changed, which ignores economies of size. Building costs for the different sized swine farm activities are just scale multiples of each other. The primary reason for constant building costs is the difficulty and lack of objective information on building cost differences for different sized operations.

**Prices**

Price levels used for corn, soybean meal, feeder pigs, and market hogs were based on average Iowa prices for the past 16 years. The 16-year time series data on these prices were
obtained from Agricultural Prices 1989-1974 Summaries. Prices prior to 1974 were not used because of the significant increase that occurred in agricultural prices in the early 1970's.

The MOTAD model will treat a time series of prices as independent draws from a stationary distribution. After analyzing the trends and variability in these price time series, it was determined that nominal prices provided a more realistic distribution for future prices rather than did real prices. The trend line based on nominal prices for all four commodities over the 16-year period is essentially flat. The nominal prices are shown in Figures 3.2 and 3.3 for corn, soybean meal, market hogs, and feeder pigs. Figures 3.4 and 3.5 show the inflation-adjusted prices.

If the prices are deflated using an implicit deflator for GNP, 1982:100, then the trend line over the 16-year period decreases. For example, with inflation-adjusted corn prices the trend line shows that prices decreased an average of $0.18 per bushel over the period, while the trend line based on nominal prices shows an decrease of $0.02 per bushel over the period. Consequently, the inflation-adjusted corn prices for 1974 and 1986 are $5.05 and $1.24 per bushel, respectively, while the nominal prices for the same years are $2.80 and $1.41 per bushel, respectively. The real price series implies a level of variability that seems unlikely. Inflation-adjusted price levels for the four commodities tend to
Figure 3.2 Nominal feed prices 1974-1989
Figure 3.3 Nominal hog prices 1974-1989
Figure 3.4 Inflation-adjusted feed prices
1974-1989
Figure 3.5 Inflation-adjusted hog prices 1974-1989
fluctuate over a wider range than the nominal prices. The nominal price levels provide a more realistic estimate of the price distribution which will be faced by the swine management cooperative today.

**Modelling Price and Production Risk**

An attachment to LOTUS 1-2-3 was used which allows probability distributions to be inputted for variables in the swine farm activity spreadsheet models. Distributions were included in the cooperative model to incorporate price and production risk into the returns to the cooperative and the farmer-members. Distributions were placed in the models for five management-influenced variables identified later, labor hours per litter for producing feeder pigs, labor hours per pig for finishing pigs, and the four price levels discussed in the previous section.

**@Risk program**

The computer program used to analyze the spreadsheets and obtain expected results was @Risk (Palisade Corporation, 1988) which operates as an attachment to LOTUS 1-2-3. @Risk allows the inclusion of distributions into LOTUS 1-2-3 spreadsheets. @Risk is unique in that any form of distribution can be inputted into the model using numerical approximation methods. In addition, @Risk allows the user to select standard distributions such as a normal or triangular distributions.
@Risk uses Monte Carlo sampling techniques and randomly selects a value for each probability distribution in the spreadsheet. The program then calculates all the values in the spreadsheet based on those selected from the distributions. The frequency of sampling is controlled by the user. The program also calculates summary statistics for requested output variables such as the return to the cooperative and its farmer-members. Each random drawing of values from the probability distributions represents one observation or state of nature of data which is used in the MOTAD model. In this analysis, the Monte Carlo model generated 100 observations for the MOTAD model.

Price distributions were approximated by uniformly drawing samples from the 16-year time series data over the period 1974 to 1989 so that each year has an equally likely chance of being selected.

**Dependency relationships**

@Risk also allows for approximating correlations among variables. A statistical analysis of the data from the Iowa State University swine records (Stevermer, 1990) showed the following correlations which have been approximated in the spreadsheets:

1. litters per sow per year and pigs weaned per litter

   \[= +.184\]
2. litters per sow per year and death loss percent from weaning to market = +.039
3. death loss percent for finishing pigs and feed efficiency for finishing feeder pigs = +.36
4. death loss percent for finishing pigs and hours of labor per pig for finishing feeder pigs = +.251

Iowa State's swine records data base consists of swine enterprise records from Iowa producers. There are approximately 300 farrow-to-finish producers, 50 feeder pig producers, and 50 feeder pig finishers annually in this data base. It is important to note that the correlations between these variables are rather weak.

**Management related variables**

The spreadsheets include management related variables which are assumed to change in response to the management services provided by the cooperative. The increased management will lead to improvements in performance measures. Five variables from the spreadsheets were identified that would capture the total impact of increased levels of management. They are litters per sow per year, pigs weaned per litter, death loss percent from weaning to market, feed efficiency for finishing feeder pigs, and death loss percent for finishing feeder pigs. Two other important management influenced variables on hours of labor per litter for producing feeder pigs and hours of labor per pig for finishing
feeder pigs were also identified. However, these were not included because they are inputs rather than performance measures. The contract payments from the cooperative to the farmer-members are a return to facilities and labor. The cooperative contract payments are based on the number of pigs produced which depends directly on the first five management related variables and not on hours of labor used per pig.

Since data on the effects of increased management on the five performance variables is not available, an effort was made to estimate the expected response. Probability distributions were developed based on data from Iowa State University's swine enterprise records (Stevermer, 1990) for the five variables and it was assumed that the distributions accurately represent all Iowa swine producers. This data base contains swine enterprise records for Iowa producers who use Iowa State's record keeping program. There were approximately 1200 observations from four years of data on litters per sow per year, pigs weaned per litter, and death loss percent from weaning to market. Approximately 150 observations from three years were available on feed efficiency and death loss for finishing feeder pigs.

A procedure was developed to use expert opinions to subjectively estimate the needed probability distributions. The function and goals of the management cooperative were explained to each expert at the beginning of each session. The experts were informed that they were allowed to change
facility design, breeding stock, feed rations, and other variables. These experts were then asked to draw on the original distribution how they believed it would shift if the population of Iowa swine producers, represented in the distributions, were placed under increased management and engaged in contracting with the management cooperative. The altered distributions were obtained independently from each expert and no revisions were permitted. Finally, the four expert opinions were averaged and this average distribution was used in the swine enterprise spreadsheets.

The experts represented experienced contractors and swine production specialists. Expert A is a contractor and a supplier of managerial services to hog producers. Expert A specializes in smaller sow operations and contracts primarily with feeder pig producers and farrow-to-finish operations. Expert B is also a contract hog producer with a large record keeping service. Expert B's clients include larger operations and all three stage of production groups. Expert A and B both have extensive data bases on the performance of swine producers raising hogs under contract with increased management. Expert C is a professor of animal science at Iowa State University who specializes in swine production. Expert D is a professor of animal science and extension specialist in swine production at Iowa State University who also manages a record keeping program.

All the distributions were normalized to make the area
under each distribution the same with @Risk. The shape of each distribution was approximated by linear segments and entered into @Risk in distributional form. 2000 iterations were then performed on each distribution to normalize them. Finally, the four expert distributions were averaged to obtain the distribution to use in the swine farm activities.

The original distributions, the four expert opinion-based distributions, and the distribution showing the average of the four experts are shown in Figures 3.1, 3.2, 3.3, 3.4, and 3.5. Table 3.1 shows some statistics on the distributions. A visual observation of the distributions shows the optimism that these four experts have on the amount of improvement that can be achieved by Iowa swine producers.

Table 3.1 also gives some interesting data on the distributions. In addition to estimating increased performance caused by the management services, these experts also predicted a decrease in the variability of the five performance measures. The standard deviation, which is a measure of variability, for each of the four expert-based distributions is smaller than the original standard deviation over all five performance variables. The experts predicted that the distributions are going to shift and become taller and narrower as the range in variability for the performance measures decreases with the increased management supplied by the cooperative.
Figure 3.6 1987-1990 farrow-to-finish litters per sow per year
Figure 3.7  1987-1990 farrow-to-finish pigs weaned per litter
Figure 3.8 1987-1990 farrow-to-finish death loss percent, weaning to market
Figure 3.9  1988-1990 finishing feeder pigs
feed efficiency
Figure 3.10  1988-1990 finishing feeder pigs
death loss percent
Table 3.2 Statistics on probability distributions from Figures 3.6, 3.7, 3.8, 3.9, 3.10

<table>
<thead>
<tr>
<th>distribution</th>
<th>average</th>
<th>high</th>
<th>low</th>
<th>standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>litters per sow per year</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>original</td>
<td>1.88</td>
<td>2.85</td>
<td>0.83</td>
<td>0.292</td>
</tr>
<tr>
<td>expert A</td>
<td>2.14</td>
<td>2.64</td>
<td>1.64</td>
<td>0.224</td>
</tr>
<tr>
<td>expert B</td>
<td>2.27</td>
<td>2.61</td>
<td>2.01</td>
<td>0.122</td>
</tr>
<tr>
<td>expert C</td>
<td>2.21</td>
<td>2.44</td>
<td>1.83</td>
<td>0.100</td>
</tr>
<tr>
<td>expert D</td>
<td>2.03</td>
<td>2.57</td>
<td>1.52</td>
<td>0.207</td>
</tr>
<tr>
<td>average</td>
<td>2.16</td>
<td>2.64</td>
<td>1.52</td>
<td>0.182</td>
</tr>
<tr>
<td>pigs weaned per litter</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>original</td>
<td>8.25</td>
<td>11.18</td>
<td>4.08</td>
<td>0.967</td>
</tr>
<tr>
<td>expert A</td>
<td>9.24</td>
<td>11.17</td>
<td>7.54</td>
<td>0.780</td>
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<td>expert B</td>
<td>9.32</td>
<td>10.32</td>
<td>6.85</td>
<td>0.616</td>
</tr>
<tr>
<td>expert C</td>
<td>9.13</td>
<td>10.39</td>
<td>8.05</td>
<td>0.336</td>
</tr>
<tr>
<td>expert D</td>
<td>8.58</td>
<td>10.97</td>
<td>5.82</td>
<td>1.072</td>
</tr>
<tr>
<td>average</td>
<td>9.07</td>
<td>11.17</td>
<td>5.82</td>
<td>0.804</td>
</tr>
<tr>
<td>death loss percent, weaning to market</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>original</td>
<td>6.49</td>
<td>31.27</td>
<td>0.35</td>
<td>3.828</td>
</tr>
<tr>
<td>expert A</td>
<td>3.50</td>
<td>7.06</td>
<td>0.26</td>
<td>1.310</td>
</tr>
<tr>
<td>expert B</td>
<td>5.77</td>
<td>17.09</td>
<td>1.34</td>
<td>2.848</td>
</tr>
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<td>expert C</td>
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<td>8.03</td>
<td>0.13</td>
<td>1.511</td>
</tr>
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<td>expert D</td>
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<td>12.56</td>
<td>0.39</td>
<td>2.246</td>
</tr>
<tr>
<td>average</td>
<td>4.58</td>
<td>17.09</td>
<td>0.13</td>
<td>2.241</td>
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<tr>
<td>feed efficiency</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>original</td>
<td>367.6</td>
<td>493.0</td>
<td>285.1</td>
<td>37.9</td>
</tr>
<tr>
<td>expert A</td>
<td>345.0</td>
<td>393.0</td>
<td>294.7</td>
<td>22.6</td>
</tr>
<tr>
<td>expert B</td>
<td>357.1</td>
<td>471.9</td>
<td>288.5</td>
<td>36.3</td>
</tr>
<tr>
<td>expert C</td>
<td>319.4</td>
<td>354.4</td>
<td>281.3</td>
<td>12.2</td>
</tr>
<tr>
<td>expert D</td>
<td>354.4</td>
<td>397.6</td>
<td>307.4</td>
<td>18.1</td>
</tr>
<tr>
<td>average</td>
<td>344.0</td>
<td>471.9</td>
<td>281.3</td>
<td>28.3</td>
</tr>
<tr>
<td>death loss percent, finishing pigs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>original</td>
<td>4.89</td>
<td>13.75</td>
<td>0.01</td>
<td>2.674</td>
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<tr>
<td>expert A</td>
<td>3.65</td>
<td>8.50</td>
<td>0.30</td>
<td>1.884</td>
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<tr>
<td>expert B</td>
<td>3.91</td>
<td>12.11</td>
<td>0.50</td>
<td>1.897</td>
</tr>
<tr>
<td>expert C</td>
<td>3.64</td>
<td>7.79</td>
<td>0.02</td>
<td>1.543</td>
</tr>
<tr>
<td>expert D</td>
<td>5.38</td>
<td>8.27</td>
<td>0.55</td>
<td>1.367</td>
</tr>
<tr>
<td>average</td>
<td>4.15</td>
<td>12.11</td>
<td>0.02</td>
<td>1.849</td>
</tr>
</tbody>
</table>
Expected values

The spreadsheets calculate the contribution to total cooperative surplus and the individual farmer-member profit for each of the 24 different swine farm activities. One hundred iterations with @Risk were generated which represents 100 observations or years of data for each of the 24 activities. These observations are then averaged for each activity to obtain expected values for the contribution to total cooperative surplus and individual farmer-member profits.

The four price distributions were seeded with @Risk which causes the program to draw the same sequence of random numbers for the 100 observations for each activity. In this way, all swine activities face the same set of input and output prices for each draw or state of nature. However, production variables were drawn independently for each farm type.

Model Specifications

Initial run

The initial run of the MOTAD model was constrained by a maximum number of 25 farmer-members. A constraint on the membership implies maximization of returns per member. A constraint is also included in the model which limits the number of feeder pigs finished to less than or equal to the number of feeder pigs produced. This constraint ensures that farmer-members who finish feeder pigs obtain their pigs from
farmer-members in the cooperative who produce feeder pigs. This constraint reflects the assumption that the cooperative would attempt to provide a predictable supply of feeder pigs to farmer-members who finish pigs and also eliminate problems with purchasing feeder pigs in co-mingled groups with unknown genetics. This was an assumption that was assumed by the four experts when eliciting their opinions on how the distributions would change or shift for the management-influenced variables.

The objective function for the MOTAD model also includes a cost of $35,000.00 to cover the costs of providing managerial services. The $35,000.00 is an approximation of the marginal costs of providing management services to 25 producers (Crosser, 1991; Junkers, 1991).

**Second run**

A second run of the MOTAD model was analyzed to determine how the portfolio of the swine management cooperative would change with a different size constraint. In the second model, a limit is placed on the total financing available for the farmer-members to purchase new buildings. This actual limit, $29,500,000, represents the total financing that is used in the initial run at the risk neutral solution. With a capital constraint, the number of members is free to vary.

The remaining model specifications for the second run are essentially the same as the first. The constraint which limits the number of feeder pigs finished to less than or
equal to the number of feeder produced has been included. The costs of supplying managerial services remain at the same per-member level of $1,400.00. However, the total cost of supplying managerial services now depends on the number of members.
CHAPTER IV.
RESULTS AND DISCUSSION

By running the swine management cooperative MOTAD model parametrically with respect to $L$, the expected deviations from mean income, a risk/return efficiency frontier is traced. The initial run developed an efficiency frontier for the swine management cooperative with a constraint limiting its farmer-members to a maximum of 25. The second run of the model analyzed the swine management cooperative with a constraint on the maximum financing available to build new facilities of $29,500,000. The results show the portfolios that are available for the cooperative and the different risk/return levels the portfolios have.

Initial MOTAD Model

The primary objective of the initial run of the cooperative MOTAD model was to determine what combinations of swine farm activities were optimal for the swine management cooperative at different risk levels and to determine if sufficient profit is generated by the farmer-member's swine operations with the increased management to support the activities of the cooperative and to provide the farmer-members with an acceptable return to their buildings, labor, and effort.
Results

The results of the initial run of the MOTAD model are presented below. Figure 4.1 shows the efficiency frontier which was estimated from parametrically running the model with respect to L, the expected deviation from mean income. Table 4.1 shows the swine management cooperative portfolios at the points labeled A through F on the efficiency frontier.

From $0 to $332,867 expected deviations (L) the model is constrained by L, rather than the number of members. The portfolio of the cooperative is as follows:

11.8% FPP.S.I,
5.0% FPF.M.F,
53.8% FTF.V.F,
26.4% FTF.M.F, and
3.0% FTF.L.F.

From $332,868 to $887,500 expected deviations (L) the member constraint becomes binding. Over this range the portfolio for the cooperative is made up of varying combinations of feeder pig producers, feeder pig finishers, and farrow-to-finish operators.

Above $887,500 expected deviations the feeder pig producers and feeder pig finishers fall out of the portfolio and the cooperative is made up entirely of combinations of medium and large farrow-to-finish producers under fixed contract. At approximately $1,560,000 expected deviations the medium farrow-to-finish producers are eliminated from the
Figure 4.1 Initial MOTAD results
maximum number of members • 25
Table 4.1 Portfolio combinations from the MOTAD model for different trade-offs between risk and cooperative surplus for the swine management cooperative with a maximum of 25 members

<table>
<thead>
<tr>
<th>Solution Number from Figure 4.1</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected Deviations from Mean Income (Risk)</td>
<td>200,000</td>
<td>332,867</td>
<td>700,000</td>
</tr>
<tr>
<td>Expected Cooperative Surplus ($)</td>
<td>443,145</td>
<td>760,794</td>
<td>1,621,919</td>
</tr>
</tbody>
</table>

Activities:
(number of members)

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>FPP.I.S</td>
<td>1.8</td>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td>FPP.I.L</td>
<td></td>
<td></td>
<td>0.2</td>
</tr>
<tr>
<td>FPF.F.M</td>
<td>0.7</td>
<td>1.2</td>
<td>0.4</td>
</tr>
<tr>
<td>FTF.F.V</td>
<td>8.1</td>
<td>13.4</td>
<td>5.2</td>
</tr>
<tr>
<td>FTF.F.M</td>
<td>4.0</td>
<td>6.6</td>
<td>15.3</td>
</tr>
<tr>
<td>FTF.F.L</td>
<td>0.5</td>
<td>0.8</td>
<td>4.0</td>
</tr>
<tr>
<td>Total Members</td>
<td>15.1</td>
<td>24.9</td>
<td>25.1</td>
</tr>
</tbody>
</table>

a FPP.I.S stands for a small, 100 sow (S), feeder pig producer (FPP), under the incentive-based (I) contract.
<table>
<thead>
<tr>
<th></th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>887,500</td>
<td>1,100,000</td>
<td>1,600,000</td>
</tr>
<tr>
<td></td>
<td>2,056,023</td>
<td>2,513,770</td>
<td>3,441,788</td>
</tr>
<tr>
<td>0.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18.8</td>
<td>12.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.0</td>
<td>12.3</td>
<td>25.0</td>
<td></td>
</tr>
<tr>
<td>25.1</td>
<td>25.0</td>
<td>25.0</td>
<td></td>
</tr>
</tbody>
</table>
portfolio. This portfolio is equivalent to the risk neutral solution.

The efficient frontier in Figure 4.1 shows the risk/return tradeoff that the cooperative faces. With lower levels of risk the cooperative is diversified to capture the gains from several assets with different levels of risk. At extremely high values of \( L \), the risk neutral solution, the cooperative specializes in the asset with the highest return, the large farrow-to-finish producer under a fixed contract. The efficiency frontier's relative lack of curvature suggests that the managers of the cooperative might select any point along the frontier. The composition of the cooperative will be extremely sensitive to the risk attitudes of the directors. The frontier is convex so that there will be a point of tangency between the cooperative's indifference curve and the frontier. Note, however, that with relatively flat indifference curves, implying a low level of risk aversion, the cooperative could choose portfolio \( F \).

By simply taking a ratio of the risk level to the expected return for various points along the efficiency frontier in Figure 4.1 an inference about the returns to the swine farm activities in the portfolios can be made. Over the frontier the ratio of risk to return varies slightly between .43 to 1 and .47 to 1. The benefits for the swine management cooperative from diversification don't come from uncorrelated returns but from risk differences between assets. The smaller
swine farm activities are less risky in an absolute sense and their return doesn't vary as much as the larger swine farm activities. At low levels of risk, the MOTAD model selects V, S, M, and L swine farm activities to receive the benefits from this form of diversification. Table 4.2 shows the actual correlations between the swine farm activities represented in the efficiency frontier. The high correlations between the activities indicates that common price risk dominates the independent production risk. The benefits from diversification for the swine management cooperative are derived from differences in risk levels between assets and not uncorrelated returns.

Table 4.2 Correlation coefficients on the returns to cooperative surplus for the activities in the initial model run

<table>
<thead>
<tr>
<th></th>
<th>FPP.I.S</th>
<th>FPP.I.L</th>
<th>FPP.F.M</th>
<th>FTF.F.V</th>
<th>FTF.F.M</th>
<th>FTF.F.L</th>
</tr>
</thead>
<tbody>
<tr>
<td>FPP.I.S</td>
<td>1.000</td>
<td>0.979</td>
<td>0.731</td>
<td>0.843</td>
<td>0.855</td>
<td>0.849</td>
</tr>
<tr>
<td>FPP.I.L</td>
<td>1.000</td>
<td>0.748</td>
<td>0.852</td>
<td>0.861</td>
<td>0.868</td>
<td></td>
</tr>
<tr>
<td>FPP.F.M</td>
<td>1.000</td>
<td>0.825</td>
<td>0.875</td>
<td>0.841</td>
<td></td>
<td></td>
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<tr>
<td>FTF.F.V</td>
<td>1.000</td>
<td>0.883</td>
<td>0.867</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FTF.F.M</td>
<td>1.000</td>
<td>0.877</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FTF.F.L</td>
<td></td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Distributing Patronage Refunds

A second objective for the initial run of the cooperative model was to determine whether or not enough profit is generated by the improved management to support the cooperative and provide farmer-members with an acceptable return to their buildings, labor, and effort. Analyzing this problem requires developing a method for distributing the cooperative surplus to its members. Each farmer-member's income comes from the contract payments received plus a portion of the total surplus.

There are several methods which can be used to allocate the cooperative surplus. The difficulty in allocation comes in deciding what is the most equitable and economically efficient way to distribute the earnings to the farmer-members. Traditional cooperatives that supply feed or other supplies allocate their surplus based on the patronage or activity of the individual farmer-members. For the swine management cooperative allocation could be based on measures such as the amount of feed used, the number of pigs produced, or even each farmer-member's contribution to the total cooperative surplus over a given time period.

The method used to allocate the cooperative surplus in this analysis was based on the relative number of pigs produced by each farmer-member. For simplicity the allocation is assumed to be the same regardless of whether the farmer-member produces feeder pigs or market hogs. After
consultation with Roger Ginder (1991) about different methods of allocating the cooperative surplus this method was determined to be the best because of tax considerations. If the cooperative allocated the surplus based on each farmer-member's contribution to the total cooperative surplus, then the surplus would be taxed at the cooperative level and at the producer level. By using an allocation based on the number of pigs produced, the surplus is only taxed once. Single taxation is based on the theory that cooperatives operate at cost. For example, if it costs $10.00 per pig to supply managerial services and the cooperative has a total surplus of $12.00 per pig after paying all costs, then by allocating $2.00 per pig in the form of patronage refunds the cooperative is achieving its basic principle of operation at cost and is only subject to single taxation. Note, however, that the per pig allocation rule would probably be unacceptable to farrow-to-finish operators if there were other enterprises in the cooperative because they would tend to use the cooperative more on a per pig basis than feeder pig finishers.

At $350,000 expected deviations the cooperative generates a surplus of $801,709 and its portfolio of members is:

<table>
<thead>
<tr>
<th>swine farm activity</th>
<th>number</th>
</tr>
</thead>
<tbody>
<tr>
<td>FPP.I.S</td>
<td>4.5</td>
</tr>
<tr>
<td>FPF.F.M</td>
<td>1.9</td>
</tr>
<tr>
<td>FTF.F.V</td>
<td>10.5</td>
</tr>
<tr>
<td>FTF.F.M</td>
<td>7.4</td>
</tr>
<tr>
<td>FTF.F.L</td>
<td>0.7</td>
</tr>
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</table>
Table 4.3 shows the dollar returns and the return on assets to each of the five types of members that are in the swine management cooperative portfolio at the $350,000 expected deviations risk level. The assumption was made that 100% of the total cooperative surplus was distributed to the members.

Table 4.3

<table>
<thead>
<tr>
<th>Farmer-Member Type</th>
<th>Return After Contract Surplus Allocation</th>
<th>ROA</th>
<th>ROA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Return After Contract Surplus Allocation</td>
<td>ROA</td>
<td>ROA</td>
</tr>
<tr>
<td>FPP.I.S</td>
<td>$9,873.14</td>
<td>9.9%</td>
<td>32.5%</td>
</tr>
<tr>
<td>FPF.F.M</td>
<td>$19,804.14</td>
<td>9.1%</td>
<td>32.8%</td>
</tr>
<tr>
<td>FTF.F.V</td>
<td>$3,346.93</td>
<td>2.6%</td>
<td>11.5%</td>
</tr>
<tr>
<td>FTF.F.M</td>
<td>$17,799.45</td>
<td>3.0%</td>
<td>12.1%</td>
</tr>
<tr>
<td>FTF.F.L</td>
<td>$50,983.73</td>
<td>4.3%</td>
<td>14.0%</td>
</tr>
</tbody>
</table>

Table 4.3 shows the benefits to the farmer-members by joining and contracting with the swine management cooperative. The values in this table are returns to farmer-members after fixed building costs have been paid. By contracting with the cooperative each farmer-member is able to capture more of the profits generated by their operation. Since the contracts used are representative of contracts currently being used in the swine industry, the cooperative does in fact generate
enough return to pay for the costs of providing managerial
services in addition to providing the farmer-members a higher
return to their labor and effort than they could achieve by
contracting with any other organizational form.

Table 4.3 has some important implications on the
advantages of contracting with a cooperative as opposed to
another business form. By capturing more of the profit the
farmer-members are able to earn a greater return to their
labor and buildings. Returning the profits to the farmer-
member or retaining the profits in the local community by the
cooperative has important implications for Iowa's economy.
With contracting it is very likely that Iowa will always
produce large numbers of hogs but if corporate contractors are
producing the majority of the hogs then all the profits will
leave the state of Iowa or the local community where the
profit was generated. The swine management cooperative is
good for Iowa pork producers and the Iowa economy.

**Second MOTAD Model**

A second efficiency frontier was estimated with a
constraint on the total financing available to build new
facilities rather than a member constraint. The total
financing available of $29,500,000.00 was derived from the
initial MOTAD model. At the risk neutral level in the initial
model the portfolio of the cooperative consists of 25 of the
large farrow-to-finish producers under a fixed contract. The
total financing required for the risk neutral portfolio is $29,500,000.00.

Results

Figure 4.2 shows the efficiency frontier and Table 4.4 lists the portfolios for points A through F on the efficiency frontier.

From $0 to $1,421,000 expected deviations (L) the model is constrained by L, rather than the total financing constraint. Over this range the relative composition of the portfolio is constant. As L is increased the number of members grows and additional financing is acquired. The portfolio of the cooperative over this range is as follows:

- 2.2% FPP.I.L
- 4.6% FPF.F.M
- 71.6% FTF.F.M
- 21.6% FTF.F.L

After $1,421,000 expected deviations the model becomes constrained by the total financing available and the percentage of each asset in the portfolio changes. At $1,664,400 expected deviations the medium farrow-to-finish members fall out of the portfolio. At approximately $1,775,000 expected deviations the larger farrow-to-finish members are eliminated from the portfolio.

Above $1,800,000 expected deviations is equivalent to the risk neutral solution. It is made up of large feeder pig
Figure 4.2 Second-run MOTAD results
maximum financing available = $29,500,000
Table 4.4 Portfolio combinations from the MOTAD model for different trade-offs between risk and cooperative surplus for the swine management cooperative with maximum financing available of $29,500,000.00

<table>
<thead>
<tr>
<th>Solution Number from Figure 4.2</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected Deviations from Mean Income (Risk)</td>
<td>100,000</td>
<td>1,421,000</td>
<td>1,600,000</td>
</tr>
<tr>
<td>Expected Cooperative Surplus ($)</td>
<td>231,794</td>
<td>3,293,797</td>
<td>3,561,253</td>
</tr>
</tbody>
</table>

Activities: (number of members)

<table>
<thead>
<tr>
<th>Activities</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>FPP.I.L(^a)</td>
<td>0.1</td>
<td>0.9</td>
<td>15.3</td>
</tr>
<tr>
<td>FPF.F.M</td>
<td>0.1</td>
<td>1.9</td>
<td>32.8</td>
</tr>
<tr>
<td>FTF.F.M</td>
<td>2.1</td>
<td>30.0</td>
<td>7.8</td>
</tr>
<tr>
<td>FTF.F.L</td>
<td>0.6</td>
<td>9.1</td>
<td>8.7</td>
</tr>
<tr>
<td>Total Members</td>
<td>2.9</td>
<td>41.9</td>
<td>64.6</td>
</tr>
</tbody>
</table>

\(^a\) FPP.I.L stands for a large, 500 sow (S), feeder pig producer (FPP), under the incentive-based (I) contract.
<table>
<thead>
<tr>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,664,400</td>
<td>1,756,850</td>
<td>1,800,000</td>
</tr>
<tr>
<td>3,647,452</td>
<td>3,754,458</td>
<td>3,767,476</td>
</tr>
</tbody>
</table>

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>19.6</td>
<td>29.9</td>
<td>31.1</td>
</tr>
<tr>
<td>42.1</td>
<td>64.0</td>
<td>66.6</td>
</tr>
<tr>
<td>9.2</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>70.9</td>
<td>94.9</td>
<td>97.7</td>
</tr>
</tbody>
</table>
producers and medium-sized feeder pig finishers. The cooperative portfolio has over 97 members. The risk neutral portfolio is considerably different from the initial run which had 25 large farrow-to-finish members. Both portfolios have the same level of total financing but the member constraint in the initial run limited the portfolio to 25 members.

A comparison of Figure 4.2 with Figure 4.1 shows that the risk/return tradeoffs for the two models are very similar. The similarity between the two models is a result of the high correlation coefficients between the activities. Both models use the same assets and the problem before the cooperative is to determine what portfolio is optimal for a given risk level regardless of the constraint. The major difference is the portfolio of activities between the two models. At lower risk levels the two models are similar with diversified portfolios of feeder pig producers, feeder pig finisher, and farrow-to-finish operations. At higher risk levels the initial run is composed of only farrow-to-finish operations while the second run's portfolio is composed of feeder pig producers and feeder pig finishers at the higher risk levels.

Another difference between the two models is the risk neutral solution. The objective value for the initial model is $3,441,788 and $3,767,476 for the second model. The two models both have $29,500,000 invested in facilities at the risk neutral portfolio. The differences come from the initial model constrained by the number of
members while the second model is constrained by the total financing available.

The efficiency frontier in Figure 4.2 also shows very little curvature. Again, depending on the risk attitudes of the directors, the cooperative could exhibit a high degree of sensitivity to risk. Alternatively, it could be quite insensitive to risk if the optimal portfolio occurs near the kink in the efficiency frontier.
CHAPTER V.
SUMMARY AND CONCLUSIONS

This study investigated the feasibility of a cooperative supplying managerial services to swine producers and contracting with its members. To analyze this problem a linear programming MOTAD model was developed. The MOTAD model uses expected values from a spreadsheet that incorporates price and production risk into the analysis. The model was used to estimate the portfolio of activities for the swine management cooperative and its feasibility.

The motivation for the study was a report which showed that only the top 20% to 25% of Iowa swine producers are competitive against large-scale "intensively managed" operations that are rapidly expanding in the South. The importance of the swine industry to Iowa's economy combined with the apparent need to make Iowa swine producers more efficient and productive suggested a need for institutional innovations to supply managerial skills.

One of the original objectives of this study was to determine the effects of increased management on production performance measures. Due to the lack of data on producer response to increased management, distributional changes were estimated by eliciting the opinions of four experts. These distributions were then normalized and compared to Iowa producers. The four experts were in agreement that with a combination of improved facilities, genetics, nutrition, and
other factors, the efficiency of Iowa producers can be significantly improved.

A spreadsheet model was then developed that incorporated estimated changes in performance for 24 different swine farm types. The spreadsheet is a budget model of a swine farm where the farmer-member is raising hogs under contract. The spreadsheet calculates the income from the swine operation and then distributes it to the farmer-member and the cooperative based on the contract provisions. The spreadsheets also incorporate price and production risk into the budget and estimate expected returns to the cooperative and the farmer-member.

The expected values from the spreadsheets were then used in a linear programming MOTAD model to determine the portfolio of swine farm activities for the swine management cooperative with different levels of risk and a maximum of 25 members. An efficiency frontier was developed based on the results from the MOTAD model which showed that diversified portfolios can be constructed that achieve various risk/return targets. Each portfolio of activities for the swine management cooperative has the maximum expected return for a given level of risk. The portfolios along the efficiency frontier reflect the choices that are available for the cooperative given its risk preference.

The model was used a second time to estimate an efficiency frontier with a constraint on the total financing
available. A comparison of the two models shows that the risk/return tradeoffs between the two models are very similar. However, the two models have different portfolios all along the efficiency frontier and especially at the risk neutral level.

The portfolio problem for the swine management cooperative is a unique one. Portfolios are usually diversified to capture the gains from uncorrelated or negatively correlated returns. Diversification for the swine management cooperative doesn't offer these benefits because correlations between the returns are very high. This is due to the impact of common price risk overwhelming the independent production risk. The swine management cooperative uses diversification to combine lumpy assets with different risk levels into a portfolio that offers the maximum return for a given level of risk. Diversification benefits are derived from different risk levels between the assets, rather than from negative or uncorrelated returns. In this case, however, diversification still serves as a risk management tool for the swine management cooperative.

Another objective of this study was to consider how distributing the cooperative's earnings through patronage refunds might be accomplished. Because of tax considerations, an allocation method was determined that distributed the cooperative surplus on the basis of the number of pigs produced by each member.
One portfolio was then selected from the first run of the MOTAD model to analyze the benefits for a farmer-member who contracts with the cooperative. After adding the patronage refunds to the contract payments received from the cooperative the returns to each member in the portfolio increased and in some cases doubled. This clearly demonstrates that one of the major advantages of contracting with a cooperative as opposed to other business forms is retention of some or all of the contractor profits.

The results from the feasibility analysis of a cooperative that supplies managerial services to swine producers and contracts with its farmer-members shows that it is indeed a viable form of business based on the assumptions made in this analysis. The success of this cooperative could improve the competitive position of Iowa swine producers and allow Iowa to maintain its dominant position in the production of pork.

**Suggestions for Further Research**

One issue that was originally proposed as an objective of this study was to analyze the composition of the swine management cooperative if the cooperative financed the buildings and equipment for the farmer-members. If the cooperative owned the buildings, the contract payments to the farmer-members would have to be adjusted to reflect returns to the farmer-member for his labor and effort only and not his
buildings. There are very few contracts of this type in the industry today. It is not clear that pooling or risk sharing by the cooperative would have an impact on credit acquisition, cost, or servicing. Further, if the cooperative owns the pigs and the buildings and supplies the management, then the farmer-members are virtually hired labor for the cooperative and may lack the involvement required for success.

Another issue which could be investigated further deals with the contracts. The contract only serves to divide the income between the farmer-member and the cooperative. When the cooperative selects portfolios it merely selects the contract style which gives the cooperative the most return and the farmer-member the least. The division of income between the contract payment and surplus has important implications for risk sharing and incentives. Contracts must also be examined from an efficiency and equity perspective.

There are no differences reflected in performance or income between the two contracts. The four experts were not able to distinguish the effects of incentive-based contracts from those of improved management services.

In this study, costs of production and performance measures were kept the same for all four sizes of swine operations. Data on the differences in these variables is difficult to locate. Economic theory suggests that larger operations may have different cost levels and performance measures due to economies of scale.
Another assumption which was used in this study was the restriction of building designs to only confinement buildings and equipment. The model could be analyzed again using confinement, loose housing, or pasture systems. To analyze this situation it would be necessary to find data on the differences in production measures and costs between the three different systems.

Finally, the acceptability of the swine management cooperative by farmers and cooperative managers needs to be closely examined. What seems feasible on paper may require significant changes in attitudes and behavior in practice. In order for the cooperative to work, farmers would be required to give up some control and power. Whether or not this tradeoff would be acceptable is an empirical question.


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