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A theoretical and financial analysis of pork production contracts

Chris Lynn Hillburn
Iowa State University

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A theoretical and financial analysis of pork production contracts

Hillburn, Chris Lynn, Ph.D.

Iowa State University, 1993
A theoretical and financial analysis
of pork production contracts

by

Chris Lynn Hillburn

A Dissertation Submitted to the
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For the Graduate College

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Ames, Iowa

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CHAPTER I PROBLEM STATEMENT AND OBJECTIVES OF THE STUDY

Contracting by Region

The use of contractual arrangements for pork production varies by region, as shown in Table I-1. The west north central region (which includes Iowa) actually produces more pork on contract than any other region. However, the relative importance of contract pork production in this region, as measured by its percentage of total pork marketed, is not as great as in the south Atlantic or north east regions. This is due to the fact that contracting has been slower to develop in the north central region than in other regions, especially the south Atlantic (Futrell, 1989). This appears to be changing in recent years.

In order to understand why and to examine the reasons for contracting it is useful to examine regional differences in pork production as shown in Table I-2. These competitive factors were described by Roy in 1972. Roy compares the south to the midwest and concludes that farmers in the south were seeking new enterprises such as pork production, but did not have the necessary managerial knowledge and did not traditionally view hogs as a profitable enterprise. Roy also concluded that farmers in the south were willing to produce hogs at a lower profit. In addition, he believed that credit was less available to farmers in the south than to farmers in the midwest.
The implications Roy drew from these factors were that contract production of pork would be primarily located in the south. This was because contractual arrangements would provide a source of capital to southern farmers in the face of credit limitations, provide lower (but acceptable) levels of profit in return for limiting the farmers' risk, and provide management expertise in pork production in a region where it was lacking. In other words, contract pork production in the south would overcome some of the competitive barriers and competitive disadvantages of this region, enabling the south to become a major pork production region. These predictions were, for the most part, accurate until about 1983, when contracting activity began to expand in the midwest (Futrell, 1989). Regional shifts in the competitive factors listed in Table I-2 seemed to be occurring. Important changes occurring were the level of risk that pork producers faced (factor 11), the availability of capital (factor 3), and the availability of a labor supply (factor 2).

Since contract production of pork is a risk sharing mechanism, this type of business organization would likely appeal to individuals operating in a riskier environment or to individuals who cannot survive adverse outcomes because of their financial position. Returns to pork producers, however, were however fairly consistent until recently (Futrell, 1989). Hog prices became much more variable since the decade of the sixties. This was caused by changes in consumer demand and
The increasing volatility of returns in recent years seems to have led to increased contracting activity in order for pork producers to limit or control risk. Additional risk also serves to limit the amount of capital producers would be willing to invest in a pork production enterprise. Variability of returns would also imply that the pork production enterprise may not generate sufficient capital to finance existing or new facilities. Credit institutions also respond to additional risk, limiting the amount of capital they are willing to invest in pork production enterprises. Poor returns to pork production during much of the 1981-1985 period combined with the financial problems of the agricultural sector during this same period also limited the availability of capital for pork production in many farm operations (Futrell, 1989).

The true test of these factors' influence on contracting in Iowa may be found in surveys of contract producers. In 1987, nearly three-fourths of all contract feeders in did so for financial reasons (Rhodes, Flottman, and Proctor, 1987). The financial reasons included availability of capital and cash flow problems (or financial risk). In 1989, after some notable increases in farm income for the agricultural sector, the percentage of contract feeders who did so for financial reasons was still about fifty percent (Rhodes, Flottman, and Proctor, 1989). The percentage of contract feeders that did
so for reduction of price risk and a steadier income remained
at about twenty percent for both surveys. Other reasons
included the desire to utilize available labor and access to
improved management, and these factors became somewhat more
important as a reason for contracting in the 1989 survey.

Contracts and Risk Management

Contract production of pork offers a feeder an
opportunity to share risk with a contractor or owner. In
particular it is the owner who bears most or all of price
variability, depending on the specific arrangement. In
addition, the owner provides a substantial portion of the
capital required for pork production. This capital is
provided directly through the provision of animals, feed, and
other inputs, again depending on the specific arrangement.
For many contractual arrangements the feeder or producer
provides (at a minimum) facilities and labor. Management is
provided by both parties in varying degrees.

Contractual arrangements for pork production, however, do
not eliminate all risks for the feeder. Although the feeder
provides labor and facilities it is the owner who typically
controls decisions about the type of livestock provided, when
livestock are provided, and the quality of inputs provided.
Compensation schedules are designed to ensure the feeder
operates in the owner's interest through incentives based on
such factors as death loss and feed efficiency. This
compensation schedule attempts to minimize the owner's risk that inputs provided will not be adversely affected by the quality and quantity of labor provided by the producer. This can lead to the feeder having responsibility and bonuses for output levels and input use without control of some of the primary factors that influence these results.

Another source of risk to a feeder is the length of the contract and the ease or difficulty of terminating this arrangement. Many contracts are for one year or less with options for renewal. However, more recent contracts are written for a specified time period or a certain number of groups of animals. Even with this there is risk of idle facilities as the time period and number of groups of animals are not combined. The bottom line is that the feeder faces the risk that facilities provided will be unoccupied. If the feeder has financed these facilities with debt capital there is a risk of not being able to meet principal and interest payments in the event of contract termination or delays between animal placings. Given that facilities are typically financed over five to seven years, a one year contract subject to termination is a source of financial risk to both a feeder and the feeder's lender. If a pork production facility and contractual arrangement are viewed as a capital budgeting problem, then this implies that the life of the project is uncertain.
Problem Statement

The production of pork through contractual arrangements is currently an established form of business organization and interest in this type of arrangement is increasing for the reasons stated above. As indicated, contracts offer the parties involved an opportunity to share risk. The key problem is how well does a contractual arrangement perform this function of risk sharing relative to other contracts and to a sole proprietorship type of business organization.

Knowledge of this will aid feeders and owners alike in better understanding and analyzing contracts. Also, in light of current and possible future legal restrictions on vertical integration in agriculture, information of this sort will aid interested individuals in making decisions on these restrictions.

Objectives of the Study

In E. P. Roy's Contract Farming and Integration the author states that he was "impressed by the slow pace of economic research in the field of contract farming and economic integration". Only recently has interest in this area been rekindled and so the overall objective of this study is to expand the knowledge of contract farming and economic integration.

In particular, a primary objective of this research is to develop a theoretical framework for economic analysis of pork
production contracts. This framework will focus on providing insights into the structure of contracts as they currently exist and on providing alternative structures and adjustments.

A second and underlying objective is to develop a framework for the analysis of the risk and return inherent to contract production of pork. This is important to the study of contractual arrangements since this form of business organization is essentially a risk sharing mechanism.

A third objective is to use the analytical framework developed to compare the risk, return, and incentives for productivity for related pork production contracts with the risk, return, and incentives for productivity for independent pork producers. For many contractual arrangements a contract producer's income variability results from biological factors only. These factors, such as death loss or feed efficiency, determine the producer's income via a contract's compensation schedule. Price risk is accepted by the contractor or owner and so the contract is a risk sharing mechanism. The independent owner and operator also faces risk from biological factors, but high levels of production efficiency are not sufficient to guarantee profitability, since a period of low prices may imply low or negative returns. Price risk also may include periods of high prices implying high returns for the independent producer, whereas a contract producer's returns are limited by biological limits to production and so it would
be the contractor that benefits from high prices.

A final objective of this study is to aid both producers and owners in developing effective contracts. Table I-2 listed some market forces that are determining the extent to which pork production contracts are used in any given region. In order for this market to work properly, however, all participants should have access to an adequate data base. This will enable interested parties to understand and evaluate the current market forces that have led to existing contracts and to possibly improve these contracts as a form of business organization. Contracts are a form of business organization and organization is being increasingly appreciated as an important influence on the productivity of economic enterprises (Tomer, 1987).

**Thesis Organization**

In the remainder of the thesis, the research completed in pursuing the objectives is summarized. In Chapter II, previous research on contract production of pork is discussed. Chapter III describes theoretical developments in the principal-agent paradigm and a model of pork production contracts using this framework is presented. Optimal compensation schedules are derived and are compared to selected contracts with suggestions for modification and improvement of these contracts. In Chapter IV the emphasis changes from optimization to that of risk analysis of pork
production contracts. A mean and variance model of risk and returns for contracts is presented and evaluated. In Chapter V the specification and estimation of a firm level model of pork production with comparative analysis of independent ownership pork production and representative contracts is described. Measures of risk and returns for these alternatives are presented and analyzed. Finally, Chapter VI summarizes the research and provides recommendations for further research.
Table I-1. Marketing of hogs and pigs by contract producers

<table>
<thead>
<tr>
<th>Region (Marketings in Thousands)</th>
<th>NE(^a)</th>
<th>ENC(^b)</th>
<th>WNC(^c)</th>
<th>SA(^d)</th>
<th>SC(^e)</th>
<th>W(^f)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contractees</td>
<td>571</td>
<td>515</td>
<td>1,221</td>
<td>448</td>
<td>410</td>
<td>86</td>
</tr>
<tr>
<td>Total</td>
<td>1,575</td>
<td>21,783</td>
<td>34,953</td>
<td>4,788</td>
<td>3,364</td>
<td>3,514</td>
</tr>
<tr>
<td>Contractees % of Total</td>
<td>36.3</td>
<td>2.4</td>
<td>3.5</td>
<td>9.4</td>
<td>12.2</td>
<td>2.4</td>
</tr>
</tbody>
</table>

\(^a\)NE = northeastern states.

\(^b\)ENC = east north central states.

\(^c\)WNC = west north central states.

\(^d\)SA = south Atlantic states.

\(^e\)SC = south central states.

\(^f\)W = western states.

Table I-2. Competitive factors between the middle west and south in hog production

<table>
<thead>
<tr>
<th>Middle West</th>
<th>South</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. A surplus of corn, which is fed mostly to hogs.</td>
<td>1. A deficit area which imports corn from the Middle West.</td>
</tr>
<tr>
<td>2. Labor supply on corn farms can be best utilized for hogs at certain seasons of the year where hogs fit well in the farm plan.</td>
<td>2. Labor supply is abundant but cannot be utilized in hogs unless specialized to a high degree in producing feeder pigs or market hogs.</td>
</tr>
<tr>
<td>3. Credit for the corn-hog farmer is readily available and sufficient even to tenants.</td>
<td>3. Credit is less available to small, part-time or tenant farmers who might be interested in hogs.</td>
</tr>
<tr>
<td>4. Hog management know-how is widespread and efficient.</td>
<td>4. Hog management know-how is limited and not always efficient.</td>
</tr>
<tr>
<td>5. Hog markets and processing plants are numerous.</td>
<td>5. Hog markets are more limited and hog processors are few.</td>
</tr>
<tr>
<td>6. Per capita pork consumption is equal to the national average.</td>
<td>6. Per capita pork consumption is above the national average.</td>
</tr>
<tr>
<td>7. Hogs are already a major enterprise.</td>
<td>7. Farmers are seeking new enterprises, shifting from crop enterprises to hogs. Poultry and eggs compete for local grain.</td>
</tr>
<tr>
<td>8. Pork is now exported to the South, which is deficient in hog production.</td>
<td>8. Only 50 percent of the South's pork consumption is produced in the South.</td>
</tr>
<tr>
<td>Middle West</td>
<td>South</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>9. Farmers are already integrated by raising their own feeder pigs and corn for feeding. In marketing, integration is less apparent.</td>
<td>9. Farmers are less integrated because feeder pigs have to be bought as well as corn. Dressed pork is imported to fill needs.</td>
</tr>
<tr>
<td>10. While corn acreage expansion might be limited, better yields are not.</td>
<td>10. Both corn and milo acreage and yields could be expanded substantially.</td>
</tr>
<tr>
<td>11. Farmers traditionally have netted good returns from hogs and from corn fed to hogs. They are willing to take more risks.</td>
<td>11. Farmers traditionally have not found hogs profitable but are willing to produce hogs at a lower profit than in the Middle West. Hogs are considered a risky enterprise.</td>
</tr>
<tr>
<td>12. Harsher climatic conditions require more investment in facilities and equipment.</td>
<td>12. Milder climatic conditions help reduce fixed investments.</td>
</tr>
<tr>
<td>13. Property taxes are high.</td>
<td>13. Property taxes are low.</td>
</tr>
</tbody>
</table>

CHAPTER II LITERATURE REVIEW

Some types of risk sharing arrangements have received substantial theoretical and empirical study. Lease arrangements in the farm sector have been examined both in terms of their ability to achieve cost efficiency and their ability to alter the lessee's or lessor's risk. Contract farming, on the other hand, has received relatively little attention. A survey of the literature indicates that research has largely been descriptive with some analysis (using simple partial budgeting) of existing contracts and their sensitivity to selected factors.

Descriptive Studies

Roy (1972) provides an overview of contract pork production. This overview includes descriptions of type of contractual arrangements for both feeder pig production and feeder pig finishing. It also includes a description of the advantages and disadvantages of contract farming. The contracts described are similar in concept to current types of contracts. Roy also identifies a number of issues which are relevant to a current analysis of pork production contracts. One such issue involves possible conflicts between producers and contractors in periods of low hog prices. Producers operating under a contract often do not plan to curtail production when prices are low, since their income depends on the number of pigs raised or finished. Contractors, however,
may find it necessary to reduce production during these periods. The result is that returns and variability of returns to a feeder from a contract will be affected by a contractor's decisions on placing animals over time. Incentives to the producer are also discussed. Roy indicates that incentive plans represent an attempt by the contractor to provide the producer with the motivation to "become part of the integrated hog program", or in other words, to operate in the contractor's interest, a key issue in designing contractual arrangements. Roy also identifies financial risk as a principal reason for contracting and points out that if producers are not in a financial position to take risks, they should consider contracting as an alternative to operating independently. To aid this decision a partial budgeting framework for comparison of returns from contracting with that of ownership is provided. In addition, Roy also lists twenty five research issues in economic integration, all of which are relevant to the current environment. Of these, three are especially relevant to this study. These three issues are what constitutes an ideal contract, how can contracts be specifically tailored so the farmer is rewarded consistent with production efficiency, and which type of contract among all those being offered provides the farmer the best combination of risk and returns.

Two other studies have described contract production of
pork (Lawrence, Hayenga, Kliebenstein, and Rhodes, 1992; Futrell, 1989). Like the study by Roy (1972) these researchers give information on the reasons for contracting, descriptions of various contract arrangements, and advantages and disadvantages of contracting. In addition, they provide some information on specific contractors types of contracts, and characteristics of a good contract.

Risk and Return Studies

Recent work on pork production contracts has sought to provide some financial analysis of the risk and returns to contract producers (Zearing and Seals, 1989; Kliebenstein, Stevermer, and Hillburn, 1989; Hetland and Kliebenstein, 1991). These studies use partial budgeting to examine financial returns to a producer or feeder under various contracts.

Zearing and Beals (1989) utilize one feeder pig production contract and one feeder pig finishing contract for their study. Using an actual producer's records for a pork enterprise, they examine cash flow for both contracts over an eight year period. They found that cash flow is relatively stable, but overall returns to a producer are at the breakeven point for the feeder pig finishing contract and are at a loss for feeder pig production when fixed costs of facilities are included. Fixed costs are determined by a fifteen year amortization. Their analysis also shows that contractors
achieved a small profit over the same period for both contracts. One limitation of this analysis is that it does not include any sensitivity analysis based on the life of the contract and the term of the loan for facilities. The term or life of the contractual arrangements they describe are guaranteed for only one year, whereas debt financing for facilities is amortized over a fifteen year period. This would add additional risk to the producer, since this represents financing a long term asset based on cash flows guaranteed for only one year.

Hetland and Kliebenstein (1991) use weekly production records for a feeder pig production enterprise to examine three feeder pig production contracts. Each of the contracts provided the producer with a positive return after all expenses. They also found that there was a substantial difference in the producer's returns for apparently similar feeder pig production contracts. When the compensation schedules for the three contracts were applied to the same producer's production levels, net returns to the producer ranged from $40,196 to $16,296, depending on the contract, showing that careful evaluation of contracts will benefit the producer substantially. The actual producer involved also indicated that monthly payments were an important factor in choosing a contract, as this provided a steady cash flow, indicating liquidity and timing of payments may be as
important as total net returns.

Kliebenstein, Stevermer, and Hillburn (1989) use a similar partial budgeting approach to examine a variety of feeder pig finishing and feeder pig production contracts. Their analysis includes compensation schedules that incorporate flat fees and production incentives and, alternatively, compensation schedules that incorporate flat fees and profit sharing in lieu of production incentives. Returns are estimated for a hypothetical pork enterprise using sensitivity analysis for prices, production efficiency, and life of the contract. Their results indicate that incentives, either through production efficiency or profit sharing, are necessary for producers to achieve profitability and cover fixed costs of facilities. Returns are also found to be sensitive to the life of the contract. The various types of contracts are examined for variability of returns relative to each other. Contracts that offered flat fees (such as a base payment per pig or per sow) and production incentives showed less variability in returns to the producer than profit sharing contracts. This reflects the elimination of price risk for the feeder in the flat fee contracts. Contracts that offer relatively larger flat fees and smaller production incentives provided less variable returns to the feeder than contracts that had relatively smaller flat fees and larger production incentives.
The use of partial budgeting and sensitivity analysis in these studies represent a simple and straightforward initial screening of contracts and provides valuable information for the development of a risk analysis approach. The weakness of partial budgeting and sensitivity analysis is that this method considers changes in only one variable at a time and so cannot capture the impact of simultaneous changes in multiple variables on outcomes such as net returns or cash flow.

None of these studies compares the risk and return of pork production contracts with that of independent ownership, a key choice variable for producers. It is likely that contracts will offer a producer less risk relative to independent ownership, but contracts will also limit the upside potential of returns in periods of high prices. The extent of this trade off between risk and returns between contracts and independent ownership has not been examined in these studies.

Theoretical and Conceptual Models

Blaich (1960) provides a conceptual framework of the structure of firms which emphasizes changes in vertical structure. He then applies this framework to pork production. His main conclusion is that pork production will likely become separated from corn production. This separation would occur due to increases in efficiency from specialization and new technology which in turn would end the advantage that the pork
and corn producer enjoys in terms of input complementarity. Blaich's analysis is based solely on efficiency arguments and ignores risk sharing implications as reasons for contracting. In light of consistent returns to pork production during this period, this is understandable. However, in the current environment of volatile returns and lack of capital availability, his framework adds little to the analysis of contract farming. As already stated, currently few producers who contract do so primarily because of access to improved management and technology but instead enter into contracts as a means of managing financial or price risk.

Roy (1972) and Long (1989) make a substantial contribution towards recommended contractual agreements. Their focus is on specific terms of contracts and what these types of arrangements should provide for in the written agreement. Since they use a legal framework they do not attempt to provide for ideal or optimal contracts. However, their work provides insights into issues that a theoretical framework should address. For example, both recognized that a contractor has a significant impact on output levels through his or her provision of inputs and the quantity, quality, and timing of these inputs. If these impacts are extended to a theoretical model of contract farming, then a theoretical analysis must include the impact of the contractor's actions on output and compensation to the feeder.
Reimund, Martin, and Moore (1981) developed a prototype structural change model for agricultural subsectors based on changes in the broiler, cattle feeding, and processing vegetables subsectors. Their model suggests that structural changes in agriculture takes place in four stages. The stages are technological change, shift in the location of production, growth and development, and adjustments to risks. They surmised that the pork subsector was in the second or the shift of location in production stage. The fourth stage, adjustments to risks, emphasizes the impact of production contracts and coordination within a subsector as risk management methods.
CHAPTER III THE PRINCIPAL-AGENT PARADIGM AND PORK PRODUCTION CONTRACTS

Although pork production contracts have been in existence for a number of years, there is a lack of standardization in the terms and provisions of these contracts (Long, 1989). In addition, a number of important items influencing the risk and return of contract production are often not included in the contract (Long, 1989).

Most contracts include payments to a producer for labor and facilities as specified in a compensation schedule included in the contract. The contractor provides pigs, feed, veterinary services, and medicine. Compensation is based on a base payment per pig plus bonuses for such factors as feed efficiency and death loss levels.

Various contracts of this sort were examined in Kliebenstein, Stevermer, and Hillburn (1989). One of the results of their analysis was that base payments alone were not sufficient to ensure replacement of facilities and profit for the producer. Higher returns were possible through production bonuses, included in many contracts. These bonuses required feed efficiency and death loss levels beyond some fixed standard established in the contract.

Since the contractor or owner provides a large portion of the inputs and the producer or feeder is compensated at least in part on production and efficiency levels, the compensation
is influenced by the contractor's level of investment, which in turn influences the quality and quantity of contractor provided inputs. The key issue is that the compensation schedule may be a function of the productive resources provided by the contractor in spite of the fact that the producer has no control over these factors. Economic theory has provided a framework to examine these types of issues, the principal-agent paradigm.

The Principal-Agent Paradigm

The principal-agent paradigm can be described as follows (McDonald, 1984). One individual, called the agent, chooses some action that results in an outcome, X. The outcome, X, results from this action and also depends on the state of nature that prevails, so uncertainty is intrinsic to the situation. The outcome provides utility to a second individual, the principal. The principal's problem is to design a compensation function for the agent before any production takes place. When the principal can observe neither the action of the agent nor the state of nature that will prevail, a moral hazard issue arises because the agent's action affects the probability distribution of the outcome. Thus, the compensation function's purpose is to induce the agent to operate in the principal's interest as well as their own.

In most principal-agent models the principal takes a
passive role in production once a reward function is designed (Carmichael, 1983). Profits or output are then determined by the agent’s efforts and the state of nature. However, a contractor (principal) does not play a passive role in pork production contracts in that this individual provides much of the investment and operating capital through feed rations, livestock, and other inputs. This in turn, implies the contractors can influence output through their actions. Thus the standard principal-agent framework described above must be modified. This modified framework is based on the research of Demski and Feltham (1978) and Callen and Livnat (1989).

The Producer’s Optimal Compensation

Assume a contractual arrangement involving a single contractor and a single producer. The contractor provides the producer with pigs, feed, and veterinary services. The level of these resources, K, measured in dollars, is determined solely by the contractor. They represent factors beyond the producer’s control.

The arrangement also provides the producer with a compensation package, C. In a principal-agent context this compensation schedule is designed so that the producer operates in the contractor’s interest. As the producer’s effort is not observable, compensation is based on production levels and input use, observable by both parties.
Although the producer provides facilities, the contractor has the opportunity to observe the facilities and use a forcing contract. This means that the facilities must meet specifications set by the contractor. This is in contrast to the producer's effort and management, which, again, is not observable. If the producer's effort were observable, the producer could be directly instructed to select the optimal level of effort. In addition, the producer could then be paid a constant amount to reward that level of effort.

The issue to be addressed is whether or not factors outside the producer's control will be included in an optimal compensation package, or is compensation a function only of the output (or its value) produced by the contractual arrangement, the producer's effort and management, e, and the state of nature. Output X is assumed to be a random variable with density function \( g(X; K, e) \). This implies that output is a stochastic function of the inputs provided by the contractor and of the producer's effort and management (e).

The contractor is assumed to solve for the optimal compensation \( C(.) \) via a standard principal-agent model where the solution is viewed as a function of \( K \). The contractor then maximizes this solution with respect to \( K \). Formally, the contractor is assumed to maximize \( Z(K) \) with respect to \( K \), where \( Z(K) \) equals maximum with respect to \( C(.) \) and \( e \) of

\[
\int V(X - K - C(.))gdg
\]
subject to:

III-2 \[ \int (U(C(.)) - T(e))gdg \]

and

III-3 \[ \int U(C(.)) g_0 dg = T'(e) \]

The contractor's utility function is \( V \), \( U \) is the producer's utility function over compensation, and \( T \) is the producer's utility function over effort and management. The contractor may or not be risk-neutral, that is \( V'' < 0 \), and it is assumed that \( U'' < 0 \) and \( T' > 0 \). Constraint (III-2) assures the agent of a minimum expected utility since \( H \) represents the minimum expected utility given a reservation wage in the labor market. Constraint (III-3) reflects a restriction that the contractor can observe output but not the feeder's effort.

Consider some specific examples with a risk neutral contractor and a risk averse producer. Risk neutrality and some simple utility functions will be utilized in order to focus on the optimal compensation schedule. The model is:

III-4 \[ U(.) = 2(C(.))^{1/2} - e^2 \]

III-5 \[ T(e) = e^2 \]

III-6 \[ X \sim (1/KE) \exp(-X/KE). \]

Expected output (value of) is thus assumed to be an increasing function of investment in productive inputs and the producer's effort and management.

The optimal compensation derived for the model described by equations (III-1) - (III-6) has the form:
In this example, the compensation function is a function of $X/K$, a return on investment formulation. In order for a contractor to achieve some level of return on investment, production standards such as death loss may be used. In addition, there could be a fixed standard for input use, such as feed efficiency. As shown in Holmstrom (1979), additional information (besides output) which can be observed by both parties can be used in constructing the compensation schedule. This corresponds well with observed contracts, which often have incentives based on feed efficiency.

Inputs not controlled by the producer are explicitly included in the optimal compensation schedule. Furthermore, the producer's compensation is inversely related to the inputs provided by the contractor, as are the standards of production.

For another example, consider a density function

$$III-8 \quad X \sim \frac{1}{(K+e)} \exp\left(-\frac{X}{(K+e)}\right).$$

The optimal compensation (derived from equations (III-1) through (III-5) and (III-8) is then

$$III-9 \quad C(.) = \left(\left(\frac{H}{2} - e^2\right) + e(X/K)\right)^2.$$

In contrast to previous example, the optimal compensation is now a profit sharing contract. It is possible to construct numerous examples of optimal compensation schedules by changes in the density function, but the main point is that these
optimal compensation schedules all explicitly include K, the inputs provided by the contractor and outside the control of the producer. In general, if e and K interact in production (in the examples interaction is through the density function) then compensation C(.) will be a function of K.

The two examples differ markedly when incentives beyond the base payment are considered. The first contract offers additional incentives if output or input use or both are favorable relative to some fixed standard. The second contract offers additional incentives through profit sharing. In this case, the producer receives a percentage of the residual profits of the contractor. The producer's incentives and risk include market or price risk in the profit sharing contract, as opposed to production risk alone when incentives are based on performance relative to some fixed standards.

Contract Standards, Incentives, and Penalties

For those contracts that offer production incentives (as opposed to profit sharing) an issue for both contractors and producers is the fixed standards of output or input use (such as death loss allowable or feed efficiency) these incentives are based upon. Demski and Feltham (1978) examined a number of budget based compensation schedules for a generalized and simple contractual situation. They found the optimal compensation schedule was characterized by relatively high standards. In other words, if the standard is relatively low,
the effort is also relatively low. This is true in the absence of any penalties for not achieving the standard. Mirrlees (1974) demonstrated that employing a low standard and an extreme penalty for not meeting the standard was optimal.

These results do not conflict with each other in that the key is the penalty for not achieving production standards. Pork production contracts, in general, contain some penalty clauses in the compensation schedule. Usually these penalties result in the sharing of expenses due to excessive death loss (excessive meaning relative to a production standard). Whether or not these types of penalties are sufficiently extreme is doubtful, since the severity of the penalty is dependent on the producer's cash flow requirements. For those producers with principal and interest payments on facilities to meet, loss of incentive payments and penalties may well be a strong motivational factor. For those producers with existing facilities that have not been modified for the contract and have incurred no debt, this may not be the case. However, there are in fact much more severe penalties implicitly contained in contracts that would affect any producer who wishes to maintain a contractual arrangement, regardless of debt obligations.

One such penalty is the timing of the delivery of the contractor's swine. Many contracts contain no explicit terms as to when animals are delivered, which gives the contractor
total control as to time and number of animals delivered (Long, 1989).

Another implicit penalty is contained in the length of the contract and in termination clauses. If the contract is for one year with option of renewal, the termination of the contract could act as a penalty for those producers not meeting the contractor's expectations. In addition, if the contract contains specific termination clauses which can be invoked before the contract length expires, this could be used as a penalty. These penalties would seem to be effective to the extent that a producer wishes to maintain a contractual agreement.

These penalties have an impact on the optimal compensation schedule. Demski and Feltham (1978) conclude that, in general, a standard or budget based contract is not a Nash equilibrium without some enforcement mechanism. The implication is that a contractor has a unilateral incentive not to honor the agreement. This would not be true with legal sanctions or a formal multiperiod agreement. This would, in turn, mitigate or eliminate any inducement from the penalties just discussed.

Implications of the Model for Actual Contracts

These examples differ in the form of the optimal compensation schedules derived. The form of an optimal compensation depends on the underlying parameters and it is
not likely that either contractors or producers know these parameters. Also, the principal-agent theory tends to lead to some very complex fee functions. This is the case for the model used above, despite some restrictive assumptions. The compensation functions derived suggest that the way output is divided between the producer and the contractor would depend on the probability distribution of exogenous factors, the relation between effort and output, the risk attitudes of both parties, and reservation utility levels specifically accounted for within the compensation function. In fact, the pork production contracts that are in use are much simpler, although the optimal compensation schedules do bear a general resemblance to the form of actual contracts in that both contain base payments, production incentives, and profit sharing. The optimal compensation schedules are based on the same utility functions, yet the form of the optimal compensation schedule can be either production based or contain an element of profit sharing. The returns and risks associated with each of these types of contracts are very dissimilar, yet both were found to be optimal. Despite these weaknesses, the model does have some implications for actual contracts and how these contracts should be structured.

The level of the producer’s effort and management affects the level of output, death loss, and feed efficiency, but not unambiguously because production is also governed by other
elements. Thus, a contract should depend upon observable output and any other information which distinguishes fluctuations in output from the producer's level of effort. The fluctuations in output also depend on the quality and quantity of inputs provided by the contractor.

In practice, some contracts explicitly recognize this and incorporate this type of information into the compensation schedule. Some feeder pig contracts in use distinguish between "farm fresh pigs" (delivered directly from another farm) and "terminal pigs" (purchased at auction from different sources). In these contracts the contractor absorbs all death losses up to 4 percent for farm fresh pigs and up to 6 percent for terminal pigs. The standard of production reflects the different quality of the contractor inputs, and the relationship is an inverse one as derived in the optimal compensation schedule.

Some pork production contracts in use do not differentiate between feeder pigs and their sources. One option for producers in these cases is to renegotiate the compensation schedule as above. Another option is to give the producer the right to reject the pigs at time of delivery. This may not be economically efficient in light of the contractor's costs following such a rejection (Long, 1989). A compromise might be to allow the producer to reject or accept the pigs based on their source or sources,
before any delivery is made.

Another result of the model was that, regardless of the form of the compensation, K, the contractor’s input, was inversely related to the optimal level of compensation. In an Iowa State University study (Kliebenstein, et. al., 1989) a number of contracts were examined and compared. One contract in particular offered better returns than other similarly structured contracts. However, discussions with producers and contractors indicated that, in practice, the higher compensation levels this contract offered were not achieved by producers because of poor quality pigs, high death losses, and lower feed efficiency. In essence, the analysis assumed similar quality of contractor inputs for all contracts, when in fact the contract offered higher compensation for lower quality inputs. If this fact were known before a producer entered into the contract this is not a problem. If not, then the contract should include provisions for this inverse relationship.

These recommendations take into account the fact that the contractor has actions available that affect the level of output. It can also be argued that the contractor’s concern about long run profits would induce this individual to provide adequate inputs or to account for the level of contractor inputs provided in a compensation schedule. This is true if the contractor’s objectives are long term in nature and to the
extent that reputations are important in pork contract production. Otherwise there exists incentives for the contractor to provide lower levels of inputs and claim that an unfavorable state of nature has occurred or let the producer bear the unfavorable consequences. This in turn shifts more risk to the feeder without additional compensation and places the feeder into a situation of responsibility without control, which is not optimal or even satisfactory.

The principal-agent model used here does provide some implications for the actual terms of a pork production contract. The most important implication is the compensation schedule derived, which is much more complex than actual contracts. Rather, it would seem that an optimal contract in practice could use a relatively simple compensation schedule. The complexity of this type of contract should be in the explicitly stated duties, rights, and responsibilities of all parties. This would seem to be lacking in many contracts currently in use. The problem then becomes an economic issue that goes beyond the usual boundaries of economic analysis.
CHAPTER IV THEORETICAL FRAMEWORK FOR FINANCIAL ANALYSIS OF PORK PRODUCTION CONTRACTS

Pork production contracts have been touted as a means of risk sharing and reducing risk (Zearing and Beals, 1989; Kliebenstein et. al., 1989; Roy, 1972; Futrell, 1989). However, little work has been done in this area to examine the magnitude of risk sharing and risk reduction available through contracting. The framework used to examine risk has been partial budgeting with sensitivity analysis. This research has provided information on how individual factors can affect returns, but has not developed any risk profiles of contracting. The current state of economic and financial analysis of pork production contracts is thus based on simple budgeting methods with ad hoc risk assessment.

Given that the majority of producers who contract do so for reasons of reduced capital requirements, financial risk, and price risk, a framework is needed to identify the risk among contractual alternatives available and contractual risk relative to independent ownership.

Concepts of Risk

As already indicated, producers who contract do so primarily because of financial reasons and price risk. In order to develop a framework for evaluating the impact of contract production on these factors it is necessary to refine these concepts so that they can be evaluated without resort to
Gabriel and Baker (1980) present a conceptual framework of total risk broken down into components of business risk and financial risk. They define business risk as the risk inherent in the firm, independent of the way the firm is financed. Applying this concept to the agricultural firm they identify two major sources of business risk. One source is the price variability for both outputs and inputs and the other source is yield or production variability. These sources of risk are reflected in the variability of net cash flow or net operating income. Low business risk is associated with a low coefficient of variation and a high business risk is associated with a high coefficient of variation.

Financial risk is defined to be the added variability of net cash flows that accrue to equity suppliers. The source of financial risk is the debt servicing requirements associated with borrowing or using debt capital.

Wilson and Gunderson (1985) provide an explicit decomposition of total risk (TR) into business risk (BR) and financial risk (FR). Net cash flows before debt payments (NCFB) are defined as:

$$\text{NCFB} = \sum_{i=1}^{n} (P_i - C_i)X_i - F$$

where $P$ is the price received for the $i$th product, $C$ is the variable cash costs of producing that product, $X$ represents
the amount of ith product produced, and F is the fixed cash
cost (excluding debt) that must be paid annually. Net cash
flows after debt payments (NCFA) but before taxes are
expressed as:

\[ \text{IV-2 } \text{NCFA} = \text{NCFB} - P - I \]

with P and I representing annual principal and interest
payments respectively. Using \( \sigma \) and the subscript \( n \) to
represent the standard deviation in NCFB, the risk components
can be written as:

\[ \text{IV-3 } \text{TR} = \sigma_n/\text{NCFA} \]
\[ \text{IV-4 } \text{BR} = \sigma_n/\text{NCFB} \]
\[ \text{IV-5 } \text{FR} = \sigma_n/\text{NCFA} - \sigma_n/\text{NCFB}. \]

Equation (IV-5) expresses the financial risk measure as a
residual value obtained from subtracting business risk from
total risk. This formulation assumes that increased levels of
debt do not alter business risk. Equation (IV-5) can be
manipulated to form an expression which shows that financial
risk is a multiplicative function of business risk,

\[ \text{IV-6 } \text{FR} = \sigma_n/\text{NCFA} \cdot (P+I)/\text{NCFA} \]

indicating that the level of financial risk is determined by
the variability in prices and yield as well as the level of
debt financing.

A similar analytical model can be used to examine
business and financial risk for a given pork production
contract if equation (IV-1) is modified. Consider a contract
which provides a base payment \((\alpha)\) per pig and production incentives \((\beta_i \text{ or } \beta_j)\) relative to fixed standards. Equation (IV-1) can be rewritten as

\[
\text{IV-7 } \text{NCFB} = \sum_{i=1}^{n} \alpha X + \beta_i (X - X_s) + \beta_j (I_i - I_s) - C_L - F
\]

where \(X_s\) is a standard for output, \(I_i\) is input use, \(I_s\) is a standard for input use, and \(C_L\) is labor cost. Production incentives are paid when the feeder performs better than the standards. For a feed efficiency standard, the incentive would be paid when pounds of feed per pound of gain is less than the production standard in the contract.

A comparison of equations (IV-1) and (IV-7) readily provides some ideas about risk sharing under independent ownership versus contracting for a producer. For the contract (IV-7) variability of NCFB is dependent only on production variability and input use, relative to fixed standards. Except for labor, both input and output variability are absorbed by the contractor. If a particular contract contains provisions that detail quality and timing of inputs provided by the contractor and the duration of the contract, then it would seem that a great deal of business risk sharing is available through a contractual arrangement. For a given compensation schedule the payoff or return for particular output and input levels is clearly defined and available to the producer in advance.
The tradeoff for the producer from this type of risk sharing is a reduction in average cash flows (NCFB). The producer also shares management responsibilities with the contractor and thus loses some freedom of action as long as the contractual arrangement is maintained. Whether or not this is a negative tradeoff is dependent on the producer and the field manager representing the contractor. Some contract producers have indicated they prefer this shared responsibility and that it provides access to improved management. Other contract producers have indicated that one of the major problems they have had is working with the contractor's field managers.

How does a contractual arrangement affect financial risk? Jolly (1983) indicates that specific risk management strategies will frequently be interdependent and that would seem to be true for a contractual arrangement. Assuming similar size of facilities and debt service requirements for both independent ownership and contracting, the change in business risk could increase, decrease, or not affect financial risk. However, the assumption of similar levels of debt service for independent ownership and contracting is a poor one to the extent that an independent owner finances livestock, feed, and other inputs with debt capital. The contract producer does not have to provide these inputs and this would have an impact on NCFA and debt service.
requirements (P+I). The impact on financial risk and total risk depends on the magnitude of changes in NCFA and principal and interest payments.

This interaction between business risk and financial risk may also have implications for the choice of size of facilities, total investment, and the use of debt capital in both independent ownership and contracting. For example, assume the contractual arrangement reduces business risk and debt service requirements. Also assume that the risk balancing hypothesis of Gabriel and Baker (1980) holds so that there is a total risk constraint, which is equal for both the contract producer and the independent owner. A contract producer in this situation might use more leverage (hence greater capital is available) and build larger facilities while maintaining the same total risk as the independent owner.

The framework also allows analysis of another aspect of business and financial risk which is unique to contractual arrangements. The contracts examined in Zearing and Beals (1989) and Kliebenstein et. al. (1989) were actually one year contracts with options for renewal. If a producer builds or modifies a facility in order to enter into a contractual arrangement and finances all or part of this with debt capital, this debt will likely be amortized on an intermediate or long term basis. These terms of the contract and the loan
allocate risk to the producer and to the producer's lender in
that they face the possibility that the contract (which is the
main source of loan repayment) may be terminated and the
facilities unoccupied.

The problem then becomes how to incorporate a stochastic
project life into the calculation of mean and variance (or
standard deviation). Furthermore, it is necessary to examine
the magnitude of the errors included in analysis of a contract
by the incorrect assumption that the contract's duration (N)
is constant. To address these problems an operational
procedure is needed to allow analysts to consider N
stochastic.

Van Horne (1977) suggested a probability tree approach in
which project life is stochastic, but the number of estimates
required hinders implementation. For example, a three-state,
ten year project requires more than 150,000 estimates.
However, the same framework that was used to examine risk can
be modified to account for this problem, with the only
information required when N is stochastic is the probability
distribution of N.

**Statistical Background for Stochastic Contract Duration**

For purposes of analyzing the impact of a stochastic N on
business and financial risk, the mean and variance will be
examined initially (for mathematical convenience). From this
analysis the impact on standard deviation can be easily
derived.

The potential error that may be introduced by assuming $N$ is constant when $N$ is actually stochastic can be analyzed by comparing the calculations of the mean and variance of the sum of $N$ variables when $N$ is certain and when $N$ is stochastic. Let

$$\text{IV-8 } X_T = X_1 + X_2 + \ldots + nE(X)$$

where $X_1$, $X_2$, ..., are independent and identically distributed stochastic variables. If $N$ is constant, the associated mean and variance are

$$\text{IV-9 } E[X_T] = E[\sum_{i=1}^{n} X_i] = nE[X]$$

$$\text{IV-10 } \sigma^2(X_T) = \sigma^2(\sum_{i=1}^{n} X_i) = n\sigma^2(X).$$

However, if $N$ is a nonnegative integer-valued stochastic variable independent of the $X_i$'s, the associated mean and variance, as given by Ross (1972) and Parzen (1963) are

$$\text{IV-11 } E[X_T] = E[\sum_{i=1}^{N} X_i] = E[N]E[X]$$

$$\text{IV-12 } \sigma^2(X_T) = \sigma^2(\sum_{i=1}^{N} X_i) = E[N]\sigma(X) + E(X)^2\sigma^2(N).$$

If $E(N) = n$, the $E[X]$ is the same when $N$ is constant and when $N$ is stochastic. However, a comparison of equations (IV-10) and (IV-12) indicates that the variance of $X$ is biased downward by a factor of $E[X]^2\sigma^2(N)$ if $N$ is assumed to be
constant when N is stochastic. The magnitude of the bias may be considerable.

The analysis can be easily extended to the more general case of nonindependent and nonidentical cash flow distributions.

**Contract Simulation for Finishing Feeder Pigs**

In order to illustrate the theoretical concepts of business risk and financial risk, the production records used in Zearing and Beals (1989) is utilized to calculate risk and return for independent ownership and for two pork production contracts in a finishing enterprise. Contract A offers a $5.50 base payment per head plus $.30 per head for each incremental reduction of .1 pounds fed per pound of gain below a feed efficiency of 4.5. Contract B offers a $8.50 base payment per head plus $.25 per head for each incremental reduction of .1 pounds fed per pound of gain below a feed efficiency of 3.3.

The production records used in Zearing and Beals (1989) are from North Carolina State University’s Production and Financial Summary, Swine Development Center for the years 1979 through 1986. The production records are for an independent producer. Since a data base for contract producers’ records does not exist, the payment schedules for the two contracts above were imposed on these production records and measures of return and risk were then calculated for this study. Table
IV-1 presents information on net cash flows before and after debt service, standard deviation of NCFB, and debt service requirements for ownership and the two contracts.

The expected risk and return tradeoff for ownership and contracting is evident in this situation. Average ownership cash flows before and after debt service are higher than for either contract but also show greater variability. The debt service requirements, which assume 100 percent of all operating costs and facilities, reflect the reduced levels of investment necessary under a contractual arrangement as opposed to ownership.

Table IV-2 presents calculations of total risk, financial risk, and business risk for the three alternatives, based on Table IV-1 and equations IV-3, IV-4, and IV-7. Total risk is more than halved under the contractual arrangements, as is financial risk, when compared to ownership. Business risk is reduced even more, as the contracts reduce this type of risk to about a fourth of the business risk under the ownership alternative.

**Stochastic Contract Duration**

Zearing and Beals (1989) indicate that a contract incentive for producers is the ability to meet their debt service requirements for facilities. The analysis presented above indicates that contract arrangements do offer reductions in risk and offer sufficient cash flow to meet debt service
requirements. However, this analysis assumes that the length of the contract \( N \) is constant and equal to the term of the loan for facilities. In fact, many pork production contracts have a duration of one to three years with options for renewal, whereas the debt service requirements are determined by an intermediate or long term loan of greater duration. Thus, the producer and lender are relying on a short term arrangement (the contract) as a source of repayment for an intermediate or long term liability.

In order to illustrate the impact of a stochastic contractual life on risk, assume the expected life of the contract \( E(N) \) is equal to the actual duration of the contract \( n \). The mean values of NCFB and NCFA (the expected returns) for both contracts thus do not change. Assume the variance equals 3, or the variance of the duration of the contract is three years. Using the same contracts as before, Table IV-3 shows the impact of this assumption on the contract risk and returns, using equation IV-12 to calculate variance. If the producer is relying on the contractual arrangement exclusively to generate cash flow the impact on risk is considerable. The standard deviation of NCFB for both contracts is now greater than that of ownership and the contracts offer lower returns. Under this assumption of stochastic contract duration the contracts offer lower returns and higher risk. The increased risk impacts on total risk, business risk, and financial risk.
The implication of these results is that the contracts are not a successful risk sharing mechanism, since accepting lower returns and higher risk is not a choice many producers would accept. This implication is valid to the extent that a contractual arrangement is relied upon as a source of revenue and capital for the producer. The increased financial and business risk reflected in Table IV-3 is based on the assumption that the producer's facilities will be empty if the contract is terminated before its expected duration. This increased risk is overstated if alternatives to a terminated contract exist. These alternatives might include other contracts or independent ownership of pigs in the system.
Table IV-1. Risk and return per head for pork contracts

<table>
<thead>
<tr>
<th>Owner</th>
<th>Contract A</th>
<th>Contract B</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCFB</td>
<td>$19.03</td>
<td>$5.73</td>
</tr>
<tr>
<td>σₜ</td>
<td>$8.60</td>
<td>$0.65</td>
</tr>
<tr>
<td>NCFA</td>
<td>$4.39</td>
<td>$0.88</td>
</tr>
<tr>
<td>P+I</td>
<td>$14.64</td>
<td>$4.84</td>
</tr>
</tbody>
</table>

Table IV-2. Risk measures for pork production contracts

<table>
<thead>
<tr>
<th>Owner</th>
<th>Contract A</th>
<th>Contract B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Risk</td>
<td>1.93</td>
<td>.74</td>
</tr>
<tr>
<td>Financial Risk</td>
<td>1.48</td>
<td>.63</td>
</tr>
<tr>
<td>Business Risk</td>
<td>.45</td>
<td>.11</td>
</tr>
</tbody>
</table>

^Total Risk = σₜ/NCFA.
^Business Risk = σₜ/NCFB.
^Financial Risk = σₜ/NCFB • (P+I)/NCFA.

Table IV-3. Risk and return for pork production contracts (stochastic contract duration)

<table>
<thead>
<tr>
<th>Owner</th>
<th>Contract A</th>
<th>Contract B</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCFB</td>
<td>$19.03</td>
<td>$5.73</td>
</tr>
<tr>
<td>σₜ</td>
<td>$8.60</td>
<td>$10.73</td>
</tr>
<tr>
<td>NCFA</td>
<td>$4.39</td>
<td>$0.88</td>
</tr>
<tr>
<td>P+I</td>
<td>$14.64</td>
<td>$4.85</td>
</tr>
<tr>
<td>Total Risk</td>
<td>1.93</td>
<td>12.44</td>
</tr>
<tr>
<td>Financial Risk</td>
<td>1.48</td>
<td>10.53</td>
</tr>
<tr>
<td>Business Risk</td>
<td>.45</td>
<td>1.91</td>
</tr>
</tbody>
</table>
CHAPTER V RISK ANALYSIS OF PORK PRODUCTION CONTRACTS

A Pork Enterprise Simulation Model

A weakness of the model used in the previous chapter is its reliance upon the coefficient of variation for the measurement of risk. One problem with this approach is that the coefficient of variation has little meaning if the mean value of cash flows is negative. Another problem is in the interpretation of the coefficient of variation as a measure of risk. For example, if it is said that contracting reduces financial risk by 50 percent, how is this to be interpreted? It is likely that this means that the probability of achieving a positive net cash flow after debt service is increased, but by how much? The only way to give meaning to this statement is by examining net cash flow after debt service and checking if it is positive for any given year or over a number of years. A procedure that analyzes the entire distribution of simulated cash flows would seem to be more informative. This information could then be interpreted in such a way so as to describe the probability that cash flow is greater than a specified amount (such as debt service requirements). This would provide a better means of evaluating risk and returns.

Hertz and Thomas (1983) have provided the framework for this risk simulation methodology. Probability distributions for the variables must be obtained. Each of the distributions is then sampled from once. This provides a single value for
each of the variables and enables a set of net cash flows, or some other performance measures, to be calculated. The distributions are then sampled from again and a new value for the performance measures is calculated, and so on. Eventually, after a large number of samplings from the distributions, probability distributions for the performance measures are drawn. The essence of this methodology is to develop a distribution based approach to decision making and to allow decision makers to clearly see the impact of sensitivity and uncertainty.

Anderson and Ikerd (1985) developed an approach to distribution based decision analysis for agricultural producers. This approach relies on simple probability distributions without simulation. This methodology allows estimation of the probability that total returns will be greater than or equal to variable costs and total costs.

The model proposed for this study is one based on simulation like that of Hertz (1983). However, an attempt is also made to make the model accessible to a wide range of decision makers. This is done through the utilization of a simulation package designed to operate with any spreadsheet program. The result is that anyone with a working knowledge of spreadsheets and basic probability (similar to the level that the Ikerd and Anderson model requires) can perform risk analysis based on simulation methods.
The model provides an analytical tool for simulating the probable impacts of different contracts on a producer's profitability, as well as a comparison of contracting and independent ownership. The model utilizes a pork enterprise template, but the analyst has the option of using several independent probability distributions for output prices, input prices, and production performance. Dependence between variables is treated as in Anderson and Ikerd (1985), in that the analyst is required to specify correlation.

Feed prices, feeder pig prices, market hog prices, and pork production data were used in the model. Average feed, feeder pig, and market hog prices were obtained from the Marketing Division of the Iowa Department of Agriculture and from the USDA for 60 months between January 1985 and December 1989. Pork production data were obtained from the Iowa State University Swine Enterprise Records for the same period. Data were collected on feed efficiency, feeder pig death loss, pigs weaned per litter, and litters weaned per sow.

The feeder to finish enterprise used in the model assumes a facility for finishing 300 feeder pigs. Initially, total investment in facilities and equipment is $22,500 or a replacement cost of $75 per pig. A replacement cost of $105 per pig (or a total investment of $31,500) will also be considered in the simulation in order to examine the sensitivity of returns and risk to fixed costs.
The feeder pig production enterprise assumes a confinement facility for 500 sows. Investment in facilities is $300,000 or a replacement cost of $600 per sow.

Risk Analysis of Feeder to Finish Contracts

Net returns for the feeder to finish enterprise were calculated using budgets like that shown in Table V-1. Stochastic prices and production efficiency measures are used to generate the probability distributions for three contracts and for sole proprietorship. The simulation model is run simultaneously for each of the arrangements, with contract payments and penalties substituted for prices where appropriate. Although the focus of this paper is primarily on risk and returns to the feeder, returns and risk for the owner (contractor) are also generated and evaluated at the same time. This is done because a contractual arrangement that is unprofitable or excessively risky to the owner is likely to be modified or terminated.

Two of the contracts are fixed payment contracts. These contracts transfer price risk from the feeder to the owner. In return, the feeder receives a base payment per finished hog and additional payments per hog based on achieving different levels of feed efficiency and death loss. The other type of contract is a profit sharing arrangement.

Table V-2 presents specific information on the payment schedules of the three contracts. Contracts A and B are fixed
payment contracts. Contract A offers a lower base payment per market hog ($5.50) than does Contract B ($8.50). Under Contract A the feeder's compensation depends more on specific death loss and feed conversion bonuses. For example, if a finisher achieved a zero death loss and a feed conversion of 2.8 lbs. of feed per pound of gain, payments per head under Contract A (base plus bonuses) would total $13.40, as opposed to a payment of $12.75 under Contract B. Conversely, poor production efficiency would be penalized more heavily under Contract A with its lower base payment and loss of bonuses. In addition, Contract A assesses an additional penalty on the feeder beyond loss of bonuses if death loss exceeds 4 percent of the delivered animals. While both of the above contracts are characterized as fixed payment contracts, they will generate different distributions of returns for the same feeder, because of differences in payment schedules. In addition, for different feeders with different levels of production efficiency, the interaction of the payment schedule for a contract with their actual results will generate different distributions of returns. Thus, contracts need to be evaluated by feeders based on the payment schedules and their expected levels of production efficiency.

The third contract, Contract C, is a profit sharing contract which also includes a base payment of $5.50 per head. Any profits, after all expenses (including base payments to
the finisher) are split equally between the feeder and the owner.

For purposes of evaluating contracts versus complete ownership by the feeder, risk and returns are also generated for a traditional sole proprietorship.

Risk Analysis for the Above Average Feeder

The feeder characterized as above average (relative to Iowa Swine Enterprise Records) has an expected death loss of 2.9% and a feed efficiency of 3.3 pounds of feed per pound of gain. This would place this feeder in the top 20 percent of the Iowa Swine Enterprise Records. Figure V-1 shows the distribution function for death loss and Figure V-2 shows the distribution for feed efficiency.

Fixed Payment Contracts for Above Average Feeder

Table V-3 presents the results from the simulation model for each of the contracts and for sole proprietorship. Contract A has payments based more on death loss and feed efficiency bonuses than Contract B and thus A's returns show greater risk or variability. Contract A has an expected return to the feeder of $346 (for a group of 300 feeder pigs) and a standard deviation of $359. Contract B relies less on performance incentives and more on base payments per pig. Contract B shows a standard deviation of $201, indicating it is less variable than Contract A. Contract B also has an expected return of $443. These results show the importance of
the interaction between the feeder's production results and the compensation schedule for each contract. For the same feeder (and a top producer at that) Contract B offers a higher return, lower risk, a better minimum expected return, and a greater probability of positive returns. This is true even though both contracts are characterized as fixed payment contracts.

One major difference in these contracts is that Contract A also has a death loss penalty for death loss exceeding 4% of delivered animals. This may seem a small difference, but it represents additional risk and lower expected returns to the feeder. Each of the fixed payment contracts already contains an implicit death loss penalty. This is because base payments are not received in full for any pig that does not reach market weight. The impact of an explicit death loss penalty can be seen by examining the results of Contract A* in Table V-3. This contract is the same as Contract A except that the death loss penalty has been eliminated from the payment schedule. This increases expected returns and lowers the standard deviation for Contract A*, while maintaining the implicit death loss penalty incurred by losing some portion of the base payment for pigs not reaching market weight. Contract A* also has a lower minimum expected return of negative $378 as compared to a minimum expected return of negative $1,206 for Contract A and has a 94% probability of
achieving positive returns as compared to 82% for Contract A.

As indicated in Chapter III, the effectiveness of this penalty as an incentive for better productivity on the part of the feeder depends on the feeder's cash flow requirements and the impact of the penalty on the feeder's returns. Implicit penalties as an incentive to efficiency already exits in the form of lost base payments, loss of the contract, and less pigs provided to the feeder by the owner. The theoretical model presented in Chapter III proposes that an explicit death loss penalty of this sort may be reflective of the owner's level of effort and not of the feeder's level of effort. In other words, is an explicit death loss penalty an incentive to the feeder's productivity or is it a means by which the owner can pass risk on to the feeder by providing low cost inputs at low compensation levels. The model in Chapter III indicates that optimal compensation provides for high compensation levels for low cost or low quality inputs, thus reflecting the feeder's level of effort, not the owner's. This question will be answered later in this chapter when the owner's returns and the efficient set of contracts are examined.

\textbf{Fixed Payment and Profit Sharing Contracts}

Contract C represents a hybrid contract, including a low base payment and profit sharing. Thus, the feeder incurs some price risk, unlike Contracts A and B. Economic theory indicates that there is a trade off between risk and return,
and the results for the profit sharing contract follow this theory. Contract C offers an expected return of $1,679, much higher than Contracts A and B, but has a standard deviation of $2,654, indicating much more variability than the fixed payment contracts. This profit sharing contract also results in a higher maximum expected return and a lower probability of achieving a positive return.

The profit sharing contract has similarities to both fixed payment contracts and to a sole proprietorship. Price risk is not eliminated in this contract, but is shared with the owner. The result is the classic trade off between increased expected returns and increased risk. The base payment per pig guarantees some returns, but not sufficient to achieve positive returns in a period of low prices.

Comparison of Contracts to Sole Proprietorship

For many feeders the choice variables on contracting include not only choosing a specific contract but also whether or not to contract or be an independent producer, bearing all production and price risk themselves. To examine these choices, returns to a sole proprietor have also been included in Table V-3. As expected, the increased risk involved with sole proprietorship is associated with higher expected returns. The proprietors has an expected return of $3,724 and a standard deviation of $6469. The minimum expected return is negative $18,305, larger than the minimum for any of the
contracts. Although the profit sharing contract also includes similar price risk, the impact of the profit sharing contract and its base payment can be seen in a lower expected minimum return of negative $1,934.

In choosing among these alternatives a feeder is faced with the balancing act of risk and returns. Higher expected returns are associated with higher risk with one exception. Contract A offers a lower expected return than Contract B yet has a higher standard deviation. A simple mean variance decision rule would eliminate Contract A from consideration.

A simple mean variance decision rule would not, however, help to choose among the contracts and sole proprietorship. One approach to decision making on these contracts would be stochastic dominance. This is appropriate since normality of the distributions for prices and production variables has not been assumed. The simulation model allows results to be examined using first-degree (FSE) and second-degree stochastic efficiency (SSE).

Figure V-3 shows the cumulative distribution functions for net returns for each of the contracts (A, A*, B, C) and for sole proprietorship. This figure graphically illustrates contracts as a risk management tool. The contracts have much less variability in returns to the feeder and also much smaller expected minimum returns than does the sole proprietorship. The trade off is that the contracts also
offer much lower maximum expected returns and lower expected returns. The fixed payment contracts can be seen clustered in the middle of the diagram. As long the feeder maintains some levels of production efficiency, potential losses will either be much smaller than either profit sharing or sole proprietorship or may be eliminated altogether as in Contract B, which has a minimum expected return of $56. The fixed payment contracts, in eliminating price risk, do have limited upside potential returns. Since the feeder faces only production or biological risk, the maximum returns are also limited by biological factors and by the manager's ability. No matter how efficient a feeder may be, it will be impossible to achieve a death loss any lower than zero and some maximum feed efficiency. This places an upper limit on returns to the feeder as is shown in Figure V-3.

Figure V-4 shows the distributions for the contracts only and Figure V-5 shows the distributions for only the fixed payment contracts (A, A*, and B).

The efficient set of choices for this feeder is contract B (fixed payment), contract C (profit sharing), and sole proprietorship. Contract A is eliminated from the efficient set. This contract does not offer sufficient production bonuses to offset the higher base payments in Contract B (even for an above average producer) and these same performance bonuses increase the risk to the feeder. If these contracts
are representative of fixed payment contracts, it appears that contracts whose payments are based on performance bonuses more so than base payments will need to have substantial bonuses to make them competitive.

Even if the death loss penalty is eliminated from Contract A (Contract A*) this contract still does not enter into the efficient set. For feeders with lower production efficiency levels, the preference for contracts with higher base payments (such as Contract B) will probably be even stronger.

**Liquidity Considerations for the Above Average Feeder**

As indicated in Chapter I, one of the main reasons why pork producers are considering or entering into contracting is financial risk, or the inability to meet financial obligations as they come due. Like production risk, financial risk will vary widely from feeder to feeder, depending on production efficiency, amount of debt, debt structure, and price risk. Contracts eliminate or modify price risk faced by a feeder, but financial risk remains an important element of the decision process. The simulation model used to generate these results assumes that facilities are completely debt financed and amortized over a seven year period.

Cash flow is estimated by adding depreciation on facilities and equipment to returns. For the feeder to finish operation, investment was assumed to be $75 per feeder pig or
a total of $22,500. Based on a seven year life of the facilities, and straight line depreciation, depreciation costs are $3,214 per year. Assuming a turnover of 2.6 groups of hogs per year, depreciation costs are estimated at $1236 per group ($3,214 divided by 2.6 groups per year). Table V-4 shows the cash flow results for the above average feeder.

One problem with this model is that it is sensitive to the interest rate on the loan. For example, if the loan is assumed to be amortized at 10 percent interest over a seven year, annual payments would be $4,620 or $1,777 per group (based on 2.6 groups per year). If the model is used to estimate the probability of being able to meet this payment, the riskier alternatives (sole proprietorship and the profit sharing contract) appear to be superior in terms of financial risk, since they have a higher expected return and thus a greater probability of servicing the debt.

However, this result is misleading in terms of financial risk. Consider a risk-averse lender. If the feeder has a negative cash flow, the lender would receive nothing. In practice the lender would either need to foreclose on the hog facilities (typically these facilities are poor collateral) or refinance the feeder. If the feeder’s cash flow exceeds the loan payment, the lender receives only the loan payment and does not share in the additional cash flow. The lender is indifferent between the size of the firm’s positive cash flow
above the loan payment, but is concerned for possible losses, where cash flow will not service the debt. Thus, the lender may be characterized as extremely risk-averse and interested in a safety-first arrangement. From this viewpoint, riskier alternatives are less desirable. In fact, given a safety-first lender, Contract B would be much more desirable. Contract B has minimum expected cash flow (Table V-4) of $1,185. The profit sharing contract and sole proprietor have a minimum expected cash flow less than zero. The probability of cash flow exceeding zero for Contract B is 100%. The profit sharing contract and sole proprietor have about a 75% probability of a positive cash flow. Contract B guarantees the lender some repayment on the debt whereas the other alternatives do not.

Rather than deal directly with the problem of interest rates, the model assumes both the lender and the feeder are interested in generating enough cash flow to meet or exceed the depreciation expense of $1,236. This depreciation expense is used as a proxy for debt service and does not include a specific interest rate. The model then estimates the probability of not achieving a cash flow of $1,236. Contract B is superior to the other alternatives in that the probability of Contract B not generating this cash flow is only 3 percent, as seen in Table V-4. This may be compared to a probability of 21 percent for the other fixed payment
contract (Contract A), a probability of 37 percent for the profit sharing contract (Contract C), and a probability of 30 percent for the sole proprietor.

Financial risk would depend on the interaction between the feeder’s production efficiency and a particular contract’s payment schedule. Contract B would seem to be a better financial risk management arrangement than Contracts A or C or sole proprietorship. If availability of capital is a problem for the feeder, this type of analysis may be even more important to decisions regarding contracting versus sole proprietorship or in choosing among contracts than the previous analysis of returns and the efficient set of choices.

Another liquidity consideration for the feeder and the feeder’s lender is the duration of the contract. Many contracts tend to be one year arrangements with options for renewal. For the feeder who finances the facilities this entails considerable financial and total risk for both the feeder and lender. This issue was examined in the theoretical model in Chapter IV, and it was shown that a stochastic contract duration increased financial and total risk for the feeder. Rather than use the theoretical approach (which assumes normal distributions) to analyze this issue, the simulation model calculates an expected payback period for each alternative. The payback method is used precisely because it ignores the prospective life of the investment in
facilities. While the life of the facilities is known, the horizon of uncertainty associated with the contract is what is important to the feeder and lender. The key issue is how long will a contract need to be in place to recoup investment in facilities or to pay off the loan on facilities. Table V-4 presents the expected payback in terms of the number of groups and in years (assuming 2.6 groups per year). Payback is calculated by dividing the expected cash flow for each alternative into the cost of facilities ($22,500). This provides the number of groups required to recoup the investment. The number of years is then calculated by taking the number of groups and dividing by 2.6 groups per year. Sole proprietorship has the shortest payback period (1.8 years) because it has the highest expected value. This is somewhat misleading in that the minimum expected cash flow for this alternative is negative. This rapid payback reflects the higher expected return associated with the higher risk for sole proprietorship. Only Contract B has an expected minimum cash flow greater than zero, and Contract B’s minimum expected payback is 7.3 years. Again, if financial risk is a key issue for the feeder and the lender then Contract B would be superior.

None of the contracts provide a payback of one year or less, the contract duration which is guaranteed. Thus, contracts may involve substantial financial risk, especially
if this is ignored. Assuming the contract duration is the same as the life of the facilities or the loan amortization period underestimates financial and total risk for the feeder and the lender.

One possible solution to this problem would be a formal arrangement between the feeder, the lender, and the owner where the duration of the contract is tied to the term of the loan. Another solution to this problem is direct owner financing of the facilities. This would give the owner a larger stake in the success of the contract, but would also increase the owner's investment requirements and risk.

Risk analysis for the owner

Table V-5 presents returns to the owner or contractor associated with the above average feeder. The fixed payment contracts (A and B) offer similar returns and risk. Expected returns to the owner exceed expected returns to the feeder for these contracts. This reflects the price risk that the owner accepts in the contractual arrangement. Contract A does offer the owner a higher return, a lower standard deviation, a higher maximum expected return, and a lower expected minimum than does Contract B. This reflects the additional risk passed on to the feeder through reliance on performance bonuses rather than base payments. The profit sharing contract (C) offers the owner a lower expected return than do the fixed payment contracts but also has a lower standard
deviation and a lower minimum expected value. This reflects the fact that risk is shared with the feeder to a greater extent than the fixed payment contracts.

Figure V-6 shows the distributions of returns for the owner for each of the contracts. The efficient set of contracts for the owner are Contracts A and C. Contract B is not in the efficient set, reflecting the above results for risk and returns to the owner. Contracts that rely on performance incentives rather than base payments may be preferred by the owner since these contracts do pass more risk on to the feeder.

The issue of death loss penalties discussed earlier remains. An explicit death loss penalty (such as the one in Contract A) may be an incentive for greater productivity on the part of the feeder or it may simply be a means of passing risk on to the feeder by providing low cost or low quality inputs at low compensation levels (contrary to the optimal compensation schedule derived in the theoretical model).

Tables V-3 and V-5 and Figures V-3 and V-6 can provide some information towards resolving this issue. Contract A is the fixed payment contract with an explicit death loss penalty. Contract A* is the same contract except that the death loss penalty has been eliminated from the payment schedule.

Mirrlees (1974) demonstrated that employing an extreme penalty for not meeting the standard (in this case the death
loss standard of 4 percent or less) was optimal in a contractual arrangement. Assume that an extreme penalty is one which, if eliminated from the payment schedule, would place the contract into or out of the efficient set of choices. Contract A is not in the efficient set of choices for the feeder. Elimination of the explicit death loss penalty (Contract A*) does not move Contract A* into the efficient set. For the feeder the explicit death loss penalty is not an extreme penalty by the above definition. For the owner, elimination of the death loss penalty from Contract A does not eliminate this contract from the efficient set. Again, by the above definition, the death loss penalty is not an extreme penalty. If this definition of an extreme penalty is acceptable, then it can be concluded that an explicit death loss penalty is not an incentive for greater productivity for the feeder, but is instead a means by which the owner can provide low cost or low quality inputs at low compensation levels, contrary to the optimal compensation schedule. This indicates that the addition of this type of performance risk does little to increase the risk and returns of the feeder (and hence productivity) and does little to reduce the risk and returns of the owner. In fact, elimination of this type of penalty tends to reduce overall variability for both the owner and feeder, while not changing the efficient set of alternatives. Contracts thus should not necessarily contain
explicit death loss penalties. If death loss penalties are contained in a contract, then these standards should be tied to the quality of the feeder pigs provided by the owner, with the feeder having the right to inspect the feeder pigs before acceptance of the animals and the accompanying death loss standards.

Risk Analysis for the Below Average Feeder

The feeder characterized as below average has an expected death loss of 4.63 percent and an expected feed efficiency of 3.64 pounds of feed per pound of gain. Figure V-7 shows the distribution function for death loss for the below average feeder and Figure V-8 shows the distribution function for feed efficiency of the below average feeder. These efficiency measures place this feeder in the lower 40 percent of Iowa feeders, relative to Iowa Swine Enterprise Records.

Fixed Payment and Profit Sharing Contracts

Results for the below average feeder are presented in Table V-6. The only change from the above average feeder is that the distribution functions for death loss and feed efficiency reflect the lower production efficiency of the below average feeder. All other information and inputs into the model remain the same.

These results are in contrast to those of the above average feeder, again showing the interaction of the production efficiency for each feeder with the payment
schedules of the contracts. Contract A, which depends more on performance bonuses, yields a negative expected return to the below average feeder with more variation than for the above average feeder. Contract B provides an expected return of $172 for the below average feeder, about $270 less than the expected return for the above average feeder expected return under this same contract. This reflects the implicit penalties of lost base payments for this feeder. With Contract A, the below average feeder is not able to cover all expenses, much less be profitable. This lack of production efficiency makes a contract such as A unattractive to a below average feeder.

The profit sharing contract (Contract B) offers the below average feeder a much higher expected return of $1,143 with only a slightly worse minimum expected return as compared to Contract A. Contract B offers a minimum expected return of $56, and so is approximately, at worst, a breakeven proposition for the below average feeder.

Figure V-9 shows the distributions of returns for the below average feeder. Maximum expected returns for the fixed payment contracts (A, B, and A*) are clustered together in the graph, indicating returns have a limited upside potential due to biological factors. Minimum expected returns for the fixed payment contracts are clustered together around zero, indicating these contracts do eliminate price risk but not
production risk. Figure V-10 shows the distributions for all of the contracts, and Figure V-11 shows the distributions for fixed payment contracts only.

The efficient set of choices for the below average feeder are Contract B, Contract C (profit sharing), and sole proprietorship. Contract B offers a lower expected return, lower risk, and a higher minimum expected return than do the other alternatives in the efficient set, indicating the difficult choice of expected returns versus risk.

Contract A, with its performance based payments, is clearly not a good choice for the below average feeder since this contract was not part of the efficient set even for a very efficient feeder. Elimination of the explicit death loss penalty (Contract A*) does not move this contract into the efficient set of alternatives for the below average feeder. This indicates that a feeder should carefully consider how expected production efficiency interacts with a contract's compensation schedule before choosing an alternative. This is especially true when evaluating promotion literature for contracts, which often seem to offer good returns to the feeder, but these returns may be unrealistic considering the feeder's actual or expected production efficiency.

Liquidity considerations for the below average feeder

Table V-7 shows information regarding cash flow for the below average feeder. Cash flow is calculated in the same
manner for this feeder as for the above average feeder. The profit sharing contract (Contract C) and sole proprietorship offer higher expected cash flows than the fixed payment contracts (A and B), a similar result to that for the above average feeder. However, for the below average feeder profit sharing and sole proprietorship offer a lower probability of not meeting the depreciation expense than do the fixed payment contracts. This is in contrast to the cash flow results for the above average feeder where the fixed payment contracts offered a lower probability of not meeting the depreciation expense. Again assuming this depreciation expense as a proxy for any debt service, the below average feeder faces less financial risk with contracts that offer higher returns and more variability in returns (as opposed to cash flow). This is due to the poor production efficiency of this feeder, which does not mix well with fixed payment contracts based on performance. Contract B does, however, offer a minimum expected cash flow of $1,185, whereas the other alternatives offer a minimum expected cash flow that is negative, allowing for only some or no servicing of the depreciation (debt) expense. From the view of a safety-first lender, Contract B would still be the best alternative since a lender does not share in cash flow above some required debt service. Contract B does offer a minimum expected cash flow almost large enough to service the depreciation expense.
Payback periods are also presented in Table V-7. In this case, the payback periods for each alternative are somewhat longer for the below average feeder as compared to the above average feeder. This reflects the poorer production efficiency of the below average feeder and subsequent lower expected cash flow. The longer payback periods for the below average feeder increase the financial risk associated with a contract that is only guaranteed for only one year.

In addition to this type of increased financial risk, if the below average feeder provides lower returns to the owner, this feeder may well be more subject to termination of the contract or to receiving fewer of the owner’s feeder pigs in his or her facilities. This will also increase financial risk to the below average feeder. Whether or not this is likely depends on the owner’s returns and how anxious the owner is to retain a particular feeder as a party to a contract.

Risk Analysis for the owner

Table V-8 presents results from the simulation model for the owner associated with the below average feeder. The lower production efficiency of this feeder still leaves the owner with positive expected returns, although these expected returns are lower than is the case where the owner contracts with the above average feeder. There is also some additional variability for the owner associated with the below average feeder and maximum expected returns are slightly lower.
Figure V-12 shows the distributions of returns for the owner contracting with the below average feeder. The efficient set consists of Contract A (fixed payment with explicit death loss penalty) and Contract C (profit sharing). This is similar to the previous results for the above average feeder, except that if the explicit death loss penalty is eliminated from Contract A, this contract is not part of the efficient set for the owner. In other words, elimination of this penalty does increase the risk and lower the returns to the owner enough to eliminate Contract A* from the efficient set. In this case it could be argued that the death loss penalty is an important part of the contract to the owner, although this penalty makes no difference to the efficient set of the below average feeder. To the extent that optimal compensation schedules can be associated with efficient sets, this confirms that the optimal compensation schedule is a function of factors unique to each party involved in the contract. It may also mean that in the case of the below average feeder, the explicit death loss penalty may not be severe enough and in fact should be even higher. This is because the results indicate that the death loss penalty makes no difference to the below average feeder's efficient set, but does impact on the owner's efficient set.

Previously it was speculated that the below average feeder may be subject to more financial risk than the above
average feeder because of a greater likelihood that an owner would terminate a below average feeder's contract. This was due to the lower expected returns and greater risk for the owner contracting with a below average feeder. A comparison of the owner's efficient set over both feeders will provide some information regarding this termination issue. The efficient set for the owner contracting with the above average feeder consists of Contract A and Contract C (profit sharing). (Contract A* was also part of this efficient set, but will be ignored for purposes of comparison.) The efficient set for the owner associated with the below average feeder was also Contract A and Contract C. Examining the distributions of the owner's returns for all of these contracts together using stochastic dominance yields an efficient set consisting only of Contracts A and C associated with the above average feeder. The difference in production efficiency and consequent change in returns to the owner does impact upon the efficient set. The owner will likely prefer a contract with the more efficient producer, if the decision is based upon risk and returns. The below average feeder would thus be more subject to termination of a contract, everything else being equal. The below average feeder would also likely receive fewer feeder pigs from an owner with a choice between feeders and might also receive lower quality (and less expensive) feeder pigs. These factors would tend to lower the below average
feeder's returns and increase financial risk even more than just the difference in production efficiency. The interaction of the feeder's production efficiency and the compensation schedule of the contract also impacts upon the owner. The likelihood of termination of a contract by the owner or less feeder pigs provided to a feeder would also depend on the availability of alternative feeders to contract with and the amount of competition among owners for finishing facilities. It is also possible that a contract with the below average feeder would be more subject to revision in the owner's favor to make the owner's expected returns and risk comparable to the arrangement with the above average feeder.

**Sensitivity Analysis of Feeder to Finish Contracts**

One aspect of pork production contracts that has not been discussed in the literature is the issue of operating leverage. Operating leverage refers to the existence of fixed costs in a firm's cost structure. Operating leverage may be calculated by dividing fixed costs by total costs. An increase in this ratio indicates higher fixed charges for a firm. In general, higher fixed charges mean greater fixed cost commitments that have to be met even if sales volume or total revenue decline. This situation implies greater risk for a firm because these fixed cost commitments cannot be reduced to meet declining sales volume or total revenue.

In comparing pork production contracts with sole
proprietorship, operating leverage should be higher for the pork production contracts. This is because most of the variable costs associated with pork production (feed costs, veterinarian costs, feeder pig costs, death loss costs, and marketing costs) are borne by the owner. The feeder is left with a cost structure consisting of variable labor costs and fixed costs for facilities. The model used in this study assumes that fixed costs for facilities are the same for both the contract feeder and the sole proprietor. Thus operating leverage must increase for the contract feeder. If operating leverage increases, the feeder's returns should be very sensitive to changes in sales volume and total revenue.

Another way of examining this issue is to explore the sensitivity of risk and returns to changes in fixed costs for the feeder. In order to do this, the simulation model was set to evaluate risk and returns for two different levels of investment. The first level of investment in facilities sufficient to finish 300 feeder pigs was set at $22,500 (or $75 replacement cost per head). This assumption gave a fixed cost of $1,236 per group. The second level of investment was set at a replacement cost of $105 per head (or a total investment of $31,500). Based on the same depreciation and turnover assumptions as before, this level of investment gives the feeder a fixed cost of $1,731 per group. On a per group basis the higher level of investment means an increase in
fixed cost for the feeder of $495. On a per head basis, the investment in facilities has been increased from $75 per head to $105 per head, a difference of $30. The $30 increase can be thought of as a reflection of widely varying types of feeder pig finishing facilities and construction costs. The $30 increase in investment should not reflect widely varying production efficiency levels due to differences in facilities, however, and so avoids the question of relating production efficiency with facilities. This assumption implies that the risk and returns of the owner will not be affected since there is no change in the production efficiency of the feeder due to investment in facilities.

Table V-9 provides a comparison of risk and returns for the above average feeder for the two levels of investment. For each alternative, expected return, maximum return, and minimum return are simply reduced by the increased fixed cost of $495. Standard deviation remains the same for each alternative. The efficient set with an increased investment remains for the above average feeder and consists of contract B (fixed payment), contract C (profit sharing), and sole proprietorship.

There are, however, some important changes in the risk and returns of the fixed payment contracts. Contract B, for example, now has a negative expected return and a negative minimum return due to the increased fixed costs. The
probability of a return greater than zero is reduced from 100 percent ($75 investment per head) to 34 percent ($105 investment per head). The most significant change due to the increased in fixed costs lies in the area of financial risk. At a $75 investment level, cash flows from the fixed payment contracts offered a very good probability of meeting the fixed costs of $1,236 (this figure was also used as a proxy for debt service). This result would be attractive to a feeder and a lender interested in meeting debt service requirements. However, increasing fixed costs by $495 increases the probability of not meeting debt service requirements by a substantial amount. Contract B now offers the feeder and lender a 78 percent chance of not meeting the fixed costs of $1,731, as opposed to only a 3 percent chance with a $75 per head investment. This result is also reflected in the payback periods for the fixed payment contracts, which would now exceed the presumed 7 year life of the facilities (and the 7 year maturity of the loan for facilities). These results reflect the sensitivity of the fixed payment contracts to an increase in fixed costs and operating leverage. This can be contrasted to the small changes in payback period and the probability of not meeting debt service requirements for the profit sharing (contract C) and sole proprietorship alternatives. Given the above results for financial risk and the payback period, the feeder would have some difficulty in
paying for facilities and replacing these facilities.

Table V-10 shows a similar comparison of the impact of increased fixed costs for the below average feeder. The changes in risk and returns for the below average feeder are similar to those for the above average feeder. Increased operating leverage impacts much more upon the fixed payment contracts than upon the profit sharing contract and sole proprietorship. The problem of paying for facilities and replacing these facilities becomes even more acute for the below average feeder with the higher investment in facilities.

With the increased fixed costs, both the above and below average feeders face a difficult choice of expected returns versus risk, as do the lenders for both of the operations. Investment levels in facilities must be carefully monitored by all producers as the contracts provide a thin (if any) margin of safety. Higher levels of investment in facilities should only be considered if the feeder is reasonably assured that this will provide increases in production efficiency.

Risk Analysis of Feeder Pig Production Contracts

Net returns for the feeder pig production enterprise are calculated using budgets like that shown in Table V-11. Probability distributions are substituted into the budget for prices, pigs weaned per litter, and litters weaned per sow per year. Contract payment schedules are substituted for the
price of feeder pigs for two feeder pig production contracts. The simulation model is run simultaneously for each of the contracts and for sole proprietorship and generates information about returns and risk for both the feeder and the owner. Two feeder pig producers are represented in the model. One producer is characterized as an above average feeder and the other is characterized as below average.

The size of the feeder pig production enterprise is assumed to be 500 sows. Production of feeder pigs and returns are calculated on an annual basis. Investment in facilities and equipment is $600 per sow.

Both of the feeder pig production contracts are fixed payment contracts. These type of contracts entail that all price risk is taken on by the owner, not the feeder. In return, the feeder receives a fixed payment for each feeder pig produced. The feeder also receives fixed payments for each sow present in the breeding herd each month in one of the contracts, but not in the other contract.

Table V-12 describes the payment schedules of the two contracts and the responsibilities of both parties. Contract A directs the feeder to supply facilities, labor, veterinary costs, and utilities. The owner supplies breeding stock, feed, and marketing of animals. Compensation is $14 per feeder pig produced.

Contract B directs the feeder to provide facilities,
labor, and utilities. The owner supplies breeding stock, feed, veterinary costs, and marketing of animals. Compensation for the feeder is $12 per feeder pig produced. In addition, the feeder receives $10 per female present in the breeding herd each month.

The structure of these compensation schedules is much simpler than that of the feeder pig finishing contracts. There are no other performance bonuses beyond the base payments. The only penalties for poor production efficiency on the part of the feeder are implicit ones, in that the loss of a feeder pig (or of a sow in one contract) means the loss of the base payment that otherwise would have been received. In evaluating these contracts the model examines the interaction of the feeder's production efficiency with the payment schedule of the contract. Different levels of production efficiency will generate different risk and returns distributions within the same payment schedule for both the feeder and the owner.

**Risk Analysis for the Above Average Feeder**

The expected number of pigs weaned per litter for the above average feeder is 9.1 and the expected litters weaned per sow is 2.1. The distributions of these variables are presented in Figures V-13 and V-14 respectively. These distributions combined with the number of sows in the breeding herd gives this feeder an annual expected output of 9,338
feeder pigs. The distribution of the number of feeder pigs produced annually is shown in Figure V-15. The number of pigs weaned per litter and the expected litters per sow place this feeder in the top 25 percent of Iowa pork producers (relative to the Iowa Swine Enterprise Records).

Results for the above average feeder are shown in Table V-13. The results indicate a large difference in the returns from the two contracts. Although Contract B offers a lower payment per feeder pig, it contains an additional incentive of payment per sow present in the breeding herd each month. The expected return for Contract B is $42,132, about eight times the expected return for Contract A. Contract B shows a smaller standard deviation, a higher expected maximum return, and a smaller minimum expected return than Contract A. Although both contracts show the possibility of a negative minimum expected return, Contract B has only a 6 percent probability of a return less than zero, whereas Contract A has a 48% probability of a negative return. Contract B would seem to be much superior in terms of risk and return to the feeder.

Contract B also compares favorably to sole proprietorship. Contract B does have a lower expected return, but also offers less variability since it has a smaller standard deviation. As is the case with most of the contracts examined in this paper, the trade off between risk and returns is quite evident. Contract B has a higher probability of a
positive return than does sole proprietorship and a smaller minimum expected return.

Contract A also offers the feeder a trade off between risk and returns when compared to sole proprietorship. However, the probability of a positive return for this contract is 52 percent and this compares unfavorably with sole proprietorship. The explanation for this result lies in the fact that the feeder pig production operation has a high level of fixed costs. For sole proprietorship, fixed costs of facilities are about 33 percent of total costs. This reflects the relatively large investment in facilities for feeder pig production. Although the contracts eliminate the costs of breeding stock and feed, the fixed costs of facilities remain in the feeder’s budget. Under the contractual arrangements fixed costs account for something over 50 percent of the feeder’s total costs. This implies that the feeder has a high degree of operating leverage and this magnifies changes in earnings that result from small changes in output of feeder pigs. Contract A is especially subject to this type of operating risk because payments are received only for feeder pigs produced and not for the number of sows in the breeding herd. Sole proprietorship has more overall variability in returns, but this reflects the price risk the independent feeder faces. Figure V-16 shows the distribution functions for the two contracts and for sole proprietorship. Maximum
returns for the two contracts are clustered together in the middle of the graph. This reflects the biological limits on the number of feeder pigs produced annually and the resulting limit on returns to the feeder. Contract B lies completely to the right of Contract A reflecting the additional payment per sow contained in Contract B. Figure V-17 shows the distribution functions for the two contracts only. The efficient set consists of Contract B and sole proprietorship.

Liquidity Considerations for the Above Average Feeder

Cash flow for the feeder is calculated by the model by adding depreciation on facilities and equipment to returns. Depreciation is calculated on a straight line basis over a period of seven years. Based on total investment of $300,000, depreciation expenses are $42,857 annually.

Table V-14 presents cash flow results for the above average feeder. Contract B has a higher expected cash flow than Contract A and less variability. Contract B also has a 100% probability of a positive cash flow, and the minimum expected cash flow for this contract is $25,255. Contract A has a 93 percent probability of a positive cash flow but has a minimum expected cash flow of negative $23,392. Sole proprietorship has a 77 percent chance of a positive cash flow.

Contract B has only a 6 percent probability of not meeting the depreciation expense of $42,857, a superior result
to either Contract A or sole proprietorship. This fact and the 100 percent probability of achieving a cash flow of at least $25,255 would make this contract very attractive to a feeder concerned with financial risk. A safety-first lender would also view these results favorably, probably more so than any other alternative.

Expected payback for Contract B is 3.5 years, less than one year longer than the expected payback for sole proprietorship. This means that there still exists some additional financial risk with Contract B since contracts are commonly guaranteed for only one year. Duration of the contract is still an important source of financial risk even for the most favorable contract.

Risk Analysis for the Owner

Given the large differences between expected returns to the feeder that exist for Contracts A and Contracts B, it is to be expected that large differences will exist for expected returns to the owner for these two contracts. Table V-15 confirms this expectation. Contract A, which is less favorable to the feeder than Contract B, offers an expected return to the owner of $63,136, almost three times the expected return to the owner under Contract B. Both contracts offer the owner about the same variability. Contract A also has a lower minimum expected return to the owner than Contract B. Contract A has a 65 percent probability of a positive
return to the owner, higher than that of Contract B at 48 percent.

Figure V-18 shows the distributions for the returns to the owner. The situation is completely opposite of that for the feeder, as Contract A clearly dominates Contract B from the owner's perspective. The difference is that the owner appears willing to pay the feeder a premium on a per sow basis. The owner is clearly trying to protect the breeding herd and is willing to pay an incentive to the feeder to do so. One possible explanation of this premium comes from the theoretical model presented in Chapter III. This model derived an optimal compensation schedule which required an inverse relationship between the quality of inputs provided by the owner and the compensation level. Based on this, it might be that this owner is providing poorer quality breeding stock to the feeder than provided under Contract A. Detailed information on the quality of the breeding stock is not available at this time, but this type of information would provide an excellent test of the theoretical model's implications.

Another possible explanation for this premium lies in the cost of acquiring feeder pigs for the owner. The cost to the owner of this additional payment per sow under Contract B is approximately $6 per feeder pig. This is a significant amount of money to both the feeder and the owner, as it
accounts for the differences in returns to both parties under the two contracts. This premium also means that Contract B is in the efficient set for the feeder, but is not in the efficient set for the owner. Despite this extra premium, the cost of feeder pigs to the owner under Contract B is $37 per pig, and this is still less than the ten year average (1981-1990) cost of $40 per feeder pigs. The cost of feeder pigs to the owner under Contract A is $32 per pig. Both owners are acquiring feeder pigs at a lower cost than the average cost of feeder pigs and still have some control over the source and quality of these feeder pigs. The owners are also assured of a large volume of feeder pigs without a large investment in facilities and equipment.

Still another explanation for this premium can be seen by comparing the owner’s returns under Contract B to the feeder’s returns. The feeder’s returns exceed the returns to the owner with this contract. This is the opposite result from all other contracts examined in this study, where the owner’s returns usually exceed the feeder’s returns. The explanation for this was that the owner accepts all or most of the price risk in marketing, and so is compensated for taking this risk with higher expected returns. In the case of feeder pig production, the feeder has a large investment in facilities and a high level of fixed costs and operating leverage. The owner may be trying to compensate the feeder for this
investment by adding a premium for each sow in the breeding herd. The owner may also be simply willing to pay a premium for the type of facilities that he or she desires for the breeding herd. In essence the owner is provided with excellent facilities at no cost and is able to enjoy very low fixed costs and low operating leverage. This would tend to balance out the price risk that the owner accepts. It would also ensure the owner with a steady supply of feeder pigs at a cost below the long term average from a single source with the only investment being the cost of the breeding herd to the owner.

If the owner who provides Contract B to a feeder wishes for approximately the same return as the owner providing Contract A, this would require a premium of only $3.24 per sow in the breeding herd per month.

**Risk Analysis for the Below Average Feeder**

The feeder pig producer characterized as below average has an expected number of pigs weaned per litter of 8.3 and the expected litters weaned per sow is 1.7. The distributions of these variables are presented in Figures V-19 and V-20 respectively. This level of production efficiency provides this feeder with an expected annual output of 6,820 feeder pigs, about 3000 less pigs per year than the above average feeder. These levels of production efficiency place this feeder in the lower 25 percent of Iowa pork producers relative
to the Iowa Swine Enterprise Records.

The smaller output of the below average feeder impacts on the expected returns of all three alternatives, as seen in Table V-16. Contract B is the only alternative with an expected greater than zero. This contract also has less variability than does Contract A or sole proprietorship. Contract B also has a greater probability of achieving a positive expected return. The maximum expected return for Contract B is $44,688, which is smaller than the maximum expected return of $334,368 for sole proprietorship. The minimum expected return for all three contracts is negative.

Contract A is not a good alternative for the below average feeder. The expected return is negative $33,531 and the maximum expected return is only $5,444, little better than breaking even.

Figure V-21 shows the distributions of returns for the below average feeder. Contract B clearly dominates Contract A for this feeder, just as is the case for the above average feeder. What is different about these results is that the efficient set for the below average feeder consists only of Contract B. Sole proprietorship is eliminated from the efficient set of choices, and this did not occur for any of the contracts previously examined. In this sense Contract B represents the best alternative by itself. This occurs because sole proprietorship has a negative expected return and
a more negative minimum expected return. Contract B offers the feeder a higher return at less risk, and so stands alone in the efficient set. Maximum expected returns for this contract are still less than maximum expected returns for sole proprietorship. This reflects the biological limits on the number of feeder pigs that can be produced with a given number of sows and the elimination of price risk under this contract.

Even though Contract B stands alone in the efficient set of the below average feeder it is probably not the solution to any profitability or financial problems the feeder may have. This feeder still has very low levels of production efficiency and it remains to be seen how this impacts upon the returns to the owner. If this contract is unprofitable to the owner it stands a good chance of being terminated or modified. This issue will be examined further when risk analysis for the owner is discussed.

Liquidity Considerations for the Below Average Feeder

Cash flow results for the below average feeder are presented in Table V-17. All three alternatives have a positive expected cash flow. Contract B looks to be the most favorable alternative as it has the highest expected cash flow of the three alternatives and has a 100 percent probability of exceeding zero. The minimum expected cash flow for this contract is $19,944, offering both the feeder and a lender a good chance of being able to service some debt on a consistent
basis. Contract B also has a lower probability of not being able to service the depreciation expense of $42,857. Payback for Contract B is actually lower than that of sole proprietorship, again a different result from previous contracts and feeders examined.

Risk Analysis for the Owner

Although Contract B is the best alternative for the feeder, the viability of this arrangement also depends on the results for the owner, since an unprofitable contract (from the owner's point of view) may be subject to termination or modification. Table V-18 presents the results for the owner associated with the below average feeder. As was the case with the above average feeder, Contract A offers the owner a higher return with comparable risk when compared to Contract B. Figure V-22 shows the distributions of returns to the owner, and Contract A dominates Contract B. The major difference for the owner associated with the below average feeder is that Contract B now provides an expected return of negative $17,754. In addition, the cost of feeder pigs for the owner is now $43 per pig, above the ten year average price of feeder pigs of $40. The owner now has a contract with an expected sizeable loss and the feeder pigs are somewhat more expensive than average. Unless the owner is willing to pay a premium above and beyond that already being paid for single source feeder pigs, the viability of the contract is in debt.
It is doubtful that the owner would be willing to pay this premium if alternative feeders (such as the above average feeder) were available to contract with. In this case the contract may be terminated, modified in favor of the contractor, or, possibly, the owner will undertake to improve the feeder’s production efficiency. Any improvement in the feeder’s production efficiency will benefit both parties, as can be seen by comparing the results for the above average and below average feeder (and owner).

Figure V-23 shows the distributions of returns to the owner for Contract A for both the above average feeder and the below average feeder. Returns to the owner associated with the above average feeder dominate returns to the owner associated with the below average feeder. This efficient set shows the owner would have a clear preference for contracting with the above average feeder given a choice between the two feeders. This supports the possibility that the owner may want to terminate or modify the contract with the below average feeder, given a choice.
Table V-1. Sample budget for calculating returns to the feeder and the owner in a feeder pig finishing enterprise

<table>
<thead>
<tr>
<th></th>
<th>Feeder</th>
<th>Owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feeder Pig Cost</td>
<td>$0.00</td>
<td>36.23</td>
</tr>
<tr>
<td>Feed Costs</td>
<td>$0.00</td>
<td>44.04</td>
</tr>
<tr>
<td><strong>OTHER VARIABLE COSTS:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feeder Compensation (cost to owner)</td>
<td>$0.00</td>
<td>8.20</td>
</tr>
<tr>
<td>Operating Costs</td>
<td>$0.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Labor Cost</td>
<td>$4.80</td>
<td>0.00</td>
</tr>
<tr>
<td>Death Loss</td>
<td>$0.00</td>
<td>1.77</td>
</tr>
<tr>
<td>Marketing Cost</td>
<td>$0.00</td>
<td>1.80</td>
</tr>
<tr>
<td><strong>TOTAL VARIABLE COSTS:</strong></td>
<td>$4.80</td>
<td>95.04</td>
</tr>
<tr>
<td><strong>TOTAL FIXED COSTS:</strong></td>
<td>$3.88</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>TOTAL PRODUCTION COSTS:</strong></td>
<td>$8.68</td>
<td>95.04</td>
</tr>
<tr>
<td><strong>ESTIMATED CASH FLOW ($/GROUP)</strong></td>
<td>$1007.00</td>
<td>2356.00</td>
</tr>
<tr>
<td><strong>ESTIMATED CASH FLOW ($/HEAD)</strong></td>
<td>$3.55</td>
<td>8.24</td>
</tr>
<tr>
<td><strong>ESTIMATED CASH FLOW ($/CWT.)</strong></td>
<td>$1.54</td>
<td>3.58</td>
</tr>
<tr>
<td><strong>ESTIMATED RETURN OVER ALL COSTS ($/GROUP)</strong></td>
<td>$-103.29</td>
<td>2356.00</td>
</tr>
<tr>
<td><strong>ESTIMATED RETURN ($/HEAD)</strong></td>
<td>$-0.34</td>
<td>8.24</td>
</tr>
<tr>
<td><strong>ESTIMATED RETURN ($/CWT)</strong></td>
<td>$-0.15</td>
<td>3.58</td>
</tr>
</tbody>
</table>
Table V-2. Feeder to finish contracts

Contract A

Producer: supplies feeding facilities, twice daily inspections, carries out vaccination program of owner, assists in loading and unloading of animals, and must submit death loss forms.

Owner: provides pigs, feed, vaccination and vet. costs, marketing of finished animals, and purchase of feeder pigs.

Compensation:

- $2.50 per head at placement
- $2.00 per head after 60 days
- $1.00 per head at marketing
- $5.50 total base per head

Death Loss Bonus/Penalty

- 4% or higher - owner and grower split death loss expense
- 3% - $0.30 per head marketed
- 3% or lower - $0.30 per head marketed for every 0.5% decrease in death loss

Feed Conversion Bonus

- 4.4 # of feed/# of gain - $0.30 per head marketed
- $0.30 per head marketed for every 0.1 improvement in feed efficiency
Table V-2. (continued)

Contract B

Producer: supplies suitable facilities, proper management supervision, aids in receiving and shipping of hogs, works with veterinarian on vaccination and health care program.

Owner: supplies feeder pigs, feed, vet. costs, and marketing of animals

Compensation:

$4.00 per head on arrival
$2.00 per head after 80 days
$2.50 per head after marketing

Death Loss Bonus:

3% - $0.30 per head

3% or lower - $0.04 per head for every .01% decrease in death loss

Feed Conversion Bonus:

3.4 # of feed/# of gain - $0.50 per head

3.4 or lower - $0.25 per head for every 0.1 improvement in feed efficiency
Table V-2. (continued)

Contract C

Producer: supplies facilities, labor, normal hog management.

Owner: supplies feeder pigs, feed, vet. expense, and marketing.

Compensation:

$2.50 inpayment per pig
$2.50 outpayment per pig

Death Loss:

Owner and producer share equally.

Profit Sharing:

After all expenses (vet., feed, trucking, pig costs, hedging, and marketing) are figured, any profits are split equally between owner and producer.
Table V-3. Feeder risk and returns per group for the above average feeder to finish enterprise ($75 per head investment)

<table>
<thead>
<tr>
<th>Item</th>
<th>A^a</th>
<th>B^a</th>
<th>C^b</th>
<th>A^c</th>
<th>Sole Proprietor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected Returns^d</td>
<td>$346</td>
<td>$443</td>
<td>$1679</td>
<td>$419</td>
<td>$3724</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>$359</td>
<td>$201</td>
<td>$2654</td>
<td>$268</td>
<td>$6469</td>
</tr>
<tr>
<td>Maximum Returns^d</td>
<td>$1204</td>
<td>$1219</td>
<td>$10314</td>
<td>$1204</td>
<td>$21730</td>
</tr>
<tr>
<td>Minimum Returns^d</td>
<td>($1206)</td>
<td>$56</td>
<td>($1934)</td>
<td>($378)</td>
<td>($18305)</td>
</tr>
<tr>
<td>P(Return &gt; 0)</td>
<td>82%</td>
<td>100%</td>
<td>65%</td>
<td>94%</td>
<td>72%</td>
</tr>
</tbody>
</table>

^a Fixed payment contracts.

^b Profit sharing contract.

^c Contract A without death loss penalty.

^d All returns in the tables = returns over all costs, including depreciation.
Table V-4. Feeder cash flow per group for the above average feeder to finish enterprise ($75 per head investment)

<table>
<thead>
<tr>
<th>Item</th>
<th>A&lt;sup&gt;a&lt;/sup&gt;</th>
<th>B&lt;sup&gt;a&lt;/sup&gt;</th>
<th>C&lt;sup&gt;b&lt;/sup&gt;</th>
<th>A&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Sole Proprietor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected Cash Flow</td>
<td>$1489</td>
<td>$1579</td>
<td>$2817</td>
<td>$1550</td>
<td>$4815</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>$376</td>
<td>$218</td>
<td>$2706</td>
<td>$283</td>
<td>$6618</td>
</tr>
<tr>
<td>Minimum Cash Flow</td>
<td>($80)</td>
<td>$1185</td>
<td>($948)</td>
<td>$749</td>
<td>($15313)</td>
</tr>
<tr>
<td>P(Cash Flow &gt; 0)</td>
<td>99%</td>
<td>100%</td>
<td>79%</td>
<td>100%</td>
<td>76%</td>
</tr>
<tr>
<td>P(Cash Flow &lt; $1236)</td>
<td>21%</td>
<td>3%</td>
<td>37%</td>
<td>10%</td>
<td>30%</td>
</tr>
<tr>
<td>Payback in Years</td>
<td>5.8</td>
<td>5.5</td>
<td>3.1</td>
<td>5.6</td>
<td>1.8</td>
</tr>
</tbody>
</table>

<sup>a</sup>Fixed payment contracts.

<sup>b</sup>Profit sharing contract.

<sup>c</sup>Contract A without death loss penalty.
Table V-5. Owner risk and returns per group for the above average feeder to finish enterprise

<table>
<thead>
<tr>
<th>Item</th>
<th>A&lt;sup&gt;a&lt;/sup&gt;</th>
<th>B&lt;sup&gt;b&lt;/sup&gt;</th>
<th>C&lt;sup&gt;b&lt;/sup&gt;</th>
<th>A&lt;sup&gt;c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected Return</td>
<td>3399</td>
<td>3316</td>
<td>2066</td>
<td>3081</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>6419</td>
<td>6450</td>
<td>4002</td>
<td>6371</td>
</tr>
<tr>
<td>Maximum Return</td>
<td>21522</td>
<td>21493</td>
<td>11441</td>
<td>20777</td>
</tr>
<tr>
<td>Minimum Return</td>
<td>(17836)</td>
<td>(18324)</td>
<td>(16790)</td>
<td>(17104)</td>
</tr>
<tr>
<td>P(Return &gt; 0)</td>
<td>70%</td>
<td>70%</td>
<td>78%</td>
<td>69%</td>
</tr>
</tbody>
</table>

<sup>a</sup>Fixed payment contracts.

<sup>b</sup>Profit sharing contract.

<sup>c</sup>Contract A without death loss penalty.
Table V-6. Feeder risk and returns per group for the below average feeder to finish enterprise ($75 per head investment)

<table>
<thead>
<tr>
<th>Item</th>
<th>A&lt;sup&gt;a&lt;/sup&gt;</th>
<th>B&lt;sup&gt;a&lt;/sup&gt;</th>
<th>C&lt;sup&gt;b&lt;/sup&gt;</th>
<th>A&lt;sup*c&lt;/sup&gt;</th>
<th>Sole Proprietor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected Returns</td>
<td>($223)</td>
<td>$172</td>
<td>$1143</td>
<td>($29)</td>
<td>$2404</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>$416</td>
<td>$175</td>
<td>$2519</td>
<td>$339</td>
<td>$6476</td>
</tr>
<tr>
<td>Maximum Return</td>
<td>$1204</td>
<td>$1219</td>
<td>$9569</td>
<td>$1204</td>
<td>$20228</td>
</tr>
<tr>
<td>Minimum Return</td>
<td>($1755)</td>
<td>$56</td>
<td>($1996)</td>
<td>($900)</td>
<td>($21011)</td>
</tr>
<tr>
<td>P(Return &gt; 0)</td>
<td>23%</td>
<td>100%</td>
<td>57%</td>
<td>33%</td>
<td>64%</td>
</tr>
</tbody>
</table>

<sup>a</sup>Fixed payment contracts.

<sup>b</sup>Profit sharing contract.

<sup>c</sup>Contract A without death loss penalty.
Table V-7. Feeder cash flow per group for the below average feeder to finish enterprise ($75 per head investment)

<table>
<thead>
<tr>
<th>Item</th>
<th>A(^a)</th>
<th>B(^a)</th>
<th>C(^b)</th>
<th>A(^c)</th>
<th>Sole Proprietor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected Cash Flow</td>
<td>$870</td>
<td>$1283</td>
<td>$2289</td>
<td>$1081</td>
<td>$3359</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>$444</td>
<td>$190</td>
<td>$2603</td>
<td>$346</td>
<td>$6895</td>
</tr>
<tr>
<td>Minimum Cash Flow</td>
<td>($658)</td>
<td>$1185</td>
<td>($917)</td>
<td>$227</td>
<td>($17109)</td>
</tr>
<tr>
<td>P(Cash Flow &gt; 0)</td>
<td>97%</td>
<td>100%</td>
<td>69%</td>
<td>100%</td>
<td>68%</td>
</tr>
<tr>
<td>P(Cash Flow &lt; $1236)</td>
<td>83%</td>
<td>71%</td>
<td>46%</td>
<td>76%</td>
<td>38%</td>
</tr>
<tr>
<td>Payback in Years</td>
<td>9.9</td>
<td>6.7</td>
<td>3.8</td>
<td>8.0</td>
<td>2.6</td>
</tr>
</tbody>
</table>

\(^a^\)Fixed payment contracts.

\(^b^\)Profit sharing contract.

\(^c^\)Contract A without death loss penalty.
Table V-8. Owner risk and returns per group for the below average feeder to finish enterprise

<table>
<thead>
<tr>
<th>Item</th>
<th>A&lt;sup&gt;a&lt;/sup&gt;</th>
<th>B&lt;sup&gt;b&lt;/sup&gt;</th>
<th>C&lt;sup&gt;c&lt;/sup&gt;</th>
<th>A&lt;sup&gt;*c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected Return</td>
<td>$2434</td>
<td>$2287</td>
<td>$1295</td>
<td>$2185</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>$6368</td>
<td>$6460</td>
<td>$4184</td>
<td>$6525</td>
</tr>
<tr>
<td>Maximum Return</td>
<td>$19984</td>
<td>$19978</td>
<td>$10698</td>
<td>$20183</td>
</tr>
<tr>
<td>Minimum Return</td>
<td>($19284)</td>
<td>($21209)</td>
<td>($19148)</td>
<td>($20067)</td>
</tr>
<tr>
<td>P(Return &gt; 0)</td>
<td>66%</td>
<td>64%</td>
<td>72%</td>
<td>65%</td>
</tr>
</tbody>
</table>

<sup>a</sup>Fixed payment contracts.

<sup>b</sup>Profit sharing contract.

<sup>c</sup>Contract A without death loss penalty.
Table V-9. Feeder risk and returns per group for the above average feeder to finish enterprise ($105 per head investment)

<table>
<thead>
<tr>
<th>Contract</th>
<th>A&lt;sup&gt;a&lt;/sup&gt;</th>
<th>B&lt;sup&gt;a&lt;/sup&gt;</th>
<th>C&lt;sup&gt;b&lt;/sup&gt;</th>
<th>A&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Sole Proprietor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expected Return</td>
<td>($149)</td>
<td>($52)</td>
<td>$1184</td>
<td>($76)</td>
<td>$3229</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>$359</td>
<td>$201</td>
<td>$2654</td>
<td>$268</td>
<td>$6469</td>
</tr>
<tr>
<td>Maximum Return</td>
<td>$709</td>
<td>$229</td>
<td>$9819</td>
<td>$709</td>
<td>$21235</td>
</tr>
<tr>
<td>Minimum Return</td>
<td>($1701)</td>
<td>($479)</td>
<td>($2429)</td>
<td>($873)</td>
<td>($18800)</td>
</tr>
<tr>
<td>P(Return &gt; 0)</td>
<td>38%</td>
<td>34%</td>
<td>60%</td>
<td>40%</td>
<td>69%</td>
</tr>
<tr>
<td>P(Cash Flow &lt; $1731)</td>
<td>82%</td>
<td>78%</td>
<td>43%</td>
<td>72%</td>
<td>32%</td>
</tr>
<tr>
<td>Payback in Years</td>
<td>8.1</td>
<td>7.7</td>
<td>4.3</td>
<td>7.8</td>
<td>2.5</td>
</tr>
</tbody>
</table>

<sup>a</sup>Fixed payment contracts.

<sup>b</sup>Profit sharing contract.

<sup>c</sup>Contract A without death loss penalty.
Table V-10. Feeder risk and returns per group for the below average feeder to finish enterprise ($105 per head investment)

<table>
<thead>
<tr>
<th>Item</th>
<th>A&lt;sup&gt;a&lt;/sup&gt;</th>
<th>B&lt;sup&gt;a&lt;/sup&gt;</th>
<th>C&lt;sup&gt;b&lt;/sup&gt;</th>
<th>A&lt;sup&gt;×c&lt;/sup&gt;</th>
<th>Sole Proprietor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected Return</td>
<td>($718)</td>
<td>($323)</td>
<td>$648</td>
<td>($524)</td>
<td>$1909</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>$416</td>
<td>$175</td>
<td>$2519</td>
<td>$339</td>
<td>$6476</td>
</tr>
<tr>
<td>Maximum Return</td>
<td>$709</td>
<td>$724</td>
<td>$9074</td>
<td>$709</td>
<td>$19733</td>
</tr>
<tr>
<td>Minimum Return ($2250)</td>
<td>($2250)</td>
<td>($439)</td>
<td>($2491)</td>
<td>($1395)</td>
<td>($21506)</td>
</tr>
<tr>
<td>P(Return &gt; 0)</td>
<td>4%</td>
<td>9%</td>
<td>51%</td>
<td>7%</td>
<td>61%</td>
</tr>
<tr>
<td>P(Cash Flow &lt; $1731)</td>
<td>99%</td>
<td>96%</td>
<td>50%</td>
<td>98%</td>
<td>40%</td>
</tr>
<tr>
<td>Payback in Years</td>
<td>13.9</td>
<td>9.4</td>
<td>5.3</td>
<td>11.2</td>
<td>3.6</td>
</tr>
</tbody>
</table>

<sup>a</sup>Fixed payment contracts.
<sup>b</sup>Profit sharing contract.
<sup>c</sup>Contract A without death loss penalty.
Table V-11. Sample budget for calculating returns to the feeder and the owner in a feeder pig production enterprise

<table>
<thead>
<tr>
<th></th>
<th>FEEDER</th>
<th>OWNER</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>INCOME</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feeder pigs:</td>
<td>$131035</td>
<td>336763</td>
</tr>
<tr>
<td>Breeding stock:</td>
<td>$0</td>
<td>34285</td>
</tr>
<tr>
<td><strong>TOTAL GROSS INCOME</strong></td>
<td>$131034</td>
<td>371048</td>
</tr>
<tr>
<td><strong>VARIABLE COSTS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Payments to feeder:</td>
<td>$0</td>
<td>131034</td>
</tr>
<tr>
<td>Feed costs:</td>
<td>$0</td>
<td>124908</td>
</tr>
<tr>
<td>Breeding stock purchases:</td>
<td>$0</td>
<td>26250</td>
</tr>
<tr>
<td>Operating Costs (miscellaneous):</td>
<td>$22500</td>
<td>0</td>
</tr>
<tr>
<td>Utilities, fuel, elect. and tele.:</td>
<td>$18750</td>
<td>0</td>
</tr>
<tr>
<td>Vet. and medicine:</td>
<td>$0</td>
<td>16500</td>
</tr>
<tr>
<td>Labor costs (operator and hired):</td>
<td>$39000</td>
<td>0</td>
</tr>
<tr>
<td>Marketing costs:</td>
<td>$0</td>
<td>9953</td>
</tr>
<tr>
<td><strong>TOTAL VARIABLE COSTS</strong></td>
<td>$80250</td>
<td>308245</td>
</tr>
<tr>
<td><strong>FIXED COSTS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depreciation (facilities and equip.):</td>
<td>$42857</td>
<td>0</td>
</tr>
<tr>
<td>Taxes and Insurance:</td>
<td>$4500</td>
<td>0</td>
</tr>
<tr>
<td><strong>TOTAL FIXED COSTS</strong></td>
<td>$47357</td>
<td>0</td>
</tr>
<tr>
<td><strong>TOTAL COST OF PRODUCTION</strong></td>
<td>$127607</td>
<td>308245</td>
</tr>
<tr>
<td><strong>CASH FLOW</strong></td>
<td>$46285</td>
<td>62803</td>
</tr>
<tr>
<td><strong>RETURNS OVER ALL COSTS</strong></td>
<td>$3428</td>
<td>62803</td>
</tr>
</tbody>
</table>
Table V-12. Feeder pig production contracts

<table>
<thead>
<tr>
<th>Contract A</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Producer:</strong></td>
<td>supplies facilities,</td>
<td>manpower, vet.</td>
</tr>
<tr>
<td></td>
<td>costs, utilities,</td>
<td>manure handling,</td>
</tr>
<tr>
<td></td>
<td>and bedding</td>
<td></td>
</tr>
<tr>
<td><strong>Contractor:</strong></td>
<td>supplies breeding</td>
<td>stock, feed,</td>
</tr>
<tr>
<td></td>
<td>stock, marketing of</td>
<td>animals, and</td>
</tr>
<tr>
<td></td>
<td>animals, and</td>
<td>transport of</td>
</tr>
<tr>
<td></td>
<td>transport of</td>
<td>animals</td>
</tr>
<tr>
<td><strong>Compensation:</strong></td>
<td>$14 per feeder pig</td>
<td>produced (45 lbs.)</td>
</tr>
<tr>
<td></td>
<td>produced</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Contract B</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Producer:</strong></td>
<td>supplies totally</td>
<td>confined facilities to contractor specifications, equipment for manure handling, management, utilities, and labor</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Contractor:</strong></td>
<td>supplies breeding</td>
<td>stock, feed, vet. costs, medications, and marketing</td>
</tr>
<tr>
<td></td>
<td>stock,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>vet. costs,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>medications, and</td>
<td></td>
</tr>
<tr>
<td></td>
<td>marketing</td>
<td></td>
</tr>
<tr>
<td><strong>Compensation:</strong></td>
<td>$10 per female</td>
<td>present in breeding herd each month</td>
</tr>
<tr>
<td></td>
<td>$12 per feeder pig</td>
<td>produced</td>
</tr>
<tr>
<td></td>
<td>produced</td>
<td></td>
</tr>
<tr>
<td><strong>Minimum size:</strong></td>
<td>500 sows or better</td>
<td></td>
</tr>
</tbody>
</table>
Table V-13. Annual feeder risk and returns for the above average feeder pig production enterprise

<table>
<thead>
<tr>
<th>Item</th>
<th>Contract</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>Sole Proprietor</td>
<td></td>
</tr>
<tr>
<td>Expected Return</td>
<td>$3,133</td>
<td>$41,132</td>
<td>$69,322</td>
<td></td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>$33,797</td>
<td>$28,979</td>
<td>$141,820</td>
<td></td>
</tr>
<tr>
<td>Maximum Return</td>
<td>$77,427</td>
<td>$105,575</td>
<td>$601,602</td>
<td></td>
</tr>
<tr>
<td>Minimum Return</td>
<td>($66,249)</td>
<td>($17,601)</td>
<td>($169,602)</td>
<td></td>
</tr>
<tr>
<td>P(Return &gt; 0)</td>
<td>52%</td>
<td>94%</td>
<td>63%</td>
<td></td>
</tr>
</tbody>
</table>
### Table V-14. Annual Feeder Cash Flow for the Above Average Feeder Pig Production Enterprise

<table>
<thead>
<tr>
<th>Item</th>
<th>Contract A</th>
<th>Contract B</th>
<th>Sole Proprietor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected Cash Flow</td>
<td>$45,990</td>
<td>$84,988</td>
<td>$112,179</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>$33,797</td>
<td>$28,979</td>
<td>$141,820</td>
</tr>
<tr>
<td>Minimum Cash Flow</td>
<td>($23,392)</td>
<td>$25,255</td>
<td>($126,744)</td>
</tr>
<tr>
<td>P(Cash Flow &gt; 0)</td>
<td>93%</td>
<td>100%</td>
<td>77%</td>
</tr>
<tr>
<td>P(Cash Flow &lt; $42,587)</td>
<td>49%</td>
<td>6%</td>
<td>38%</td>
</tr>
<tr>
<td>Payback in Years</td>
<td>6.5</td>
<td>3.5</td>
<td>2.7</td>
</tr>
</tbody>
</table>
Table V-15. Annual owner risk and returns for the above average feeder pig production enterprise

<table>
<thead>
<tr>
<th>Item</th>
<th>Contract A</th>
<th>Contract B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected Return</td>
<td>$62,136</td>
<td>$23,137</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>$131,429</td>
<td>$132,751</td>
</tr>
<tr>
<td>Maximum Return</td>
<td>$529,033</td>
<td>$500,018</td>
</tr>
<tr>
<td>Minimum Return</td>
<td>($173,357)</td>
<td>($206,534)</td>
</tr>
<tr>
<td>P(Return &gt; 0)</td>
<td>65%</td>
<td>48%</td>
</tr>
</tbody>
</table>
Table V-16. Annual feeder risk and returns for the below average feeder pig production enterprise

<table>
<thead>
<tr>
<th>Item</th>
<th>Contract</th>
<th></th>
<th>Sole Proprietor</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td></td>
</tr>
<tr>
<td>Expected Return</td>
<td>($33,541)</td>
<td>$10,754</td>
<td>($2,966)</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>$15,922</td>
<td>$13,671</td>
<td>$95,000</td>
</tr>
<tr>
<td>Maximum Return</td>
<td>$5,444</td>
<td>$44,688</td>
<td>$334,368</td>
</tr>
<tr>
<td>Minimum Return</td>
<td>($71,503)</td>
<td>($22,912)</td>
<td>($174,722)</td>
</tr>
<tr>
<td>P(Returns &gt; 0)</td>
<td>2%</td>
<td>77%</td>
<td>40%</td>
</tr>
</tbody>
</table>
Table V-17. Annual feeder cash flow for the below average feeder pig production enterprise

<table>
<thead>
<tr>
<th>Item</th>
<th>Contract A</th>
<th>Contract B</th>
<th>Sole Proprietor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected Cash Flow</td>
<td>$9,315</td>
<td>$53,611</td>
<td>$39,890</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>$15,922</td>
<td>$13,671</td>
<td>$95,006</td>
</tr>
<tr>
<td>Minimum Cash Flow</td>
<td>($28,646)</td>
<td>$19,944</td>
<td>$131,915</td>
</tr>
<tr>
<td>P(Cash Flow &gt; 0)</td>
<td>70%</td>
<td>100%</td>
<td>61%</td>
</tr>
<tr>
<td>P(Cash Flow &lt; $42,587)</td>
<td>98%</td>
<td>23%</td>
<td>60%</td>
</tr>
<tr>
<td>Payback in Years</td>
<td>32.2</td>
<td>5.6</td>
<td>7.5</td>
</tr>
</tbody>
</table>
Table V-18. Annual owner risk and returns for the below average feeder pig production enterprise

<table>
<thead>
<tr>
<th>Item</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected Return</td>
<td>$26,542</td>
<td>($17,754)</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>$93,197</td>
<td>$93,621</td>
</tr>
<tr>
<td>Maximum Return</td>
<td>$303,618</td>
<td>$293,086</td>
</tr>
<tr>
<td>Minimum Return</td>
<td>($179,069)</td>
<td>($189,048)</td>
</tr>
<tr>
<td>P(Return &gt; 0)</td>
<td>55%</td>
<td>34%</td>
</tr>
</tbody>
</table>
Figure V-1. Distribution of feeder pig death loss for the above average feeder
Figure V-2. Distribution of feed efficiency for the above average feeder
Figure V-3. Distributions of returns to the above average feeder for all contracts and sole proprietorship.
Figure V-4. Distributions of returns to the above average feeder for all contracts.
Figure V-5. Distributions of returns to the above average feeder for fixed payment contracts
Figure V-6. Distributions of returns to the owner (above average feeder)
Figure V-7. Distribution of feeder pig death loss for the below average feeder
Figure V-8. Distribution of feed efficiency for the below average feeder.
Figure V-9. Distributions of returns to the below average feeder for all contracts and sole proprietorship
Figure V-10. Distributions of returns to the below average feeder for all contracts
Figure V-11. Distributions of returns to the below average feeder for fixed payment contracts
Figure V-12. Distributions of returns to the owner (below average feeder)
Figure V-13. Distribution of pigs weaned per litter for the above average feeder pig production enterprise
Figure V-14. Distribution of litters weaned per sow per year for the above average feeder pig production enterprise
Figure V-15. Distribution of feeder pigs produced for the above average feeder pig production enterprise
Figure V-16. Distributions of returns to the above average feeder pig production enterprise for all contracts and sole proprietorship
Figure V-17. Distributions of returns to the above average feeder pig production enterprise for all contracts

LEGEND:
- Contract A
- Contract B
Figure V-18. Distributions of returns to the owner (above average feeder pig production enterprise)
Figure V-19. Distribution of pigs weaned per litter for the below average feeder pig production enterprise
Figure V-20. Distribution of litters weaned per sow per year for the below average feeder pig production enterprise
Figure V-21. Distributions of returns to the below average feeder pig enterprise for all contracts and sole proprietorship
Figure V-22. Distributions of returns to the owner (below average feeder pig production enterprise)
Figure V-23. Comparison of the owner's efficient sets for Contract A
CHAPTER VI CONCLUSIONS AND IMPLICATIONS FOR FURTHER RESEARCH

Implications of the Theoretical Model

The theoretical model of contracting presented in Chapter III had two major implications. The first was that the optimal compensation schedule could be of various forms, including fixed payment contracts and profit sharing. The optimal compensation schedule depends on factors unique to the situation and to the parties involved in the contract. If optimality can be associated with stochastic efficiency, then the results in Chapter IV support this implication. The efficient set of contracts determined through stochastic dominance contained both fixed payment and profit sharing contracts. The simulation model of Chapter IV also showed how factors unique to the feeder, especially feed efficiency, death loss of feeder pigs, pigs weaned per litter, and litters per sow per year, interacted with the compensation schedule to provide different levels of risk and return to both the feeder and the owner. The efficient set of alternatives, not just the optimal compensation schedule, also depends on factors unique to both the owner and feeder. This would seem to preclude using data from experiment stations to evaluate contracts since feeders' levels of production efficiency vary widely and so then will their risk and returns from contracting. This would also preclude relying on promotional literature to evaluate contracts, since the feeder's operation
may or may not be able to obtain similar levels of production efficiency. Evaluation of contracts by a feeder should be based on their own individual records.

The second major implication of the theoretical model was that the optimal compensation schedule is inversely related to the level of effort of the owner. This means that the contracts examined are actually models of an agent-agent relationship, as opposed to a principal-agent one. The implication of this model was that compensation of feeders should be related to the quality of inputs provided by the owner. For example, feeder pigs from various sources will likely have a higher death loss, and base payments and performance incentives and penalties should reflect this. Alternatively, the feeder should have the right of inspection and refusal of any animals coming into his or her facility. This would be a forcing contract based on observable factors.

The weakness of the theoretical model is that it produces very complex contracts, dependent on a large number of factors which would differ widely from feeder to feeder and from owner to owner. Creation of optimal contracts for each situation would be very difficult even if all of these factors were known due to the time involved and transactions costs. The actual contracts that exist are probably second best solutions to the problems of transactions costs. Still, there are a wide variety of contracts available reflecting different
wide variety of contracts available reflecting different attitudes and attributes of the parties involved, and this does mirror the predictions of the theoretical model that optimal contracts may vary widely.

Implications of the Simulation Model

The literature review and background to contracting indicated that pork production contracts are responses to financial stress and are a form of risk management. As a risk management tool, contracts are supposed to allow the feeder to trade off some expected returns for less risk. In return for a less variable return and cash flow, the feeder accepts a lower expected return. The owner accepts a large portion of risk in return for higher expected returns. The contracts examined in the simulation model of Chapter IV generally performed this function just as described above, offering lower returns and less risk relative to sole proprietorship. Owner’s returns for these same contracts typically showed higher expected returns, more risk, and the potential of large losses and large returns.

As a risk management tool, the results of the contracts are similar to the use of futures contracts or forward pricing to manage price risk. The contracts place a limit on losses to the feeder, but also limit upside potential or maximum expected returns. The limits on maximum expected returns are a result of biological factors and the producer’s management
ability. The limit on losses to the feeder results from a known payment per feeder pig or finished animal, and so the feeder typically deals with production or output risk alone, as opposed to price risk.

The contracts examined also reduced financial risk to the feeder. This aspect of contracting would appeal to feeders with financial problems or a lack of capital. This would also appeal to lenders, since some contracts offered a steady income and a better probability of servicing debt. Since the lender does not directly share in returns or cash flow above debt payments, contracts may increase the amount of capital available to agriculture.

One problem with contracts and financial risk is the duration of the contract. The theoretical model of financial risk showed that the uncertain life of a contract led to underestimation of financial risk and total risk to the feeder. The implication is that the duration of the contract must be examined carefully by both the feeder and his or her lender. The expected payback periods estimated in the simulation model showed that termination of a contract after one year would leave a feeder with substantial financial obligations and that the cash flow from the contracts would not recoup the investment in facilities in a single year.

Another problem with contracts is the change in operating leverage for the feeder. Owners provide many of the required
inputs and thus in some contracts the owner pays such variable costs as feed, veterinary expenses, and medicine. The feeder typically supplies facilities and must cover the fixed costs associated with these facilities. Fixed costs then become a larger portion of the feeder’s total costs and the feeder’s operating leverage increases. This gives the contract feeder a high fixed cost commitment, which cannot be reduced even if output levels fall. This will make the feeder’s returns sensitive to small changes in output. The cash flow analysis for the contract feeders showed less risk overall relative to sole proprietorship, however, indicating that the reduction in price risk with contracts more than offsets this increase in operating leverage. In addition, the feeder will have smaller requirements in terms of working capital since the owner provides many of the inputs, and this would also tend to offset increases in operating leverage.

Results for the feeders with low production efficiency do show that contracts are not a solution to management problems. These feeders did little better than break even and still had potential losses with most of the contracts examined. Those contracts where the below average feeder fared the best offered the lowest returns to the owner. Given a choice, the owners would choose to deal with above average feeders. When the efficient set of contracts for the owner was compared across different feeders, the below average feeder was
eliminated from this efficient set, implying that production
efficiency is a key variable for both feeders and owners. The
interaction of production efficiency with the payment
schedules of the contracts impacts on the risk and returns for
both parties. Improving production efficiency should be a
common goal for both the feeder and the owner as it improves
the contract's performance for everyone involved.

One weakness of the simulation study is that contracts
were examined as a risk management tool, but alternative risk
management strategies were not compared to these contracts.
The simulation model overstates risk to the sole proprietor
and to the owner to the extent that these parties utilize
futures markets or forward contracting to price their feeder
pigs or finished animals. Contracting as a risk management
tool should be compared to other alternative strategies.

The simulation model also examined risk from the
perspective of a single enterprise, whereas many farms are
actually widely diversified businesses, at least in the number
of enterprises in the farm business. Diversification of
enterprises has been a standard and successful risk management
strategy for many farmers over a long period of time. The
results may overstate the ability of contracts to reduce risk
as a result. Further study of contracts might examine how
contracting affects diversification, risk, and returns in a
whole farm context.
The Issue of Equitable Contracts

One issue considered throughout this study is the question of whether or not pork production contracts are equitable to both the feeder and to the owner. Based on the limited number of contracts examined previously the answer to this question seems to be that some contracts are equitable and some are not.

The theoretical model indicates that contracts may not be equitable to the feeder if the owner's quantity and quality of inputs do not enter into the optimal compensation schedule. This means that an equitable contract must allow for some monitoring of the performance of each of the parties, rather than basing compensation only on actual output. The contracts examined allowed monitoring of the feeder in terms of facilities and production efficiency, but did not allow for monitoring of the owner's performance by the feeder. The theoretical model also indicated an increase in risk for the feeder due to the short term duration of the contracts relative to the time required to pay for facilities. This was examined through the assumption of a stochastic life for the contract. The implication was that the length of the contract should, in some way, be tied to the financing terms of the facility. However, increasing the length of the contract and limiting the ability of either parties to cancel the contract could pose different equity issues for both the feeder and
owner. For example, an owner probably not want to continue a contract for an extended period of time with a feeder that is a consistently poor manager. If the feeder is truly an independent contractor the owner should not necessarily be obliged to provide management expertise (although the owner may very well choose to do so). In a similar fashion, a feeder would not necessarily want to work with an owner who provides poor quality inputs or management support over an extended contract.

The risk and returns for the contracts examined through the simulation model also aid in examining the issue of equitable contracts. Pork production contracts are a business organization that allows risk sharing between the owner and the feeder. The sharing of risk is a fundamental way of reducing the risk to each party. Thus, contracts may be seen as a way of modifying the shape of the probability distributions of returns faced by each sharing partner. In order to evaluate the effectiveness of risk management through these risk sharing arrangements, the probability distributions of returns for each party should be compared to a benchmark distribution. That benchmark should be the probability distribution of returns for the sole proprietor, assuming both owners and feeders have this alternative available to them. This allows a comparison of the risks and returns faced by the owner and feeder in a contractual arrangement relative to an
alternative available to both of them, sole proprietorship. Equitable contracts should thus benefit both parties as a risk sharing arrangement as compared to either party operating solely on their own.

In order to make this comparison results for the above average feeder and the associated owner (for a feeder to finish operation with an investment of $105 per head) were utilized. The efficient set of contracts for the above average feeder consisted of contract B, contract C, and sole proprietorship. The distributions of returns to the owner for each of these contracts can then be combined into a set of possible alternatives. This provides the necessary information to compare the probability distributions of returns for the contract feeder and owner with the benchmark distribution of the sole proprietor. Table VI-1 shows the risk and returns for each of these alternatives. Figure VI-1 shows a comparison of the cumulative distributions of returns for the feeder and owner under Contract C (profit sharing) with that of sole proprietorship. Figure VI-2 shows a comparison of returns for the feeder and owner under contract B (fixed payment) with that of sole proprietorship.

These comparisons provide some expected and unexpected results. An examination of Figure VI-1 and Table VI-1 indicates that the profit sharing contract C provides the results expected from a risk sharing arrangement. Relative to
sole proprietorship, both the owner and feeder are able to reduce risk through a contractual arrangement with each other. This can be seen by examining the distributions and by the fact that the standard deviation and the expected minimum return under the contract is less than that of sole proprietorship. The penalty to these sharing parties is that the expected return is reduced. The contract is accomplishing the expected result of a risk sharing arrangement for both the owner and feeder. In addition the profit sharing contract provides the feeder a reasonably good chance of paying off the contract in less than seven years. This would then seem to be an equitable contract for both parties given that they are engaged in risk sharing.

The fixed payment contract, contract B, provides the expected result for a risk sharing arrangement for the feeder. Table VI-1 and Figure VI-2 indicate that the feeder does achieve the expected result of reduced risk (and reduced returns) with this risk sharing arrangement. Standard deviation and expected minimum returns for the feeder are less than that of sole proprietorship. The one problem the feeder may have with the contract is the lack of ability to pay for facilities. This is reflected by the expected return of negative $323. The owner is apparently receiving the advantage of being able to utilize the feeder's facilities without paying for their use and replacement. The equity of
this particular contract is thus questionable.

The results for the owner under this fixed payment contract are somewhat unexpected for a risk sharing arrangement. Expected returns for the owner are very similar to expected returns for sole proprietorship, as is the standard deviation of returns. In fact, the cumulative distributions for the owner and the sole proprietor are virtually identical. The risk sharing arrangement has not reduced risk or returns for the owner in contrast to the above results. There would seem to be at least two possible explanations for this result. One explanation is that the costs to the owner have been understated by the model. For example, no debt service requirements for the owner have been incorporated into the analysis. In addition, the model does not incorporate any labor or management costs for the owner such as those associated with a field manager who works directly with the feeder. This would explain the similarity of expected returns for the owner and the sole proprietor. Adding these costs to the owner's cost data would reduce expected returns. These additional costs would not, however, explain the similarity of risk under these alternatives and so would not be a full explanation of these unexpected results. Another explanation of these results would incorporate the additional costs to the owner discussed above and the reduced risk from not having to invest in facilities. Recall that the
feeder must provide and pay for facilities. The owner thus has no fixed investment costs with this contract. This implies that the cost of exiting the contract is minimal. If the owner does not have to invest in facilities, this would provide a great deal of flexibility and reduce the risk exposure of the owner. The owner has no operating leverage to contend with and can walk away from the facilities by terminating the contract. The terms of the contract allow the owner to do so. The magnitude of reduced risk for the owner due to this flexibility and lack of fixed investment has not been included in the model. Subtracting additional costs of labor and management to the owner’s returns along with this flexibility would then provide reduced risk and returns for the owner as expected with a risk sharing arrangement. Even so, the contract is not necessarily equitable at the investment level of $105 per head since the owner is still able to utilize the feeder’s facilities without compensating the feeder fully.

It should be noted, however, that at an investment level of $75 per head this same fixed payment contract offered the feeder positive returns and a 100 percent chance of meeting debt servicing requirements. The fixed payment contract is very sensitive to fairly small changes in costs and cash flows.

The above analysis points out an important facet of
contract pork production from the owner's point of view. The owner essentially substitutes a compensation schedule (payments to the feeder) for investment in facilities. The cost sharing that occurs in this type of arrangement thus provides the owner with more flexibility than a sole proprietorship. Further research into contracts should incorporate this substitution and flexibility into the analysis in examining the equity of contracts.

Implications for Further Research

The number of contracts examined in this study was limited. Yet even among this small number of contracts there were a number of significant differences that impacted on the risk and returns to the feeder and the owner. A comparison of additional contracts could be easily be done and other significant differences among contracts might be identified. It might also be beneficial to examine additional contracts by region and by the amount of competition among owners in a geographical area to examine the impact of these factors upon contractual arrangements.

Contracts are offered by different economic agents with differing goals and objectives. Contracts could be examined for systematic differences due to the agent that is providing the arrangement. For example, how do contracts offered by cooperatives to members compare to contracts offered by independent contractors or feed companies or food processors?
Another group of agents that offer contracts to farmers are other farmers. How do these contracts compare to contracts offered by outside investors.

Another topic for further study is how will contracting impact on producers who choose to remain independent. Meat packers are typically interested in a large and steady volume of animals into their facilities. If contracts were able to provide this volume, how would this impact on the marketing opportunities of independent producers.

An issue typically ignored by economists is the organizational behavior aspects of contracting. If an owner is represented by a field manager who works directly with feeders, the relationship between the field manager and the feeder could have an impact on the success or failure of the contract. Presumably, a field manager would have some background in pork production. It might be possible for management practices of feeders to be improved through an owner or field manager with a broad knowledge of facilities and production practices. The contracts evaluated in this study showed that some contracts were mutually beneficial to both parties if the feeder was an efficient producer, so there is some incentive for owners to provide management expertise.

Little is known about how feeders respond to specific production incentives. Theoretical models in the agency literature implied that standards should be set at high levels
to encourage high levels of performance, or that standards should be enforced by severe penalties. Feeders might or might not respond to incentives in the manner which the theoretical models predict. One possible advantage of contracts and their production objectives would be to make the feeder very goal oriented and to implement management by objectives into the production process. Feeders would still be motivated by profit, but in this case profit would depend on setting and achieving production objectives. This would not involve the same marketing objectives of an independent producer. Feeders might respond favorably to the smaller number of objectives inherent in contracts or they might reject standards and production practices imposed upon them by owners.

The returns estimated by the simulation model were on a before tax basis. Farmers currently can use cash accounting to calculate taxable income and cash accounting allows for the prepayment of expenses and delay of sales receipts to lessen tax liability. In a contractual arrangement, the expenses of the farmer may not include feed as it is provided by the owner. This might limit the ability of the farmer to prepay expenses and so increase his or her tax liability.

Finally, contracts and their impact on pork production and the structure of the pork industry should be examined on an ongoing basis, not just in one study every decade or so.
This would allow the development of a data base which would aid in the understanding of contracts and how these contracts might be made more effective. If contracting in pork production continues to increase throughout the United States, this would represent still another major structural change in American agriculture. A data base on contracting would then aid in the understanding of how agriculture and the rural areas of the United States are changing and evolving over time.
Table VI-1. Contract C: owner and feeder returns for the above average feeder to finish enterprise ($105 per head investment)

<table>
<thead>
<tr>
<th>Item</th>
<th>Feeder</th>
<th>Owner</th>
<th>Sole Proprietor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected Return</td>
<td>$1184</td>
<td>$2066</td>
<td>$3229</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>$2654</td>
<td>$4002</td>
<td>$6469</td>
</tr>
<tr>
<td>Maximum Return</td>
<td>$9819</td>
<td>$11441</td>
<td>$21235</td>
</tr>
<tr>
<td>Minimum Return</td>
<td>($2429)</td>
<td>($16790)</td>
<td>($18800)</td>
</tr>
</tbody>
</table>
Table VI-2. Contract B: owner and feeder returns for the above average feeder to finish enterprise ($105 per head investment)

<table>
<thead>
<tr>
<th>Item</th>
<th>Feeder</th>
<th>Owner</th>
<th>Sole Proprietor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expected Return</td>
<td>($52)</td>
<td>$3316</td>
<td>$3229</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>$203</td>
<td>$6450</td>
<td>$6469</td>
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<tr>
<td>Maximum Return</td>
<td>$229</td>
<td>$21493</td>
<td>$21235</td>
</tr>
<tr>
<td>Minimum Return</td>
<td>($479)</td>
<td>($18324)</td>
<td>($18800)</td>
</tr>
</tbody>
</table>
Figure VI-1. Contract C: owner and feeder returns for the above average feeder to finish enterprise ($105 per head investment)
Figure VI-2. Contract B: owner and feeder returns for the above average feeder to finish enterprise ($105 per head investment)


