Hog producers' marketing decisions

Daniel Stephen Tilley

Iowa State University

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by

Daniel Stephen Tilley

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I. INTRODUCTION

That knowledge precedes understanding and understanding leads to progress is the basic premise of most scientific research. So it is with this research. Knowledge of the marketing decisions made by participants\(^{1}\) in the hog-pork vertical market structure\(^{2}\) and an understanding of why participants made decisions should help the hog-pork industry progress. Emphasis in this volume is placed on the hog marketing system—the activities and services performed from the time hogs reach a marketable weight until they are slaughtered. In particular, farmers' outlet selection activities are analyzed and related to the structure and potential structure of the market channel. Hog farmers' weight choice decisions are analyzed and related to stimuli produced in the marketing system that may cause farmers to change the weight of hogs they market.

A. Objectives

Both outlet selection and weight choice decisions have practical and theoretical implications. The practical implications are related to how well a price-coordinated\(^{3}\) system operates. The theoretical implications are related to the way interaction between levels in a market structure are synchronized. Raikes, Ladd and Skadberg (106) discuss several alternative forms of coordination.

---

\(^{1}\) A participant is any firm or person in the set of firms, consumers or farmers in the marketing channel.

\(^{2}\) A vertical market structure is a set of firms, consumers or farmers between which cooperative relationships exist. A firm is a member of the set if cooperative relationships exist between it and at least one other member of the set. A cooperative relationship is that which permits the exchange of goods and services among firms in different levels in the vertical structure. The levels are defined by competitive relationships between firms (6, pp. 8-11).

\(^{3}\) Coordination refers to the way interaction between levels in a market structure are synchronized. Raikes, Ladd and Skadberg (106) discuss several alternative forms of coordination.
tions relate to how well standard constrained profit-maximizing theory of the firm explains hog marketing decisions. A theoretical model of hog producers' production and marketing decisions is developed in this thesis. For both the outlet and weight decisions, characteristics and attitudes of producers making particular decisions are analyzed to determine if knowledge of producer characteristics can help explain hog marketing decisions.

1. Outlet selection decisions

The dominant trend in outlet selection has been growing use of direct outlets. Direct outlets include packing plants, packer-operated buying stations, independent buying stations and dealers and collection points operated by various producer groups. Terminal markets have declined in importance while auction markets have maintained nearly a constant proportion of the total volume of slaughter hogs purchased by packers in the United States as shown in Table 1.1.

The relative importance of various types of outlets depends of course on farmers' willingness to sell at particular types of outlets. One of the principle objectives is to determine how the characteristics and attitudes of producers using alternative direct outlets differ. Particular emphasis is given to the choice between local buying stations and packing plants. An Illinois study identified the relatively high per-head cost of operating buying stations (15). Packers and independent dealers continue to operate small, local buying stations even though the total cost of marketing from farm to plant has been
Table 1.1. Packer purchases of hogs in the United States (132)

<table>
<thead>
<tr>
<th>Year</th>
<th>Direct, County Dealers, etc. (per cent)</th>
<th>Terminals (per cent)</th>
<th>Auctions (per cent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1961</td>
<td>59.6</td>
<td>29.2</td>
<td>11.2</td>
</tr>
<tr>
<td>1962</td>
<td>59.6</td>
<td>29.3</td>
<td>11.1</td>
</tr>
<tr>
<td>1963</td>
<td>60.7</td>
<td>26.6</td>
<td>12.7</td>
</tr>
<tr>
<td>1964</td>
<td>63.1</td>
<td>23.8</td>
<td>13.1</td>
</tr>
<tr>
<td>1965</td>
<td>62.9</td>
<td>23.4</td>
<td>13.7</td>
</tr>
<tr>
<td>1966</td>
<td>62.7</td>
<td>22.1</td>
<td>15.2</td>
</tr>
<tr>
<td>1967</td>
<td>65.7</td>
<td>18.8</td>
<td>15.5</td>
</tr>
<tr>
<td>1968</td>
<td>66.6</td>
<td>19.3</td>
<td>14.1</td>
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<tr>
<td>1969</td>
<td>67.4</td>
<td>18.9</td>
<td>13.7</td>
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<td>1970</td>
<td>68.5</td>
<td>17.1</td>
<td>14.3</td>
</tr>
<tr>
<td>1971</td>
<td>69.3</td>
<td>16.9</td>
<td>13.8</td>
</tr>
<tr>
<td>1972</td>
<td>70.4</td>
<td>16.3</td>
<td>13.3</td>
</tr>
</tbody>
</table>

shown to decrease if fewer, larger buying stations were operated (126).

The relatively high per-head cost of buying station operation is reflected in the fact that price quotations at buying stations are generally lower than packing plant price quotations (139). Because of the cost, packers would probably prefer not to continue operating buying stations if they could secure sufficient volume by only buying at the plant. Apparently packers feel that local buying stations are necessary because farmers use criteria other than price and cost when choosing an outlet and that the cost of operating buying stations is less than the price differential packers would have to pay to secure sufficient volume at the plant.

Identification of the outlet characteristics that producers feel are important should be useful to researchers interested in examining the feasibility of alternative forms of coordination. The justification for
some coordination proposals has rested on the potential for reducing marketing costs, thus enabling producers to receive higher net prices. However, the outlet characteristics producers rate as important may be incompatible with some forms of coordination and market structures.

The theoretical implications of this thesis relate to the standard assumption that firms in general intend to maximize net revenue when they make selling decisions. One basic hypothesis of this research is that a sales decision depends on subjective factors and may constrain the farmer's outlet selection such that net revenue is not maximized. Hypotheses generated from a theoretical model that does not assume profit maximization are tested.

2. Weight choice decisions

In addition to outlet selection, a producer must decide what the hogs he sells should weigh. If slaughter hogs of different weight are viewed as different products, the problem of weight decisions can be viewed as a product mix decision. Again the decision has both practical and theoretical implications.

That the most profitable weight of slaughter hogs to sell depends on price differentials for various weights and input costs has been documented by Beneke and Dobbins (9). Of interest is the extent producers recognize potential profit from varying the weight of hogs produced. If some producers prefer not to vary the weight of hogs produced, then the reasons for their behavior need to be understood. Similarly we need to know why producers choose to vary the weight of hogs
produced. Given this information, more effective extension education programs could be developed to help farmers select weight ranges that are consistent with their objectives and constraints.

The theoretical implication again relates to whether standard theory of the firm can be used to demonstrate and explain hog farmer's product mix decisions. The theoretical model in this thesis incorporates subjective sales decision constraints. The hypothesis is that subjective variables in the sales function may for some producers constrain the product mix decision such that profits are not maximized.

B. Data Source

The data used to assist the development of the theory and to test the hypothesis comes from 489 personal interviews of Iowa hog producers. The interviews were made in February, 1972, with most responses relating to 1971 hog production and marketing activities. The complete questionnaire is included as Appendix B and the sample design is described in Appendix C.

C. Following Chapters

Chapter II is a review of three related studies that demonstrate more of the motivation for the work in this volume. Chapter III discusses the need for psychological analysis of economic activity and shows the approach used in this study to measure the importance of factors affecting outlet and weight decisions. Chapter IV is a presentation of the general theoretical model. Chapter V contains simplified versions of the model.
in Chapter IV and tells how hypotheses are related to the models.

Chapter VI contains the results of the hypothesis testing procedures and Chapter VII summarizes the conclusions of the analysis.
II. LITERATURE REVIEW

Three types of research are reviewed in Chapter II. Section A is an appraisal of the linear programming approach to hog-pork coordination research. The principal source reviewed is "Quantitative Estimates of the Incentives for Structural Change in the Hog Industry" (123). The paper was chosen as the representative for a great volume of research because it summarizes the linear programming "approach used to develop quantitative estimates of the incentives for structural change in the hog industry" (123, p. 2). Because the thrust of my appraisal is directed toward the approach rather than the reliability of the coefficients, the paper's emphasis on approach makes it more appropriate for review than the numerous theses that were produced during the developmental stages of the linear programming model.

Sections B and C of Chapter II review two of the principal sources that inspired the model developed in Chapter IV. Section B reviews the theoretical model of livestock production and marketing decisions presented by Hildreth and Jarrett (50). The model should provide an excellent preview for the basic structure and the kinds of results expected from the model developed in Chapter IV.

Section C of Chapter II reviews the theoretical model presented in Chapter 7 of Holdren's The Structure of a Retail Market and the Market Behavior of Retail Units (52). Holdren's work is reviewed because of its introduction of nonprice competition to multiproduct theory of the firm.
The model to be presented in Chapter IV is a hybrid of the nonprice competition characteristics of Holdren's work and the basic structural model presented by Hildreth and Jarrett.

A. The Linear-Programming Approach

The linear programming approach involves "the construction of a linear programming model of hog procurement/slaughter/processing/product sales activities of hog slaughter and processing firms" (123, p. 4). The four sources of incentives to coordination examined by Snyder and Candler were quality\(^1\), regularity\(^2\), product profile\(^3\), and live hog profile\(^4\). Because emphasis of this thesis is farm level production and marketing decisions, final product profile changes—specifically product branding and advertising aspects of processor-retail coordination—are ignored. Changes in quality, regularity, and live hog profile are variables that affect processor's profit and are the result of changes in production and marketing decisions made by hog producers.

The discussion of the linear programming approach centers around 1) the source of producer motivation for coordination, 2) the nature of the "quantitative" answers, 3) the assumed conditions analyzed, and

\(^1\) Quality refers to effective yield of red meat from all weight/grade categories.

\(^2\) Regularity refers to how closely volume approaches the "optimum level of slaughter processing" (123, p. 19).

\(^3\) Product profile refers to degree of product branding.

\(^4\) Live hog profile to the distribution of hogs in the various grade categories.
4) aggregation problems.

1. Motivation for coordination

The motivation for moving toward coordination rests on the idea that monetary gains earned from being more coordinated enter the objective functions of the participants and will be distributed. To quote:

If there is a substantial gain there would be an incentive for producers, as well as for packers, to coordinate production so as to provide better supplies of hogs, and, hopefully, competition would eventually distribute the gains among all participants in the hog production/marketing system from corn grower to pork consumer (123, p. 3).

There are problems with using hog enterprise income gains as the only motivation for coordination. First, for the multiproduct farm firm, activities required to achieve hog enterprise coordination with packers may conflict with achieving gains from other enterprises. The absence of farm production activities in their weekly model is a serious handicap that would be difficult if not virtually impossible to overcome. More than one type of production unit would have to be included in the model. Typical types of farm production units would be difficult to define because of the multiproduct nature of the farm firm and the variety of products produced on different farms. It would also be necessary to determine how many hogs should be produced from each type of production unit. If typical farm producing units were included, the high opportunity cost of labor or other hog production resources during certain key crop producing months of the year might bid the resources away from the activities required to increase regularity of hog sales. Also, production costs may vary seasonally because of weather conditions in
principal hog producing states giving further reasons for seasonal, non-
regular hog production.

Similar comments can be made about improved quality and live hog profile. Improving quality and controlling the live hog profile are not uncostly activities at the farm level and the costs of these activities would to some degree reduce the gains from coordinating these factors. It would also be interesting to examine the results of the analysis with the additional constraint that producers' incomes not be reduced below pre-coordination levels. It seems possible that while packers may benefit from coordination, producers would suffer the costs of coordination.

A second motivation problem is related to defining monetary gains as the single objective of the participants. As Candler and Boehlje stated when proposing methods to incorporate multiple objectives in a capital budgeting linear programming problem:

...a firm cannot avoid the problem of multiple goals in capital budgeting by deciding to concentrate on the 'single' objective of profit maximization (18, p. 328).

The same comment can be made with respect to marketing and production decisions made by producers and production decisions made by firms. Other objectives may not be harmonious with the single assumed monetary goal.

For example, farmers may consider outlet characteristics in addition to price when choosing an outlet. If farmers feel convenience is an important characteristic, slaughter firms may have to add costly service activities to the procurement operation in order to achieve benefits of higher volume and greater regularity. Even though the service activities are costly, they may be less expensive than paying higher hog prices to
encourage greater volume. Certainly the cost of the additional service activities would tend to reduce or eliminate gains. This would be true if regularity and higher volume result only if the firms are able to buy hogs from a larger region. Per-head assembly costs are likely to increase substantially as the procurement region size increases.

A producer may prefer a particular selling method and outlet because of the amount of carcass information he receives or because he prefers a particular selling method, not because the price is higher for that particular method.

Still other producers may choose a particular outlet because that outlet is considered the "innovative" outlet. These producers might enjoy their reputations as technological leaders in their community and feel that it is important to be first in choosing a particular new outlet, selling method, or procedure.

A procedure for solving linear programming problems with multiple goal objective functions has been suggested (18). Unfortunately, the procedure involves recursive responses from decision makers—i.e., if the decision makers don't like the answers, change the weights for the multiple criteria in the objective function until decision makers do agree with the answers generated. A solution is declared optimal if and only if the decision makers agree that the solution is optimal. To apply the procedure to a coordination problem, participants at the various levels of the marketing channel would have to agree on the weights for the alternative objectives.

But even an appropriate multiple goal solution procedure would not
solve all of the problems. As Ladd suggests, "The appropriate linear pro-
gram for some managers would interchange the monetary objective function
and the labor hour constraints. These are managers who desire to work
the minimum number of hours to earn enough to support a specified level
of living" (68, pp. 87-88). Which and how many producers would be
assumed to have the different types of objectives?

2. **Quantitative answers**

The second weakness of the approach was recognized by Snyder and
Candler: "If the coefficients used do not apply to any one firm, to
what do they apply? But on the other hand, if they do apply to a specific
firm,..., what do they tell us about any other firm, or the industry
generally" (123, p. 8). That is, for all but the particular firm
analyzed, the answers are qualitative rather than quantitative.

3. **Assumed conditions**

The third criticism concerns the assumed conditions used to generate
the quantitative estimates. The model's results indicate that if pre-
ferred conditions can be achieved then profits are higher. The question
of how to accomplish the necessary conditions for higher profits is un-
answered.

The results of this research could complement the linear programming
approach by showing how firms might generate some of the desirable condi-
tions by properly motivating the farm production units.
4. **Aggregation**

The fourth question concerns whether what is good for a single firm in the industry is necessarily profitable or desirable when all firms attempt to achieve the necessary conditions for higher profits. The industry may be such that all firms cannot simultaneously achieve the higher profit conditions. Existence of incentives for a single firm does not necessarily imply incentives exist for all firms simultaneously.

In sum, the linear programming approach does provide interesting answers to how much quality, regularity, product profile, and live hog profile are worth under various conditions; but to date, the answers tell us little about how the structure will change. The incentives are strictly single processor's profit incentives and one cannot conclude that because of the processor's incentives the industry structure will become more coordinated. The difficulties of incorporating farm production, detailed procurement activities and multiple objectives into a linear programming model make conclusions based on the results of a linear programming model tenuous.

**B. Hildreth-Jarrett Model**

The Hildreth-Jarrett model (50) is a multiperiod constrained utility maximization model of the livestock producing firm. For each period, utility is constrained by the firm's production function and two accounting relationships. The first accounting equation describes the relationship between product carryover from the previous period, production
and sales in the current period and carryover into the following period. The second accounting equation defines money withdrawals in each period as total revenue minus total cost.

The two periods are linked together because output carryover from the first period enters the first accounting relationship for the second period and is an argument of the second period's production functions. Also, fixed input existing at the end of the first period represents quantity of fixed input available at the beginning of the second period entering both the production function and the money withdrawal relationship.

The decision-making situation postulated is:

During a given time interval t, the entrepreneur knows the quantities of fixed inputs. He observes the prices of the output and inputs in the current period and forms anticipations about output and input prices in the following periods. He then decides variable input usage, production, sales, fixed input carryover into the second period, and money withdrawals and forms anticipations about variable input usage, production, sales, fixed input carryover and money withdrawals in the second period, so as to maximize his preference function subject to the constraints previously defined (50, p. 100).

Several characteristics of the model are interesting. First, some "variable" input usage decisions must be made in the previous production period and second, the firm's own output is used as an input in the production function.

Nineteen first order conditions are derived. Seven basic relationships are derived from first order conditions:

1. For an input decision made when price of product and price of input are known, the static condition that marginal-value
1. Expected marginal value product (MVP) equals price of the input holds.

2. For an input decision made before prices are known, expected MVP equals anticipated price of the input.

3. Expected marginal value product of a planned input equals anticipated price.

4. The marginal rate of substitution (MRS) between planned withdrawals and planned holdings of capital equipment equals the anticipated price of capital equipment.

5. The MRS between planned withdrawals in a current period and planned holdings of output for production purposes in the following period equals the anticipated price of the output in the current period.

6. The marginal contribution of the fixed resource to value of product in the current period plus the marginal contribution of the fixed resource to money withdrawals in the future period equals the subjective cost of a marginal unit of fixed resources in terms of expected future withdrawals.

7. The marginal increase in withdrawals in the future period due to an increase in output carryover equals the value of the reduction in current withdrawals occasioned by adding a unit to output carryover.

Similar types of relationships are derived in the model presented in Chapter IV.

The most important points to note are:
1. The model's objective function was a utility or preference function rather than simply a profit function.

2. Although the theoretical model was developed in terms of abstract relationships, Hildreth and Jarrett were able to relate the theoretical model to empirically derived relations.

C. Holdren's Nonprice Offer Variation

Holdren's book The Structure of a Retail Market and the Market Behavior of Retail Units (52) is related to this thesis because he develops a multiproduct model which incorporates nonprice offer variation. Holdren identifies 11 types of nonprice offer variations for retail supermarkets.1 Packaging, quality, environment in which exchange takes place, terms and conditions of sale, and product line are examples of nonprice offer variation.

It is useful to introduce the general form of the model.

Each product has a demand function of the form:

\[ w_n = f_n (r_1, r_2, \ldots, r_N, a_1, a_2, \ldots, a_M) \] (2.1)

where:

\[ n = 1, 2, \ldots, N \text{ products.} \]
\[ w_n = \text{quantity demand of product } n. \]
\[ r_n = \text{price of product } n. \]

1Holdren (52, pp. 102-124) identifies 13 offer variations, 11 of which are nonprice offer variations.
\( a_m = \text{nonprice variation in the seller's offer; } m = 1, 2, \ldots, M \) types of nonprice offer variation.

The seller's cost function is of the form

\[
K = K(w_1, w_2, \ldots, w_N, a_1, a_2, \ldots, a_M)
\]

(2.2)

The seller's profit function thus takes the form

\[
\pi = \sum_{n=1}^{N} r_n w_n - K
\]

(2.3)

For \( \pi \) to be a maximum, \( N + M \) first order conditions must be satisfied. That is for price offer variation, the \( N \) first order conditions are:

\[
\frac{\partial \pi}{\partial r_1} = w_1 + \sum_{n=1}^{N} (r_n - \frac{\partial K}{\partial w_n}) \frac{\partial w_n}{\partial r_1} = 0
\]

\[
\vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots
\]

(2.4)

\[
\frac{\partial \pi}{\partial r_N} = w_N + \sum_{n=1}^{N} (r_n - \frac{\partial K}{\partial w_n}) \frac{\partial w_n}{\partial r_N} = 0
\]

For nonprice offer variation the first order conditions are:

\[
\frac{\partial \pi}{\partial a_m} = \sum_{n=1}^{N} (r_n - \frac{\partial K}{\partial w_n}) \frac{\partial w_n}{\partial a_m} - \frac{\partial K}{\partial a_m} = 0 \quad m = 1, 2, \ldots, M
\]

(2.5)

Solving Equation 2.4 for margin on the \( N^{\text{th}} \) product, Equation 2.6 is derived:

\[
r_N - \frac{\partial K}{\partial w_n} = \frac{-w_N - \sum_{n=1}^{N-1} (r_n - \frac{\partial K}{\partial w_n}) \frac{\partial w_n}{\partial r_N}}{\partial w_n / \partial r_N}
\]

(2.6)
That is, margin for each product (price minus marginal cost) equals price offer variation cost in equilibrium. The right side of 2.6 deserves comment. The summation is the sum of margins for all other products multiplied by the change in quantity caused by a change in the price of the \( N \)th commodity. Given that \( \partial w_n / \partial r_N \) is negative, Holdren thus establishes the result:

\[ \ldots \text{if the dominant relationship is one of complementarity} \]

\[ \sum_{n=1}^{N-1} \left( r_n - \frac{\partial K}{\partial w_n} \right) \frac{\partial^2 w_n}{\partial a_M^2} < 0 \]

The equilibrium profit margin on the \( n \)th commodity may be zero, greater than zero, or less than zero (52, pp. 128-129).

Solving 2.5 for profit margins yields \( N \) times \( M \) equations of the form:

\[ r_N - \frac{\partial K}{\partial w_N} = \frac{\partial K}{\partial a_M} - \sum_{n=1}^{N-1} \left( r_n - \frac{\partial K}{\partial w_n} \right) \frac{\partial^2 w_n}{\partial a_M^2} \]

(2.7)

Again, the summation is the sum of total change in margin (per unit margin multiplied by the change in units) caused by changes in non-price variable \( a_m \). Assuming \( \sum_{n=1}^{N-1} \left( r_n - \frac{\partial K}{\partial w_n} \right) \frac{\partial^2 w_n}{\partial a_M^2} < 0 \) and \( \frac{\partial K}{\partial a_M} \) is invariant or increases at a rate less than one with respect to product line width, Holdren concludes "the wider the product line the higher is the equilibrium level of utilization of any \( a_m \)" (52, p. 131).

The most important implications of Holdren's work for this thesis are:

1. Nonprice offer variation was successfully merged into multi-product theory of the firm.
2. The theoretical model served as a very useful tool for development of insights into firm's behavior (see Chapter 8, of Holdren's book (52) for the full impact of this point).
III. ECONOMIC PSYCHOLOGY

Economic psychology implies interdisciplinary research using the conceptual and methodological principles of psychology on studies of economic behavior. As a field of study, economic psychology emphasizes the usefulness of both economic and psychological variables when explaining human behavior.

The concept of economic psychology is intuitively appealing because as social science researchers, our ability to predict human behavior should improve if both psychological and economic variables of the environment are included in the analyses. The more variables of the environment that can be analyzed, the better we should be able to predict and understand human reaction to the environment.

Chapter III has three sections. Section A elaborates on the above points and develops the need for psychological analysis of economic behavior. Section B identifies the psychological variables that will be analyzed as factors affecting hog producers' marketing decisions. Section C describes the procedures used for attaching quantitative values to psychological feelings.

A. Need for Psychology in Economics

The premise of this research is that economists could make great strides in understanding economic behavior if the effects of psychological variables as well as economic variables are analyzed. By including psychological variables in the analysis, economists may be able
to detect changes in economic behavior based on changes in psychological as well as economic stimuli.

The need for psychology in economics has been recognized for several decades. In 1918 J. M. Clark wrote

The economist may attempt to ignore psychology, but it is sheer impossibility for him to ignore human nature.... If the economist borrows his conception of man from the psychologist, his constructive work may have some chance of remaining purely economic in character. But if he does not, he will not thereby avoid psychology. Rather, he will force himself to make his own, and it will be bad psychology (22, p. 4).

Between 1918 and 1951, a great deal was written. George Katona's book Psychological Analysis of Economic Behavior (60) provides an excellent summary of the ideas presented by economists interested in psychological economics prior to 1951. Unfortunately by 1951 the state of the science had not progressed much beyond that indicated by Clark's 1918 statement. Katona stated

Although economic analysis in the main continues to disregard empirical psychological studies, it is not devoid of psychological assumptions. Most commonly it proceeds on the premise that human beings behave mechanistically (60, p. 6).

Katona's

...book purports to show that it makes a difference in our understanding of economic processes if we focus our attention on the human actors and on the psychological analysis of decision formation and actions (60, p. 2).

Katona urges economists to

...ask under what conditions economic behavior of a certain type, and under what conditions economic behavior of another type, is more likely to occur (60, p. 15).

Because of the nature of psychological economic analysis, the data must be obtained at the micro level. Motivation is a characteristic of individuals...
rather than of aggregates of individuals.

Katona's book is recommended for anyone desiring to determine the state of economic psychology in 1951. After the introductory section Parts II, III and IV cover consumer behavior, business behavior and economic fluctuations, respectively. Part V - Research Methods is especially important because it serves as a forecast of research that followed. In Chapter 15, Economic-Psychological Surveys, Katona states that economic psychology will not be able to rely on published data and will have to use sample-interview techniques. Much economic psychology research since Katona's book has used the research techniques proposed.

Three relatively recent studies that used survey techniques are reviewed.

Skinner (120) in 1969 published an empirical epilogue to Holdren's (52) theoretical model of supermarket behavior. Skinner's work is based on a sample of 300 Columbus, Ohio consumers. Each consumer rated the importance of 87 motivational statements using a 1 to 7 score (the higher the number the greater the importance to the consumer in selecting a supermarket). Many of the statements can be related to the different types of nonprice offer variation identified by Holdren. Skinner uses factor analysis to reduce and simplify the statements to eight basic motivational factors. Of importance is that Skinner was able to identify discrepancies between what the food industry thought consumers feel is important and what consumers feel is important.

Ladd (66) in 1967 analyzed the ranking of dairy bargaining cooperative objectives by cooperative managers. Consistent with Katona's philosophy, Ladd's beginning premise was that
Economists are interested in the objectives of economic agents because information on objectives can be used to understand and predict behavior (66, p. 881).

The results of the study are hypotheses about the determinants of the relative importance of various objectives to grade A milk cooperatives. Ladd uses discriminant analysis, multiple regression and principal components to analyze his data.

More recently, Ladd and Oehrtman (70) factor analyzed psychological-economic data from a survey of 242 fluid milk processing plant managers. Their objective was "to improve our understanding of market structure by determining some of the economic, sociological, and psychological variables that fluid-milk processors...believe are relevant to their marketing problems and by determining some of the important relations among these variables" (70, p. 547).

Although neither Ladd, Skinner nor Ladd and Oehrtman reference Katona's earlier work, their studies are for the most part consistent with and could fit very well in Parts II and III of Katona's book as examples of empirical economic psychology studies.

Although the frontier of economic psychology research as Katona recognized has been empiricized to some degree, further research can well be fruitful and more economists need to recognize the relevance of psychological influences on economic decisions. And new frontiers for economic psychology are being discovered. Fox (37) and Fox and Van Moeseke (38) are concerned with the problems of concept and measurement of economic and noneconomic objectives in development planning. As was Katona, Fox and Van Moeseke (38) are suggesting interdisciplinary work
when they suggest sociopsychological and economic rationale for the social income concept. Social income is defined as "the sum of the equivalent dollar values of all rewards during the current accounting period that are derived from endowments" (38, p. 23). Drawing heavily on sociopsychological concepts, they view the individual as seeking to optimize the allocation of his time among behavior settings. Fox suggests an "extension of general equilibrium theory to all outputs of a society" (37, p. 1). Fox has yet to conquer all of the measurement and aggregation problems Katona (60) raised but does again lay a thought provoking, if not rigorous, foundation for continued development and eventual empirical applications.

To be sure, incorporating psychological variables in economic analyses will not perfect the analyses. Problems remain. We must continue to base our work on the premise that human behavior is governed by laws that are not arbitrary, unpredictable, or indeterminate. Man must be assumed to react consistently to his economic and psychological stimuli.

Second, learning may change participants' perceptions of the psychological and economic environment. The possibility that a participant may experiment with alternative reactions to the same environment will make the road to learning the basic laws of human behavior less than smooth.

Despite the problems, the hypothesis that the inclusion of psychological attitude variables in the analysis will improve predictive power is maintained. This thesis is quite similar to work presented by
Skinner (120), Ladd (66), and Ladd and Oehrtman (70). Unlike the three studies mentioned, this volume also includes a theoretical general model similar to the work done by Holdren (52) which was later empiricized by Skinner. Section B identifies particular attitude variables that may affect hog marketing decisions and Section C outlines the procedure used to quantify the attitude variables.

B. Psychological Factors Influencing Hog Marketing Decisions

Two specific hog marketing activities—selection of outlet and choice of weight—are examined.

1. Outlet selection

Hog producers can choose between different types of outlets and may be able to choose between several outlets of each different type. Types of outlets available include salaried packer buying stations, packing plants, auction markets, independent dealers and order buyers, and terminal markets.

The goal is to identify and measure the relative importance of psychological factors that affect producers' hog outlet type choices. In particular, the relative importance of convenience, premium and discount schedules, reliability of weighing, sorting and grading procedures, amount of personal attention received, the number of competing buyers at the outlet are factors that could be of importance to producers. Correlation of the relative importance of the reasons for choosing an outlet type with producer characteristics and outlet type choices may be especially useful. If producers' characteristics and attitudes are changing we may
expect to see changes in marketing patterns and the structure of hog procurement activities. Prediction of structural change is more likely to be accurate if we are able to know why outlet types are preferred.

2. **Weight of hogs marketed**

    Producers may also sell hogs at various weights. Understanding why producers sell at various weights is important because it may help us understand the time lapse between hog farrowing and marketing. Also the quantity of pork available for consumption is partially a function of the weight at which the hogs are sold.

    We need to know whether producers understand how the most profitable weight for production varies in relation to price level change, feed cost changes, variation in premiums and discounts for various weights and the genetic characteristics of the hogs. The reasons for not varying the weight of hogs marketed also needs to be understood. Information programs could be developed to illuminate the potential merits of alternative market weight strategies.

    Choice of market weight may be related to type of production unit, time available to market hogs, feelings about what is good for the industry, feed supplies, and expected hog prices.

    Section C describes the procedure used to quantify the relationships between psychological motivation, producer characteristics and marketing activities.
C. Quantifying Psychological Variables

Producers were surveyed with respect to the importance of various factors that may have influenced their hog marketing decisions. The questionnaire is included in Appendix B.

Sections IV and V of the questionnaire include the questions about outlet selection and market weight choice. The basic procedure in both sections is to first ask producers what they did and then to ask them to rate the importance of factors that may have influenced their decisions. In general, the premise was that if you want to know how individuals feel about a particular factor, ask them. This premise requires that a respondent knows how he feels about the particular factor and is willing to express that feeling.

The rating given by each producer is a quantitative measure of the producer's attitude toward the factor. An attitude is the degree of effect associated with a psychological object. The psychological object in this case is the factor for which the rating was given.

Each factor was rated once using a 1-99 scale. The directions to the respondents were:

In some of the following questions I will be asking you to use this scale to assess the importance of different factors affecting decisions made by hog producers. You will note the "1" indicates it is of no importance, while "99" indicates maximum importance, with various degrees of importance between. We would appreciate your making the distinctions as fine as you are able for the questions on which we use this scale.
The use of 99 response categories has the advantage that it allows people more freedom to choose a category that reflects their judgment than does a five or ten point scale. Also, research (74, 141) has indicated that when responses are transformed to normal deviates, reliability and the number of categories is positively correlated. The rationale for the transformation to normal deviates is presented by Liu (74)¹. The normal

¹Liu (74) also proposes transforming the standard deviates by dividing by the variance of responses calculated for each respondent. This was not done because reliability is not expected to improve if the questions do not evoke defensive reactions or ego-involvement (11, pp. 178-200). The factors scored in the present questionnaire were not likely to evoke defensive reactions or ego-involvement.
deviates corresponding to the 1-99 categories are presented in Table 3.1.

In question 23 on page 11 (see Appendix B) of the questionnaire, producers were asked to list markets which they used and in question 26, page 13, the producer was asked to rate the importance of various factors' influence on his choice of outlets. Question 32, page 18, asked producers about their market practices with respect to weight. Those producers marketing all of their hogs at only one weight or varying weight of marketing for season of the year were asked to rate the importance of the influence of factors listed in question 33. Those indicating they change preferred weight ranges according to current conditions were asked to rate the influence of factors listed in question 34.
### Table 3.1. Standard normal deviates of responses

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IV. THE GENERAL MODEL FORMULATION

A. Introduction

A theoretical model of a hog producer's week-to-week hog production and marketing decisions is developed and presented. The purpose of the theoretical model is to lead economists to ask the right questions—not to answer them. The model helps organize thoughts and is used to generate hypotheses about systematic variation in variables associated with decision processes and the decisions that were made. Perhaps more important, the implicit assumptions that exist in a hypothesis testing situation are more likely to surface when the hypotheses are generated in the context of a more general theoretical model.

1. General structure

Special effort is taken to attempt to include the important elements of the hog producer's week-to-week\(^1\) production and marketing decisions. The model is designed for the utility maximizing hog producer who recognizes the impact of decisions made in one period on the set of alternatives available in the following period and is willing to sell hogs at more than one weight. Particular emphasis is placed on attitudes and characteristics that influence and constrain the producers' sales decisions.

The model is a constrained utility maximization model. The

\(^1\)A week in this context has many of the characteristics of a Hicks week (49, p. 122). Prices are not allowed to change within the week and there is only one opportunity to make decisions at the start of the week. A week in this model is a seven-day period.
producer's utility maximization objective is constrained by production functions, sales functions, marketing cost functions, and accounting relationships connecting the multiple time periods in a planning horizon. A planning horizon consists of the number of weeks over which the hog producer has developed input and output price expectations. The end of the planning horizon is defined by the end of his expectations.

It is assumed the producer has single valued expectations of future prices and costs although specification of his objective function as a utility function allows high subjective discounting rates for future money withdrawals. Degree of uncertainty about the future is also indicated by the length of the planning horizon.

Multiple outlets in the model are different types of outlets. It is assumed the producer decides which outlet of each type that he considers best and then decides and compares types of outlets. Multiple products in the model are different weights of hogs. Other farm enterprises and activities are included only as exogenous producer characteristics.

The producer is assumed to enter the planning horizon with a group of barrows and gilts averaging 190-200 pounds. Each week in his planning horizon, the producer decides which hogs to sell (if any) and which should be carried over to be used as an input of the production function the following period. He must decide to which type of outlet the hogs he decides to sell will be shipped.

The producer is assumed to know prices of inputs and outputs for the first week of the planning horizon and to have developed expectations about
prices in future weeks of the planning horizon.

2. **Notation**

Variables will carry one or more of four possible subscripts signifying time periods within the planning horizon \( t = 1, 2, \ldots, T \) weeks, output weights \( i = 1, 2, \ldots, I \) weights, market outlet type \( j = 1, 2, \ldots, J \) outlet types), or variable input type \( k = 1, 2, \ldots, K \) inputs). Greek symbols will be used to identify functional forms. An asterisk on a variable indicates the variable is subjectively rather than objectively measured. Notation for each variable is defined after its initial use, and a glossary of notation is included in Appendix A.

**B. The Utility Function**

The utility function represents the producer's subjective evaluation of his well-being given various results from his hog operation. Although the model is developed for a firm, a profit function was not used as the objective function for three reasons.

First, a utility function is believed to more realistically reflect the true objective function of producers. Few people are likely to agree on profits as their only objective. A utility function leaves room for flexibility in what the firm considers important. Profit maximization can be considered a special form of utility maximization.

The second related reason for adopting utility maximization is that the utility framework allows the valuation of marginal dollars or returns to diminish. A profit function does not. That is, a producer earning
$1.20 profit per head is not generally concerned as much about earning an additional ten cents per head profit as is a producer earning 10 cents per head profit.

Third, multiperiod analysis requires the producer to develop subjective expectations about future prices and costs. Monetary returns based on the subjective expectations should be evaluated using an ordinal rather than cardinal function. One might argue that returns from future periods could be evaluated using a discount rate. I will argue that if a discount rate is used the magnitude of the rate should be personalized using factors that would be subjectively evaluated by producers. The subjective nature of the producer's objectives is best recognized by specifying a utility function objective.

Formally stated, the utility function is Equation 4.1:

$$
\phi = \phi(MW_1, MW_2, \ldots, MW_T, C_{T+1,1}, C_{T+1,2}, \ldots, C_{T+1,I}) \tag{4.1}
$$

That is, utility is a function of money withdrawals (net income from the hog enterprise, $MW_t$) in each of the $T$ periods within the planning horizon and of carryover ($C_{T+1,i}$) of each of the $I$ product qualities into the next planning horizon. It is assumed that the marginal utility of additional money withdrawals is positive but diminishing. The marginal utility of carrying various weights of hogs over into another planning horizon will be positive.

Money withdrawals are defined by $T$ equations of the form:

$$
MW_t = \sum_{i,j} P_{tij} S_{tij} - \sum_{i,k} h_{tik} Q_{tik} - \sum_{j} MC_{tj} \tag{4.2}
$$
where:

\[ P_{tij} = \text{output prices in period } t \text{ for quality } i \text{ at outlet } j. \]

Prices in the current period are known, those in future are expectations.

\[ S_{tij} = \text{sales and planned sales to outlet } j \text{ of quality } i \text{ in period } t. \]

\[ h_{tk} = \text{prices and expected prices of input } k \text{ in period } t. \]

Input prices for the first period in the planning horizon are known, those in other periods are expectations.

\[ q_{tik} = \text{quantity of input } k \text{ used to produce quality } i \text{ in period } t. \]

\[ MC_{tj} = \text{total marketing cost at outlet type } j \text{ in period } t. \]

That is, money withdrawals in period \( t \) equals total revenue from sales of \( I \) qualities at \( J \) market types minus total cost of \( K \) inputs used to produce \( I \) different qualities and total marketing costs at \( J \) market outlet types.

Although producers' characteristics and attitudes do not appear in the utility function, by substituting the definition of money withdrawals into 4.1, attitude and producer characteristics do affect the value of the objective function because sales are a function of attitudes and producer's characteristics. As will be shown later, this means that even though utility is not directly a function of farmers' attitudes and characteristics, because of the constraints imposed, the equilibrium level of utility does depend on the farmers' attitudes and characteristics.
C. The Sales Function

Sales \( S_{tij} \) in period \( t \) of quality \( i \) at outlet type \( j \) are a function of market characteristics, producers' characteristics, producers' attitudes toward the outlet, prices, producers' attitudes toward selling a particular weight and production. All of the sales function arguments except production are exogenous variables. Therefore, none of them appear in the presentation of the first order conditions. Vectors will be used to represent the exogenous characteristics and attitudes with examples of the types of elements in each of the vectors given. All of the characteristics and attitudes are identified in the following chapter.

The vector MCHAR will represent market characteristics. Many of Holdren's (52) types of nonprice offer variations would be market characteristics. For example, location, distance from the consumer (producer) and time required to market at the outlet are factors that could be included in the vector. Note that characteristics of all \( J-1 \) competing outlets are included as well as characteristics of outlet \( j \). The number and types of characteristics included in the vector can be adjusted for particular applications of the model.

Producer's attitudes towards outlet types (PAT0*) and producers' attitudes towards sales at different weights (PATW*) are vectors of variables subjectively measured using the technique presented in Chapter III. Convenience and personal attention received are examples of factors related to outlet types that producers could be asked to rate on importance. Among the subjective factors that may be related to choice
of a particular weight are need of facilities for other hogs and labor availability.

Producer characteristics are represented by the vector PCHAR. Examples of variables included in PCHAR are number of years as a hog producer, number of acres in cropland and number of bids received each time hogs are marketed.

Prices for all qualities at all market types are included in the sales function for each quality, outlet, and time period. Sales of one quality at an outlet is a function of prices of all qualities at that outlet. The vector of prices is represented by P.

The number of hogs at each weight in period t \((X_{ti}, i = 1, \ldots, I)\) is included as an argument of the sales functions for weight \(i\) in period t. The production variables \((X_{t1})\) are the only endogenous arguments of the sales functions.

The sales function is formally stated as Equation (4.3):

\[
S_{tij} = \Gamma_{tij}(MCHAR, PATO*, PATW*, PCHAR, P, X_{t1}, X_{t2}, \ldots, X_{ti}) \tag{4.3}
\]

That is, the level of sales by a producer in a time period of a particular quality at a particular outlet depends on market characteristics of all outlets, the producers' attitudes toward the importance of factors associated with outlet types, producer characteristics, prices at all outlets, factors related to selling particular weights and production. There are \(T \times I \times J\) sales constraints in the model.

The interdependency of the weight decisions and outlet selection decisions should be recognized. Sales to the \(j^{th}\) outlet are a function
of the producer's attitudes towards selling different weights and the number of hogs at each of the different weights as well as market characteristics, producer characteristics, the producer's attitudes toward outlets, and prices. Sales of the \( i^{th} \) weight are a function of the market characteristics of the outlets being considered, prices of the various qualities at the different outlets, the producer's attitudes towards outlets as well as the producer's attitudes towards selling different weights, producer characteristics, prices and the number of hogs at the different weights available for sale. Simply stated, the producer's outlet decision may be a function of his weight decision and the producer's weight decision may depend on the outlets he is considering.

The hypothesized signs of the first partial derivatives of the sales function with respect to its arguments are presented in Chapter V where specific elements in MCHAR, PATW*, PATO* and PCHAR are identified.

D. The Production Functions

The production functions for the model are better thought of as short-run transformation functions or weight gaining functions. Within the planning horizon of the model, only growing or weight gaining activities for butcher hogs are considered. That is, smaller hogs gain weight and the production function expresses the transformation of smaller to larger hogs. It is assumed the hogs do not lose weight therefore larger butcher hogs do not enter the production function for smaller butcher hogs. Inputs to the production function are variable feed inputs and output carryover of the weight in question (weight \( i \)) and the next smaller
weight \((i-1)\) from the previous period of the planning horizon. There are \(I \times T\) production or weight-gaining relationships of the form:

\[
X_{t_i} = \psi_{t_i}(q_{t_1i}, q_{t_2i}, \ldots, q_{t_{ki}}, C_{t_i, i-1}, i, C_{t_i, i, i})
\]

That is, the number of hogs at the \(i^{th}\) weight in period \(t\) is a function of the quantities of variable inputs (feed) used \((q_{t_{ki}})\) and the quantities of smaller hogs produced in the previous period used in production of larger hogs this period. Because of the short time periods involved, fixed facilities are ignored.

The marginal physical productivities of variable purchased inputs \((q_{t_{ki}})\) are assumed positive but diminishing. The marginal physical productivities of carryover are expected to be positive with \(\frac{\partial \psi_{t_i}}{\partial C_{t_i, i-1, i}}\) less than \(\frac{\partial \psi_{t_i}}{\partial C_{t_i, i, i}}\).

\(T \times I\) accounting equations define carryover out of the period as the difference between production and sales:

\[
C_{t+1, i, i+1} + C_{t+1, i, i} = X_{t_i} - \sum_j S_{tij}
\]

E. Marketing Costs

Marketing cost in period \(t\) for market type \(j\) is a function of \(I\) distance to the outlet \((D_j)\), volume shipped to outlet \(j\) \((\sum_i S_{tij})\), season of the year measured by the opportunity cost of labor \(OCL_t\), time spent marketing \((TM_j)\), shrinkage \((SH_j)\) and marketing services \((MS_j)\) for which there is a cost.

Like the production function, the marketing cost function represents
a technical relationship. There are $T \times J$ marketing cost equations of the form:

$$MC_{tj} = \theta_{tj}(D_j, \sum_{i} S_{tij}, OCL_t, SH_j, TM_j, MS_j)$$

The first partials of $\theta_{tj}$ with respect to all arguments are expected to be positive. The second partials with respect to $D_j$ and $\Sigma_{tij}$ are expected to be negative. The second partials with respect to $OCL_t$, $SH_j$, $TM_j$, $MS_j$, are generally expected to be nearly zero.

**F. The Restricted Full Model**

A model with a two-period planning horizon ($T = 2$), one variable input, ($K = 1$), two weights of output ($I = 2$), and two outlet types ($J = 2$) is presented. To simplify the presentation $U_{tij}$, $U_{ti}$, and $U_{ij}$ will be used to represent the right hand sides of Equations 4.3, 4.5, and 4.6. Money withdrawals ($MW_t$) are defined by Equation 4.2 and carryover between periods and out of the planning horizon is defined by Equation 4.4. Carryover of the two qualities into the planning horizon is exogenously determined and represented by $C_{ll}$ and $C_{l2}$.

The model stated in standard Lagrangian form is:

\[\text{Dot notation indicates summation. } C_{ll}, C_{l2}, C_{31}, C_{32} \text{ are carryover variables summed over final product usage.}\]
\[
\text{MAX } L = \phi - \gamma_1 (S_{111} - \Gamma_{111}) - \gamma_2 (S_{121} - \Gamma_{121}) \\
- \gamma_3 (S_{112} - \Gamma_{112}) - \gamma_4 (S_{122} - \Gamma_{122}) - \gamma_5 (S_{211} - \Gamma_{211}) \\
- \gamma_6 (S_{221} - \Gamma_{221}) - \gamma_7 (S_{212} - \Gamma_{212}) - \gamma_8 (S_{222} - \Gamma_{222}) \\
- \lambda_1 (X_{11} - \Psi_{11}) - \lambda_2 (X_{12} - \Psi_{12}) - \lambda_3 (X_{21} - \Psi_{21}) - \lambda_4 (X_{22} - \Psi_{22}) \\
- \mu_1 (MC_{11} - \Theta_{11}) - \mu_2 (MC_{12} - \Theta_{12}) - \mu_3 (MC_{21} - \Theta_{21}) - \mu_4 (MC_{22} - \Theta_{22}) \\
- \alpha_1 [M_W_1 - P_{111} S_{111} - P_{112} S_{112} - P_{121} S_{121} - P_{122} S_{122} \\
+ h_{11} (q_{111} + q_{112}) + MC_{11} + MC_{12}] \\
- \alpha_2 [M_W_2 - P_{211} S_{211} - P_{212} S_{212} - P_{221} S_{221} - P_{222} S_{222} \\
+ h_{21} (q_{211} + q_{212}) + MC_{21} + MC_{22}] \\
- \alpha_3 (S_{111} + S_{112} - X_{11} + C_{211} + C_{212}) - \alpha_4 (S_{121} + S_{122} - X_{12} + C_{222}) \\
- \alpha_5 (S_{211} + S_{212} - X_{21} + C_{31}) - \alpha_6 (S_{221} + S_{222} - X_{22} + C_{32}) \\
- \alpha_7 (C_{111} + C_{112} - C_{111}) \\
(4.7)
\]

where the \( \gamma, \lambda, \mu, \alpha \) are Lagrangian multipliers. The constraints with \( \gamma \) multipliers are the sales constraints—the relevant form of Equation 4.3 for each period, outlet type, and product quality. The \( \lambda \) multipliers are for the four \((I \times T)\) production function constraints. The \( \mu \) multipliers apply to the marketing cost constraints and the \( \alpha \) multipliers apply to the accounting equations. The constraints associated with the \( \alpha_1 \) and \( \alpha_2 \) multipliers define money withdrawals in each period.

The \( \alpha_3 \) and \( \alpha_4 \) constraints are of the standard form stated in Equation
4.4 and are hog counting relationships. The $\alpha_5$ and $\alpha_6$ constraints are different forms of Equation 4.4 because carryover into the next planning horizon ($C_{31'}$ and $C_{32'}$) is not allocated to producing different products until the next planning horizon. The constraint associated with $\alpha_7$ insures equality between endogenously determined allocations of carry-in into the current planning horizon ($C_{111'}$, $C_{112'}$) and the volume carried in ($C_{11}$). All of weight two carry-in must be used in production of weight two. The decision variables of the model are $X_{11}$, $X_{12}$, $X_{21}$, $X_{22}$, $S_{111'}$, $S_{121'}$, ..., $S_{222'}$, $C_{111'}$, $C_{112'}$, $C_{211'}$, $C_{212'}$, $C_{222'}$, $C_{31'}$, $C_{32'}$, $q_{111'}$, $q_{112'}$, $q_{211'}$, $q_{212'}$, $MW_1$, $MW_2$, $MC_{11'}$, $MC_{12'}$, $MC_{21'}$, $MC_{22'}$.

1. **The first order conditions**

The 53 first order conditions for maximization are represented by Equations 4.8 to 4.36 and the 24 constraints.

The partial derivatives of 4.7 with respect to production variables are Equations 4.8 through 4.11:

$$\frac{\partial L}{\partial x_{11}} = \gamma_1 \frac{\partial x_{11}}{\partial x_{11}} + \gamma_2 \frac{\partial x_{12}}{\partial x_{11}} + \gamma_3 \frac{\partial x_{11}}{\partial x_{11}} + \gamma_4 \frac{\partial x_{12}}{\partial x_{11}} - \lambda_1 + \alpha_3 = 0$$

(4.8)

$$\frac{\partial L}{\partial x_{12}} = \gamma_1 \frac{\partial x_{11}}{\partial x_{12}} + \gamma_2 \frac{\partial x_{12}}{\partial x_{12}} + \gamma_3 \frac{\partial x_{11}}{\partial x_{12}} + \gamma_4 \frac{\partial x_{12}}{\partial x_{12}} - \lambda_2 + \alpha_4 = 0$$

(4.9)

$$\frac{\partial L}{\partial x_{21}} = \gamma_5 \frac{\partial x_{21}}{\partial x_{21}} + \gamma_6 \frac{\partial x_{22}}{\partial x_{21}} + \gamma_7 \frac{\partial x_{21}}{\partial x_{21}} + \gamma_8 \frac{\partial x_{22}}{\partial x_{21}} - \lambda_3 + \alpha_5 = 0$$

(4.10)
The partial derivatives of Equation 4.7 with respect to the eight sales variables are Equations 4.12 through 4.19:\(^1\)

\[
\frac{\partial L}{\partial s_{111}} = -\gamma_1 + \alpha_1 p_{111} - \alpha_3 + \mu_1 \left( \frac{\partial \theta_{111}}{\partial s_{111}} \right) + \frac{\partial \Theta_{111}}{\partial s_{111}} = 0 \quad (4.12)
\]

\[
\frac{\partial L}{\partial s_{121}} = -\gamma_2 + \alpha_1 p_{121} - \alpha_4 + \mu_1 \left( \frac{\partial \Theta_{111}}{\partial s_{121}} \right) = 0 \quad (4.13)
\]

\[
\frac{\partial L}{\partial s_{112}} = -\gamma_3 + \alpha_1 p_{112} - \alpha_3 + \mu_2 \left( \frac{\partial \Theta_{12}}{\partial s_{112}} \right) + \frac{\partial \Theta_{112}}{\partial s_{112}} = 0 \quad (4.14)
\]

\[
\frac{\partial L}{\partial s_{122}} = -\gamma_4 + \alpha_1 p_{122} - \alpha_4 + \mu_2 \left( \frac{\partial \Theta_{12}}{\partial s_{122}} \right) + \frac{\partial \Theta_{122}}{\partial s_{122}} = 0 \quad (4.15)
\]

\[
\frac{\partial L}{\partial s_{211}} = -\gamma_5 + \alpha_2 p_{211} - \alpha_5 + \mu_3 \left( \frac{\partial \Theta_{21}}{\partial s_{211}} \right) + \frac{\partial \Theta_{21}}{\partial s_{211}} = 0 \quad (4.16)
\]

\[
\frac{\partial L}{\partial s_{221}} = -\gamma_6 + \alpha_2 p_{221} - \alpha_6 + \mu_3 \left( \frac{\partial \Theta_{21}}{\partial s_{221}} \right) + \frac{\partial \Theta_{221}}{\partial s_{221}} = 0 \quad (4.17)
\]

\[
\frac{\partial L}{\partial s_{212}} = -\gamma_7 + \alpha_2 p_{212} - \alpha_5 + \mu_4 \left( \frac{\partial \Theta_{21}}{\partial s_{212}} \right) + \frac{\partial \Theta_{21}}{\partial s_{212}} = 0 \quad (4.18)
\]

\(^1\)All of the partials of the summation terms with respect to an element in the summation are, of course, equal to 1 (e.g., \(\frac{\partial \Theta_{111}}{\partial s_{111}} = 1\)).
The partial derivatives of 4.7 with respect to the seven endogenous carry-over variables \(^1\) are Equations 4.20 through 4.26:

\[
\frac{\partial L}{\partial S_{222}} = -\gamma_1 + \alpha_2 P_{222} - \alpha_6 + \mu_4 \left( \frac{\partial S_{212}}{\partial S_{222}} \right) \frac{\partial S_{212}}{\partial S_{222}} = 0 \quad (4.19)
\]

\[
\frac{\partial L}{\partial c_{111}} = \lambda_1 \frac{\partial \psi_{11}}{\partial c_{111}} - \alpha_7 = 0 \quad (4.20)
\]

\[
\frac{\partial L}{\partial c_{112}} = \lambda_2 \frac{\partial \psi_{12}}{\partial c_{112}} - \alpha_7 = 0 \quad (4.21)
\]

\[
\frac{\partial L}{\partial c_{211}} = \lambda_3 \frac{\partial \psi_{21}}{\partial c_{211}} - \alpha_3 = 0 \quad (4.22)
\]

\[
\frac{\partial L}{\partial c_{212}} = \lambda_4 \frac{\partial \psi_{22}}{\partial c_{212}} - \alpha_3 = 0 \quad (4.23)
\]

\[
\frac{\partial L}{\partial c_{222}} = \lambda_4 \frac{\partial \psi_{22}}{\partial c_{222}} - \alpha_4 = 0 \quad (4.24)
\]

\(^1\)Since the amount of carryover into the current planning horizon is fixed (\(c_{11.} \) and \(c_{12.} \)) and heavy hogs cannot be used to produce light hogs the production functions of the model are rather special forms of Equation 4.5. That is:

\[
X_{11} = \psi_{11}(q_{111}, c_{111})
\]

\[
X_{12} = \psi_{12}(q_{112}, c_{112}, \bar{c}_{12.})
\]

\[
X_{21} = \psi_{21}(q_{211}, c_{211})
\]

\[
X_{22} = \psi_{22}(q_{212}, c_{212}, c_{222})
\]
\[ \frac{\partial L}{\partial c_{31}} = \frac{\partial \phi}{\partial c_{31}} - \alpha_5 = 0 \] (4.25)

\[ \frac{\partial L}{\partial c_{32}} = \frac{\partial \phi}{\partial c_{32}} - \alpha_6 = 0 \] (4.26)

The partial derivatives of Equation 4.7 with respect to quantities of variable purchased input used are Equations 4.27 through 4.30:

\[ \frac{\partial L}{\partial q_{111}} = \lambda_1 \frac{\partial \psi_{11}}{\partial q_{111}} - \alpha_1 h_{11} = 0 \] (4.27)

\[ \frac{\partial L}{\partial q_{112}} = \lambda_2 \frac{\partial \psi_{12}}{\partial q_{112}} - \alpha_1 h_{11} = 0 \] (4.28)

\[ \frac{\partial L}{\partial q_{211}} = \lambda_3 \frac{\partial \psi_{21}}{\partial q_{211}} - \alpha_2 h_{21} = 0 \] (4.29)

\[ \frac{\partial L}{\partial q_{212}} = \lambda_4 \frac{\partial \psi_{22}}{\partial q_{212}} - \alpha_2 h_{21} = 0 \] (4.30)

The partials with respect to money withdrawals are Equations 4.31 and 4.32:

\[ \frac{\partial L}{\partial mw_1} = \frac{\partial \phi}{\partial mw_1} - \alpha_1 = 0 \] (4.31)

\[ \frac{\partial L}{\partial mw_2} = \frac{\partial \phi}{\partial mw_2} - \alpha_2 = 0 \] (4.32)

The partials of 4.7 with respect to marketing costs are Equations 4.33 through 4.36:
\[ \frac{\partial L}{\partial \mathbf{C}_{11}} = -\mu_1 - \alpha_1 = 0 \]  
\[ \frac{\partial L}{\partial \mathbf{C}_{12}} = -\mu_2 - \alpha_1 = 0 \]  
\[ \frac{\partial L}{\partial \mathbf{C}_{21}} = -\mu_3 - \alpha_2 = 0 \]  
\[ \frac{\partial L}{\partial \mathbf{C}_{22}} = -\mu_4 - \alpha_2 = 0 \]  

2. **Solutions for Lagrangian multipliers**

Solutions for the Lagrangian multipliers are given by Equations 4.37 through 4.57. The equation numbers of the equations used in solving for each Lagrangian are shown in parentheses following each solution. Lagrangian solutions are shown in the order in which the Lagrangian multipliers are shown in Equation 4.7, not necessarily in the order in which the solutions were derived.

\[ \gamma_1 = \frac{\partial \phi}{\partial \mathbf{M}_{W_1}} \mathbf{P}_{111} - \frac{(\partial \phi/\partial \mathbf{M}_{W_2}) \mathbf{C}_{21}(\partial \psi_{22}/\partial q_{212}) - (\partial \phi/\partial \mathbf{M}_{W_1}) (\partial \theta_{12}/\partial \mathbf{S}_{111})}{(\partial \psi_{22}/\partial q_{212})} \]  
\[ \gamma_2 = \frac{\partial \phi}{\partial \mathbf{M}_{W_1}} \mathbf{P}_{121} - \frac{(\partial \phi/\partial \mathbf{M}_{W_2}) \mathbf{C}_{21}(\partial \psi_{22}/\partial q_{212}) - (\partial \phi/\partial \mathbf{M}_{W_1}) (\partial \theta_{12}/\partial \mathbf{S}_{111})}{(\partial \psi_{22}/\partial q_{212})} \]  
\[ \gamma_3 = \frac{\partial \phi}{\partial \mathbf{M}_{W_1}} \mathbf{P}_{112} - \frac{(\partial \phi/\partial \mathbf{M}_{W_2}) \mathbf{C}_{21}(\partial \psi_{22}/\partial q_{212}) - (\partial \phi/\partial \mathbf{M}_{W_1}) (\partial \theta_{12}/\partial \mathbf{S}_{112})}{(\partial \psi_{22}/\partial q_{212})} \]
\[\gamma_4 = \frac{\partial \phi}{\partial \mathbf{M}_1} \mathbf{P}_{122} - \frac{(\partial \phi/\partial \mathbf{M}_2) h_{21} (\partial \psi_{22}/\partial \mathbf{C}_{222})}{(\partial \psi_{22}/\partial \mathbf{q}_{212})} - \frac{\partial \phi}{\partial \mathbf{M}_1} \frac{\partial \theta_{12}}{\partial \mathbf{S}_{1i2}} \]  
(4.40)

\[\gamma_5 = \frac{\partial \phi}{\partial \mathbf{M}_2} \mathbf{P}_{211} - \frac{\partial \phi}{\partial \mathbf{C}_{31}} - \frac{\partial \phi}{\partial \mathbf{M}_2} \frac{\partial \theta_{21}}{\partial \mathbf{S}_{2i1}} \]  
(4.41)

\[\gamma_6 = \frac{\partial \phi}{\partial \mathbf{M}_2} \mathbf{P}_{221} - \frac{\partial \phi}{\partial \mathbf{C}_{32}} - \frac{\partial \phi}{\partial \mathbf{M}_2} \frac{\partial \theta_{21}}{\partial \mathbf{S}_{2i1}} \]  
(4.42)

\[\gamma_7 = \frac{\partial \phi}{\partial \mathbf{M}_2} \mathbf{P}_{212} - \frac{\partial \phi}{\partial \mathbf{C}_{31}} - \frac{\partial \phi}{\partial \mathbf{M}_2} \frac{\partial \theta_{22}}{\partial \mathbf{S}_{2i2}} \]  
(4.43)

\[\gamma_8 = \frac{\partial \phi}{\partial \mathbf{M}_2} \mathbf{P}_{222} - \frac{\partial \phi}{\partial \mathbf{C}_{32}} - \frac{\partial \phi}{\partial \mathbf{M}_2} \frac{\partial \theta_{22}}{\partial \mathbf{S}_{2i2}} \]  
(4.44)

\[\lambda_1 = \frac{(\partial \phi/\partial \mathbf{M}_1) h_{11}}{(\partial \psi_{11}/\partial \mathbf{q}_{111})} \]  
(4.45)

\[\lambda_2 = \frac{(\partial \phi/\partial \mathbf{M}_1) h_{11}}{(\partial \psi_{12}/\partial \mathbf{q}_{112})} \]  
(4.46)
\[ \lambda_3 = \frac{(\partial \phi / \partial \mathbf{m}_2) h_{21}}{(\partial \psi_{21} / \partial q_{211})} \]  
(4.47)

\[ \lambda_4 = \frac{(\partial \phi / \partial \mathbf{m}_2) h_{21}}{(\partial \psi_{22} / \partial q_{212})} \]  
(4.48)

\[ \mu_1 = \mu_2 = -\partial \phi / \partial \mathbf{m}_1 \]  
(4.49)

\[ \mu_3 = \mu_4 = -\partial \phi / \partial \mathbf{m}_2 \]  
(4.50)

\[ \alpha_1 = \frac{\partial \phi}{\partial \mathbf{m}_1} \]  
(4.51)

\[ \alpha_2 = \frac{\partial \phi}{\partial \mathbf{m}_2} \]  
(4.52)

\[ \alpha_3 = \frac{(\partial \phi / \partial \mathbf{m}_2) h_{21} (\partial \psi_{21} / \partial q_{211})}{(\partial \psi_{21} / \partial q_{211})} = \frac{(\partial \phi / \partial \mathbf{m}_2) h_{21} (\partial \psi_{22} / \partial q_{212})}{(\partial \psi_{22} / \partial q_{212})} \]  
(4.53)
\[ \alpha_4 = \frac{\partial \phi / \partial MW_1 h_{21} (\partial \psi_{22} / \partial C_{222})}{(\partial \psi_{22} / \partial q_{221})} \]  
\[ (4.24, 4.48) \]

\[ \alpha_5 = \frac{\partial \phi}{\partial C_{31}}. \]  
\[ (4.25) \]

\[ \alpha_6 = \frac{\partial \phi}{\partial C_{32}}. \]  
\[ (4.26) \]

\[ \alpha_7 = \frac{(\partial \phi / \partial MW_1) h_{11} (\partial \psi_{11} / \partial C_{111})}{(\partial \psi_{11} / \partial q_{111})} = \frac{(\partial \phi / \partial MW_1) h_{11} (\partial \psi_{12} / \partial C_{112})}{(\partial \psi_{12} / \partial q_{112})} \]  
\[ (4.20, 4.21, 4.45, 4.46) \]

3. **Relationships**

The solutions for \( \alpha_7 \) measure the sensitivity of the optimal value of the objective function to variation in the number of units of carry-over (\( C_{11} \)) into the planning horizon. Assuming \( \frac{\partial \phi}{\partial MW_1} \), \( h_{11} \), \( \frac{\partial \psi_{11}}{\partial q_{111}} \), \( \frac{\partial \psi_{11}}{\partial C_{111}} \), and \( \frac{\partial \psi_{12}}{\partial C_{112}} \) are positive, the objective function value and \( C_{11} \) are positively related.

Using the dual solutions for \( \alpha_7 \) presented in Equation 4.57 and rearranging, Equation 4.58 is derived:

\[ \frac{(\partial \psi_{11} / \partial C_{111})}{(\partial \psi_{11} / \partial q_{111})} = \frac{(\partial \psi_{12} / \partial C_{112})}{(\partial \psi_{12} / \partial q_{112})} \]  
\[ (4.58) \]
Using the dual solutions for $\alpha_3$ presented in Equation 4.53 and rearranging, Equation 4.59 is derived:

$$\frac{\psi_{21}/\partial c_{211}}{\psi_{21}/\partial q_{211}} = \frac{\psi_{22}/\partial c_{212}}{\psi_{22}/\partial q_{212}} \quad (4.59)$$

Equations 4.58 and 4.59 express the first order conditions that inputs should be allocated to producing each weight such that ratios of the marginal physical products of each input producing weight one should equal the ratio of marginal physical products for each input producing weight two. Note that carryover of weight two is not used in production of weight one\(^1\) and therefore marginal productivity allocation of weight two carryover between products is not specified by Equations 4.58 and 4.59.

Substitution of the definitions for $\gamma_1$, $\gamma_2$, $\gamma_3$, $\gamma_4$, $\lambda_1$, and $\alpha_3$, (Equations 4.37, 4.38, 4.39, 4.40, 4.45, and 4.53\(^2\)) into Equation 4.8 yields 4.60:

\(^1\)Use of larger butcher hogs to produce smaller butcher hogs is not allowed.

\(^2\)The second definition of $\alpha_3$ has been used throughout.
Equation 4.60 can be rewritten as Equation 4.61:

\[
(1 - \frac{\partial \Gamma_{11}}{\partial x_{11}}) \left( \frac{\partial \psi_{22}}{\partial c_{212}} - \frac{\partial \Gamma_{121}}{\partial x_{11}} + \frac{\partial \Gamma_{122}}{\partial x_{11}} \frac{\partial \psi_{22}}{\partial c_{222}} \right) \left( \frac{\partial \phi/\partial mw_{1}}{\partial \psi_{11}/\partial q_{111}} \right)
\]

\[+ \left[ \frac{\partial \phi}{\partial mw_{1}} \right] \left( p_{111} - \frac{\partial \theta_{11}}{\partial \Sigma_{1111}} \right) \frac{\partial \psi_{11}}{\partial x_{11}} + \left( p_{121} - \frac{\partial \theta_{11}}{\partial \Sigma_{1111}} \right) \frac{\partial \Gamma_{121}}{\partial x_{11}}\]

\[+ \left( p_{112} - \frac{\partial \theta_{12}}{\partial \Sigma_{1121}} \right) \frac{\partial \Gamma_{112}}{\partial x_{11}} + \left( p_{112} - \frac{\partial \theta_{12}}{\partial \Sigma_{1121}} \right) \frac{\partial \Gamma_{122}}{\partial x_{11}}\]

\[= \frac{\partial \psi_{11}/\partial q_{111}}{(\partial \psi_{11}/\partial q_{111})} \]  

Equation 4.61 is the model's equivalent to the standard condition that in equilibrium, marginal revenue equals marginal cost. The first line of 4.61 relates the effect of changes in output of weight one.
on carryover into the next period of the planning horizon. The second two lines of 4.61 on the left of the equality are sums of marginal net revenue times marginal sales (caused by changing $X_{11}$) summed over outlets and weights and multiplied by the marginal utility of money withdrawals. The first term in Equation 4.61 $(1 - \frac{\partial \Gamma_{111}}{\partial X_{11}} - \frac{\partial \Gamma_{112}}{\partial X_{11}})$ is the marginal propensity to carryover weight one production in period one into the second period of the planning horizon. That is, one minus the marginal propensity to sell weight one at outlet one in period one, minus the marginal propensity to sell weight one at outlet two in period one equals the marginal propensity to carry weight one over into the second period of the planning horizon. The marginal propensity to carryover weight one production is multiplied by the marginal physical productivity of weight one carryover used in production of weight two in the second period $\partial \psi_{22}/\partial c_{212}$.

Sales of weight two are also a function of production of weight one ($X_{11}$). The term $(-\frac{\partial \Gamma_{121}}{\partial X_{11}} + \frac{\partial \Gamma_{122}}{\partial X_{11}})$ represents the marginal change in sales of weight two to both outlets caused by a change in production of weight one. The negative of the total change in sales of weight two $(-\frac{\partial \Gamma_{121}}{\partial X_{11}} - \frac{\partial \Gamma_{122}}{\partial X_{11}})$ is marginal change in carryover of weight two. The marginal carryover of weight two is multiplied by the marginal physical productivity of weight two in the production of weight two in the second period.

To summarize, within the first pair of brackets is marginal change in carryover of weight one times the marginal physical product of weight one in the second period plus the marginal change in carryover of weight
two times the marginal physical productivity of weight two carryover in
the second period of the planning horizon.

In the second pair of brackets in the first line is the period two
price of the purchased input (h^2_{21}) multiplied by the marginal utility of
money withdrawals in period two all divided by the marginal physical product
of the purchased input used in producing weight two. The numerator then
is the expense in utility terms of marginal units of purchased input.
Dividing by the marginal physical product of the input we get the
marginal expense in utility terms of producing additional weight two
output or subjective marginal out-of-pocket expense of additional weight
two output in period two.

In words the first line of 4.61 could be stated as:

\[
\left\{ \begin{array}{c}
\text{Marginal propensity to carryover weight 1 production into period 2} \\
\text{Marginal change in weight 2 sales caused by change in weight 1 production in period 1}
\end{array} \right\} \left\{ \begin{array}{c}
\text{Marginal physical product of weight 1 production producing weight 2 in period 2} \\
\text{Marginal physical product of weight 2 used in production of weight 2 in period 2}
\end{array} \right\} - \\
\text{Subjective marginal expense of additional weight 2 production in period 2}
\]

The third set of brackets on lines two and three of Equation 4.61 encompas-
ses four terms that can be termed pseudo marginal revenue terms. The first
term within the bracket \( p_{111} - \frac{\partial \theta_{11}}{\partial z_{111}} \) is marginal per-head net revenue
(price minus marginal marketing cost) of sales of weight one to outlet one. Marginal net revenue per head is then multiplied by marginal sales and the product represents a marginal revenue from producing more of weight one \( (X_{11}) \). Production of weight one may provide three additional changes in revenue. Production of weight one may affect revenue from sales of weight two to outlet one, \( (p_{121} \cdot \frac{\partial \Gamma}{\partial S_{11}} \cdot \frac{\partial \Gamma}{\partial X_{11}}) \); revenue from sales of weight one to outlet two, \( (p_{112} \cdot \frac{\partial \Gamma}{\partial S_{11}} \cdot \frac{\partial \Gamma}{\partial X_{11}}) \); and revenue from sales of weight two at outlet two, \( (p_{122} \cdot \frac{\partial \Gamma}{\partial S_{11}} \cdot \frac{\partial \Gamma}{\partial X_{11}}) \). The interdependence of the outlet and weight decisions is now apparent. Production of weight one affects sales of weight one to both outlets as well as sales of weight two to both outlets.

The sum of the four terms within the brackets is the total marginal effect on revenue of increased production or marginal revenue. The summed marginal effects on revenue are multiplied by the marginal utility of additional withdrawals in the first period of the planning horizon.

The right side of the equality is the period one price of the input \( (h_{11}) \) multiplied by the marginal utility of money in period one divided by the marginal physical product of the input. The numerator of the right side is the marginal expense of additional purchased variable input in utility terms. Dividing by the marginal physical product of the input yields the marginal expense in utility terms of producing additional weight one output or subjective marginal out-of-pocket expense of additional weight one output in period one.
To summarize in words, Equation 4.61 is:

\[
\left(\frac{\text{Marginal propensity to carryover weight 1 production into period 2}}{\text{Marginal physical product of weight 1 production producing weight 2 in period 2}}\right) - \\
\left(\frac{\text{Marginal change in weight 2 sales caused by change in weight 1 production}}{\text{Marginal physical product of weight 2 used in production of weight 2 in period 2}}\right) - \\
\left(\frac{\text{Marginal utility of withdrawals in period 1}}{\text{Price minus marginal marketing cost of weight 1 at outlet 1 in period 1}}\right) + \\
\left(\frac{\text{Price minus marginal marketing cost of weight 2 at outlet 1 in period 1}}{\text{Marginal change in sales of weight 2 to outlet 1 in period 1 caused by a change in weight 1 production}}\right) + \\
\left(\frac{\text{Price minus marginal marketing cost of weight 1 at outlet 2 in period 1}}{\text{Marginal propensity to sell weight 1 to outlet 2 in period 1}}\right) + \\
\left(\frac{\text{Price minus marginal marketing cost of weight 2 at outlet 2 in period 1}}{\text{Subjective marginal cost of additional weight 1 production in period 1}}\right) = \\
\left(\frac{\text{Marginal change in sales of weight 2 to outlet 2 in period 1 caused by a change in weight 1 production}}{\text{Subjective marginal cost of additional weight 1 production in period 1}}\right)
\]

For expository purposes assume that the marginal utility of money withdrawals in the second period is zero. The first line of 4.61 would then be zero.
Cancelling $\frac{\partial \phi}{\partial MW_1}$ from the remainder of both sides of the 4.61 yields:

$$\sum_{i=1}^{2} \sum_{j=1}^{2} \left( p_{lij} - \frac{\partial \theta_{ij}}{\partial x_{ij}} (\frac{\partial \Gamma_{lij}}{\partial x_{ij}}) \right) = \frac{h_{ij}}{\frac{\partial \psi_{ij}}{\partial q_{ij}}} \quad (4.62a)$$

If both sides of 4.62 are multiplied by $\frac{\partial \psi_{ij}}{\partial q_{ij}}$ Equation 4.62b is derived:

$$\sum_{i=1}^{2} \sum_{j=1}^{2} \left( p_{lij} - \frac{\partial \theta_{ij}}{\partial x_{ij}} (\frac{\partial \Gamma_{lij}}{\partial x_{ij}}) \frac{\partial \psi_{ij}}{\partial q_{ij}} \right) = h_{ij} \quad (4.62b)$$

The term in brackets in 4.62b is the sum of prices minus marginal marketing costs multiplied by the changes in sales resulting from additional weight one production. The bracketed term then is marginal revenue. Multiplying marginal revenue times the marginal physical product of the purchased input one yields marginal value product of the input. Therefore, Equation 4.62b is the multiple outlet equivalent of saying that in equilibrium, the input should be used until the marginal value product of the input equals the price of the input.

This is the first of the seven basic relationships derived from the Hildreth-Jarrett model (50) and stated in Chapter II.

An interesting analogy can be drawn between Equation 2.5 presented when discussing Holdren's book (52) and 4.62b. Consider the following analogous terms in the equations ($\approx$ is used to mean analogous to):
\[ P_{lij} = \frac{r}{n} \] prices of outputs;

\[ \frac{\partial \delta_{ij}}{\partial s_{lij}} = \frac{\partial \beta}{\partial w} \] marginal costs of selling additional output;

\[ \frac{1}{2} \sum_{i=1}^{n} s_{lij} \] marginal change in sales from additional use of an input or nonprice competition;

\[ \frac{\partial \gamma_{lij}}{\partial x_{1i}} \frac{\partial \psi_{ll}}{\partial q_{1ll}} = \frac{\partial w}{\partial a} \] marginal cost of purchasing additional input or nonprice competition.

That is, Holdren's (52) equilibrium conditions for nonprice offer variation are not too different from the equilibrium conditions for purchased input usage in Equation 4.62b. Even though the decision setting and problems are considerably different, the supermarket manager and a hog producer face similar static equilibrium conditions and the elements of the decision situations are nearly the same.

A similar marginal condition is derived for production of weight two in period one. By inserting the solutions for \( \gamma_1, \gamma_2, \gamma_3, \gamma_4, \lambda_2, \) and \( \alpha_4 \) into Equation 4.9, and rearranging, Equation 4.63 is derived:

---

1 The term \( \frac{\partial \psi_{ll}}{\partial q_{ll}} \) was moved inside the summation.
Equation 4.63 can be given the same explanation as Equation 4.61 with reference to production of weight two in period one.

Slightly different marginal cost-marginal revenue conditions are derived for period two production by substituting Lagrangian definitions into Equations 4.10 and 4.11. Substituting the solutions for $Y_5$, $Y_6$, $Y_7$, $Y_8$, $\lambda_3$, and $\alpha_5$ (Equations 4.41, 4.42, 4.43, 4.44, 4.47, and 4.55) into 4.10 and rearranging, Equation 4.64 is derived:

\[
\begin{align*}
(1- \frac{\partial \Gamma_{21}^{11}}{\partial x_{21}} - \frac{\partial \Gamma_{22}^{12}}{\partial x_{21}} (\frac{\partial \phi}{\partial c_{32}^2}) - (\frac{\partial \Gamma_{22}^{12}}{\partial x_{21}} + \frac{\partial \Gamma_{22}^{22}}{\partial x_{21}} (\frac{\partial \phi}{\partial c_{32}^2})) \\
+ \frac{\partial \phi}{\partial \mu_{22}^1} [(p_{211} - \frac{\partial \theta_{21}}{\partial \mu_{22}^1}) (\frac{\partial \Gamma_{21}^{22}}{\partial x_{21}}) + (p_{221} - \frac{\partial \theta_{21}}{\partial \mu_{22}^1}) (\frac{\partial \Gamma_{21}^{22}}{\partial x_{21}})] = \frac{\partial \phi}{\partial \mu_{22}^1} h_{21}^{22} \\
+ (p_{212} - \frac{\partial \theta_{22}}{\partial \mu_{22}^1}) (\frac{\partial \Gamma_{22}^{12}}{\partial x_{21}}) + (p_{222} - \frac{\partial \theta_{22}}{\partial \mu_{22}^1}) (\frac{\partial \Gamma_{22}^{22}}{\partial x_{21}})] = \frac{\partial \phi}{\partial \mu_{22}^1} h_{21}^{22} \\
(4.64)
\end{align*}
\]
Equation 4.64 is quite similar to Equation 4.61 because it represents the marginal condition for production of weight one in period two. Equation 4.64 is simpler because carryover of weights one and two into the next planning horizon are arguments of the utility function. Whereas in Equation 4.61, carryover was evaluated in accordance with its ability to produce in the second period of the planning horizon, in Equation 4.64, carryover is valued by its marginal utility.

The first term of Equation 4.64 is the marginal propensity to carryover weight one production into the next planning horizon \(1 - \frac{\partial \Gamma_{211}}{\partial x_{21}} - \frac{\partial \Gamma_{212}}{\partial x_{21}}\). The marginal propensity to carryover is equal to one minus the marginal propensity to sell additional carryover at each of the outlets. Marginal propensity to carryover weight one is appropriately multiplied by the marginal utility of additional weight one carryover into the next planning horizon.

The negative of the marginal changes in sales of weight two caused by increasing production of weight one \((-\frac{\partial \Gamma_{211}}{\partial x_{21}} - \frac{\partial \Gamma_{222}}{\partial x_{21}}\) is the marginal change in carryover of weight two and is appropriately multiplied by the marginal utility of additional weight two carryover into the next planning horizon.

The second and third lines of Equation 4.64 are the exact period two counterparts of the second and third lines of Equation 4.61 and can be given the same interpretation.

The left side of Equation 4.64 then is the marginal increase in utility from additional carryover plus the marginal increase in utility
from the revenue created from additional weight one production. To sum-
marize, the marginal utility generated from additional weight one
production equals the marginal expense of the added production. Also,
if the marginal utility of carryover into the next planning horizon
is zero \( \frac{\partial \phi}{\partial c_{31}} = \frac{\partial \phi}{\partial c_{32}} = 0 \) the first line of 4.64 is zero and the
second two lines can be summarized in exactly the period two equivalents
of 4.62 and 4.62b.

Substituting the solutions for \( \gamma_5, \gamma_6, \gamma_7, \gamma_8, \lambda_4 \), and \( \alpha_5 \) (Equations
4.41, 4.42, 4.43, 4.44, 4.48, and 4.56) into 4.11 and rearranging,
Equation 4.65 is derived:

\[
(1 - \frac{\partial \Gamma_{221}}{\partial x_{22}} - \frac{\partial \Gamma_{222}}{\partial x_{22}} \frac{\partial \phi}{\partial c_{32}} - \frac{\partial \Gamma_{211}}{\partial x_{22}} + \frac{\partial \Gamma_{212}}{\partial x_{22}} \frac{\partial \phi}{\partial c_{32}})
\]

\[
+ \frac{\partial \phi}{\partial MW_2} [(p_{211} - \frac{\partial \theta_{21}}{\partial S_{211}}) \frac{\partial \Gamma_{211}}{\partial x_{22}} + (p_{221} - \frac{\partial \theta_{21}}{\partial S_{211}}) \frac{\partial \Gamma_{221}}{\partial x_{22}}]
\]

\[
+ (p_{212} - \frac{\partial \theta_{22}}{\partial S_{212}}) \frac{\partial \Gamma_{212}}{\partial x_{22}} + (p_{222} - \frac{\partial \theta_{22}}{\partial S_{212}}) \frac{\partial \Gamma_{222}}{\partial x_{22}} = \frac{(\partial \phi/\partial MW_2) h_{21}}{(\partial \psi_{22}/\partial q_{212})} (4.65)
\]

Equation 4.65 is the weight two, period two equivalent to Equation
4.64 and can be interpreted similarly.

To summarize, Equation 4.61, 4.63, 4.64 and 4.65 are the model's
marginal revenue equals marginal cost conditions couched in a multiple
outlet, product, and period framework. Careful examination of the
relationships has revealed the strong connections between sales and
production decisions.

Production of each weight affects sales of that weight to the outlets
as well as sales of other weights to the outlets.

The integration of sales and production decisions has conceptually been accomplished. The model is easily generalized to include more than one purchased input, additional periods and additional weights or qualities of output. Chapter V will examine simplifications of the general model. Simplified versions of the model will be used to determine the effects of exogenous changes on equilibrium.
V. SIMPLIFIED MODELS

The purpose of simplifying the model presented in Chapter IV is 1) to transform the theoretical discussion into smaller models that can be used to generate hypotheses and 2) to develop models for which the data requirements are met. In order to reduce the size of the model, less general, smaller models are presented. Section A presents an outlet selection model that assumes only one weight is sold. Section B presents a weight choice model that assumes only one outlet is used. In Section A average weight of hogs sold is treated as an exogenous producer characteristic while in Section B the results of the outlet selection decisions are treated as exogenous producer characteristics.

In some cases data is the prime consideration when deciding which variables to include in each of the two smaller models. In particular, weekly sales decision data was not obtained. Ideally, one would ask producers at the point of every sale why they sold at a particular outlet and why they sold hogs at that particular weight.

For each producer, monthly sales and weights from question 9, page 6 (see Appendix B) and the proportion of hogs sold to a particular outlet type from question 23 (see Appendix B) are available. The questions asking why a producer sells at a particular outlet and follows a particular policy with respect to weight (questions 26, 33 and 34 in Appendix B) are asked only once and refer to all outlet and weight decisions made during the year. The data is a summary of the results of many different weekly decisions.
The consequence of the above data limitations is that the smaller models cannot be interpreted in a multiple period framework. Monthly sales and weights are not sufficient because 1) the reasons for weight and outlet decisions aren't given by months, and 2) in 30 days hogs gain enough weight (approximately 60 pounds) such that the key weight decisions are by-passed. Therefore, both of the simplified models incorporate only one time period.

Also, both of the simplified models assume that the producers know per-head marketing costs for each weight at each outlet type. Implicitly, it is assumed that each producer knows the load size, time required to market at the outlet types and the cost of marketing services at the outlets. Although explicit recognition of marketing costs was not possible, each producer's rating of the importance of marketing costs when selecting an outlet is included as an argument in the sales function for the outlet decision model.

In all of Chapter V, the general hypothesis is that knowledge of common characteristics and attitudes will make it possible to predict changes in the nature of hog procurement activities given hypothesized changes in producer characteristics and attitudes.

A. Model Describing Outlet Selection Decisions

Each producer is postulated to enter the outlet decision period with a group of hogs in his feedlot \( \bar{C}_{101} \) just below market weight. The producer must decide how many hogs to raise to market weight \( X_{11} \) and the amount of feed \( a_{111} \) the hogs are fed. All of the \( X_{11} \)
hogs that reach market weight must be sold to outlet type one \( S_{111} \) or outlet type two \( S_{112} \). The hogs not brought up to market weight are carried over into the next decision horizon. The producer is implicitly assumed to know marketing cost per head at each outlet and the net price (bid less marketing costs). Each producer is assumed to first decide which outlet of each type is preferred then to compare outlets of different types. Of course, in order to compare the alternative outlet types it is assumed the producer knows the characteristics of each outlet type. The producer makes decisions consistent with an objective function that has current money income from hogs \( MW_1 \) and carryover \( C_{201} \) of hogs into the next planning horizon as arguments. The simplified decision situation can be represented by:

\[
\text{Maximize } \phi(MW_1, C_{201}) \tag{5.1}
\]

subject to:

\[
S_{111} = \Gamma_{111} (\text{MCHAR, PATO*}, \text{PCHAR}, p_{111}, p_{112}, \text{PATW*}, x_{11}) \tag{5.2}
\]

\[
S_{112} = \Gamma_{112} (\text{MCHAR, PATO*}, \text{PCHAR}, p_{111}, p_{112}, \text{PATW*}, x_{11}) \tag{5.3}
\]

\[
x_{11} = \psi_{11} (q_{111}, c_{101}) \tag{5.4}
\]

\[
MW_1 = p_{111} S_{111} + p_{112} S_{112} - h_{11} q_{111} \tag{5.5}
\]

---

1 The notation of Chapter IV and Appendix A will continue to be used with only two exceptions. \( C_{101} \) and \( C_{201} \) are carryin and carryout of hogs just below market weight.
The endogenous variables are $S_{111}$, $S_{112}$, $X_{11}$, $q_{111}$, $MW_1$, and $C_{201}$. Equations 5.2 and 5.3 are the sales functions, 5.4 is the weight gaining or production function, 5.5 defines money withdrawals, 5.6 specifies that all production must be sold, and 5.7 states the relationship between carryin, production and carryover.

The production function indicates the number of light hogs carried into the period at below-market weight that will reach market weight when the $C_{101}$ hogs are fed $q_{111}$ amount of feed. The number of hogs ($X_{11}$) reaching market weight depends on the number of hogs in the lot $C_{101}$ at the beginning of the period and the amount of feed ($q_{111}$) the producer feeds the lot of hogs during the period. Part ($X_{11}$) of the $C_{101}$ hogs reach market weight but some ($C_{201}$) do not. The producer sells only those $X_{11}$ hogs that reach market weight, and no other hogs. He does not consider selling the lighter weight hogs and the light weight hogs ($C_{201}$) are carried over into the next marketing decision period.

The condition that all production must be sold (Equation 5.6) implies that in equilibrium the sum of the marginal propensities to sell additional output at the outlet types equals one. That is:

$$1 - \frac{\partial \Gamma_{111}}{\partial X_{11}} - \frac{\partial \Gamma_{112}}{\partial X_{11}} = 0$$

(5.8)

although neither $\partial \Gamma_{111}/\partial X_{11}$ or $\partial \Gamma_{112}/\partial X_{11}$ are restricted in sign.
There are six unknowns and six constraints, but the constraints (5.2-5.7) do not satisfy the Jacobian assumption that the matrix of first order partial derivatives is of full row rank (56, pp. 31-32). If the determinant of the six by six Jacobian matrix of 5.2 through 5.7 is zero, the Jacobian assumption does not hold. The determinant of the Jacobian matrix is:

\[
\begin{vmatrix}
1 & 0 & -\frac{\partial \Gamma_{111}}{\partial x_{11}} & 0 & 0 & 0 \\
0 & 1 & -\frac{\partial \Gamma_{112}}{\partial x_{11}} & 0 & 0 & 0 \\
0 & 0 & 1 & -\frac{\partial \Gamma_{11}}{\partial q_{111}} & 0 & 0 \\
-\frac{\partial \psi_{111}}{\partial x_{111}} & -\frac{\partial \psi_{112}}{\partial x_{111}} & 0 & h_{11} & 1 & 0 \\
-1 & -1 & 1 & 0 & 0 & 0 \\
0 & 0 & -1 & 0 & 0 & -1 \\
\end{vmatrix}
\]

which equals zero as long as 5.8 holds. Five of the six constraints can be shown to be independent. Dropping 5.3,¹ the Jacobian matrix of the remaining constraints (5.2, 5.4, 5.5, 5.6 and 5.7) is

¹Equation 5.2 could also have been dropped with similar results.
The determinant of the five by five matrix consisting of the last five columns of 5.10 is \(-\frac{\partial^2 \Gamma_{111}}{\partial x_{11} \partial q_{111}}\)(-\frac{\partial \Gamma_{11}}{\partial q_{111}}) which is clearly nonzero as long as \(\frac{\partial \Gamma_{111}}{\partial x_{11}}\) or \(\frac{\partial \psi_{11}}{\partial q_{111}}\) do not equal zero. Therefore, the Jacobian matrix given in Equation 5.10 is of full row rank.

1. Lagrangian formulation

In order to write the Lagrangian formulation, Equation 5.3 is dropped and Equations 5.6 and 5.7 are used to define \(s_{112}\) and \(x_{11}\) respectively in the other constraints. The substitutions eliminate the need for two equations and two variables \((x_{11} \text{ and } s_{112})\). In Lagrangian form the simplified model can be written as:

\[
\begin{pmatrix}
1 & 0 & \frac{\partial \Gamma_{111}}{\partial x_{11}} & 0 & 0 & 0 \\
0 & 1 & 1 & \frac{\partial \psi_{11}}{\partial q_{111}} & 0 & 0 \\
-p_{111} & -p_{112} & 0 & h_{11} & 1 & 0 \\
-1 & -1 & 1 & 0 & 0 & 0 \\
0 & 0 & -1 & 0 & 0 & -1
\end{pmatrix}
\]

\[
(5.10)
\]

\[
\text{In the sales function } x_{11} \text{ is replaced by } \frac{c_{101}}{c_{201}}. \text{ Note that } \frac{\partial \Gamma_{111}}{\partial c_{201}} = \frac{\partial \Gamma_{111}}{\partial x_{11}}, \frac{\partial^2 \Gamma_{11}}{\partial x_{11} \partial c_{201}} = \frac{\partial^2 \Gamma_{111}}{\partial x_{11}^2} \text{ equals } \frac{\partial^2 \Gamma_{111}}{\partial x_{11}^2}.\]
\[ L = \phi - \gamma_1 (S_{111} - \Gamma_{111}) - \lambda_1 (C_{101} - C_{201} - \psi_{11}) \]

\[ - \alpha_1 [M_{W1} - P_{111} S_{111} - P_{112} (C_{101} - C_{201} - S_{111}) + h_{11} q_{111}] \]  \hspace{1cm} (5.11)

The instrument variables are \( M_{W1}, S_{111}, C_{201}, \) and \( q_{111} \). The first order conditions for a maximum are:

\[ \frac{\partial L}{\partial M_{W1}} = \frac{\partial \phi}{\partial M_{W1}} - \alpha_1 = 0 \]  \hspace{1cm} (5.12)

\[ \frac{\partial L}{\partial S_{111}} = -\gamma_1 + \alpha_1 (P_{111} - P_{112}) = 0 \]  \hspace{1cm} (5.13)

\[ \frac{\partial L}{\partial C_{201}} = \gamma_1 \frac{\partial \Gamma_{111}}{\partial C_{201}} + \lambda_1 - \alpha_1 P_{112} + \frac{\partial \phi}{\partial C_{201}} = 0 \]  \hspace{1cm} (5.14)

\[ \frac{\partial L}{\partial q_{111}} = \lambda_1 \frac{\partial \psi_{11}}{\partial q_{111}} - \alpha_1 h_{11} = 0 \]  \hspace{1cm} (5.15)

\[ \frac{\partial L}{\partial \gamma_1} = \Gamma_{111} - S_{111} = 0 \]  \hspace{1cm} (5.16)

\[ \frac{\partial L}{\partial \lambda_1} = -C_{101} + C_{201} + \psi_{11} = 0 \]  \hspace{1cm} (5.17)

\[ \frac{\partial L}{\partial \alpha_1} = -M_{W1} + P_{111} S_{111} + P_{112} (C_{101} - C_{201} - S_{111}) - h_{11} q_{111} = 0 \]  \hspace{1cm} (5.18)

The Lagrangian multiplier solutions are:

\[ \alpha_1 = \frac{\partial \phi}{\partial M_{W1}} \]  \hspace{1cm} (5.19)

\[ \gamma_1 = \frac{\partial \phi}{\partial M_{W1}} (P_{111} - P_{112}) \]  \hspace{1cm} (5.20)
\[ \lambda_1 = \frac{\partial \phi}{\partial MW_1} h_{11}/(\partial q_{111}) = \frac{\partial \psi}{\partial MW_1} P_{112} \]

- \[ \frac{\partial \phi}{\partial MW_1} (p_{111} - p_{112})(\partial R_{111}/\partial C_{201}) - \frac{\partial \phi}{\partial C_{201}} \]

Rearranging 5.21, 5.22a is derived:

\[ \frac{\partial \phi}{\partial MW_1} ((1 + \partial R_{111}/\partial C_{201})P_{112} - (\partial R_{111}/\partial C_{201})P_{111}) = \frac{\partial \phi}{\partial MW_1} h_{11} + \frac{\partial \phi}{\partial C_{201}} \] (5.22a)

Equation 5.22a is the simplified version of Equation 4.61 or 4.62 of the full model. To fully interpret the left side of Equation 5.22a it is useful to recognize that \[ \partial R_{111}/\partial C_{201} \] is the negative of \[ \partial R_{111}/\partial x_{11} \]. The first term in brackets on the left of the equality can be interpreted as the price at outlet two multiplied by one minus the marginal propensity to sell at outlet one. Using 5.8, we know that one minus the marginal propensity to sell at outlet one equals the marginal propensity to sell additional output at outlet two. The second term in brackets on the left side of Equation 5.22a is the marginal propensity to sell additional production at outlet one multiplied times price at outlet one. The revenue from sales is multiplied by the marginal utility of the additional revenue.

The right side of Equation 5.22a is the marginal cost of producing another unit plus the marginal utility of additional carryover. Both elements represent what the producer must marginally give up in utility terms in order to produce. The left side of the equation is the
producer's marginal gain in utility from producing another unit. In equilibrium, the marginal utility gained from producing another unit (left side of 5.22a) should be equal to the marginal utility lost from producing an additional unit (right side of 5.22a).

The second order conditions for a local maximum require that the last $v$ minus $u$ leading principle minors of the bordered Hessian have determinants that alternate in sign, the sign of the first being $(-1)^{u+1}$ where $v$ is the number of endogenous variables and $u$ is the number of constraints in the model (56, p. 36). The bordered Hessian for the current model is:

$$
H = \begin{pmatrix}
0 & 0 & 0 & -1 & p_{111} - p_{112} & -p_{112} & -h_{11} \\
0 & 0 & 0 & 0 & -1 & \frac{\partial \Gamma_{111}}{\partial c_{201}} & 0 \\
0 & 0 & 0 & 0 & 0 & 1 & \frac{\partial \psi_{11}}{\partial q_{111}} \\
-1 & 0 & 0 & \frac{\partial^2 \phi}{\partial m_{w1}} & 0 & \frac{\partial^2 \phi}{\partial m_{w1} \partial c_{201}} & 0 \\
p_{111} - p_{112} & -1 & 0 & 0 & 0 & 0 & 0 \\
p_{112} & \frac{\partial \Gamma_{111}}{\partial c_{201}} & +1 & \frac{\partial^2 \phi}{\partial m_{w1} \partial c_{201}} & 0 & \frac{\partial^2 \phi}{\partial c_{201}^2} + \gamma \frac{\partial^2 \psi_{11}}{\partial c_{201}^2} & 0 \\
-h_{11} & \frac{\partial \psi_{11}}{\partial q_{11}} & 0 & 0 & 0 & 0 & \lambda_1 \partial q_{111}^2
\end{pmatrix}_{(5.23)}
$$
With four \((v=4)\) instrument variables and three \((u=3)\) constraints, if the determinant of \(H\) is positive, the second order conditions are satisfied. The determinant of \(H\) is (see Appendix D for the gory details):

\[
|H| = -\left(\frac{\partial \phi}{\partial \text{MW}_1} h_{11} / (\partial q_{111})\right) \left(\frac{\partial^2 \psi_{111}}{\partial q_{111}^2}\right)
\]

\[
-\left[\frac{\partial^2 \phi}{\partial \text{MW}_1 \partial C_{201}} \left(p_{111} - p_{112}\right) \left(\frac{\partial \Gamma_{111}}{\partial q_{111}}\right) + h_{11} \left(p_{111} - p_{112}\right) \left(\frac{\partial \psi_{111}}{\partial q_{111}}\right)^2\right]
\]

\[
-2 \left(\frac{\partial \psi_{111}}{\partial q_{111}}\right) \left(\frac{\partial^2 \phi}{\partial \text{MW}_1 \partial C_{201}}\right) \left[p_{111} - p_{112}\right] \left(\frac{\partial \Gamma_{111}}{\partial q_{111}}\right) \left(\frac{\partial \psi_{111}}{\partial q_{111}}\right) + h_{11} \left(p_{111} - p_{112}\right) \left(\frac{\partial \psi_{111}}{\partial q_{111}}\right)^2
\]

Equation 5.24

To evaluate Equation 5.24 it is assumed that the marginal utilities of \(\text{MW}_1\) and \(C_{201}\) are positive but diminish (i.e., \(\partial \phi/\partial \text{MW}_1 > 0\) \(\partial \phi/\partial C_{201} < 0 \); \(\partial^2 \phi/\partial \text{MW}_1^2 > 0 \); \(\partial^2 \phi/\partial C_{201}^2 < 0 \)); input and output prices are positive and the marginal physical product of feed is positive but diminishes (i.e., \(\partial \psi_{111}/\partial q_{111} > 0 \); \(\partial^2 \psi_{111}/\partial q_{111}^2 < 0 \)). It is also assumed that \(\partial^2 \phi/\partial \text{MW}_1 \partial C_{201}\) is positive. The first assumption about the production function implies that as the amount of feed \((q_{111})\) given the lot of hogs increases, the number of hogs reaching market weight increases. The second assumption means that as more and more hogs reach
market weight the marginal number reaching market weight as feed usage increases diminishes.

That \( \frac{\partial^2 \phi}{\partial MW_1 \partial C_{201}} \) is positive implies that the more current withdrawals (MW_1) the producer has, the greater is the marginal utility of hogs in the lot (C_{201}) and vice versa. The two utility function arguments can be viewed as having different liquidity and the producer tries to balance his portfolio holdings between the two assets. Liquid money assets in the current period provide a hedge against price declines while hogs in the lot provide a hedge against price increases in following periods. A producer that is uncertain about future prices might well wish to maintain a balance between the two assets which is implied by the positive cross partial. Using the above assumptions, sufficient conditions for the determinant of \( H \) to be positive are

a) if \( P_{111} > P_{112} \) then \( \frac{\partial \Gamma_{111}}{\partial C_{201}} < 0 \) and \( \frac{\partial^2 \Gamma_{111}}{\partial C_{201}^2} < 0 \), or

b) if \( P_{111} < P_{112} \) then \( \frac{\partial \Gamma_{111}}{\partial C_{201}} > 0 \) and \( \frac{\partial^2 \Gamma_{111}}{\partial C_{201}^2} > 0 \).

The most difficult part of Equation 5.24 to evaluate is the last set of terms in brackets. Rewriting Equation 5.22a, 5.22b is derived:

\[
\begin{align*}
\psi_{111} & = \left( P_{112} \frac{\partial \psi_{111}}{\partial q_{111}} \right) + \left( P_{111} - P_{112} \right) \left( \frac{\partial \Gamma_{111}}{\partial C_{201}} \frac{\partial \psi_{111}}{\partial q_{111}} \right) + h_{11} \\
& = \left( \frac{\partial \phi}{\partial C_{201}} \frac{\partial \psi_{111}}{\partial q_{111}} \right) / \left( \frac{\partial \phi}{\partial MW_1} \right)
\end{align*}
\]

(5.22b)

The right side of Equation 5.22b is negative. The left side of Equation
5.22b is the last set of terms in brackets in Equation 5.24 and thus is also negative.

2. **Hypotheses**

Of concern are hypotheses about how exogenous changes in attitudes and producers' characteristics might affect equilibrium sales to different types of outlets. Specifically, the procedure will be to determine the qualitative effect of the exogenous shock on the equilibrium values of the endogenous variables. The first order conditions are totally differentiated with respect to the exogenous shock and then the subsequent equations are used to solve for the effect of the change on the equilibrium values of the endogenous variables.

All of the attitude and characteristic variables for which changes are considered are arguments in the sales function and do not appear in any other functional forms of the model. Therefore, once the first order conditions have been shocked for any one of the attitude or characteristic variables in the sales function, the same resulting equations can be used to evaluate the effects of changes in any of the other exogenous variables in the sales function.

Thus the procedure for hypothesis generation will be:

1. Differentiate the first order conditions with respect to a change in any sales function argument (designated A).

2. Set up the resulting equations in matrix notation and use Cramer's rule to solve for $\frac{\partial S}{\partial A}$.
3. Evaluate the solution from step two for each of the characteristic and attitude variables of interest.

4. State the evaluations in step three as testable hypotheses.

Totally differentiating 5.12 through 5.18 with respect to a change in an argument of the sales function \( A \) yields 5.25 through 5.31.

\[
\frac{\partial^2 \phi}{\partial MW_1} - \frac{\partial^2 \phi}{\partial MW_1 \partial C_{201}} - \frac{\partial \alpha_1}{\partial A} = 0 \tag{5.25}
\]

\[
- \frac{\partial \gamma_1}{\partial A} + \frac{\partial \alpha_1}{\partial A} (p_{111} - p_{112}) = 0 \tag{5.26}
\]

\[
\frac{\partial \gamma_1}{\partial A} \frac{\partial \Gamma_{111}}{\partial C_{201}} + \frac{\partial \Gamma_{111}}{\partial A} + \frac{\partial^2 \phi}{\partial C_{201}} + \frac{\partial \alpha_1}{\partial A} = 0 \tag{5.27}
\]

\[
\frac{\partial \lambda_1}{\partial A} \frac{\partial \psi_{11}}{\partial q_{111}} + \frac{\partial \psi_{11}}{\partial A} = \frac{\partial \alpha_1}{\partial A} h_{11} = 0 \tag{5.28}
\]

\[
\frac{\partial \Gamma_{111}}{\partial A} + \frac{\partial \Gamma_{111}}{\partial C_{201}} - \frac{\partial s_{111}}{\partial A} = 0 \tag{5.29}
\]

\[
\frac{\partial C_{201}}{\partial A} + \frac{\partial \psi_{11}}{\partial q_{111}} \frac{\partial q_{111}}{\partial A} = 0 \tag{5.30}
\]

\[
- \frac{\partial MW_1}{\partial A} + (p_{111} - p_{112}) \frac{\partial s_{111}}{\partial A} - p_{112} \frac{\partial C_{201}}{\partial A} - \frac{\partial q_{111}}{\partial A} h_{11} = 0 \tag{5.31}
\]
Equations 5.25 through 5.31 can be arranged and rewritten in matrix notation as

\[
\begin{bmatrix}
0 & 0 & 0 & -1 & P_{111} - P_{112} & -h_{111} \\
0 & 0 & 0 & 0 & -1 & \frac{\partial \Gamma_{111}}{\partial C_{201}} \\
0 & 0 & 0 & 0 & 0 & +1 \\
-1 & 0 & 0 & \frac{\partial^2 \phi}{\partial M N_1} & 0 & \frac{\partial^2 \phi}{\partial M W_1 \partial C_{201}} \\
-1 & 0 & 0 & \frac{\partial \Gamma_{111}}{\partial C_{201}} & +1 & \frac{\partial^2 \phi}{\partial M W_1 \partial C_{201}} \\
-h_{111} & 0 & 0 & \frac{\partial \psi_{11}}{\partial q_{111}} & 0 & \frac{\partial^2 \psi_{11}}{\partial q_{111}^2} + \lambda_1 \frac{\partial^2 \psi_{11}}{\partial q_{111}^2}
\end{bmatrix}
\]

\[
\begin{bmatrix}
\frac{\partial \Gamma_{111}}{\partial A} \\
\frac{\partial \psi_{11}}{\partial A} \\
\frac{\partial \Gamma_{111}}{\partial A} \\
\frac{\partial \Gamma_{111}}{\partial A} \\
\frac{\partial \Sigma_{111}}{\partial A} \\
\frac{\partial \Sigma_{201}}{\partial A} \\
\frac{\partial \psi_{11}}{\partial A}
\end{bmatrix}
= \begin{bmatrix}
0 \\
-\frac{\partial \Gamma_{111}}{\partial A} \\
0 \\
0 \\
0 \\
-\frac{\partial \Sigma_{201}}{\partial A} \frac{\partial \Gamma_{111}}{\partial C_{201}} \\
0
\end{bmatrix}
\]

(5.32)
Note that the seven by seven matrix of coefficients in 5.32 is exactly the bordered Hessian. Thus, when using Cramer's rule to solve for \( \frac{\partial S_{111}}{\partial A}, \frac{\partial M_{21}}{\partial A}, \frac{\partial C_{201}}{\partial A}, \frac{\partial q_{111}}{\partial A} \), the denominator of the solutions will always be 5.24. The numerators of the solutions will be the determinants of the seven by seven coefficients matrix with particular columns replaced by the right hand side of 5.32. That is:

\[
\frac{\partial S_{111}}{\partial A} = \frac{1}{|H|}
\]

\[
\begin{vmatrix}
0 & 0 & 0 & -1 & 0 & -p_{112} & -h_{11} \\
0 & 0 & 0 & 0 & \frac{\partial^2 \phi}{\partial M_{21}^2} & \frac{\partial^2 \phi}{\partial M_{21} \partial C_{201}} & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 1 \\
-1 & 0 & 0 & \frac{\partial^2 \phi}{\partial M_{21}^2} & 0 & \frac{\partial^2 \phi}{\partial M_{21} \partial C_{201}} & 0 \\
-p_{112} & \frac{\partial^2 \phi}{\partial C_{201}^2} & +1 & \frac{\partial^2 \phi}{\partial C_{201} \partial M_{21}} & -\gamma_1 \partial C_{201} \partial A & \partial C_{201} \partial A & \partial C_{201} \partial A & 0 \\
-h_{11} & 0 & \frac{\partial \psi_{11}}{\partial g_{111}} & 0 & 0 & 0 & \lambda_1 g_{111}^2 & \partial g_{111} \partial g_{111} & 0
\end{vmatrix}
\]

(5.33a)
\[ \frac{1}{|H|} \begin{bmatrix} \frac{\partial^2 \psi_{11}}{\partial q_{111}} - \frac{\partial^2 \phi}{\partial q_{111}} \frac{\partial \Gamma_{111}}{\partial A} \frac{\partial h_{11}'}{\partial q_{111}} \\ -\left(\frac{\partial^2 \phi}{\partial q_{111}} \frac{\partial \Gamma_{111}}{\partial A} \frac{\partial q_{111}}{\partial MW_1} \right) \left[ h_{11} - p_{112} \left(\frac{\partial \psi_{11}}{\partial q_{111}}\right) \right] \\ -\left(\frac{\partial \Gamma_{111}}{\partial A} \right) \left[ h_{11} + \frac{\partial \Gamma_{111}}{\partial C_{201}} \left(\frac{\partial \psi_{11}}{\partial q_{111}}\right) \left( p_{111} - p_{112} \right) - \frac{\partial \psi_{11}}{\partial q_{111}} \right] \\ \left[ -p_{112} \left(\frac{\partial \psi_{11}}{\partial q_{111}}\right) \left(\frac{\partial^2 \phi}{\partial MW_1^2} \right) + \left(\frac{\partial^2 \phi}{\partial C_{201} \partial MW_1} \right) \left(\frac{\partial \psi_{11}}{\partial q_{111}}\right) + \left(\frac{\partial^2 \phi}{\partial MW_1^2} \right) h_{11}' \right] \\ -\left(\frac{\partial \psi_{11}}{\partial q_{111}}\right)^2 \left\{ \left(\frac{\partial \Gamma_{111}}{\partial C_{201}} \right) \left(\frac{\partial q_{111}}{\partial MW_1} \right) \left( p_{111} - p_{112} \right) - \left(\frac{\partial \Gamma_{111}}{\partial A} \right) + \left(\frac{\partial \Gamma_{111}}{\partial C_{201}} \right) \left(\frac{\partial^2 \phi}{\partial C_{201}^2} \right) \right\} \\ + \left(\frac{\partial \phi}{\partial MW_1} \right) \left( p_{111} - p_{112} \right) \left(\frac{\partial^2 \Gamma_{111}}{\partial C_{201}^2} \right) \right] \]

Solutions for \( \frac{\partial MW_1}{\partial A} \), \( \frac{\partial C_{201}}{\partial A} \), and \( \frac{\partial q_{111}}{\partial A} \) could also be found, but because we are only interested in hypotheses about how changes in sales function arguments affect the equilibrium levels of sales, the other solutions are not presented.

To evaluate the sign of Equation 5.33a the assumptions used to evaluate the determinant of \( H \) and the sufficiency conditions for the determinant of \( H \) to be positive are used. Also, it is assumed that \( h_{11} - p_{112} \left(\frac{\partial \psi_{11}}{\partial q_{111}}\right) \) is negative. If prices at the outlets are equal \( p_{111} = p_{112} \), then \( h_{11} - p_{112} \left(\frac{\partial \psi_{11}}{\partial q_{111}}\right) \) is negative by Equation 5.22b. Since interest is centered around how nonprice characteristics influence
outlet decision, it is assumed prices at the two outlets are equal.

Under the assumption of equal prices, the solution for $\frac{\partial S_{111}}{\partial A}$
given in Equation 5.33a simplifies considerably and is presented as

$$
\frac{\partial S_{111}}{\partial A} = \left[ -\frac{\partial^2 \psi_1}{\partial q_{111}^2} \right] \left( \frac{\partial \Gamma_{111}}{\partial A} \right) \left( \frac{\partial \phi}{\partial \text{MW}_1} \right) h_{11} \left( \frac{\partial \psi_1}{\partial q_{111}} \right)
$$

$$
- \left( \frac{\partial^2 \psi_1}{\partial q_{111}^2} \right) \left( \frac{\partial \Gamma_{111}}{\partial A} \right) \left( \frac{\partial \phi}{\partial \text{MW}_1} \right) h_{11} \left( \frac{\partial \psi_1}{\partial q_{111}} \right)
$$

$$
- \left( \frac{\partial \Gamma_{111}}{\partial A} \right) \left( \frac{\partial \psi_1}{\partial q_{111}} \right) \left( \frac{\partial \phi}{\partial \text{MW}_1} \right) h_{11}
$$

$$
+ \left( \frac{\partial^2 \phi}{\partial \text{MW}_1 \partial q_{111}} \right) \left( \frac{\partial \psi_1}{\partial q_{111}} \right) + \left( \frac{\partial^2 \phi}{\partial \text{MW}_1^2} \right) h_{11}
$$

$$
- \left( \frac{\partial \psi_1}{\partial q_{111}} \right)^2 \left( \frac{\partial \Gamma_{111}}{\partial A} \right) \left( \frac{\partial \phi}{\partial \text{MW}_1} \right) h_{11}
$$

(5.33b)

Evaluating Equation 5.33b under the above assumptions, it can be stated that $\frac{\partial S_{111}}{\partial A}$ has the common signs\(^1\) of $\frac{\partial \Gamma_{111}}{\partial A}$ and

$-\frac{\partial^2 \Gamma_{111}}{\partial \text{C}_{201} \partial A}$. If $\frac{\partial \Gamma_{111}}{\partial A}$ and $\frac{\partial^2 \Gamma_{111}}{\partial \text{C}_{201} \partial A}$ are positive the numerator of Equation 5.33b is positive and since the denominator of 5.33b is also positive, $\frac{\partial S_{111}}{\partial A}$ is positive. If $\frac{\partial \Gamma_{111}}{\partial A}$ and

$-\frac{\partial \Gamma_{111}}{\partial \text{C}_{201} \partial A}$ are negative the numerator of 5.33b is negative and

\(^1\)Note that $-\frac{\partial \Gamma_{111}}{\partial \text{C}_{201} \partial A}$ equals $\frac{\partial^2 \Gamma_{111}}{\partial x_{11} \partial A}$. 
\( \frac{\partial S_{111}}{\partial A} \) is negative. Simply stated, if \( \frac{\partial \Gamma_{111}}{\partial A} \) and \( \frac{\partial^2 \Gamma_{111}}{\partial C_{201} \partial A} \) have the same sign then \( \frac{\partial S_{111}}{\partial A} \) will carry this sign.

Outlet type designation one has not yet been given a set of characteristics and the arguments of the sales function have not been identified. In order to develop hypotheses about different outlet types, outlet designation one will be allowed to sequentially assume the characteristics of buying stations, terminal markets and packing plants. Equation 5.10 actually represents three models, one when outlet one is a buying station, a second model when outlet one is a terminal market and a third model when outlet one is a packing plant. In each of the three different versions of 5.10, the difference between production \( (X_{11}) \) and sales to outlet type one \( (S_{111}) \) is sold to all other outlet types at some average price \( p_{112} \). For example, when outlet one is a packing plant, outlet designation two simultaneously represents buying stations, and terminal outlets.

When \( A \) represents an attitude about a market or a producer characteristic associated with selling more to type one outlets \( \frac{\partial \Gamma_{111}}{\partial A} \) and \( \frac{\partial \Gamma_{111}}{\partial X_{11} \partial A} \) will be assumed positive. When \( A \) represents an attitude about a market or producer characteristic generally associated with selling more to other outlets \( \frac{\partial \Gamma_{111}}{\partial A} \) and \( \frac{\partial \Gamma_{111}}{\partial X_{11} \partial A} \) will be assumed negative.

Table 5.1 presents the outlet types of interest and the sales function arguments for which hypotheses are developed. Descriptions of the different types of outlets should make many of the hypotheses more plausible. The
Table 5.1. Sales function arguments and qualitative hypotheses for the outlet selection models

<table>
<thead>
<tr>
<th>Line Number</th>
<th>Argument descriptions and symbols</th>
<th>Hypothesized signs of $\frac{\partial s_1}{\partial a}$ when outlet one designates:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Buying Stations</td>
</tr>
<tr>
<td>1</td>
<td>Age (Y)</td>
<td>?</td>
</tr>
<tr>
<td>2</td>
<td>Number of years as a hog producer (YH)</td>
<td>?</td>
</tr>
<tr>
<td>3</td>
<td>Number of butcher hogs marketed for the year (N)</td>
<td>+</td>
</tr>
<tr>
<td>4</td>
<td>Education level in years (E)</td>
<td>?</td>
</tr>
<tr>
<td>5</td>
<td>Number of acres in cropland (CR)</td>
<td>+</td>
</tr>
<tr>
<td>6</td>
<td>Number of cattle sold for slaughter (CA)</td>
<td>+</td>
</tr>
<tr>
<td>7</td>
<td>Number of feeder pigs purchased (FPP)</td>
<td>?</td>
</tr>
<tr>
<td>8</td>
<td>Percentage of hogs sold on live basis (PL)</td>
<td>?</td>
</tr>
<tr>
<td>9</td>
<td>Percentage of hogs sold on carcass basis (PC)</td>
<td>?</td>
</tr>
<tr>
<td>10</td>
<td>Number of bids received (NB)</td>
<td>+</td>
</tr>
<tr>
<td>11</td>
<td>Percentage of farm income from hog enterprise (FI)</td>
<td>-</td>
</tr>
<tr>
<td>12</td>
<td>Number of days hogs are marketed (NDHM)</td>
<td>+</td>
</tr>
<tr>
<td>13</td>
<td>Capacity of confinement finishing building (CFI)</td>
<td>?</td>
</tr>
<tr>
<td>14</td>
<td>Capacity of confinement farrowing building (CFA)</td>
<td>?</td>
</tr>
<tr>
<td>15</td>
<td>Number of bred sows and gilts sold (BSS)</td>
<td>?</td>
</tr>
<tr>
<td>16</td>
<td>Number of boars sold for breeding purposes (BBS)</td>
<td>?</td>
</tr>
<tr>
<td>17</td>
<td>Average lot size (ALS)</td>
<td>-</td>
</tr>
<tr>
<td>18</td>
<td>Average weight of hogs sold (AWGT)</td>
<td>?</td>
</tr>
<tr>
<td>19</td>
<td>Change in number produced 1967-1971 (AN)</td>
<td>?</td>
</tr>
</tbody>
</table>
Table 5.1 (Continued)

<table>
<thead>
<tr>
<th>Line Number</th>
<th>Argument descriptions and symbols</th>
<th>Buying Stations</th>
<th>Packing Plants</th>
<th>Terminal Markets</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>Convenience (CV*)</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>21</td>
<td>Reliability of weighing (RW*)</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>22</td>
<td>Shrinkage (Sh*)</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>23</td>
<td>Number of competing buyers (CB*)</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>24</td>
<td>Personal attention received (PA*)</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>25</td>
<td>Quality premiums for his weight or grade (QP*)</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>26</td>
<td>Length of wait between sale and receipt of money (LW*)</td>
<td>+</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>27</td>
<td>Marketing costs (MC*)</td>
<td>+</td>
<td>?</td>
<td>-</td>
</tr>
</tbody>
</table>

Marketing Characteristics (MCHAR)

<table>
<thead>
<tr>
<th>Line Number</th>
<th>Argument descriptions and symbols</th>
</tr>
</thead>
<tbody>
<tr>
<td>28</td>
<td>Distance to the outlet type (DIST)</td>
</tr>
</tbody>
</table>
term buying station refers to local relatively small, one-buyer, collection points. Generally the physical facility consists of unloading and loading facilities, several holding pens and a small office. Hogs delivered by farmers to buying stations are seldom held more than 24 hours before shipment to packing plants. The facilities may be operated by individuals, producers' organizations or firms that also own packing plants. For live-weight sales, the farmer generally receives payment when the hogs are delivered. Some packers do purchase hogs on a carcass weight basis at buying stations in which case the farmer would not receive payment until the hogs are slaughtered. There were 228 salaried packer buying stations, and 832 registered dealers and order buyers in Iowa in 1971 (126).

Terminal markets are referred to as public stockyards or central public markets. A stockyards company owns and maintains the physical facilities. Two or more commission firms must operate on such a market (4, p. 5). Commission firms generally act as producer representatives for selling and buying livestock and the producer does not need to go to the outlet with his livestock. Feed, yardage and selling service costs are deducted from the selling price to determine how much the producer receives. There are public stockyards located at Sioux City and Webster City, Iowa, Omaha, Nebraska, St. Joseph, Missouri, East St. Louis and Peoria, Illinois, St. Paul, Minnesota and Sioux Falls, South Dakota that receive hogs from Iowa producers.

Packing plants have basically the same physical procurement facilities as local buying stations except that they are somewhat larger. Plant buying operations are capable of handling a much larger volume. In general plant buyers buy from producers and independent dealers.
Because there are only 22 major hog slaughter facilities in Iowa, they are usually further from most producers than are buying stations.

The arguments of the sales function are presented in the second column of Table 5.1. The list of variables does not exhaust the number and type of arguments that could be related to outlet selection decisions. However, for each of the variables listed, a quantitative value is available from the responses to the questionnaire in Appendix B (question 26).

Hypothesized signs of \[ \frac{\partial S_{111}}{\partial A} \] for each outlet type and variable are also presented in Table 5.1. For the arguments and outlet types where a plus (minus) sign appears in the cell at the intersection of the respective row and column the hypothesis is: the greater (smaller) the value of the variable, the greater (smaller) will be the number of hogs sold to that outlet type. For the arguments and outlet types where a question mark appears the hypothesis is: there is a nonzero (positive or negative) relationship between the argument and sales to a particular type of outlet.

Several of the producer characteristics included reflect traditionalism. Because terminal markets were more predominant outlets 20 to 30 years ago, it is expected that older producers that have been hog producers for a long time are the producers most likely to ship hogs to terminal markets (lines 1 and 2 in Table 5.1). Skadberg (119, p. 62) presented some evidence indicating age and terminal market usage are positively related.

Number of butcher hogs marketed for the year, \( N \), (line 3) and sales
to each type of outlet are hypothesized to be positively related, based on Ward's (140, p. 47) work. Education level, E, (line 4) is expected to be negatively related to sales to terminal outlets because education and age are expected to be negatively related.

Number of acres in cropland, CR, (line 5), number of cattle sold for slaughter, CA, (line 6) and percent of farm income from the hog enterprise, FI, (line 11) are variables that indicate the nature of each producer's total farming operation. In general it is expected that CR and CA will be negatively related to FI. Newberg (90, p. 176) indicated that percentage of butcher hogs sold to dealers and local markets is negatively related to FI. If there is a relatively strong negative correlation between C, CR and FI then it is expected that C and CR would be positively related to sales to buying stations.

Feeder pig purchases, FPP, (line 7) and sales to outlets that are generally further from the producer (packing plants and terminals) are expected to be positively related because it is expected that producers that buy feeder pigs in large uniform lots will also have market hogs to sell in larger more uniform lots. Similarly, average lot size, ALS, (line 17) and number of hogs shipped to packers are expected to be positively related. These hypotheses are based on the idea that large lots can be shipped long distances at relatively low per head costs while shipping hogs long distances in small loads is relatively expensive (126, p. 95).

The percent of hogs sold live, PL, and percent sold on a carcass basis, PC, (lines 8 and 9) are related to outlet selection since terminals
and auctions do not, in general, offer carcass selling systems while most packing plants do offer a carcass selling method and buying stations sometimes do. The hypothesized signs reflect the availability of the methods at the outlet types.

Number of bids received, NB, (line 10) is also related to outlet characteristics. While it is not uncommon for plant buyers and buying station operators to visit farms to bid on livestock, terminal market commission agents and auction operators do not bid on livestock prior to sale although they may visit the farm and estimate what they feel they could pay for the livestock at their facility.

The confinement finishing, CFI, and confinement farrowing, CFA, capacity variables (lines 13 and 14) are included to reflect the nature of the farmer's production unit. Specific expectations for the signs of the hypotheses are not stated. Breeding sow and boar sales, BSS, BBS, (lines 15 and 16) are included to reflect the extent to which each producer is a breeding stock or purebred producer. Again no a priori expectations for the signs are stated. Average weight of hogs sold, AWGT, (line 18) and change in number of butcher hogs sold, ΔN, (line 19) are included but no expected signs are presented.

Maki and Strand (78, p. 104) provide an excellent source for developing expectations for the signs of ηs_{111}/ηA when A is the producer's attitude toward outlet characteristics. Specifically, their results indicate that the number of hogs sold to terminals and auctions should be positively related to the producer's rating of the importance of number of competing buyers, CB*, (line 23) and that the number of hogs sold to
buying stations and packing plants should be negatively related to the score given to CB*. In addition, the Maki and Strand report indicates we should expect the score given to convenience, CV*, (line 20) to be positively related to the number of hogs shipped to buying stations and packing plants and negatively related to the number of hogs shipped to terminals. Personal attention received, PA*, (line 24) shrinkage, Sh* (line 22) and length of wait between sale and receipt of money, LW*, (line 26) are variables that would also be rated high by a person giving a high rating to the importance of convenience. Therefore the hypotheses for PA*, Sh*, and LW* are the same as those for convenience. Expectations for the nature of the relationships between sales to the outlet types and reliability of weighing RW*, (line 21) and quality premiums, QP*, (line 25) are not specified. As was stated earlier, each producer's rating of the importance of marketing costs, MC*, (line 27) is included as a substitute for the inclusion of actual marketing costs in the smaller models. Importance of marketing costs is hypothesized to be positively related to number of hogs shipped through buying stations and negatively related to the number shipped through terminal outlets based on the relative average distances to each type and the fact that yardage and commission fees must be paid when livestock are shipped through terminal outlets. Since packing plants are somewhat further from most farmers than buying stations yet closer than terminals, a specific hypothesized relationship is not stated in the packing plant column.
B. Model Describing the Weight Choice Decision

The model presented in Section B describes the weight choice decision. As stated previously, it is assumed producers sell to only one outlet and per head prices and marketing costs for each weight are known. While in the outlet decision model hogs could be sold at only one weight, the weight choice model allows hogs to be sold at two different weights. Producers decide how many hogs to sell at each of the weights. Each producer enters the single period planning horizon with \( C_{11} \) hogs weighing a light but marketable weight. He can increase the average weight of the lot by giving the hogs feed which increases the number of heavy hogs in the lot. The producer knows how many hogs will reach the heavier weight as he feeds more feed, the prices of light and heavy hogs, and the price of feed. All \( C_{11} \) hogs are sold at a light \( (S_{111}) \) or heavy \( (S_{121}) \) weight. The decision situation is described by the following model:

\[
\text{Maximize } \phi(MW_1) \tag{5.37}
\]

subject to:

\[
S_{111} = C_{11} - S_{121} \tag{5.38}
\]

\[
X_{12} = \psi_{12}(q_{112}, C_{11}) \tag{5.39}
\]

\[
S_{121} = \gamma_{121}(MCHAR, PCHAR, PATO*, PATW*, P_{121}, P_{111}, X_{12}) \tag{5.40}
\]

\[
MW_1 = p_{111}S_{111} + p_{121}S_{121} - h_{11}q_{112} \tag{5.41}
\]
The decision variables are $S_{111}$, $X_{12}$, $q_{112}$, $S_{121}$, and $MW_{1}$. The producer chooses those variables such that the constraints are satisfied and 5.37 is maximized. Equation 5.37 defines sales at the light weight as the difference between carryover and sales at the heavier weight. Equation 5.39 states the known relationship between the number of heavier hogs in the lot and the amount of feed fed ($q_{112}$). Equation 5.40 is the sales function for heavier hogs and 5.41 defines money withdrawals as the difference between revenues and cost. The four constraints can be shown to satisfy the Jacobian assumption of independence. The Jacobian matrix of 5.38 through 5.41 is:

$$
C = \begin{bmatrix}
1 & 1 & 0 & 0 & 0 \\
0 & 0 & 1 & -\frac{\partial \psi_{12}}{\partial q_{112}} & 0 \\
0 & 1 & -\frac{\partial \Gamma_{121}}{\partial X_{12}} & 0 & 0 \\
-P_{111} & -P_{121} & 0 & h_{11} & 1
\end{bmatrix}
$$

(5.42)

The determinant of the matrix consisting of the last four columns of $C$ is

$$-(\frac{\partial \psi_{12}}{\partial q_{112}})(\frac{\partial \Gamma_{121}}{\partial X_{12}})$$

and is clearly nonzero.

1. **Lagrangian formulation**

In order to recognize the joint nature of the sales and production decisions and to simplify the Lagrangian model, the weight gaining function (5.39) is substituted into 5.40 as the definition of $X_{12}$. The substitution eliminates one variable ($X_{12}$) and a constraint (5.39).
Also, 5.38 is substituted for $S_{111}$ into Equation 5.41 eliminating the need for 5.38 and $S_{111}$. The Lagrangian formulation then has three endogenous variables ($S_{121}$, $q_{112}$, and $MW_1$) and two constraints and can be expressed as:

\[ L = \phi(MW_1) - \gamma_1 [S_{121} - \Gamma_{121}(\text{PCCHAR, MCHAR, PATO*, PATW*, } P_{111}, P_{121}, \psi_{12})] \]

\[ \alpha_1 [MW_1 - P_{121}S_{121} - P_{111}(C_{11}, -S_{121}) + h_{11}q_{112}] \] (5.43)

The first order conditions are:

\[ \frac{\partial L}{\partial MW_1} = \frac{\partial L}{\partial MW_1} - \alpha_1 = 0 \] (5.44)

\[ \frac{\partial L}{\partial S_{121}} = -\gamma_1 + \alpha_1 (P_{121} - P_{111}) = 0 \] (5.45)

\[ \frac{\partial L}{\partial q_{112}} = \gamma_1 (\frac{\partial \psi_{12}}{\partial q_{112}}) - \alpha_1 h_{11} = 0 \] (5.46)

\[ \frac{\partial L}{\partial \gamma_1} = -S_{121} + \Gamma_{121} = 0 \] (5.47)

\[ \frac{\partial L}{\partial \alpha_1} = -MW_1 + P_{121}S_{121} + P_{111}(C_{11}, -S_{121}) - h_{11}q_{112} = 0 \] (5.48)

Solving 5.44 and 5.45 for $\alpha_1$ and $\gamma_1$ yields

\[ \alpha_1 = \frac{\partial \phi}{\partial MW_1} \] (5.49)

\[ \gamma_1 = \frac{\partial \phi}{\partial MW_1} (P_{121} - P_{111}) \] (5.50)
Substituting 5.49 and 5.50 into 5.46 and rearranging yields:

\[
\frac{\partial \phi}{\partial M_{1}} \left( P_{121} - P_{111} \right) \frac{\partial \Gamma_{121}}{\partial \psi_{12}} = \frac{(\partial \phi/\partial M_{1}) h_{11}}{(\partial \psi_{12}/\partial q_{112})} \quad (5.51)
\]

Equation 5.51 is equivalent to 4.61 and 4.62 in the general model.

Since it has been assumed that everything produced is sold, the marginal propensity to sell weight two production \( \frac{\partial \Gamma_{121}}{\partial \psi_{12}} \) equals one. Cancelling \( \frac{\partial \phi}{\partial M_{1}} \) from both sides of 5.51 and equating \( \frac{\partial \Gamma_{121}}{\partial \psi_{12}} \) to one, 5.51 states that marginal revenue \( (P_{121} - P_{111}) \) from additional heavy hogs equals the marginal expense of producing additional heavy hogs \( \left( \frac{h_{11}}{\partial \psi_{12}/\partial q_{112}} \right) \).

Assuming that all heavier hogs produced are sold (i.e., \( \frac{\partial \Gamma_{121}}{\partial \psi_{12}} = 1 \)) means that the second partial derivatives of the sales function are zero (i.e., \( \frac{\partial^{2} \Gamma_{121}}{\partial \psi_{12}^{2}} = \frac{\partial^{2} \Gamma_{121}}{\partial \psi_{12} \partial A} = 0 \)). Therefore, the second order conditions are satisfied if the determinant of \( H \) is negative where \( H \) is:

\[
H = \begin{bmatrix}
0 & 0 & -1 & P_{121} - P_{111} & -h_{11} \\
0 & 0 & 0 & -1 & \frac{\partial \psi_{12}}{\partial q_{112}} \\
-1 & 0 & \frac{\partial^{2} \phi}{\partial M_{1}^{2}} & 0 & 0 \\
P_{121} - P_{111} & -1 & 0 & 0 & 0 \\
-h_{11} & \frac{\partial \psi_{12}}{\partial q_{112}} & 0 & 0 & \gamma_{1} \left( \frac{\partial^{2} \psi_{12}}{\partial q_{112}^{2}} \right)
\end{bmatrix} \quad (5.52)
\]
The determinant of $H$ is:

$$|H| = \frac{\partial^2 \phi}{\partial MW_1^2} (P_{121} - P_{111}) \frac{\partial^2 \psi_{12}}{\partial q_{112}^2}$$  

(5.56)

and is negative if heavy hogs are worth more than light hogs (per head), the marginal propensity of money withdrawals is positive and the marginal physical productivity of feed diminishes.

2. Hypotheses

Hypotheses are generated from shocking the model with a change in either producer characteristics or producers' attitudes toward selling different weights. Again the model is structured such that hypothesis generation requires minimal matrix or determinant evaluation because all of the variables of interest are arguments only of the sales function.

Totally differentiating the first order conditions with respect to an argument of the sales function (designated $A$) yields:

$$\frac{\partial^2 \phi}{\partial MW_1^2} \frac{\partial MW_1}{\partial A} - \frac{\partial \alpha_1}{\partial A} = 0$$  

(5.53)

$$- \frac{\partial \gamma_1}{\partial A} + \frac{\partial \alpha_1}{\partial A} (P_{121} - P_{111}) = 0$$  

(5.54)

$$\frac{\partial \gamma_1}{\partial A} \frac{\partial \psi_{12}}{\partial q_{112}} + \gamma_1 \frac{\partial^2 \psi_{12}}{2 \partial q_{112}^2} - \frac{\partial q_{112}}{\partial A} - h_{11} \frac{\partial \alpha_1}{\partial A} = 0$$  

(5.55)

$$- \frac{\partial S_{121}}{\partial A} + \frac{\partial \Gamma_{121}}{\partial A} + \frac{\partial \Gamma_{121}}{\partial \psi_{12}} \frac{\partial \psi_{12}}{\partial q_{112}} \frac{\partial q_{112}}{\partial A} = 0$$  

(5.56)
Again the assumptions that all heavier hogs produced are sold
\( \frac{\partial^2 \Gamma_{112}}{\partial \psi_{12}^2} = 1 \) and that the second partial derivatives of the sales function are zero \( \frac{\partial^2 \Gamma_{121}}{\partial \psi_{12}^2} = 0 \) were used. Therefore 5.53 through 5.57 can be rewritten as:

\[
H \begin{bmatrix} \frac{\partial \omega_1}{\partial A} \\ \frac{\partial \gamma_1}{\partial A} \\ \frac{\partial \omega_1}{\partial A} \\ \frac{\partial \psi_{12}}{\partial A} \\ \frac{\partial q_{112}}{\partial A} \end{bmatrix} = \begin{bmatrix} 0 \\ -\frac{\partial \Gamma_{121}}{\partial A} \\ 0 \\ 0 \\ 0 \end{bmatrix}
\]  

(5.58)

Using Cramer's rule to solve for \( \frac{\partial \psi_{12}}{\partial A} \) yields

\[
\frac{\partial \psi_{12}}{\partial A} = \frac{1}{|H|} \left\{ \left( \frac{\partial \Gamma_{121}}{\partial A} \right) \left( \frac{\partial \psi_{12}}{\partial \omega_1} \right) \left( \frac{\partial \omega_1}{\partial A} \right)^2 \right\}
\]

(5.59)

Using knowledge that the determinant of \( H \) is negative, \( \frac{\partial \psi_{12}}{\partial A} \) will be positive if \( \frac{\partial \Gamma_{121}}{\partial A} \) is positive and \( \frac{\partial \psi_{12}}{\partial A} \) will be negative if \( \frac{\partial \Gamma_{121}}{\partial A} \) is negative, as long as \( \frac{\partial \phi}{\partial \omega_1} \) and \( (P_{121} - P_{111}) \) are positive and

\[ \frac{\partial \omega_1}{\partial A} \] and \[ \frac{\partial q_{112}}{\partial A} \] can also be found.
\[ \frac{\partial^2 \psi_{112}}{\partial q_{112}^2} \] is negative. That is, heavier hogs must be worth more than light hogs, the marginal utility of money must be positive and the marginal physical product of the variable input must diminish.

Again, the sales function arguments (designated A) of interest and hypotheses need to be identified and stated. The second column of Table 5.2 lists the arguments of interest and the third column states the hypothesis to be tested. Unlike the outlet decision, very little previous research has analyzed the relationship between producer characteristics and attitudes and the weight choice decision. Therefore, in many cases hypothesized signs are not presented. Where signs are presented, the hypotheses are for the most part based on the author's intuitive judgment, analysis and common sense (or lack of it). Some variables are listed in order to lead other researchers to more productive research areas. Negative results—finding no significant relationship between a variable and the weight decision—will be nearly as useful as the discovery of significant relationships. Question marks are again used to indicate that the hypotheses are of the more general form: there is a significant relationship. Plus and minus signs indicate that the hypotheses are of the form: there is a positive (negative) relationship between the variable and the number of heavy hogs sold. Where the arguments are discrete rather than continuous variables (lines 16 and 17) marginal changes are not possible but the variables are listed for completeness (N/A means not applicable). Age, Y, (line 1) and number of years as a hog producer, YH, (line 2) are included again to reflect
Table 5.2. Hypothesized relationships between number of heavy hogs sold and the sales function arguments

<table>
<thead>
<tr>
<th>Line</th>
<th>Argument description and symbol</th>
<th>Producers' Characteristics (PCHAR)</th>
<th>Hypothesized sign of Ss121 SsA</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Age (Y)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Number of years as a hog producer (YH)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Number of butcher hogs marketed (N)</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Education level in years (E)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Number of acres in cropland (CR)</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Number of feeder pigs purchased (FPP)</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Percent of hogs sold on a live basis (PL)</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Percent of hogs sold on a carcass basis (PC)</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Number of bids received (NB)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Number of days hogs on market (NDHM)</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Percent of time producer sorts properly (PSP)</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Capacity of confinement finishing building (CFI)</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Number of bred sows and gilts sold (BSS)</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Number of boars sold for breeding purposes (BBS)</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Average lot size (ALS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Outlet types used (OT)</td>
<td>N/A^a</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Uses livestock scale (SCAL)</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Inclination toward varying the weight of hogs (GVR)</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

Producers' ratings of factors affecting sales at different weights (PATW*)

<table>
<thead>
<tr>
<th>Line</th>
<th>Argument description and symbol</th>
<th>Need facilities for other hogs or livestock (FN*)</th>
<th>Labor availability (LA*)</th>
<th>Lack of labor (LL*)</th>
<th>Supply of home grown feed (HF*)</th>
<th>Importance of sorting properly (SP*)</th>
<th>Time available to market hogs (TA*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td></td>
<td>-</td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
<td>+</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td></td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td></td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td></td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td></td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

^a N/A means not applicable.
traditionalism. Number of hogs marketed for the year, \( N \), (line 3) and education, \( E \), (line 4) are included to test for differences between different sized operations and producers with different levels of formal education. Specific signs for the hypotheses about \( Y \), \( Y_H \) and \( E \) are not presented. Number of heavy hogs sold is expected to be positively related to \( N \).

Number of acres in cropland, \( CR \), (line 5) is hypothesized to be positively related to \( S_{121} \) because producers with a great amount of field work to do sometimes are simply too busy to take time to market hogs. \(^1\) Number of feeder pigs purchased, \( FPP \), (line 6) is included to test for differences between producers that have a farrow-to-finish operation as opposed to those that feed out purchased feeder pigs. Number of bids received, \( NB \), (line 9) and average lot size, \( ALS \), (line 15) are also included although no specific hypotheses are presented. Percent sold live, \( PL \), and percent sold carcass, \( PC \), (lines 7 and 8) are hypothesized to be negatively and positively related to number of heavy hogs sold because it is felt that producers selling more of their hogs on a carcass basis can sell heavier hogs and still receive top prices (assuming quality is maintained). Number of days hogs are marketed, \( NDHM \), and percent of the time the producer feels he succeeds in sorting properly, \( PSP \), (lines 10 and 11) are included to test whether producers who sort carefully and market often sell heavier

\(^1\) One of my undergraduate students described some heavy hogs he marketed in early November as suffering from corn-picking, soybean harvest disease.
or lighter hogs. Capacity of confinement finishing building, CPI, (line 12) is included to test for a relationship between facility types and weight of hogs sold. Breeding stock sales BSS, BBS, (lines 13 and 14) are hypothesized to be positively related to number of heavy hogs sold because of the trend toward larger hogs and the feeling that people selling breeding stock as well as market hogs should be leading the trend.

Outlet type used, OT, (line 16) represents three classification variables that will be used to test if there is a connection between the outlet types producers use and their weight decision. Use of livestock scale, ULS, (line 17) will test whether those producers that have or use a scale sell heavier or lighter hogs.

Inclination toward varying the weight of hogs, GVR, (line 18) could well be considered an attitude variable. The variable will be set up to test for a connection between the producer's attitude toward varying the weight of hogs sold and the number of heavy hogs sold. The information about producers' attitudes towards varying weight is found in question 32 (see Appendix B).

Six variables rated on importance by all of the producers are also hypothesized to be related to the weight choice decision. It is hypothesized that a producer rating need of facilities for other livestock, FN*, (line 19) and lack of labor, LL*, (line 22) high will market smaller hogs while producers that rate labor availability, LA*, (line 20) high will market heavier hogs. Importance given to sorting properly, SP*, (line 23), supply of home grown feed, HF*, (line 22)
and time availability, $TA^*$, (line 24) are included but the signs of the hypotheses are not stated.
VI. STATISTICAL PROCEDURES AND RESULTS

The purpose of Chapter VI is to tell how the hypotheses were tested and to show and discuss the results of the testing procedures. Section A presents a brief discussion of general linear regression models and discriminant analysis. Section B is a description of how the theoretical outlet selection hypotheses were tested using the statistical procedures presented in Section A and a discussion of the results. Section C is a discussion of the results of the tests of the weight decision hypotheses.

A. Statistical Procedures

Linear regression models and discriminant analysis differ with respect to the questions they attempt to answer, the assumptions used to derive the estimators and test statistics, the estimation procedures used and the ways results are best presented. Johnston (58) will be used as the primary source for the brief linear regression discussion while Rao (107, 108), Anderson (5) and Hallberg (44) will be used as primary sources for the discriminant analysis discussion. Theoretical discussions showing the derivation of the statistical techniques are not presented but sources for the reader interested in the appropriate theoretical derivations are given.

1. Linear regression models

Linear regression models are widely used by researchers interested in associating the size of a dependent variable Y with numerous independent variables, Z_i. In Chapter VI regression models are used to test
the hypotheses in Tables 5.1 and 5.2. The sales functions will be assumed to take a linear form and hypotheses about \( \frac{\partial S_{121}}{\partial A} \) and \( \frac{\partial S_{111}}{\partial A} \) will be tested by testing hypotheses about regression coefficients.

The linear regression model can be written in matrix notation as:

\[
Y = ZB + u
\]  

(6.1)

where:

- \( Y \) is a \( n \times 1 \) vector of the dependent variable;
- \( Z \) is a \( n \times k \) matrix of \( k \) explanatory variables;
- \( B \) is a \( k \times 1 \) vector of coefficients; and
- \( u \) is a \( n \times 1 \) vector of error terms.

In order to estimate the coefficients, the following ordinary least squares assumptions are used:

\[
E(u) = 0; \quad (6.2a)
\]

\[
E(uu') = \sigma^2 I_n; \quad (6.2b)
\]

\( Z \) is a set of fixed numbers; and

\( Z \) has rank \( k < n \). \hspace{1cm} (6.2c)

The first assumption says that the expected value of each \( u \) is zero and the second assumption states that the errors have constant variance (are homoscedastic) and are pairwise uncorrelated. Assumption 6.2c means "that in repeated sampling the sole source of variation in

---

1The \( Z_i \) are not restricted to being continuous variables but can also be classification variables. When an intercept is desired the first column of \( Z \) is a column of 1's.

2\( E(u) \) means the "expected value of \( u \)."
the $Y$ vector is variation in the $u$ vector and the properties of the estimator and tests are conditional upon $Z$ (58, p. 123).''

Using the four assumptions, the well-known best linear unbiased estimators of $B$ are given by (58, p. 124):

\[ \hat{B} = (Z'Z)^{-1}Z'Y. \]  
\[ (6.3) \]

Using assumptions 6.2a-6.2d, $\hat{B}$ can be shown to be unbiased by showing that $E(\hat{B}) = B$ and $\hat{B}$ is the best estimator because it has as small a sampling variance as any other linear unbiased estimator. $\hat{B}$ is a linear estimator because it is formed from linear combinations of $Y$.

The vector of errors is estimated by

\[ e = Y - Z\hat{B}. \]  
\[ (6.4) \]

Also using assumptions 6.2a-6.2d an unbiased estimator of $\sigma^2$ is given by

\[ s^2 = \frac{e'e}{n-k}. \]  
\[ (6.5) \]

and the variance of $\hat{B}$ is estimated by:

\[ \text{Var}(\hat{B}) = (Z'Z)^{-1}s^2. \]  
\[ (6.6) \]

To derive significance tests for the $\hat{B}$ it is usually customary to add to assumptions 6.2a-6.2d the assumption that $u$ is normally distributed. That is:
Expression 6.7 can be used to summarize the three assumptions about \( u \). Using 6.7 in addition to 6.2c and 6.2d, it can be shown that

\[ B \sim N(B, (Z'Z)^{-1} \sigma^2) \]  \hspace{1cm} (6.8)

and that an appropriate test statistic for individual \( B_i \) (i.e., \( H_0: \hat{B}_i = B_i \)) is

\[
t = \frac{\hat{B}_i - B_i}{\sqrt{\sigma^2 a_{ii}}} \]  \hspace{1cm} (6.9)

where \( B_i \) is the hypothesized value and \( a_{ii} \) is the \( i \)th diagonal element in \((Z'Z)^{-1}\). The appropriate test for the hypothesis that all \( \hat{B}_i = 0 \) is given by

\[
F = \frac{\hat{B}'Z'Y / (k-1)}{\sigma^2 / (n-k)} \]  \hspace{1cm} (6.10)

with \( k-1 \) and \( n-k \) degrees of freedom. To test whether a subset of the \( \hat{B}_i \) is equal to zero the appropriate test statistic is

\[
F = \frac{(\hat{B}'Z'Y - \hat{B}'\hat{Z}'Y) / (k-r)}{\sigma^2 / (n-k)} \]  \hspace{1cm} (6.11)

with \( k-r \) and \( n-k \) degrees of freedom where \( \hat{B}'\hat{Z}'Y \) is the regression sum of squares for the reduced model, \( \hat{B}'\hat{Z}'Y \) is the regression sum of squares from the full model and \( k-r \) is the number of variables included in the full model that were not included in the reduced model.
Another statistic often used when reporting regression results is the coefficient of multiple correlation ($R^2$) which is given by

$$R^2 = \frac{\hat{y}'(Y - nY)^2}{Y'Y - nY^2}$$  \hspace{1cm} (6.12)

which summarizes the model by indicating the proportion of the total corrected variation in $Y$ which is explained by variation in $X$.

Quite often it is wise to test the homoscedasticity assumption (Equation 6.2b) when doing cross-sectional regression analysis. To test for heteroscedasticity, simple regression models are run to determine if one or more of the $Z_1$ can be used to predict the absolute value of the error term defined by Equation 6.4. The testing equations take the general form:

$$|e| = f[h(Z_1), h(Z_2), \ldots, h(Z_n)]$$  \hspace{1cm} (6.13)

Both simple and multivariate models were run with $h(Z_k)$ representing linear, square root and square transformations. Also, since $\hat{Y}$ represents a linear combination of the $Z_k$, $\hat{Y}$ was used in 6.13 as a dependent variable. If none of the models have a significant $F$ value, heteroscedasticity is apparently not a problem. If evidence of heteroscedasticity is found, two approaches may be used. For equations with a proportion or percentage as the dependent variable, the transformation

$$Y^* = \text{arc sine } \sqrt{Y}$$  \hspace{1cm} (6.14)

where the arc sine is measured in radians tends to equalize variance so
that errors of the transformed data are homoscedastic (68, Chapter 6, page 32; 121, p. 327).

A generalized least squares transformation suggested by Glejser (42) is used when the dependent variable is not a proportion. For generalized least-squares, Assumption 6.2b is replaced by

\[ E(\mathbf{uu'}) = \sigma^2 \Omega \quad (6.2b') \]

where \( \Omega \) is a \( n \times n \) symmetric positive definite matrix of order \( n \).

Under the assumption that the errors are heteroscedastic \( \Omega \) is diagonal. The generalized least squares estimates of \( \mathbf{B} \) are given by

\[ \mathbf{b} = (\mathbf{Z}'\Omega^{-1}\mathbf{Z})^{-1}\mathbf{Z}'\Omega^{-1}\mathbf{y} . \quad (6.15) \]

The elements of \( \Omega \) are estimated by the best model from Equation 6.13. For example where the best form of 6.13 is

\[ \hat{\mathbf{e}} = \hat{\alpha}_0 + \hat{\alpha}_1 \mathbf{z}_1 . \quad (6.16) \]

\( \Omega \) would be estimated by

\[
\hat{\Omega} = \begin{bmatrix}
\hat{\varepsilon}_1^2 & & \\
& \hat{\varepsilon}_2^2 & \\
& & \hat{\varepsilon}_3^2 \\
& & & \ddots \\
& & & & \hat{\varepsilon}_n^2
\end{bmatrix} . \quad (6.17)
\]
Operationally, \( b \) can be found by defining the matrix \( P \) such that

\[ PP' = \Omega^{-1} \quad (6.18) \]

\( P \) satisfies 6.18 if \( P \) is defined by

\[
P = \begin{bmatrix}
\hat{e}_1^{-1} & \\
\hat{e}_2^{-1} & \\
\vdots & \\
\hat{e}_n^{-1} & 
\end{bmatrix}
\quad (6.19)
\]

Substituting 6.18 into 6.15 yields

\[
\hat{b} = (Z'PP'Z)^{-1}Z'PP'Y
\quad (6.20)
\]

Letting \( Z^* \) equal \( Z'P \) and \( Y^* \) equal \( P'Y \), the generalized least squares estimators can be found by the ordinary least squares regression

\[
\hat{b} = (Z^*Z^*)^{-1}Z^*Y^*
\quad (6.21)
\]

All of the testing procedures derived for ordinary least squares are applicable to the coefficients from Equation 6.21. If the errors from the transformed model still exhibit heteroscedasticity properties, the transformation process can be repeated. The biggest problem faced for a user of the procedure is specifying the form of Equation 6.13. Once specified, \( Z^* \) and \( Y^* \) are found by dividing all of the \( Z \) variables (including the column of 1's) and \( Y \) for each observation by the predicted \( \hat{e} \) for each observation from Equation 6.13.
Discriminant analysis

Discriminant analysis is one of several procedures designed for taxonomic or classification problems. The technique was first reported by biologist R. A. Fisher in 1936: "When two or more populations have been measured in several characters $x_1, x_2, \ldots, x_8$ special interest attaches to certain linear functions of the measurements by which the populations are best discriminated (36, p. 179)".

Whereas Fisher's original empirical example was concerned with distinguishing between two flower varieties, economists have used discriminant analysis to distinguish between countries with high, medium and low development potential (2), to divide used car loans into bad-loan and good-loan groups (29), and to discriminate between cooperative members in favor of, opposed to and indifferent to a merger (44).

Researchers using discriminant analysis usually cite Rao (107, 108) or Anderson (5) for the theoretical derivations of discriminant functions. Hallberg (44) does an excellent job of describing how to use Anderson's (5) classification criteria. The basic principle of discriminant analysis is to produce linear functions of a set of measurements $Z_{nkm}$ such that the variation between each pair of $M$ ($m=1,2,\ldots,M$) groups is maximized relative to the variation within groups. It is usually assumed that each of the $M$ populations or groups has a multivariate normal distribution with respect to the $K$ ($k=1,2,\ldots,K$) variables. In addition, quite often it is also assumed that the groups share a common variance-covariance matrix. That is:
\[ Z_{nk1} \sim N(u_1, \Sigma) \]
\[ Z_{nk2} \sim N(u_2, \Sigma) \]
\[ \vdots \]
\[ Z_{nkM} \sim N(u_M, \Sigma) \]  \hspace{1cm} (6.22)

where the \( u_m \) are \( K \times 1 \) vectors of \( K \) variable means and \( \Sigma \) is a \( K \times K \) matrix of variances and covariances. The \( K \) elements in the vectors of means for each group \( Z_m \) are of course estimated by

\[
\bar{z}_{km} = \frac{1}{N_m} \sum_{n=1}^{N_m} z_{nkm}, \quad k = 1, 2, \ldots, K
\]

where \( N_m \) is the number in the \( m \)th group. The variance-covariance matrix \( \Sigma \) has elements estimated by

\[
S_{kk'} = \frac{1}{N - M} \sum_{m=1}^{M} \sum_{n=1}^{N_m} (z_{nk'm} - \bar{z}_{km})(z_{nkm} - \bar{z}_{km})
\]  \hspace{1cm} (6.24)

where \( k, k' = 1, 2, \ldots, K; N_m \) is the number of observations in the \( m \)th group and \( N = \sum_{m=1}^{M} N_m \).

In addition to the probability density function specifications, prior probabilities \( \pi_1, \pi_2, \ldots, \pi_M \) for the populations are also specified. Also, a loss function that specifies the loss in identifying an individual of the \( i \)th population as a member of the \( j \)th population are sometimes specified. Throughout this thesis it will be assumed that the losses due to wrong classification are equal.
Using the above assumptions, Hallberg (44) states the classification rule derived by Anderson (5) as: An individual $i$ should be classified into that group $m$ for which

$$D_{mm'} \geq \ln \left( \frac{\pi_{m'}}{\pi_m} \right)$$

(6.25)

for all

$m' = 1, 2, \ldots, M$, $m \neq m'$ where

$$D_{mm'} = \alpha_{mm'} + Z_i B_{mm'}.$$  

(6.26)

The coefficients of 6.26 are estimated by

$$\hat{B}_{mm'} = S^{-1}(\bar{Z}_m - \bar{Z}_{m'})$$

(6.27)

and

$$\hat{\alpha}_{mm'} = -0.5(\bar{Z}_m + \bar{Z}_{m'}) S^{-1}(\bar{Z}_m - \bar{Z}_{m'}).$$

(6.28)

where $S$ is the estimate of $\Sigma$ and has elements defined by 6.24 and $Z_i$ are vectors of values of the $K$ multivariate normally distributed variables for observation $i$. Rao (108, p. 575) on the other hand, says to classify the observation into the group for which $I_m$ is greatest where $I_m$ is defined by

$$I_m = \left( \bar{Z}_m S^{-1} \right) Z_i - \frac{1}{2} \bar{Z}_m S^{-1} \bar{Z}_m + \ln \pi_m, \quad m = 1, 2, \ldots, M.$$  

(6.29)

$^1D_{mm'} = -D_{m'm}.$

$^2$Rao also states the general criteria when it is not assumed that the variance matrices are equal (108, p. 575).
Appendix E presents a proof that the criteria represented by Equations 6.25 and 6.29 are equivalent.

In the absence of prior probabilities, Hallberg (44, p. 3) estimates the $\pi_m$ by the sample proportions of the observations found in each class, as does Rao in his worked example (108, p. 577). Without appropriate prior information, in the work that follows, weighted sample proportions using the weights found in Appendix Table C.1 are used instead of prior proportions. It should also be noted that the discriminant function given by 6.29 is Fisher's (36) original discriminant function expanded to the M group case. The two-group case is exactly the function Fisher used (108, p. 575).

In general, the assumption that the Z variables are jointly normally distributed is untenable. Although Hallberg did not discuss the problem, his variable "percent of income earned off-farm" is likely to be zero for a great many of the dairy cooperative members. Nonnormality problems would be especially acute if qualitative or classification variables are to be used as Z variables. Gilbert (41) studied the problem using computer experiments with dichotomous independent variables in a discriminant problem. Of the four discriminant procedures tested she concluded that "the loss involved from using Fisher's LDF (Linear Discriminant Function) for classification as opposed to any of the other procedures is too small to be of much importance. Thus the simplicity and familiarity of Fisher's LDF in addition to the possibility of combining discrete and continuous variables makes its use seem desirable (41, p. 1410)". Unfortunately the variance
formulas and testing procedures given by Hallberg (44, pp. 6-7) are derived using the assumption that the variables are normally distributed. However, the tests will be performed even though it is not necessarily expected that the variables will be normally distributed. The asymptotic variance of \( \hat{\beta}_w \) (one of the \( \hat{\beta}_{nm} \), in the vector given by Equation 6.27) is given by

\[
\text{Var}(\hat{\beta}_w) = \frac{\hat{\beta}_w^2}{N} + \frac{C_{ww}}{N} \hat{\beta}_{mm}'(\overline{Z}_m - \overline{Z}_m') + \left[ \frac{1}{N_m} + \frac{1}{N_m'} \right] (C'V_{mm}C_w) \tag{6.30}
\]

where \( C_w \) is the \( w \)th column of \( S^{-1} \) and \( V_{mm} \) is a \( K \times K \) matrix with elements defined by

\[
v_{kk'} = \frac{1}{N_m + N_{m'}} \sum_{t=1}^{N_m + N_{m'-2}} (Z_{tkm} - \overline{Z}_m)(Z_{tk'm'} - \overline{Z}_{k'm'}),
\]

with \( \overline{Z}_m, \overline{Z}_{k'm'} \), the means of variables \( k \) and \( k' \) over the two groups \( m \) and \( m' \). The \( \hat{\beta}_{mm} \) will be compared to their variance and an approximate \( t \) will be calculated for each.

In addition to the tests for individual coefficients, a criterion for appraising the results of the full model is needed. The obvious test is to determine how many of the observations are correctly classified. Analyzing the groups from which misclassified observations come should help determine the overall significance of each of the discriminant functions defined by 6.27.
3. **Summary**

For both discriminant models and least squares regression models, tests for individual coefficients and statistics indicating the overall strength of the models have been presented. For each regression model the following will be presented:

1. $\hat{B}$ from Equation 6.3 or 6.21.
2. $t$ statistics for each $\hat{B}$.
3. $F$ statistic for the full model from Equation 6.10.

If a transformation for heteroscedasticity has been made the specific form of Equation 6.13 will be presented. If an analysis of covariance model is used, the appropriate test for interaction will be made using Equation 6.11.

For each discriminant model the following will be presented:

1. $\hat{b}_{mn}$ from Equation 6.27.
2. $t$ statistic for each $\hat{b}$ using the variances from 6.30.
3. A summary table showing the results of the classification procedure.

**B. Outlet Selection Results and Analysis**

In Chapter V a theoretical outlet decision model was used to generate testable hypotheses. In Section A of this chapter statistical procedures were described. The purpose of Section B is to show how the survey data, hypotheses and statistical procedures are related.

For each type of outlet considered, three classes of producers
were defined. The producers were classified as 1) selling none of their hogs to that type, 2) selling all of their hogs to that type or 3) selling part but not all of their hogs to that type of outlet. Of the 489 questionnaires available, 433 were found to have complete data for all of the variables listed in Table 5.1. Table 6.1 shows how many of the producers sold all, part, and none of their hogs to each type of outlet. It is apparent that for the 433 producers, buying stations were by far the most popular type of outlet with only 91 producers not selling hogs at buying stations whereas 314 and 355 producers did not sell to packing plants and terminals.

Table 6.1. Number of producers that sold all, part and none of their hogs to each type of outlet

<table>
<thead>
<tr>
<th>Outlet Type</th>
<th>Number of producers selling</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All</td>
<td>Part</td>
</tr>
<tr>
<td>Buying stations</td>
<td>249</td>
<td>93</td>
</tr>
<tr>
<td>Packing plants</td>
<td>42</td>
<td>77</td>
</tr>
<tr>
<td>Terminals</td>
<td>32</td>
<td>46</td>
</tr>
</tbody>
</table>

Two types of analyses will be carried out. For each outlet type two regression models will be fit to the observations in the middle column of Table 6.1. Only those producers that sold part but not all of their hogs to the particular outlet type were included because these were the producers that make marginal changes in the number of hogs they sell to at least two different outlet types. In terms of the theoretical
model, for each of the producers that sell to two or more outlet types 
both $S_{111}$ and $S_{112}$ are positive and $\frac{\partial S}{\partial A}$ has meaning. Those pro-
ducers that sell all of their hogs to one type of outlet are not 
evaluating the decision situation suggested by the theoretical model pre-
ented in Chapter V.

One regression model for each outlet type will have number sold 
to that outlet as the dependent variable while the second will have 
percentage sold to that outlet type as the dependent variable. Although 
the theoretical model generated hypotheses about how variation in number 
sold at each outlet type is related to the independent variables, per-
centage sold was also used as a dependent variable because it was felt 
that percentage sold rather than number sold might better reflect a 
producer's attitude toward the outlet type.

The independent variables will be the variables listed in Table 5.1. 
Three of the suggested independent variables in Table 5.1 were not in-
cluded. Age and years as a hog producer were found to be highly corre-
lated and therefore age was omitted from the models. Percent of hogs 
sold live (PL) and percent of hogs sold on a carcass basis (PC) were 
 omitted because very few producers that sold part to each type of outlet 
sold hogs on a carcass basis.

The results of the six regression models are presented in Tables 
6.2, 6.6 and 6.10. The procedures used to correct for heteroscedasticity 
problems are described in the footnotes of the tables. In general, the 
buying station models in Table 6.2 gave the poorest results while the 
packing plant and terminal market models were statistically better. The
relatively poor fit in the buying station equation with number sold as the dependent variable made the Glejser (42) procedure less easy to apply because of difficulties of specifying the error model.

The second type of analysis deals with differences between producers in the different columns of Table 6.1. Discriminant analysis is used to see if those producers that sell all, part and none of their hogs to each outlet type can be distinguished. Also discriminant analysis was used to determine if producers that sell all of their hogs to each type of outlet can be distinguished. The hypotheses are that the variables listed in Table 5.1 can be successfully used in a discriminant model to classify producers that sell all, part and none of their hogs to each type of outlet and to classify producers that sell all of their hogs to one type of outlet by the outlet type they use. To summarize, four discriminant models are used—one for each row of Table 6.1 and one for the "all" column of Table 6.1.

Tables 6.3, 6.7, 6.11 and 6.15 present the classification results of the discriminant functions and the prior probabilities, $\pi_m$, that were used. A perfect discriminant function would classify all producers along the diagonal of the tables. The discriminant function coefficients and significance levels are shown in Table 6.4, 6.8, 6.12 and 6.16. Note that the coefficients in any one column can be derived by properly forming linear combinations of the coefficients in the other two columns of the same table.

Before presenting a discussion of the results, a note on how to
interpret discriminant function coefficients is in order. Consider a positive element in $\hat{\beta}_{mm'}$, the corresponding $Z_{ik}$, $D_{mm}$, and Equation 6.25. From Equation 6.26 it follows that as $Z_{ik}$ increases, $D_{mm}$ increases and vice versa if $\hat{\beta}_{mm'}$ is greater than zero. As $D_{mm}$ increases, the likelihood that 6.25 holds for $m, m'$ increases. Therefore, membership in group $m$ as opposed to group $m'$ is more likely if $Z_{ik}$ is large. A negative coefficient can be interpreted similarly. When interpreting Tables 6.4, 6.8, 6.12 and 6.16, variables with positive coefficients are positively related to the probability of being assigned to the first named group at the top of the column (group $m$) and negatively related to membership in the group named second at the top of the column (group $m'$). Each group name (none, part and all)\(^1\) appears twice in the column headings. In Tables 6.4, 6.8 and 6.12 none appears at the top of the first two columns, all appears in the last two column headings and part appears in the first and third column headings. Therefore, for each group there are two relationships between membership in that group and the variables listed. To determine the nature of the combined relationship two columns have to be examined. For example, to determine the combined relationship between the value of $Y_H$ and selling none to buying stations, the coefficients for $Y_H$ in the first two columns of Table 6.6 must be examined. Finding both negative indicates a negative combined relationship between the value of $Y_H$ and selling none to buying stations. To find the nature of

---

1 Members of groups designated "none", "part" and "all" are those producers that sell none, part and all of their hogs to each outlet type.
the relationship between selling part to buying stations and the value of \( YH \), the coefficients in the first and third columns of the \( YH \) row in Table 6.4 are examined. The negative coefficient in the third column indicates a negative relationship between selling part to buying stations and \( YH \). The negative coefficient in the first column indicates a positive relationship between selling part to buying stations because "part" is the second group name listed in the column heading. Therefore, the combined relationship between \( YH \) and selling part to buying stations is indeterminate. Tables 6.9, 6.13, 6.17 and 6.21 give the combined relationships between each of the variables and group membership for the discriminant coefficients presented in Tables 6.4, 6.8, 6.12 and 6.16. A plus sign in Tables 6.9, 6.13, 6.17 and 6.21 indicates that the probability of membership in the group at the top of the column and the variable have a combined positive relationship (i.e., both coefficients examined indicated a positive relationship). A negative sign indicates a negative combined relationship (i.e., both coefficients examined indicated a negative relationship). A question mark indicates an indeterminate relation between the variable and membership in the group at the top of the column (i.e., one of the coefficients indicated a positive relationship and the other indicated a negative relationship). Asterisks indicate if one or both of the coefficients examined are significant.

To summarize, for each outlet type four tables are presented. One table is used to present the regression model results, another to show the classification results of the discriminant model,
a third to show the coefficients for the discriminant functions and a fourth to display the combined relationships between group membership and the discriminant function variables. For each outlet type regression results are discussed in the first subsection, discriminant results are discussed in the second subsection and the third subsection serves as a summary section.

Before beginning the discussion of the results, it should be re-emphasized that all of the statements about expected increases and/or decreases in number or percentage sold from the regression models refer only to those producers that sold part but not all of their hogs to each type of outlet.

1. Buying station results

Buying stations were used by more producers than any other type of outlet. The statistical results are presented in Tables 6.2 through 6.5.

a. Regression results

The buying station regression results are presented in Table 6.2. Note that the R-squares for the equations are quite low and few of the variables have significant coefficients. For the most part, the coefficients that are significant have the expected signs.

As expected, number sold to buying stations was found to be positively related to N, and CR (lines 3 and 5). Also, number sold was found to be negatively related to FPP, CFI, and BSS (lines 7, 12 and 13). That is, producers that sell part but not all of their hogs to buying stations are likely to sell more hogs to buying stations if they raise
Table 6.2. Regression results for testing the hypothesized signs of $\partial S_{111}/\partial A$ presented in the buying station column of Table 5.1. Transformed percentages and number sold to buying stations are the dependent variables.

<table>
<thead>
<tr>
<th>Line</th>
<th>Dependent Variables</th>
<th>Percent Sold$^a$</th>
<th>Number Sold$^b$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Intercept</td>
<td>$\hat{\beta}$</td>
<td>$t$</td>
</tr>
<tr>
<td>2</td>
<td>Years as hog producer (YH)</td>
<td>-0.0020</td>
<td>0.405</td>
</tr>
<tr>
<td>3</td>
<td>Total number of hogs sold (N)</td>
<td>0.0018</td>
<td>0.975</td>
</tr>
<tr>
<td>4</td>
<td>Education level (E)</td>
<td>0.0210</td>
<td>0.976</td>
</tr>
<tr>
<td>5</td>
<td>Acres in cropland (CR)</td>
<td>0.0022</td>
<td>0.563</td>
</tr>
<tr>
<td>6</td>
<td>Number of cattle sold (CA)</td>
<td>-0.0001</td>
<td>-0.270</td>
</tr>
<tr>
<td>7</td>
<td>Feeder pig purchases (FPP)</td>
<td>-0.0002</td>
<td>-1.137</td>
</tr>
<tr>
<td>8</td>
<td>Number of bids (NB)</td>
<td>-0.0030</td>
<td>-0.055</td>
</tr>
<tr>
<td>9</td>
<td>Proportion of income from hogs (FI)</td>
<td>0.0010</td>
<td>0.389</td>
</tr>
<tr>
<td>10</td>
<td>Number of days hogs were marketed (NDHM)</td>
<td>-0.0005</td>
<td>-0.058</td>
</tr>
<tr>
<td>11</td>
<td>Capacity of confinement farrowing facilities (CFA)</td>
<td>-0.0078</td>
<td>-1.205</td>
</tr>
</tbody>
</table>

$^a$The dependent variable was arc sin $\sqrt{\text{percent}}$.

$^b$The estimates are obtained using the Glejser (42) procedure. Using the ordinary least squares estimates of $\hat{S}, e=Y-Z\hat{S}$ were calculated. The best form of Equation 6.13 was $|e|=90.212+0.075N$. The Y and Z variables were transformed using the estimated P matrix. The estimated coefficients were calculated using the transformed Z* and Y* in Equation 6.21.

*Significant at the 0.15 level.
**Significant at the 0.10 level.
***Significant at the 0.05 level.
****Significant at the 0.01 level.
Table 6.2 (Continued)

<table>
<thead>
<tr>
<th>Line</th>
<th>Independent Variable</th>
<th>Percent Sold&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Number Sold&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dependent Variables</td>
<td>β</td>
<td>t</td>
</tr>
<tr>
<td>12</td>
<td>Capacity of confinement finishing facilities (CFI)</td>
<td>-0.0003</td>
<td>-0.748</td>
</tr>
<tr>
<td>13</td>
<td>Number of sows for breeding purposes sold (BSS)</td>
<td>-0.0007</td>
<td>-0.834</td>
</tr>
<tr>
<td>14</td>
<td>Number of boars sold for breeding (BBS)</td>
<td>-0.0004</td>
<td>-0.133</td>
</tr>
<tr>
<td>15</td>
<td>Average lot size sold (ALS)</td>
<td>0.0011</td>
<td>0.337</td>
</tr>
<tr>
<td>16</td>
<td>Average weight (AWGT)</td>
<td>0.0036</td>
<td>0.965</td>
</tr>
<tr>
<td>17</td>
<td>Change in number sold 1967-1971 (ΔN)</td>
<td>-0.0002</td>
<td>-1.480*</td>
</tr>
</tbody>
</table>

Producers Attitudes Towards Outlets (PATO*)

<table>
<thead>
<tr>
<th>Line</th>
<th>Independent Variable</th>
<th>Percent Sold&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Number Sold&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>Convenience (CV*)</td>
<td>0.1032</td>
<td>5.764****</td>
</tr>
<tr>
<td>19</td>
<td>Reliability of weighing (RW*)</td>
<td>0.0453</td>
<td>1.185</td>
</tr>
<tr>
<td>20</td>
<td>Shrinkage (Sh*)</td>
<td>0.0534</td>
<td>1.202</td>
</tr>
<tr>
<td>21</td>
<td>Number of competing buyers (CB*)</td>
<td>-0.0011</td>
<td>-0.036</td>
</tr>
<tr>
<td>22</td>
<td>Personal attention received (PA*)</td>
<td>-0.0173</td>
<td>-0.460</td>
</tr>
<tr>
<td>23</td>
<td>Quality premiums (QP*)</td>
<td>-0.0640</td>
<td>-2.106***</td>
</tr>
<tr>
<td>24</td>
<td>Length of wait for payment (LW*)</td>
<td>-0.0137</td>
<td>-0.409</td>
</tr>
<tr>
<td>25</td>
<td>Marketing costs (MC*)</td>
<td>-0.0353</td>
<td>-0.863</td>
</tr>
<tr>
<td>26</td>
<td>Distance (DIST)</td>
<td>0.0146</td>
<td>2.216***</td>
</tr>
</tbody>
</table>

\[
R^2 = \frac{\hat{y} - \bar{y} - n(\bar{y}^*)^2}{\hat{y} - \bar{y} - n(\bar{y})^2}
\]

Calculated from \( R^2 = \frac{\hat{y} - \bar{y} - n(\bar{y})^2}{\hat{y} - \bar{y} - n(\bar{y})^2} \)
more hogs and farm larger farms while they tend to sell fewer hogs to buying stations if they purchase feeder pigs, have confinement finishing facilities and sell sows for breeding purposes.

Two definite attitude traits are also identified. Producers tend to sell more hogs to buying stations the greater their rating of the importance of convenience, CV*, (line 18) and the lower their rating of quality premiums, QP*, (line 23) as factors affecting choice of outlet.

Also, it was found that producers that hauled hogs longer distances to buying stations sold more hogs at buying stations. Apparently, some producers may sell a few hogs to buying stations simply because the buying station is nearby, not because it is their primary outlet for slaughter hogs. Those producers that consider buying stations their primary outlet are willing to ship longer distances to sell at buying stations.

Three of the four significant coefficients in the percentage sold equation lend support to the results from the number sold equation. Percentage sold to buying stations is positively related to CV* (line 18), negatively related to QP* (line 23) and positively related to DIST (line 26). The fourth significant coefficient adds one important but weakly significant result. Percentage sold to buying stations is negatively related to change in number sold 1967-1971, AN (line 17). This means that producers that increased production tended to sell a smaller percentage of their hogs to buying stations and vice versa.

To summarize, for those producers that sold part but not all of their hogs to buying stations, number sold to buying stations is
significantly and positively related to $N$, $CR$, $CV^* \text{ and } \text{DIST}$ and significantly and negatively related to $\text{FPF}$, $\text{CFI}$, $\text{BSS}$ and $\text{QP}^*$. Percentage sold to buying stations was found to be negatively related to $\Delta N$ and $\text{QP}^*$ and positively related to $\text{CV}^*$ and $\text{DIST}$.

b. Discriminant analysis results

Tables 6.3, 6.4 and 6.5 present the results of the discriminant analysis used to classify producers into groups that sold none, part and all of their hogs to buying stations.

In Table 6.3 we find that 71 percent of the producers were correctly classified. There is great disparity in classification success between groups. Approximately 97 percent of the all group, 57 percent of the none group and 17 percent of the part group were correctly classified. Apparently, producers that sell all to buying stations have more in common than those producers that sell part or none to buying stations. This seems reasonable because included in the "none" group are producers that

<table>
<thead>
<tr>
<th>Prior probabilities ($\pi_i$)</th>
<th>Number of observations classified from type</th>
<th>Number of Observations classified into type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All</td>
<td>All</td>
</tr>
<tr>
<td>0.617</td>
<td>241</td>
<td>5</td>
</tr>
<tr>
<td>0.146</td>
<td>65</td>
<td>16</td>
</tr>
<tr>
<td>0.237</td>
<td>33</td>
<td>6</td>
</tr>
</tbody>
</table>
sell all to terminals, producers that sell all to packing plants and producers that sell some to each of these two types. Included in the part group are producers that have sold part of their hogs to each of the three types of outlets.

Tables 6.4 and 6.5 show some interesting coefficients and resulting combined relationships between group membership and the variables.

The combined relationships shown in Table 6.5 are derived using coefficients shown in Table 6.4. For example, the negative and significant coefficient in the "none versus part" column of Table 6.4 indicates that producers are more likely to sell none to buying stations the lower is the value of FI. The positive coefficient in the middle column of Table 6.4 indicates that being classified as selling none to buying stations is positively related to the value of FI. Therefore because of the opposite signs of the relationships a questionmark is written in line 9 of Table 6.5 in the "none" column. The single asterisk by the questionmark indicates that one of the coefficients examined was significant. The negative and significant coefficient in the "none versus part" column of Table 6.4 also indicates a positive relationship between selling part to buying stations and the value of FI. The positive and significant coefficient in line 9 of the "part versus all" column also indicates a positive relationship between selling part to buying stations and the value of FI. Therefore, a plus sign is written in the FI row and the "part" column of Table 6.5. The two asterisks by the plus sign indicate that both coefficients examined were significant. The positive coefficients in the last two columns of
Table 6.4 indicate negative relationships between being classified as selling all to buying stations and the value of FI. Since both coefficients indicate a negative relationship, a negative combined relationship is presented in the FI row of Table 6.5. The single asterisk again indicates that only one of the coefficients examined is significant. The other combined relationships were derived similarly.

Thus, supported by two significant coefficients, the combined relationships indicate that being classified as selling none to buying stations is positively related to N, CB*, and DIST (lines 3, 21 and 26) and negatively related to YH, NB, AWGT, AN, and RW* (lines 2, 8, 16, and 17). Similarly supported by two significant coefficients it can be stated that being classified as selling part to buying stations is positively related to NB, FI, CFI, and AN (lines 8, 9, 12 and 17) and negatively related to CFA (line 11). Also supported by two significant coefficients, it can be stated that being classified as selling all to buying stations is positively related to YH, PA, and LW (lines 2, 22 and 24) and negatively related to N, E, MC* and DIST (lines 3, 4, 25 and 26).

Contrasts between the all and none columns of Table 6.5 are especially interesting. The combined relationships for YH, N and E (lines 2, 3 and 4) indicate that older producers that produce fewer hogs and have less education are more likely to sell all of their hogs to buying stations while younger producers that produce more hogs and have more education are more likely to sell none of their hogs to buying stations. Provided that producers do not switch to buying stations as
they grow older, it is likely that buying stations will decline in importance as the older producers retire.

The combined distance relationships indicate that producers selling none of their hogs to buying stations haul their hogs a longer distance than do producers that sell all of their hogs to buying stations.

c. **Summary**  The regression results and the discriminant analysis results are difficult to compare. Comparing the characteristics of producers that were analyzed in the regression model to the characteristics of producers that sold none and all of their hogs to buying stations we find that those producers that sold part of their hogs to buying stations were the producers that received more bids, relied on hogs for a larger share of their income and had increased production in the last five year period. These are the producers that should be expected to evaluate the outlet choice decision suggested by the theoretical model.

The positive distance coefficient in the regression model is quite interesting. I hypothesize that an empirical parallel to the result might be found during a test of Holdren's supermarket model. That is, amount purchased at a supermarket might very well be positively related to how far the shopper traveled to shop at that particular store. The reader might well be wondering how the positive coefficient for distance and the positive coefficient for importance of convenience can be reconciled. Distance and convenience are not measuring the same factor. Convenience may encompass availability of backhauls of farm supplies, type of loading facilities available, availability of trucking services
Table 6.4. Discriminant function coefficients and significance levels for the functions used to classify producers as selling none, part and all of their hogs to buying stations

<table>
<thead>
<tr>
<th>Line</th>
<th>Variable</th>
<th>None vs. Part</th>
<th>None vs. All</th>
<th>Part vs. All</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Constant</td>
<td>-3.2703</td>
<td>-6.2160</td>
<td>-2.9457</td>
</tr>
<tr>
<td></td>
<td><strong>Producer Characteristics (PCHAR)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Years as hog producer (YH)</td>
<td>-0.0268***</td>
<td>-0.0409***</td>
<td>-0.0141**</td>
</tr>
<tr>
<td>3</td>
<td>Total number of hogs sold (N)</td>
<td>0.0010***</td>
<td>0.0014**</td>
<td>0.0004*</td>
</tr>
<tr>
<td>4</td>
<td>Education level (E)</td>
<td>0.0313</td>
<td>0.0922*</td>
<td>0.0609*</td>
</tr>
<tr>
<td>5</td>
<td>Acres in cropland (CR)</td>
<td>-0.0015**</td>
<td>-0.0009</td>
<td>0.0006</td>
</tr>
<tr>
<td>6</td>
<td>Number of cattle sold (CA)</td>
<td>-0.0004</td>
<td>0.0011</td>
<td>0.0015***</td>
</tr>
<tr>
<td>7</td>
<td>Feeder pig purchases (FPP)</td>
<td>-0.0000</td>
<td>-0.0003</td>
<td>-0.0003</td>
</tr>
<tr>
<td>8</td>
<td>Number of bids (NB)</td>
<td>-1.5808***</td>
<td>-0.9376**</td>
<td>0.6432***</td>
</tr>
<tr>
<td>9</td>
<td>Proportion of income from hogs (FI)</td>
<td>-0.0092**</td>
<td>0.0005</td>
<td>0.0096***</td>
</tr>
<tr>
<td>10</td>
<td>Number of days hogs were marketed (NDHM)</td>
<td>-0.0226</td>
<td>-0.0028</td>
<td>0.0198</td>
</tr>
<tr>
<td>11</td>
<td>Capacity of confinement farrowing facilities (CFA)</td>
<td>0.0272**</td>
<td>0.0101</td>
<td>-0.0171*</td>
</tr>
<tr>
<td>12</td>
<td>Capacity of confinement finishing facilities (CFI)</td>
<td>-0.0012*</td>
<td>-0.0022</td>
<td>0.0010*</td>
</tr>
<tr>
<td>13</td>
<td>Number of sows sold for breeding purposes (BSS)</td>
<td>-0.0032</td>
<td>-0.0026</td>
<td>0.0006</td>
</tr>
<tr>
<td>14</td>
<td>Number of boars sold for breeding (BBS)</td>
<td>-0.0487</td>
<td>-0.0190</td>
<td>0.0296***</td>
</tr>
<tr>
<td>15</td>
<td>Average lot size (ALS)</td>
<td>0.0021</td>
<td>-0.0099</td>
<td>-0.0120***</td>
</tr>
<tr>
<td>16</td>
<td>Average weight (AWGT)</td>
<td>0.0239***</td>
<td>0.0228***</td>
<td>-0.0010</td>
</tr>
<tr>
<td>17</td>
<td>Change in number sold 1967-1971 (AN)</td>
<td>-0.0018***</td>
<td>-0.0007*</td>
<td>0.0011***</td>
</tr>
</tbody>
</table>

*Significant at 0.10 percent level.

**Significant at 0.05 percent level.

***Significant at 0.01 percent level.
Table 6.4 (Continued)

<table>
<thead>
<tr>
<th>Line</th>
<th>Variable</th>
<th>Producers' Attitudes Towards Outlets (PATO*)</th>
<th>Market Characteristics (MCHAR)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>None vs. Part</td>
<td>None vs. All</td>
</tr>
<tr>
<td>18</td>
<td>Convenience (CV*)</td>
<td>0.0655</td>
<td>0.1575*</td>
</tr>
<tr>
<td>19</td>
<td>Reliability of weighing (RW*)</td>
<td>-0.1839***</td>
<td>-0.2438***</td>
</tr>
<tr>
<td>20</td>
<td>Shrinkage (Sh*)</td>
<td>-0.0419</td>
<td>-0.0051</td>
</tr>
<tr>
<td>21</td>
<td>Number of competing buyers (CB*)</td>
<td>0.2460***</td>
<td>0.1929***</td>
</tr>
<tr>
<td>22</td>
<td>Personal attention received (PA*)</td>
<td>-0.0314</td>
<td>-0.2297***</td>
</tr>
<tr>
<td>23</td>
<td>Quality premiums (QP*)</td>
<td>-0.0124</td>
<td>0.0900</td>
</tr>
<tr>
<td>24</td>
<td>Length of wait for payment (LW*)</td>
<td>-0.0303</td>
<td>-0.1570**</td>
</tr>
<tr>
<td>25</td>
<td>Marketing costs (MC*)</td>
<td>-0.0644</td>
<td>0.2843**</td>
</tr>
<tr>
<td>26</td>
<td>Distance (DIST)</td>
<td>0.0490***</td>
<td>0.1081***</td>
</tr>
</tbody>
</table>

Table 6.5. Nature of the combined relationship between discriminant model variables and classifying a producer as selling none, part and all of his hogs to buying stations

<table>
<thead>
<tr>
<th>Line</th>
<th>Variable description and symbol</th>
<th>Relationship between the variable and membership in group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>None</td>
</tr>
<tr>
<td>1</td>
<td>Constant</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Producer Characteristics (PCHAR)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Years as hog producer (YH)</td>
<td>-**</td>
</tr>
<tr>
<td>3</td>
<td>Total number of hogs sold (N)</td>
<td>+**</td>
</tr>
<tr>
<td>4</td>
<td>Education level (E)</td>
<td>+*</td>
</tr>
<tr>
<td>5</td>
<td>Acres in cropland (CR)</td>
<td>-*</td>
</tr>
<tr>
<td>6</td>
<td>Number of cattle sold (CA)</td>
<td>?</td>
</tr>
</tbody>
</table>

*Only one coefficient significant at 0.10 level or above.
**Both coefficients significant at 0.10 level or above.
Table 6.5 (Continued)

<table>
<thead>
<tr>
<th>Line</th>
<th>Variable</th>
<th>Relationship between the variable and membership in group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Producer Characteristics (PCHAR)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Continued)</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Feeder pig purchases (FPP)</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>Number of bids (NB)</td>
<td>-**</td>
</tr>
<tr>
<td>9</td>
<td>Proportion of income from hogs (FI)</td>
<td>?*</td>
</tr>
<tr>
<td>10</td>
<td>Number of days hogs were marketed (NDHM)</td>
<td>-</td>
</tr>
<tr>
<td>11</td>
<td>Capacity of confinement farrowing facilities (CFA)</td>
<td>+*</td>
</tr>
<tr>
<td>12</td>
<td>Capacity of confinement finishing facilities (CFI)</td>
<td>+*</td>
</tr>
<tr>
<td>13</td>
<td>Number of sows sold for breeding purposes (BSS)</td>
<td>-</td>
</tr>
<tr>
<td>14</td>
<td>Number of boars sold for breeding (BBS)</td>
<td>-</td>
</tr>
<tr>
<td>15</td>
<td>Average lot size (ALS)</td>
<td>?</td>
</tr>
<tr>
<td>16</td>
<td>Average weight (AWGT)</td>
<td>+**</td>
</tr>
<tr>
<td>17</td>
<td>Change in number sold (AN)</td>
<td>-**</td>
</tr>
<tr>
<td></td>
<td>Producers' Attitudes Toward Outlets (PATO*)</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Convenience (CV*)</td>
<td>+*</td>
</tr>
<tr>
<td>19</td>
<td>Reliability of weighing (RW*)</td>
<td>-**</td>
</tr>
<tr>
<td>20</td>
<td>Shrinkage (Sh*)</td>
<td>-</td>
</tr>
<tr>
<td>21</td>
<td>Number of competing buyers (CB*)</td>
<td>+**</td>
</tr>
<tr>
<td>22</td>
<td>Personal attention received (PA*)</td>
<td>-</td>
</tr>
<tr>
<td>23</td>
<td>Quality premiums (QP*)</td>
<td>?</td>
</tr>
<tr>
<td>24</td>
<td>Length of wait for payment (LW*)</td>
<td>-*</td>
</tr>
<tr>
<td>25</td>
<td>Marketing costs (MC*)</td>
<td>?*</td>
</tr>
<tr>
<td></td>
<td>Market Characteristics (MCHAR)</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Distance (DIST)</td>
<td>+**</td>
</tr>
</tbody>
</table>
or types of roads available to particular outlets. Convenience may or may not include distance.

2. Packing plant results

The packing plant models' results are presented in Tables 6.6 through 6.9. In general, in both the regression and discriminant model results there are more significant relationships to examine than in the buying station tables.

a. Regression results

Although the packing plant regression models yielded more significant coefficients than the buying station model some of the coefficients in Table 6.6 are difficult to explain.

Of the producer characteristics, number sold to packing plants was found to be positively related to total number of hogs sold, N, number of bids received, NB, number of days hogs were marketed, NDHM, capacity of confinement finishing facilities, CFI, and average lot size, ALS (lines 3, 8, 10, 12 and 15). Number sold to packing plants was found to be negatively related to years as a hog producer, YH, number of cattle sold, CA, and change in number of hogs produced, \( \Delta N \) (lines 2, 6 and 17).

That YH and number sold to packing plants are negatively related is not surprising because packing plants are a nontraditional outlet type. It was expected that producers that developed marketing patterns prior to the construction of interior plants would continue those patterns. The positive relationships between N, NB, ALS and number sold were expected. Note that the relationship between CFI and number sold to
packing plants is positive, the reverse of the sign found in the buying station model. It was expected that NDHM would be negatively related to number sold to packing plants but the opposite was found. Apparently, even though ALS and number sold to packing plants are positively related, producers that tend to market more hogs to packing plants also tend to market more often. That AN and number sold to packing plants are negatively related indicates that producers who increased production tended to sell fewer hogs at packing plants.

Several interesting significant relationships between producers' attitudes and number sold to packing plants were also found in Table 6.6. Number sold to packing plants was found to be positively related to importance given to personal attention received, PA*, quality premiums, QP*, and marketing costs, MC*, (lines 22, 23 and 25) and negatively related to importance given to shrinkage Sh*, number of competing buyers, CB*, and length of wait for payment, LW* (lines 20, 21 and 24). The relationships between CB*, PA* and number sold were expected. The causal ordering for the relationship between PA* and number sold may be reversed. It may well be that because producers market a large number of hogs at plants, they receive a great deal of personal attention. Because they receive a great deal of personal attention they rate the importance of personal attention received high. This was not the case in the buying station model results presented in Table 6.2, line 17. Apparently, producers selling large numbers of hogs to buying stations do not rate personal attention high. Perhaps buying station operators do not give producers selling a large number of hogs more
Table 6.6. Regression results for testing the hypothesized signs of $\frac{\partial S_{112}}{\partial A}$ presented in the packing plant column of Table 5.1. Transformed percentages and number sold are the dependent variables.

<table>
<thead>
<tr>
<th>Line</th>
<th>Independent variables</th>
<th>Percent Sold&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Number Sold&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$\hat{\beta}$</td>
<td>$t$</td>
</tr>
<tr>
<td>1</td>
<td>Intercept</td>
<td>0.5543</td>
<td>0.571</td>
</tr>
<tr>
<td></td>
<td>Producer Characteristics (PCHAR)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Years as hog producer (YH)</td>
<td>-0.0074</td>
<td>-1.504*</td>
</tr>
<tr>
<td>3</td>
<td>Total number of hogs sold (N)</td>
<td>-0.0001</td>
<td>-0.672</td>
</tr>
<tr>
<td>4</td>
<td>Education level (E)</td>
<td>-0.0039</td>
<td>-0.148</td>
</tr>
<tr>
<td>5</td>
<td>Acres in cropland (CR)</td>
<td>0.0002</td>
<td>0.683</td>
</tr>
<tr>
<td>6</td>
<td>Number of cattle sold (CA)</td>
<td>-0.0003</td>
<td>-1.144</td>
</tr>
<tr>
<td>7</td>
<td>Feeder pig purchases (FPP)</td>
<td>0.0001</td>
<td>0.455</td>
</tr>
<tr>
<td>8</td>
<td>Number of bids (NB)</td>
<td>0.1070</td>
<td>1.977***</td>
</tr>
<tr>
<td>9</td>
<td>Proportion of income from hogs (FI)</td>
<td>-0.0023</td>
<td>-0.732</td>
</tr>
<tr>
<td>10</td>
<td>Number of days hogs were marketed (NDHM)</td>
<td>0.0154</td>
<td>1.802**</td>
</tr>
<tr>
<td>11</td>
<td>Capacity of confinement farrowing facilities (CFA)</td>
<td>-0.0039</td>
<td>-0.594</td>
</tr>
<tr>
<td>12</td>
<td>Capacity of confinement finishing facilities (CFI)</td>
<td>0.0002</td>
<td>0.709</td>
</tr>
</tbody>
</table>

<sup>a</sup>The dependent variable was arc sine $\sqrt{\text{percent}}$.

<sup>b</sup>The estimates were obtained using the Glejser (42) procedure. Using ordinary least squares estimates of $\hat{\beta}$, $e=Y-Z\hat{\beta}$ was calculated. The best form of 6.13 found was $|e|=41.753+0.346Y-0.0002Y^2+0.0529N$. The $Y$ and $Z$ variables were transformed using the transformation using the estimated $P$ matrix. The coefficients were derived using the $Z^*$ and $Y^*$ in Equation 6.21.

* Significant at the 0.15 level.
** Significant at the 0.10 level.
*** Significant at the 0.05 level.
**** Significant at the 0.01 level.
Table 6.6 (Continued)

<table>
<thead>
<tr>
<th>Line</th>
<th>Independent variables</th>
<th>Percent Sold&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Number Sold&lt;sup&gt;b&lt;/sup&gt;</th>
<th>(\hat{\beta})</th>
<th>t</th>
<th>b</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Number of sows sold for breeding stock (BSS)</td>
<td>0.0005</td>
<td>0.5068</td>
<td>0.614</td>
<td>0.866</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Number boars sold for breeding (BBS)</td>
<td>0.0003</td>
<td>0.0762</td>
<td>0.079</td>
<td>0.036</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Average lot size sold (ALS)</td>
<td>0.0035</td>
<td>2.4028</td>
<td>1.293</td>
<td>1.482*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Average weight (AWGT)</td>
<td>0.0008</td>
<td>0.4927</td>
<td>0.228</td>
<td>0.329</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Change in number sold 1967-1971 (ΔN)</td>
<td>-0.0002</td>
<td>-0.3328</td>
<td>-1.232</td>
<td>-3.792****</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Convenience (CV*)</td>
<td>-0.0171</td>
<td>-2.6195</td>
<td>-0.410</td>
<td>-0.129</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Reliability of weighing (RW*)</td>
<td>0.0312</td>
<td>14.8382</td>
<td>0.739</td>
<td>0.745</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Shrinkage (Sh*)</td>
<td>-0.1109</td>
<td>-48.9970</td>
<td>-2.170***</td>
<td>-1.987***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Number of competing buyers (CB*)</td>
<td>-0.0713</td>
<td>-29.3465</td>
<td>-1.876**</td>
<td>-1.537*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Personal attention received (PA*)</td>
<td>0.0528</td>
<td>39.9299</td>
<td>1.206</td>
<td>1.860**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Quality premiums (QP*)</td>
<td>0.0310</td>
<td>26.1774</td>
<td>0.795</td>
<td>1.492*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Length of wait for payment (LW*)</td>
<td>-0.0677</td>
<td>-51.4562</td>
<td>-1.588*</td>
<td>-2.419***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Marketing costs (MC*)</td>
<td>0.1389</td>
<td>74.0005</td>
<td>2.932****</td>
<td>3.550****</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Distance (DIST)</td>
<td>-0.0059</td>
<td>-3.0744</td>
<td>-2.611****</td>
<td>-2.181***</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ R^2 = \frac{\hat{Y}'Y - n(\bar{Y})^2}{Y^*Y - n(Y)^2} \]

\[ F = 1.610** \quad 17.6367**** \]
attention than producers selling a small number of hogs at buying stations.

The negative relationship between Sh* and number sold was not hypothesized but perhaps should have been. Contrary to the original hypothesis, plants are far enough away from most producers so that shrinkage becomes an important consideration. The positive coefficient for MC* and the negative coefficient for DIST are consistent with the Sh* coefficient. It appears that location of the producer relative to the plant was an important consideration when producers were deciding how many hogs to sell at packing plants.

The equation with percentage sold as the dependent variable had fewer significant coefficients. All of the significant coefficients were consistent with the coefficients in the equation with number sold as the dependent variable. Percentage sold was found to be negatively related to YH, Sh*, CB* and DIST (lines 2, 20, 21 and 26) and positively related to NB, NDHM and MC* (lines 8, 10 and 25).

b. Discriminant analysis results Tables 6.7, 6.8 and 6.9 present the results of the discriminant model used to classify producers into groups that sold none, part and all of their hogs to buying stations. Although Table 6.7 shows that 74 percent of the producers were correctly classified, only 12 percent of those from the all category and 18 percent in the part category were classified properly into their respective categories. Of the 314 producers in the none category, 249 sold all of their hogs to buying stations and 32 sold all of their hogs
to terminals. In general these were the producers that were also correctly classified in the buying station model. The rather poor classification of the all and part groups is perhaps a result of the nature of packing plants. Plants are in general less convenient and more distant from producers than buying stations and relatively more convenient and less distant from most producers than terminals. Also, since most packing plants also have country buying points, company loyalties rather than outlet type preferences may be confusing the results.

Table 6.7. Classification results for the discriminant model designed to distinguish between those producers that sold none, part and all of their hogs to packing plants

<table>
<thead>
<tr>
<th>Prior Probabilities (π₁)</th>
<th>Number of observations classified from type</th>
<th>Number of observations classified into type</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>All</td>
<td>Part</td>
</tr>
<tr>
<td>0.115</td>
<td>All</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>0.134</td>
<td>Part</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>0.751</td>
<td>None</td>
<td>9</td>
<td>5</td>
</tr>
</tbody>
</table>

Nonetheless, there are several interesting combined relationships represented in Table 6.9. Supported by two significant coefficients, it can be stated that being classified as selling none to packing plants is positively related to BBS, CB*, and PA* and negatively related to AWGT, QP*, MC* and DIST. Similarly supported by two significant coefficients, it can be stated that being classified as selling part to
Table 6.8. Discriminant analysis coefficients and significance levels for the functions used to classify producers as selling none, part and all of their hogs to packing plants

<table>
<thead>
<tr>
<th>Line</th>
<th>Variable</th>
<th>None vs. Part</th>
<th>None vs. All</th>
<th>Part vs. All</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Constant</td>
<td>5.0253</td>
<td>3.4105</td>
<td>-1.6149</td>
</tr>
<tr>
<td>2</td>
<td>Years as hog producer (YH)</td>
<td>0.0057</td>
<td>0.0210***</td>
<td>0.0154***</td>
</tr>
<tr>
<td>3</td>
<td>Total number of hogs sold (N)</td>
<td>0.0003</td>
<td>-0.0026***</td>
<td>-0.0029***</td>
</tr>
<tr>
<td>4</td>
<td>Education level (E)</td>
<td>-0.0728**</td>
<td>0.0295</td>
<td>0.1023***</td>
</tr>
<tr>
<td>5</td>
<td>Acres in cropland (CR)</td>
<td>-0.0019***</td>
<td>0.0020***</td>
<td>0.0039***</td>
</tr>
<tr>
<td>6</td>
<td>Number of cattle sold (CA)</td>
<td>-0.0003</td>
<td>0.0001</td>
<td>0.0004</td>
</tr>
<tr>
<td>7</td>
<td>Feeder pig purchases (FPP)</td>
<td>-0.0008***</td>
<td>0.0011***</td>
<td>0.0019***</td>
</tr>
<tr>
<td>8</td>
<td>Number of bids (NB)</td>
<td>-0.5640***</td>
<td>0.1855**</td>
<td>0.7495***</td>
</tr>
<tr>
<td>9</td>
<td>Proportion of income from hogs (FI)</td>
<td>-0.0017</td>
<td>0.0124***</td>
<td>0.0140***</td>
</tr>
<tr>
<td>10</td>
<td>Number of days hogs were marketed (NDHM)</td>
<td>-0.0315**</td>
<td>-0.0010</td>
<td>0.0305**</td>
</tr>
<tr>
<td>11</td>
<td>Capacity confinement farrowing facilities (CFA)</td>
<td>0.0068</td>
<td>-0.0341***</td>
<td>-0.0409***</td>
</tr>
<tr>
<td>12</td>
<td>Capacity confinement finishing facilities (CFI)</td>
<td>-0.0004</td>
<td>0.0010**</td>
<td>0.0014**</td>
</tr>
<tr>
<td>13</td>
<td>Number sows sold for breeding (BSS)</td>
<td>-0.0025</td>
<td>0.0039**</td>
<td>0.0064***</td>
</tr>
<tr>
<td>14</td>
<td>Number of boars sold for breeding (BBS)</td>
<td>-0.0222***</td>
<td>0.0141*</td>
<td>0.0363***</td>
</tr>
<tr>
<td>15</td>
<td>Average lot size (ALS)</td>
<td>0.0047</td>
<td>0.0144***</td>
<td>0.0097**</td>
</tr>
<tr>
<td>16</td>
<td>Average weight (AWGT)</td>
<td>-0.0080*</td>
<td>-0.0178***</td>
<td>-0.0098**</td>
</tr>
<tr>
<td>17</td>
<td>Change in number sold 1967-1971 (AN)</td>
<td>-0.0019***</td>
<td>0.0014***</td>
<td>0.0033***</td>
</tr>
</tbody>
</table>

* Significant at 0.10 percent level.
** Significant at 0.05 percent level.
*** Significant at 0.01 percent level.
Table 6.8 (Continued)

<table>
<thead>
<tr>
<th>Line</th>
<th>Variable</th>
<th>None vs. Part</th>
<th>None vs. All</th>
<th>Part vs. All</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Producers' Attitudes Towards Outlet (PATO*)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Convenience (CV*)</td>
<td>0.3012***</td>
<td>-0.0708</td>
<td>-0.3720***</td>
</tr>
<tr>
<td>19</td>
<td>Reliability of weighing (RW*)</td>
<td>0.0752</td>
<td>0.2712***</td>
<td>0.1960***</td>
</tr>
<tr>
<td>20</td>
<td>Shrinkage (Sh*)</td>
<td>-0.1579***</td>
<td>-0.0563</td>
<td>0.1016</td>
</tr>
<tr>
<td>21</td>
<td>Number of competing buyers (CB*)</td>
<td>0.1292***</td>
<td>0.2856***</td>
<td>0.1564***</td>
</tr>
<tr>
<td>22</td>
<td>Personal attention received (PA*)</td>
<td>0.1098**</td>
<td>0.2497***</td>
<td>0.1399**</td>
</tr>
<tr>
<td>23</td>
<td>Quality premiums (QP*)</td>
<td>-0.1567***</td>
<td>-0.1518***</td>
<td>0.0048</td>
</tr>
<tr>
<td>24</td>
<td>Length of wait for payment (LW*)</td>
<td>0.0990**</td>
<td>-0.0498</td>
<td>-0.1487***</td>
</tr>
<tr>
<td>25</td>
<td>Marketing costs (MC*)</td>
<td>-0.2399***</td>
<td>-0.2445***</td>
<td>-0.0046</td>
</tr>
<tr>
<td></td>
<td>Market Characteristics (MCHAR)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Distance (DIST)</td>
<td>-0.0263***</td>
<td>-0.0341***</td>
<td>-0.0078*</td>
</tr>
</tbody>
</table>

Packing plants was found to be positively related to CR, FPP, NB, NDHM and BBS (lines 5, 7, 8, 10 and 14) and negatively related to CV* (line 18). In the "all" column of Table 6.9, again supported by two significant coefficients, it can be stated that being classified as selling all to packing plants is positively related to N, CFA, AWGT, and DIST (lines 3, 11, 16 and 26) and negatively related to YH, CR, FPP, NB, FI, CFI, BSS, BSS, ALS, ΔN, RW*, CB*, and PA* (lines 2, 5, 7, 8, 9, 12, 13, 14, 15, 17, 19, 21, and 22).

By comparing the combined relationships across the columns of Table 6.9 several conclusions can be drawn. Producers are more likely to be
classified as not selling to packing plants if they sell more boars for breeding purposes, rate importance of competing buyers and personal attention high and haul hogs shorter distances while they are more likely to be classified as selling none of their hogs to plants if they don't sell boars for breeding purposes, sell heavier weights, rate competing buyers and personal attention received low and haul hogs long distances.

c. Summary That producers who sell all of their hogs to plants rate personal attention received lower than producers who sell none of their hogs to plants does not substantiate the positive relationship found for personal attention received and number sold to plants in the regression model. The fact that selling all to plants is negatively related to CB* and selling none to plants is positively related to CB* does substantiate the results found in the regression model. That is, producers who sell part of their hogs to packing plants are likely to sell more of their hogs to packing plants if they rate the importance of competing buyers low and a producer is more likely to be classified as selling all of his hogs to packing plants if he rates the importance of CB* low. Also, producers in the part column of Table 6.9 received more bids, marketed more different days and were the producers who increased production the past five year period.

3. Terminal market results

The terminal outlet results are presented in Tables 6.10 through 6.13. The terminal models had the most significant coefficients and pro-
Table 6.9. Nature of the combined relationship between discriminant model variables and classifying a producer as selling none, part and all of his hogs to packing plants

<table>
<thead>
<tr>
<th>Line</th>
<th>Variable description and symbol</th>
<th>Relationship between the variable and membership in group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>None</td>
</tr>
<tr>
<td>1</td>
<td>Constant</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Producer Characteristics (PCHAR)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Years as hog producer (YH)</td>
<td>+*</td>
</tr>
<tr>
<td>3</td>
<td>Total number of hogs sold (N)</td>
<td>?*</td>
</tr>
<tr>
<td>4</td>
<td>Education level (E)</td>
<td>?*</td>
</tr>
<tr>
<td>5</td>
<td>Acres in cropland (CR)</td>
<td>?**</td>
</tr>
<tr>
<td>6</td>
<td>Number of cattle sold (CA)</td>
<td>?</td>
</tr>
<tr>
<td>7</td>
<td>Feeder pig purchased (FPP)</td>
<td>?**</td>
</tr>
<tr>
<td>8</td>
<td>Number of bids (NB)</td>
<td>?**</td>
</tr>
<tr>
<td>9</td>
<td>Proportion of income from hogs (FI)</td>
<td>?*</td>
</tr>
<tr>
<td>10</td>
<td>Number of days hogs were marketed (NDHM)</td>
<td>?*</td>
</tr>
<tr>
<td>11</td>
<td>Capacity of confinement farrowing facilities (CFA)</td>
<td>?*</td>
</tr>
<tr>
<td>12</td>
<td>Capacity of confinement finishing facilities (CFI)</td>
<td>?*</td>
</tr>
<tr>
<td>13</td>
<td>Number of sows sold for breeding purposes (BSS)</td>
<td>?**</td>
</tr>
<tr>
<td>14</td>
<td>Number of boars sold for breeding (BBS)</td>
<td>+++</td>
</tr>
<tr>
<td>15</td>
<td>Average lot size (ALS)</td>
<td>+*</td>
</tr>
<tr>
<td>16</td>
<td>Average weight (AWGT)</td>
<td>-**</td>
</tr>
<tr>
<td>17</td>
<td>Change in number sold (AN)</td>
<td>?**</td>
</tr>
<tr>
<td></td>
<td>Producers' Attitudes Toward Outlets (PATO*)</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Convenience (CV*)</td>
<td>?*</td>
</tr>
<tr>
<td>19</td>
<td>Reliability of weighing (RW*)</td>
<td>+*</td>
</tr>
</tbody>
</table>

* Only one coefficient significant at 0.10 or above.
** Both coefficients significant at 0.10 level or above.
<table>
<thead>
<tr>
<th>Line</th>
<th>Variable description and symbol</th>
<th>Relationship between the variable and membership in group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>None</td>
</tr>
<tr>
<td>Producers' Attitudes Toward Outlets (PATO*) (Continued)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Shrinkage (Sh*)</td>
<td>-*</td>
</tr>
<tr>
<td>21</td>
<td>Number of competing buyers (CB*)</td>
<td>+***</td>
</tr>
<tr>
<td>22</td>
<td>Personal attention received (PA*)</td>
<td>+**</td>
</tr>
<tr>
<td>23</td>
<td>Quality premiums (QP*)</td>
<td>-**</td>
</tr>
<tr>
<td>24</td>
<td>Length of wait for payment (LW*)</td>
<td>?*</td>
</tr>
<tr>
<td>25</td>
<td>Marketing costs (MC*)</td>
<td>-**</td>
</tr>
<tr>
<td>Market Characteristics (MCHAR)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Distance (DIST)</td>
<td>-**</td>
</tr>
</tbody>
</table>

vided some of the more interesting contrasts although few of the producers used terminals.

a. Regression results  Again, although there are a great many significant coefficients in Table 6.10, some of the signs of the coefficients are difficult to explain.

Number of years as a hog producer, YH, (line 2) was found to be negatively related to number sold to terminals. It was hypothesized that, because of past traditional dominance of terminals, older producers would tend to sell more to terminals. Apparently, younger producers who sell hogs to terminals sell more hogs to terminals than do the older producers. The negative relationship between number sold to terminals and N (line 3) was also the reverse of the hypothesized relationship. However, the
Table 6.10. Regression results for testing the hypothesized signs of $\frac{\partial S_{12}}{\partial A}$ presented in the terminal market column of Table 5.1. Transformed percentages and number sold to terminals on the dependent variables

<table>
<thead>
<tr>
<th>Line</th>
<th>Independent Variables</th>
<th>Percent Sold$^a$</th>
<th>Number Sold$^b$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$\hat{\beta}$</td>
<td>$t$</td>
</tr>
<tr>
<td>1</td>
<td>Intercept</td>
<td>0.2291</td>
<td>4.080***</td>
</tr>
<tr>
<td></td>
<td><strong>Producer Characteristics (PCHAR)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Years as hog producer (YH)</td>
<td>-0.0103</td>
<td>-1.802**</td>
</tr>
<tr>
<td>3</td>
<td>Total number of hogs sold (N)</td>
<td>-0.0004</td>
<td>-1.042</td>
</tr>
<tr>
<td>4</td>
<td>Education (E)</td>
<td>-0.0247</td>
<td>-0.970</td>
</tr>
<tr>
<td>5</td>
<td>Acres in cropland (CR)</td>
<td>0.0000</td>
<td>0.083</td>
</tr>
<tr>
<td>6</td>
<td>Number of cattle sold (CA)</td>
<td>0.0004</td>
<td>1.848**</td>
</tr>
<tr>
<td>7</td>
<td>Number of feeder pigs purchased (FPP)</td>
<td>-0.0002</td>
<td>-0.573</td>
</tr>
<tr>
<td>8</td>
<td>Number of bids (NB)</td>
<td>-0.2860</td>
<td>-4.308****</td>
</tr>
<tr>
<td>9</td>
<td>Proportion of income from hogs (FI)</td>
<td>0.0041</td>
<td>1.571*</td>
</tr>
<tr>
<td>10</td>
<td>Number of days hogs were marketed (NDHM)</td>
<td>-0.0035</td>
<td>-0.169</td>
</tr>
<tr>
<td>11</td>
<td>Capacity of confinement farrowing facilities (CFA)</td>
<td>-0.0337</td>
<td>-1.296</td>
</tr>
<tr>
<td>12</td>
<td>Capacity of confinement finishing facilities (CFI)</td>
<td>0.0007</td>
<td>0.831</td>
</tr>
<tr>
<td>13</td>
<td>Number of sows sold for breeding purposes (BSS)</td>
<td>-0.0012</td>
<td>-0.588</td>
</tr>
</tbody>
</table>

$^a$The dependent variable was arc sine $\sqrt{\text{percent}}$.

$^b$The estimates were obtained using the Glejser (42) procedure. Using ordinary least squares estimates of $\hat{\beta}$, $|e|=Y-Z\hat{\beta}$ was calculated. The best form of 6.13 found was $|e|=-144.3466-0.1896Y+0.0004Y^2+0.8276N$. The Y and Z variables (including a column of ones) were transformed to $Z^*$ and $Y^*$ using the estimated P matrix. The coefficients were then derived using $Y^*$ and $Z^*$ in Equation 6.21.

*Significant at the 0.15 level.
**Significant at the 0.10 level.
***Significant at the 0.05 level.
****Significant at the 0.01 level.
Table 6.10 (Continued)

<table>
<thead>
<tr>
<th>Line</th>
<th>Independent Variables</th>
<th>Percent Sold&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Number Sold&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>β</td>
<td>t</td>
</tr>
<tr>
<td></td>
<td><strong>Producer Characteristics (PCHAR) (Continued)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Number of boars sold for building purposes (BBS)</td>
<td>-0.0082</td>
<td>-1.550*</td>
</tr>
<tr>
<td>15</td>
<td>Average lot size sold (ALS)</td>
<td>0.0024</td>
<td>0.476</td>
</tr>
<tr>
<td>16</td>
<td>Average weight (AWGT)</td>
<td>0.0062</td>
<td>1.641*</td>
</tr>
<tr>
<td>17</td>
<td>Change in number sold 1967-1971 (ΔN)</td>
<td>0.0003</td>
<td>1.064</td>
</tr>
<tr>
<td></td>
<td><em><em>Producers' Attitudes Towards Outlet (PATO</em>)</em>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Convenience (CV*)</td>
<td>-0.0262</td>
<td>-0.732</td>
</tr>
<tr>
<td>19</td>
<td>Reliability of weighing (RW*)</td>
<td>-0.097</td>
<td>-1.900**</td>
</tr>
<tr>
<td>20</td>
<td>Shrinkage (Sh*)</td>
<td>-0.0981</td>
<td>-1.806**</td>
</tr>
<tr>
<td>21</td>
<td>Number of competing buyers (CB*)</td>
<td>0.1155</td>
<td>2.540***</td>
</tr>
<tr>
<td>22</td>
<td>Personal attention received (PA*)</td>
<td>0.0592</td>
<td>1.432</td>
</tr>
<tr>
<td>23</td>
<td>Quality premiums (QP*)</td>
<td>0.0686</td>
<td>1.903**</td>
</tr>
<tr>
<td>24</td>
<td>Length of wait for payment (LW*)</td>
<td>-0.0529</td>
<td>-1.067</td>
</tr>
<tr>
<td>25</td>
<td>Marketing costs (MC*)</td>
<td>0.0746</td>
<td>1.292</td>
</tr>
<tr>
<td></td>
<td><strong>Marketing Characteristics (MCHAR)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Distance (DIST)</td>
<td>0.0003</td>
<td>0.247</td>
</tr>
<tr>
<td></td>
<td>R²</td>
<td>0.81</td>
<td></td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>3.44****</td>
<td></td>
</tr>
</tbody>
</table>
fact that smaller producers sell more hogs to terminals than do larger producers is significant when coupled with the fact that the size of production units has increased in the past few years and will probably continue to increase. That is, terminals are likely to continue having problems sustaining their volume as producers increase in size.

The negative relationship between education level, E, (line 4) and number sold to terminals was hypothesized. Also note that acres in cropland, CR, (line 5) and sales to terminals were found to be negatively related which is the reverse of the relationship found in the buying station model.

The positive relationship between number of cattle sold, CA, (line 6) and number of hogs sold at terminals indicates that there may be some complementary relationship between sales of hogs and cattle at terminals. This seems logical because of the multi-specie nature of terminal markets and the corresponding ability of the commission firm to handle a producer's hogs and cattle.

The negative relationship between number of bids, NB, (line 8) received at the farm prior to sale and terminal outlet sales was expected because commission men do not bid on livestock at the farm. The positive coefficient for proportion of income from hogs, FI, (line 9) indicates that for those producers selling more hogs at terminals hog income is more important which is consistent with the negative coefficient for CR (line 5). The signs for average lot size, ALS, and number of days hogs were marketed, NDHM, (lines 15 and 10) are both positive indicating that producers who sell more hogs to terminals market more often in
larger loads.

The coefficients for the confinement facility capacity variables, CFA and CFI (lines 11 and 12) indicate that number of hogs sold to terminals is positively related to CFI and negatively related to CFA. The sign for number of boars sold for breeding purposes, BBS, (line 14) is negative indicating that producers who have a purebred business sell a smaller number of hogs to terminals.

To summarize, for producers who sell part but not all of their hogs through terminals, number sold to terminals is positively related to CA, FI, NDHM, CFI, ALS and AWGT and negatively related to YH, N, E, CR, NB, CFA and BBS.

All but two of the producers' attitude variables were also found to be significant. As expected, number sold through terminals was found to be negatively related to importance of shrinkage, Sh*, (line 20) and positively related to importance of number of competing buyers, CB* (line 21). The positive relationships for PA* and MC* (lines 22 and 25) are the reverse of those hypothesized. Apparently, commission firms can make a producer feel he receives personal attention. The positive sign for MC* may have resulted because producers who pay high marketing costs rated the importance of marketing costs high. Number of hogs sold to terminals was also found to be negatively related to importance of reliability of weighing, RW*, and positively related to importance of quality premiums, QP*.

Again all of the significant coefficients in the percentage sold equation are consistent with the results in the number sold equation.
Percentage sold to terminals was found negatively related to YH, NB, BBS, RW*, and Sh* (lines 2, 8, 14, 19 and 20) and positively related to CA, FI, AWGT and QP* (lines 6, 9, 16 and 23).

b. Discriminant analysis results

Table 6.11, 6.12 and 6.13 present the discriminant analysis results.

In Table 6.11, 87 percent of the producers were correctly classified but again there is great disparity in the classification success rate between groups. The none group was nearly completely correct while only 56 and 18 percent of the all and part groups were classified properly. Again the none group contains the producers who sold 100 percent to buying station and again they are correctly classified.

Table 6.11. Classification results for the discriminant model used to distinguish between producers that sold none, part and all of their hogs to terminal markets

<table>
<thead>
<tr>
<th>Prior probabilities</th>
<th>Number of observations classified from type</th>
<th>Number of observations classified into type</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>All</td>
<td>Part</td>
</tr>
<tr>
<td>0.115</td>
<td>All</td>
<td>18</td>
<td>0</td>
</tr>
<tr>
<td>0.084</td>
<td>Part</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>0.876</td>
<td>None</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

Also, the part group was found to be most difficult group to classify correctly as was the case in Table 6.3.

The combined relationships presented in Table 6.13 and the coefficients in Table 6.12 are interesting. Supported by two significant coefficients it can be stated that membership in the none group
is negatively related to CA, FI and DIST (lines 6, 9, 26). Similarly supported by two significant coefficients it can be stated that membership in the part group is positively related to NB and MC* and negatively related to ALS (lines 8, 25 and 15). Supported by two significant coefficients, membership in the all group can be said to be positively related to E, FI, CV*, and DIST (lines 4, 9, 18 and 26) and negatively related to YH, NB, and QP* (lines 2, 8 and 23).

The combined relationships in Table 6.13 for FI and DIST (lines 9 and 26) indicate that for producers selling none to terminals, hogs are a less important source of income and they haul hogs shorter distances while for producers selling all to terminals, hogs are a more important source of income, and they haul hogs longer distances.

Again as in Tables 6.9 and 6.5, producers selling part to terminals are those that received more bids. The positive relationship between selling all to terminals and CV* indicates that producers selling all to terminals feel that convenience is an important factor influencing their decision. Perhaps the fact that producers do not necessarily need to accompany their hogs to terminals is the reason for the relationship.

c. Summary Several of the relationships found in the regression equations were substantiated by the discriminant functions while others were not. The negative relationship between selling all to terminals and YH can be considered an extension of the negative relationship between number sold and YH in the regression equation. Similarly, the negative relationship between N and selling all to buying stations, and
Table 6.12. Discriminant function coefficients and significance levels for the functions used to classify producers as selling none, part and all of their hogs to terminal markets

<table>
<thead>
<tr>
<th>Line</th>
<th>Variable</th>
<th>None vs. All</th>
<th>None vs. Part</th>
<th>Part vs. All</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Constant</td>
<td>4.8056</td>
<td>1.7628</td>
<td>-3.0428</td>
</tr>
<tr>
<td></td>
<td><strong>Producer Characteristics (PCHAR)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Years as hog producer (YH)</td>
<td>-0.0076</td>
<td>0.0442***</td>
<td>0.0518**</td>
</tr>
<tr>
<td>3</td>
<td>Total number of hogs sold (N)</td>
<td>-0.0004</td>
<td>0.0010</td>
<td>0.0013**</td>
</tr>
<tr>
<td>4</td>
<td>Education level (E)</td>
<td>0.0025</td>
<td>-0.1327*</td>
<td>-0.1352**</td>
</tr>
<tr>
<td>5</td>
<td>Acres in cropland (CR)</td>
<td>0.0001</td>
<td>0.0010</td>
<td>0.0008</td>
</tr>
<tr>
<td>6</td>
<td>Number of cattle sold (CA)</td>
<td>-0.0043***</td>
<td>-0.0046***</td>
<td>-0.0003</td>
</tr>
<tr>
<td>7</td>
<td>Feeder pig purchases (FPP)</td>
<td>-0.0000</td>
<td>-0.0005</td>
<td>-0.0004</td>
</tr>
<tr>
<td>8</td>
<td>Number of bids (NB)</td>
<td>-0.2742***</td>
<td>1.7959***</td>
<td>2.0701***</td>
</tr>
<tr>
<td>9</td>
<td>Proportion of income from hogs (FI)</td>
<td>-0.0129***</td>
<td>-0.0289***</td>
<td>-0.0160**</td>
</tr>
<tr>
<td>10</td>
<td>Number of days hogs were marketed (NDHM)</td>
<td>0.0266</td>
<td>0.0315</td>
<td>0.0049</td>
</tr>
<tr>
<td>11</td>
<td>Capacity confinement farrowing facilities (CFA)</td>
<td>0.0223**</td>
<td>-0.0015</td>
<td>0.0012</td>
</tr>
<tr>
<td>12</td>
<td>Capacity confinement finishing facilities (CFI)</td>
<td>0.0005</td>
<td>0.0235</td>
<td>-0.0020**</td>
</tr>
<tr>
<td>13</td>
<td>Number of sows sold for breeding purposes (BSS)</td>
<td>0.0008</td>
<td>0.0028</td>
<td>0.0020</td>
</tr>
<tr>
<td>14</td>
<td>Number of boars sold for breeding purposes (BBS)</td>
<td>0.0135</td>
<td>0.0256</td>
<td>0.0391**</td>
</tr>
<tr>
<td>15</td>
<td>Average lot size (ALS)</td>
<td>0.0110***</td>
<td>-0.0025</td>
<td>-0.0135**</td>
</tr>
<tr>
<td>16</td>
<td>Average weight (AWGT)</td>
<td>-0.0087</td>
<td>0.0077</td>
<td>0.0164**</td>
</tr>
<tr>
<td>17</td>
<td>Change in number sold 1967-1971 (ΔN)</td>
<td>-0.0001</td>
<td>0.0002</td>
<td>0.0002</td>
</tr>
</tbody>
</table>

*Significant at the 0.10 percent level.

**Significant at the 0.05 percent level.

***Significant at the 0.01 percent level.
Table 6.12 (Continued)

<table>
<thead>
<tr>
<th>Line</th>
<th>Variable Description and Symbol</th>
<th>None vs. Part</th>
<th>None vs. All</th>
<th>Part vs. All</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Producers' Attitudes Towards Outlets (PATO*)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Convenience (CV*)</td>
<td>-0.0313</td>
<td>-0.4619***</td>
<td>-0.4306***</td>
</tr>
<tr>
<td>19</td>
<td>Reliability of weighing (RW*)</td>
<td>0.1522**</td>
<td>-0.0595</td>
<td>-0.2117**</td>
</tr>
<tr>
<td>20</td>
<td>Shrinkage (Sh*)</td>
<td>0.0614</td>
<td>0.3569***</td>
<td>0.2955***</td>
</tr>
<tr>
<td>21</td>
<td>Number of competing buyers (CB*)</td>
<td>-0.0832</td>
<td>-1.0010***</td>
<td>-0.9178***</td>
</tr>
<tr>
<td>22</td>
<td>Personal attention received (PA*)</td>
<td>-0.0910</td>
<td>0.0712</td>
<td>0.1622*</td>
</tr>
<tr>
<td>23</td>
<td>Quality premiums (QP*)</td>
<td>0.0479</td>
<td>0.2603**</td>
<td>0.2124***</td>
</tr>
<tr>
<td>24</td>
<td>Length of wait for payment (LW*)</td>
<td>0.1106*</td>
<td>0.1358</td>
<td>0.0252</td>
</tr>
<tr>
<td>25</td>
<td>Marketing costs (MC*)</td>
<td>-0.4690***</td>
<td>0.1541</td>
<td>0.6230***</td>
</tr>
</tbody>
</table>

Market Characteristics (MCHAR)

<table>
<thead>
<tr>
<th>Line</th>
<th>Variable Description and Symbol</th>
<th>Relationship between the variable and membership in group</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>Distance (DIST)</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.0870***</td>
</tr>
</tbody>
</table>

Table 6.13. Nature of the combined relationship between discriminant model variables and selling none, part and all to terminal outlets

<table>
<thead>
<tr>
<th>Line</th>
<th>Variable Description and Symbol</th>
<th>Relationship between the variable and membership in group</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Constant</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Producer Characteristics (PCHAR)

<table>
<thead>
<tr>
<th>Line</th>
<th>Variable Description and Symbol</th>
<th>Relationship between the variable and membership in group</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Years as hog producer (YH)</td>
<td>*</td>
</tr>
<tr>
<td>3</td>
<td>Total number of hogs sold (N)</td>
<td>?</td>
</tr>
<tr>
<td>4</td>
<td>Education level (E)</td>
<td>*</td>
</tr>
<tr>
<td>5</td>
<td>Acres in cropland (CR)</td>
<td>+</td>
</tr>
</tbody>
</table>

* Only one coefficient significant at 0.10 level or above.

** Both coefficients significant at 0.10 level or above.
Table 6.13 (Continued)

<table>
<thead>
<tr>
<th>Line</th>
<th>Variable description and symbol</th>
<th>Relationship between the variable and membership in group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>None</td>
</tr>
<tr>
<td>6</td>
<td>Number of cattle sold (CA)</td>
<td>-**</td>
</tr>
<tr>
<td>7</td>
<td>Feeder pig purchases (FPP)</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>Number of bids (NB)</td>
<td>?**</td>
</tr>
<tr>
<td>9</td>
<td>Proportion of income from hogs (FI)</td>
<td>-**</td>
</tr>
<tr>
<td>10</td>
<td>Number of days hogs were marketed (NDHM)</td>
<td>+</td>
</tr>
<tr>
<td>11</td>
<td>Capacity of confinement farrowing facilities (CFA)</td>
<td>?*</td>
</tr>
<tr>
<td>12</td>
<td>Capacity confinement finishing facilities (CFI)</td>
<td>+</td>
</tr>
<tr>
<td>13</td>
<td>Number of sows sold for breeding (BSS)</td>
<td>+</td>
</tr>
<tr>
<td>14</td>
<td>Number of boars sold for breeding (BBS)</td>
<td>?</td>
</tr>
<tr>
<td>15</td>
<td>Average lot size (ALS)</td>
<td>?*</td>
</tr>
<tr>
<td>16</td>
<td>Average weight (AWGT)</td>
<td>?</td>
</tr>
<tr>
<td>17</td>
<td>Change in number sold (AN)</td>
<td>?</td>
</tr>
<tr>
<td>18</td>
<td>Convenience (CV*)</td>
<td>-*</td>
</tr>
<tr>
<td>19</td>
<td>Reliability of weighing (RW*)</td>
<td>?*</td>
</tr>
<tr>
<td>20</td>
<td>Shrinkage (Sh*)</td>
<td>++</td>
</tr>
<tr>
<td>21</td>
<td>Number of competing buyers (CB*)</td>
<td>-*</td>
</tr>
<tr>
<td>22</td>
<td>Personal attention received (PA*)</td>
<td>?</td>
</tr>
<tr>
<td>23</td>
<td>Quality premiums (QP*)</td>
<td>++</td>
</tr>
<tr>
<td>24</td>
<td>Length of wait for payment (LW*)</td>
<td>++</td>
</tr>
<tr>
<td>25</td>
<td>Marketing costs (MC*)</td>
<td>?*</td>
</tr>
<tr>
<td>26</td>
<td>Distance (DIST)</td>
<td>-**</td>
</tr>
</tbody>
</table>

Producer Characteristics (PCHAR)  
Producers' Attitudes Towards Outlet (PATO*)  
Market Characteristics (MCHAR)
the negative coefficient for NB in the number sold equation are consistent, as is the positive coefficient for FI in the number sold equation and the positive relationship between selling all to terminals and FI.

Although number sold to terminals was found to be positively related to QP* the probability of being classified as selling all to terminals was found to be negatively related to QP*. Similarly, E was found to be negatively related to number sold to terminals in the regression model but positively related to the probability of being classified as selling all to terminals.

4. **100 Percent to each outlet type**

Tables 6.14, 6.15 and 6.16 present the results of the discriminant model designed to classify producers selling 100 percent of their hogs to one type of outlet.

In Table 6.14, 85 percent of the 323 producers who sold all of their hogs to one type of outlet were correctly classified. As before, there are great disparities between groups. Nearly 98 percent of the producers selling 100 percent to buying stations were correctly classified but only 29 percent of the producers selling 100 percent to packing plants and 63 percent of the producers selling 100 percent to terminals were correctly classified. Again, many members in the group of producers correctly classified were those producers who were correctly classified in the other discriminant models. That the packing plant group was most difficult to classify correctly was not surprising given the results of the model used to distinguish between those selling all
part and none to packing plants. Note that none of the buying station
group was classified into the terminal group and none in the terminal
group was classified into the packing plant group.

Table 6.14. Classification results for the discriminant model used to
distinguish between producers that sold 100 percent of their
hogs to buying stations, packing plants and terminals

<table>
<thead>
<tr>
<th>Prior probabilities ($\pi_i$)</th>
<th>Number of observations classified as selling 100 percent to</th>
<th>Number of observations classified as selling 100 percent to</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Buying stations</td>
<td>Packing plants</td>
</tr>
<tr>
<td>0.762</td>
<td>244</td>
<td>5</td>
</tr>
<tr>
<td>0.141</td>
<td>27</td>
<td>12</td>
</tr>
<tr>
<td>0.096</td>
<td>12</td>
<td>0</td>
</tr>
</tbody>
</table>

In Table 6.15 many interesting coefficients were found and the re-
sulting combined relationships are shown in Table 6.16. Supported by two
significant coefficients, it can be stated that being classified as
selling only to terminals is positively related to $E$, $CA$, $FI$ and $CB^*$
(lines 4, 6, 9, and 21) and negatively related to $YH$, $N$, $NB$ and $BSS$
(lines 2, 3, 8 and 13). Similarly, supported by two significant coeffi-
cients, selling all to packing plants is positively related to $N$, $AWGT$,
$QP^*$ and $MC^*$ (lines 3, 16, 23 and 25) and negatively related to $FPP$, $ALS$,
$RW^*$, and $CB^*$ (lines 7, 15, 19 and 21). Also supported by two signifi-
cant coefficients it can be stated that selling only to buying stations
is positively related to $YH$, $NB$, $BBS$ and $AN$ (lines 2, 8, 14 and 17)
and negatively related to $CA$, $CV^*$ and $DIST$ (lines 6, 18 and 26).

Moving across the columns of Table 6.16 for the $YH$, $N$, $CA$, $NB$,
Table 6.15. Discriminant function coefficients and significance levels for the functions used to classify producers as selling 100 percent of their hogs to each outlet type

<table>
<thead>
<tr>
<th>Line</th>
<th>Variable</th>
<th>Terminal vs. Packing</th>
<th>Terminal vs. Buying</th>
<th>Packing vs. Buying</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Constant</td>
<td>-0.9161</td>
<td>-6.2725</td>
<td>-5.3564</td>
</tr>
<tr>
<td></td>
<td><strong>Producer Characteristics (PCHAR)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Years as hog producer (YH)</td>
<td>-0.0278*</td>
<td>-0.0584***</td>
<td>-0.0306***</td>
</tr>
<tr>
<td>3</td>
<td>Total number of hogs sold (N)</td>
<td>-0.0050***</td>
<td>-0.0021*</td>
<td>0.0029***</td>
</tr>
<tr>
<td>4</td>
<td>Education level (E)</td>
<td>0.1836**</td>
<td>0.1917**</td>
<td>0.0080</td>
</tr>
<tr>
<td>5</td>
<td>Acres in cropland (CR)</td>
<td>0.0014</td>
<td>-0.0014</td>
<td>-0.0028***</td>
</tr>
<tr>
<td>6</td>
<td>Number of cattle sold (CA)</td>
<td>0.0035**</td>
<td>0.0051***</td>
<td>0.0016*</td>
</tr>
<tr>
<td>7</td>
<td>Feeder pig purchases (FPP)</td>
<td>0.0021***</td>
<td>0.0012</td>
<td>-0.0009**</td>
</tr>
<tr>
<td>8</td>
<td>Number of bids (NB)</td>
<td>-1.7430***</td>
<td>-2.2712***</td>
<td>-0.5282***</td>
</tr>
<tr>
<td>9</td>
<td>Proportion of income from hogs (FI)</td>
<td>0.0366***</td>
<td>0.0299***</td>
<td>-0.0067</td>
</tr>
<tr>
<td>10</td>
<td>Number of days hogs were marketed (NDHM)</td>
<td>0.0031*</td>
<td>0.0022</td>
<td>-0.0077</td>
</tr>
<tr>
<td>11</td>
<td>Capacity confinement farrowing facilities (CFA)</td>
<td>0.0309</td>
<td>0.0232</td>
<td>0.0351***</td>
</tr>
<tr>
<td>12</td>
<td>Capacity confinement finishing facilities (CFI)</td>
<td>-0.0505*</td>
<td>-0.0153</td>
<td>-0.0010</td>
</tr>
<tr>
<td>13</td>
<td>Number of sows sold for breeding (BSS)</td>
<td>0.0148*</td>
<td>0.0083</td>
<td>-0.0065</td>
</tr>
<tr>
<td>14</td>
<td>Number of boars sold for breeding (BBS)</td>
<td>-0.1298**</td>
<td>-0.1965**</td>
<td>-0.0667*</td>
</tr>
<tr>
<td>15</td>
<td>Average lot size (ALS)</td>
<td>0.0222***</td>
<td>0.0039</td>
<td>-0.0183***</td>
</tr>
<tr>
<td>16</td>
<td>Average weight (AWGT)</td>
<td>-0.0189*</td>
<td>0.0060</td>
<td>0.0248***</td>
</tr>
<tr>
<td>17</td>
<td>Change in number sold 1967-1971 (ΔN)</td>
<td>0.0012</td>
<td>-0.0004</td>
<td>-0.0016***</td>
</tr>
</tbody>
</table>

* Significant at the 0.10 level.
** Significant at the 0.05 level.
*** Significant at the 0.01 level.
Table 6.15 (Continued)

<table>
<thead>
<tr>
<th>Line</th>
<th>Variable</th>
<th>Terminal vs. Packing</th>
<th>Terminal vs. Buying</th>
<th>Packing vs. Buying</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Producers' Attitudes Toward Outlets (PATO*)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Convenience (CV*)</td>
<td>0.1754</td>
<td>0.4051**</td>
<td>0.2297**</td>
</tr>
<tr>
<td>19</td>
<td>Reliability of weighing (RW*)</td>
<td>0.3929***</td>
<td>-0.0414</td>
<td>-0.4343***</td>
</tr>
<tr>
<td>20</td>
<td>Shrinkage (Sh*)</td>
<td>-0.3320**</td>
<td>-0.2620</td>
<td>0.0700</td>
</tr>
<tr>
<td>21</td>
<td>Number of competing buyers (CB*)</td>
<td>1.2317***</td>
<td>1.0879***</td>
<td>-0.1438**</td>
</tr>
<tr>
<td>22</td>
<td>Personal attention received (PA*)</td>
<td>0.0031</td>
<td>-0.2241</td>
<td>-0.2272***</td>
</tr>
<tr>
<td>23</td>
<td>Quality premiums (QP*)</td>
<td>-0.3518***</td>
<td>-0.2030</td>
<td>0.1488**</td>
</tr>
<tr>
<td>24</td>
<td>Length of wait for payment (LW*)</td>
<td>-0.1859</td>
<td>-0.2079</td>
<td>-0.0220</td>
</tr>
<tr>
<td>25</td>
<td>Marketing costs (MC*)</td>
<td>-0.3253**</td>
<td>0.0584</td>
<td>0.3837***</td>
</tr>
</tbody>
</table>

Market Characteristics (MCHAR)

<table>
<thead>
<tr>
<th>Line</th>
<th>Variable</th>
<th>Relationship between variables and selling 100 percent to</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>Distance (DIST)</td>
<td>Terminals Packing Buying</td>
</tr>
<tr>
<td></td>
<td></td>
<td>N/A</td>
</tr>
</tbody>
</table>

Table 6.16. Summary of the consistency between group membership and variables in the discriminant model used to distinguish those that sold 100 percent to each type of outlet

<table>
<thead>
<tr>
<th>Line</th>
<th>Variable description and symbol</th>
<th>Relationship between variables and selling 100 percent to</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Constant</td>
<td>Terminals Packing Buying</td>
</tr>
<tr>
<td></td>
<td></td>
<td>N/A</td>
</tr>
<tr>
<td>2</td>
<td>Years as hog producer (YH)</td>
<td>-**</td>
</tr>
<tr>
<td>3</td>
<td>Total number of hogs sold (N)</td>
<td>-**</td>
</tr>
<tr>
<td>4</td>
<td>Education level (E)</td>
<td>+**</td>
</tr>
</tbody>
</table>

* Only one coefficient significant at 0.10 level or above.
** Both coefficients significant at 0.10 level or above.
<table>
<thead>
<tr>
<th>Line</th>
<th>Variable description and symbol</th>
<th>Relationship between variables and selling 100 percent to</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Terminals</td>
</tr>
<tr>
<td>5</td>
<td>Acres in cropland (CR)</td>
<td>?</td>
</tr>
<tr>
<td>6</td>
<td>Number of cattle sold (CA)</td>
<td>+**</td>
</tr>
<tr>
<td>7</td>
<td>Feeder pig purchases (FPP)</td>
<td>+*</td>
</tr>
<tr>
<td>8</td>
<td>Number of bids (NB)</td>
<td>-**</td>
</tr>
<tr>
<td>9</td>
<td>Proportion of income from hogs (FI)</td>
<td>+**</td>
</tr>
<tr>
<td>10</td>
<td>Number of days hogs were marketed (NDHM)</td>
<td>+*</td>
</tr>
<tr>
<td>11</td>
<td>Capacity confinement farrowing facilities (CFA)</td>
<td>+</td>
</tr>
<tr>
<td>12</td>
<td>Capacity confinement finishing facilities (CFI)</td>
<td>-*</td>
</tr>
<tr>
<td>13</td>
<td>Number of sows sold for breeding (BSS)</td>
<td>+*</td>
</tr>
<tr>
<td>14</td>
<td>Number of boars sold for breeding (BBS)</td>
<td>-**</td>
</tr>
<tr>
<td>15</td>
<td>Average size (ALS)</td>
<td>+*</td>
</tr>
<tr>
<td>16</td>
<td>Average weight (AWGT)</td>
<td>?*</td>
</tr>
<tr>
<td>17</td>
<td>Change in number sold 1967-1971 (AN)</td>
<td>?</td>
</tr>
</tbody>
</table>

**Producers' Attitudes Toward Outlets (PATO*)**

<table>
<thead>
<tr>
<th>Line</th>
<th>Variable description and symbol</th>
<th>Relationship between variables and selling 100 percent to</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>Convenience (CV*)</td>
<td>+**</td>
</tr>
<tr>
<td>19</td>
<td>Reliability of weighing (RW*)</td>
<td>?*</td>
</tr>
<tr>
<td>20</td>
<td>Shrinkage (Sh*)</td>
<td>-*</td>
</tr>
<tr>
<td>21</td>
<td>Number of competing buyers (CB*)</td>
<td>+**</td>
</tr>
<tr>
<td>22</td>
<td>Personal attention received (PA*)</td>
<td>?</td>
</tr>
<tr>
<td>23</td>
<td>Quality premiums (QP*)</td>
<td>-*</td>
</tr>
<tr>
<td>24</td>
<td>Length of wait for payment (LW*)</td>
<td>-</td>
</tr>
<tr>
<td>25</td>
<td>Marketing cost (MC*)</td>
<td>?*</td>
</tr>
</tbody>
</table>

**Market Characteristics (MCHAR)**

<table>
<thead>
<tr>
<th>Line</th>
<th>Variable description and symbol</th>
<th>Relationship between variables and selling 100 percent to</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>Distance (DIST)</td>
<td>+**</td>
</tr>
</tbody>
</table>
BBS and CB* (lines 2, 3, 6, 8, 14 and 21) rows there are opposing signs in two of the columns with both of the coefficients significant.

The negative sign for YH (line 2) in the terminal outlet column is consistent with the regression coefficient for YH in the terminal market model. Quite simply, more hogs are sold to terminals by younger producers. Similarly, the positive sign for YH in the buying station column is consistent with the regression coefficient for YH in the buying station model. Selling only to buying stations and selling a large number of hogs to buying stations are positively related to number of years as a hog producer.

The signs of the relationships for N (line 3) can be given a similar interpretation. Selling only to terminals is negatively related to N and N and number sold to terminals are negatively related. Also, selling only to packing plants is positively related to N as well as in number sold to packing plants from the regression model.

The positive relationship between CA (line 6) and selling only to terminals is consistent with previous findings in the regression models but the negative relationship between selling only to buying stations was not collaborated by the regression results.

Given the regression results, the negative sign for NB (line 8) in the terminal column was expected. The positive sign for NB in the buying column was not expected however.

According to relationships in the BBS (line 14) row, producers selling boars are more likely to sell only to buying stations and less likely to sell only to terminals. The negative relationship between BBS
<table>
<thead>
<tr>
<th>Line</th>
<th>Variable</th>
<th>Buying Stations</th>
<th>Packing Plants</th>
<th>Terminals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Hypothesis</td>
<td>Test</td>
<td>Hypothesis</td>
</tr>
<tr>
<td>1</td>
<td>YH</td>
<td>?</td>
<td>+</td>
<td>?</td>
</tr>
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<td>2</td>
<td>N</td>
<td>+</td>
<td>+****</td>
<td>+</td>
</tr>
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<td>3</td>
<td>E</td>
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<td>+</td>
<td>?</td>
</tr>
<tr>
<td>4</td>
<td>CR</td>
<td>+</td>
<td>+*</td>
<td>?</td>
</tr>
<tr>
<td>5</td>
<td>CA</td>
<td>+</td>
<td>+</td>
<td>?</td>
</tr>
<tr>
<td>6</td>
<td>FPP</td>
<td>?</td>
<td>-***</td>
<td>?</td>
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<td>7</td>
<td>NB</td>
<td>?</td>
<td>+</td>
<td>+</td>
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</tr>
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<td>9</td>
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<td>-</td>
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<td>11</td>
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<td>?</td>
<td>-*</td>
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<td>BSS</td>
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<td>13</td>
<td>BBS</td>
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<td>?</td>
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<td>+</td>
<td>+</td>
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<tr>
<td>15</td>
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<td>?</td>
<td>+</td>
<td>?</td>
</tr>
<tr>
<td>16</td>
<td>AN</td>
<td>?</td>
<td>+</td>
<td>?</td>
</tr>
</tbody>
</table>

^a From Table 5.1.
^b From Table 6.2.
^c From Table 6.6.
^d From Table 6.10.

* 15 percent level.
** 10 percent level.
*** 5 percent level.
**** 1 percent level.
Table 6.17 (Continued)

<table>
<thead>
<tr>
<th>Line</th>
<th>Variable</th>
<th>Buying Stations Hypothesis</th>
<th>Packing Plants Hypothesis</th>
<th>Terminals Hypothesis</th>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Hypothesis</td>
<td>Test</td>
<td>Hypothesis</td>
<td>Test</td>
</tr>
<tr>
<td>17</td>
<td>CV*</td>
<td>+</td>
<td>+++*</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>18</td>
<td>RW*</td>
<td>?</td>
<td>+</td>
<td>?</td>
<td>+</td>
</tr>
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<td>19</td>
<td>Sh*</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-***</td>
</tr>
<tr>
<td>20</td>
<td>CB*</td>
<td>+</td>
<td>+</td>
<td>-</td>
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</tr>
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<td>21</td>
<td>PA*</td>
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<td>+</td>
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</tr>
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<td>+</td>
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<td>LW*</td>
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<td>+</td>
<td>-***</td>
</tr>
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<td>24</td>
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<td>-</td>
<td>?</td>
<td>+++*</td>
</tr>
<tr>
<td></td>
<td>DIST</td>
<td>-</td>
<td>+++*</td>
<td>-</td>
<td>-***</td>
</tr>
</tbody>
</table>

and selling all to terminals is consistent with the regression results. In the CB* (line 21) row the signs add more collaboration to an already well established relationship between importance given to number of competing buyers and sales to terminals.

5. Summary

To summarize 300 discriminant function coefficients and approximately 150 regression coefficients is not an easy job. In Table 6.17 the hypothesized signs of the relationships in Table 5.1 and the signs of the coefficients in the regression equations with number sold as the dependent variable reported in Tables 6.2, 6.6 and 6.10 are presented. Reading across the rows of Table 6.17 gives considerable insight into
differences among the relationships between number sold at each of the three outlet types and the independent variables. All of the variables were significant in at least one of the equations.

Perhaps the most interesting results in the group of producer characteristics were the coefficients for N. That number sold to terminals is negatively related to N was not expected but perhaps should have been, given the simultaneous decline in terminal usage and increase in hog production unit size.

The positive coefficient for NB in the packing plant model and the negative coefficient for NB in the terminal market equation reflect the way which producers selling to the different outlets approach the marketing decision.

The producers' ratings of the importance of various factors also provided for some interesting results. CV* was significant and positively related to number sold to buying stations but not significant in the packing plant or terminal market models. SH* was found to be negatively related to number sold to outlets some distance from most farmers (packing plants and terminals) and was not significant in the buying station model. Again as expected, CB* has a positive coefficient in the terminal market model and has a negative coefficient in the packing plant model.

The most unexpected coefficients were the positive coefficients for MC* in the packing plant and terminal models. As stated previously, producers for which marketing costs were high were apparently rating the importance of marketing costs high. Those that were not paying high marketing costs apparently did not rate marketing costs as an important
factor.

The coefficients for QP* were all significant. Number sold to packing plants and terminals was found to be positively related to QP* while number of sales to buying stations was found to be negatively related to QP*.

The positive coefficient for DIST in the buying station model was surprising yet easily reconciled.

In general, the discriminant models' coefficients provided for interesting collaboration for many of the relationships found in the regression results. The classification results seemed biased toward classifying producers in the category with the greatest prior probability. Each of the large categories contained the same 249 producers that sold only at buying stations. Two possible explanations for their continual correct classification are 1) the group had a great deal in common or 2) the high prior probabilities for the larger group made it very difficult for producers to be classified in the smaller groups. Producers selling to packing plants were generally the most difficult to classify both in the none-part-all model for packing plants and the 100 percent to each type model.

The combined relationship between the variables and selling none and all to each of the three outlet types are presented in Table 6.18. Because the members in the part group have been previously analyzed by the regression results they were omitted from Table 6.18. Table 6.18 serves to point out that for each outlet type the variables affected classification as selling all and none differently. For example, in the
Table 6.18. Summary of the combined relationships for the all and none groups for buying stations, packing plants and terminal market discriminant analyses

<table>
<thead>
<tr>
<th>Line</th>
<th>Variable</th>
<th>Buying&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Packing&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Terminals&lt;sup&gt;c&lt;/sup&gt;</th>
<th>Buying&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Packing&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Terminals&lt;sup&gt;c&lt;/sup&gt;</th>
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<td>1</td>
<td>PCHAR</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>YH</td>
<td>**</td>
<td>+**</td>
<td>**</td>
<td>**</td>
<td>**</td>
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<td>+**</td>
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<td>-**</td>
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<td>+**</td>
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<td>4</td>
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<td>?</td>
<td>-**</td>
<td>-</td>
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<td>+**</td>
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<td>6</td>
<td>FPP</td>
<td>-</td>
<td>?**</td>
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<td>+**</td>
<td>+**</td>
<td>+</td>
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<td>?**</td>
<td>?**</td>
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<tr>
<td>8</td>
<td>FI</td>
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<td>?**</td>
<td>-**</td>
<td>-**</td>
<td>+**</td>
<td>+**</td>
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<td>?</td>
<td>?*</td>
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<tr>
<td>10</td>
<td>CFH</td>
<td>+**</td>
<td>?</td>
<td>?</td>
<td>+**</td>
<td>?</td>
<td></td>
</tr>
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<td>11</td>
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<td>+</td>
<td>?</td>
<td>-**</td>
<td>?*</td>
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<td>+</td>
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<td>-**</td>
<td>-</td>
</tr>
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<td>13</td>
<td>BBS</td>
<td>+**</td>
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<td>?*</td>
<td>-**</td>
<td>-*</td>
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</tr>
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<td>14</td>
<td>ALS</td>
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<td>+**</td>
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<td>+**</td>
<td>-**</td>
<td>+**</td>
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<td>?*</td>
<td>+**</td>
<td>-</td>
</tr>
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</tr>
</tbody>
</table>

<sup>a</sup>From Table 6.5.  
<sup>b</sup>From Table 6.9.  
<sup>c</sup>From Table 6.13.  

* Only one coefficient significant.  
** Both coefficients significant.
buying station discriminant models used to classify producers that sold none, part and all of their hogs to each outlet type, DIST was positively related to being classified as selling none to buying stations and negatively related to being classified as selling none to packing plants and terminals. Exactly the opposite was true for the all classification.

Again, each of the variables was significant in at least one of the models' discriminant functions. This indicates that perhaps more variables from the survey could have been used successfully in one or more of the discriminant models or regression equations.
C. Weight Decision Results and Analysis

The weight decision model provided a more formidable data challenge than did the outlet decision models. Although the theoretical models called for number of heavy hogs sold in order to test the hypotheses presented in Table 5.2, the distribution of hogs sold by weight is not available from the questionnaire. Monthly numbers sold and average weights are given in question 9 (see Appendix B). But even then, it is not possible to arrive at a figure that represents number of heavy hogs sold. Also, given only average weights, it is not possible to define or discriminate between producers who always sell at only one weight and those who sell at more than one weight. Also as with the outlet selection decisions, reasons for the weight decisions are not associated with a particular weight decision but refer to all weight decisions made during one year. Therefore to test the hypotheses, average weight of butcher hogs sold for the year was used as the dependent variable in a regression equation with the variables listed in Table 5.2 used as independent variables. This procedure of course assumes that as the number of heavy hogs sold increases the average weight of hogs sold increases. That is, if \( \frac{dS_{121}}{dA} \) is expected to be positive then \( \frac{d\text{AWGT}}{dA} \) is expected to be positive and vice versa.

The outlet type variable (line 16, Table 5.1) was interpreted in a regression form as a classification variable for each outlet type. The variables were coded plus one if the producer used that outlet type and minus one if he did not. Similarly, livestock scale usage was coded
plus one if the producer used a livestock scale and minus one if he did not.

The inclination toward varying the weight of hogs sold was represented as two classification variables. The first was coded plus one if the producer answered a to question 32, zero if answer b was given and minus one if answer c was given (see Appendix B). The second variable was coded zero if answer a was given, plus one for answer b and minus one for answer c.

The analysis of variance table used to test for interactions and the main effects is presented as Table 6.19 and the coefficients and their significance levels are presented in Table 6.20. Note that only 422 of the 489 producers were found to have complete data for all of the variables listed in Table 5.2. Note in Table 6.18 that interactions were found not to be significant and the GVR (inclination toward varying weight variable) variable was found to be significant. The hypotheses that the classification variables test are presented in the footnotes to Table 6.20.

Table 6.19. Analysis of covariance table for the average weight equation

<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regression</td>
<td>39</td>
<td>20,702.5767</td>
<td>530.8353</td>
<td>4.1572***</td>
</tr>
<tr>
<td>GVR</td>
<td>2</td>
<td>4,195.5037</td>
<td>2,097.7519</td>
<td>16.4284***</td>
</tr>
<tr>
<td>Interactiona</td>
<td>14</td>
<td>972.9207</td>
<td>69.4943</td>
<td>0.54424</td>
</tr>
<tr>
<td>Error</td>
<td>382</td>
<td>48,777.8024</td>
<td>127.6906</td>
<td></td>
</tr>
<tr>
<td>Corrected</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>421</td>
<td>69,480.3791</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

aBecause of inversion problems it was possible to test only for two-way interactions.

****Significant at the 0.01 level.
Table 6.20. Regression results for testing hypothesized signs of $\frac{\delta S_{121}}{\delta A}$ presented in Table 5.2. Average weight of hogs sold is the dependent variable

<table>
<thead>
<tr>
<th>Line</th>
<th>Sales function argument</th>
<th>Coefficient</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Intercept</td>
<td>237.135</td>
<td>43.092****</td>
</tr>
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<td></td>
<td><strong>Producer Characteristics (PCHAR)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Years as hog producer (YH)</td>
<td>0.189</td>
<td>3.520****</td>
</tr>
<tr>
<td>3</td>
<td>Total number of hogs sold (N)</td>
<td>-0.003</td>
<td>-1.156</td>
</tr>
<tr>
<td>4</td>
<td>Education (E)</td>
<td>-0.362</td>
<td>-1.302</td>
</tr>
<tr>
<td>5</td>
<td>Acres in cropland (CR)</td>
<td>0.008</td>
<td>2.077***</td>
</tr>
<tr>
<td>6</td>
<td>Number of feeder pigs purchased (FPP)</td>
<td>0.001</td>
<td>0.393</td>
</tr>
<tr>
<td>7</td>
<td>Number of bids received (NB)</td>
<td>0.522</td>
<td>0.723</td>
</tr>
<tr>
<td>8</td>
<td>Number of days hogs were marketed (NDHM)</td>
<td>-0.009</td>
<td>-0.081</td>
</tr>
<tr>
<td>9</td>
<td>Percent of time he sorts properly (PSP)</td>
<td>-0.135</td>
<td>-4.063****</td>
</tr>
<tr>
<td>10</td>
<td>Capacity of confinement finishing building (CFI)</td>
<td>-0.002</td>
<td>-0.614</td>
</tr>
<tr>
<td>11</td>
<td>Number of sows sold for breeding stock (BSS)</td>
<td>0.003</td>
<td>0.186</td>
</tr>
<tr>
<td>12</td>
<td>Number of boars sold for breeding stock (BBS)</td>
<td>-0.070</td>
<td>-0.925</td>
</tr>
<tr>
<td>13</td>
<td>Average lot size (ALS)</td>
<td>0.016</td>
<td>0.556</td>
</tr>
<tr>
<td>14</td>
<td>Uses buying stations$^a$</td>
<td>-0.715</td>
<td>-0.854</td>
</tr>
<tr>
<td>15</td>
<td>Uses packing plant$^b$</td>
<td>-0.569</td>
<td>-0.776</td>
</tr>
<tr>
<td>16</td>
<td>Uses terminal outlet$^c$</td>
<td>2.654</td>
<td>2.922****</td>
</tr>
</tbody>
</table>

$^a$Variable coded +1 for those that used buying stations, -1 for those that did not.

$^b$Variable coded +1 for those that used packing plants, -1 for those that did not.

$^c$Variable coded +1 for those that used terminals, -1 for those that did not.

***Significant at the 0.05 level.
****Significant at the 0.01 level.
Table 6.20 (Continued)

<table>
<thead>
<tr>
<th>Line</th>
<th>Sales function argument</th>
<th>Coefficient</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>Uses livestock scale&lt;sup&gt;d&lt;/sup&gt;</td>
<td>-1.037</td>
<td>-1.228</td>
</tr>
<tr>
<td>18</td>
<td>Percent sold live (PL)</td>
<td>0.040</td>
<td>1.643**</td>
</tr>
<tr>
<td>19</td>
<td>GVR1</td>
<td>-3.161</td>
<td>-2.915***&lt;sup&gt;e&lt;/sup&gt;</td>
</tr>
<tr>
<td>20</td>
<td>GVR2</td>
<td>-1.263</td>
<td>-0.684&lt;sup&gt;f&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

**Attitude Variables (PATW*)**

<table>
<thead>
<tr>
<th>Line</th>
<th>Sales function argument</th>
<th>Coefficient</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>Importance of sorting properly (SP*)</td>
<td>-0.585</td>
<td>-0.926</td>
</tr>
<tr>
<td>22</td>
<td>Need facilities for other livestock (FN*)</td>
<td>-1.674</td>
<td>-3.422****</td>
</tr>
<tr>
<td>23</td>
<td>Labor availability (LA*)</td>
<td>1.169</td>
<td>1.869***</td>
</tr>
<tr>
<td>24</td>
<td>Supply of home grown feed (HF*)</td>
<td>0.138</td>
<td>0.340</td>
</tr>
<tr>
<td>25</td>
<td>Time available to market (TA*)</td>
<td>-0.031</td>
<td>-0.058</td>
</tr>
<tr>
<td>26</td>
<td>Lack of labor (LL*)</td>
<td>-0.861</td>
<td>-1.349</td>
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<table>
<thead>
<tr>
<th></th>
<th>F</th>
<th>6.282****</th>
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<tbody>
<tr>
<td></td>
<td>R&lt;sup&gt;2&lt;/sup&gt;</td>
<td>.28</td>
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</table>

*Significant at the 0.15 level.
**Significant at the 0.10 level.
<sup>d</sup>Coded +1 if a scale was used, -1 if a scale was not used.
<sup>e</sup>Tests the null hypothesis that there is no difference in average weight of hogs sold by producers that answered "a" to question 32 and those that answered "c" to question 32. The significant coefficient indicates that producers that answered "a" sold lighter hogs than those that answered "c". The null hypothesis is rejected.
<sup>f</sup>Tests the null hypothesis that there is no difference in average weight of hogs sold by producers that answered "b" to question 32 and those that answered "c" to question 32. The null hypothesis was not rejected.

The equation yielded a small number of significant coefficients and a low R-square although the F-test was highly significant. That YH and average weight are positively related indicates that producers who have been producing hogs for a long time produce heavier hogs. The positive
coefficient for CR provides a small piece of evidence that producers with large crop farming operations have less time to market hogs and in general they are likely to market heavier hogs. The negative coefficient for PSP indicates that producers who feel they sort properly market lighter hogs than those producers who feel they do not sort properly. The positive coefficient for percent sold live is the opposite of the hypothesized relationship. Selling lighter hogs and selling on a carcass basis are positively related.

The classification variables provide two interesting results. Producers selling to terminals sold hogs heavier than producers who did not sell to terminals. The GVR1 coefficient indicates that producers who try to market in a single weight range market hogs lighter than producers who change the weight of hogs they market according to current conditions.

The two significant importance variables carried the hypothesized signs. FN* was negatively related to average weight sold and LA* was positively related to average weight.

Those farmers who feel they are sorting properly, sell more on a carcass basis, and need facilities for other livestock sell lighter hogs than those producers that are older, have large crop operations, use terminal markets and have labor available.
Table 6.21. Hypothesized and derived signs of $\frac{\partial S}{\partial A}$ for the weight decision model

<table>
<thead>
<tr>
<th>Line</th>
<th>Variable</th>
<th>Hypothesis</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Producer Characteristics (PCHAR)</strong></td>
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<td></td>
</tr>
<tr>
<td>1</td>
<td>Years as a hog producer (YH)</td>
<td>?</td>
<td>+****</td>
</tr>
<tr>
<td>2</td>
<td>Total number of hogs sold (N)</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>Education (E)</td>
<td>?</td>
<td>-</td>
</tr>
<tr>
<td>4</td>
<td>Acres in cropland (CR)</td>
<td>+</td>
<td>+***</td>
</tr>
<tr>
<td>5</td>
<td>Number of feeder pigs purchased (FPP)</td>
<td>?</td>
<td>+</td>
</tr>
<tr>
<td>6</td>
<td>Number of bids received (NB)</td>
<td>?</td>
<td>+</td>
</tr>
<tr>
<td>7</td>
<td>Number of days hogs were marketed (NDHM)</td>
<td>?</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>Percent of time he sorts properly (PSP)</td>
<td>?</td>
<td>-****</td>
</tr>
<tr>
<td>9</td>
<td>Capacity of confinement finishing building (CFI)</td>
<td>?</td>
<td>-</td>
</tr>
<tr>
<td>10</td>
<td>Number of sows sold for breeding (BSS)</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>11</td>
<td>Number of boars sold for breeding stock (BBS)</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>12</td>
<td>Average lot size (ALS)</td>
<td>?</td>
<td>+</td>
</tr>
<tr>
<td>13</td>
<td>Uses buying stations</td>
<td>N/A</td>
<td>-</td>
</tr>
<tr>
<td>14</td>
<td>Uses packing plant</td>
<td>N/A</td>
<td>-</td>
</tr>
<tr>
<td>15</td>
<td>Uses terminal outlets</td>
<td>N/A</td>
<td>+****</td>
</tr>
<tr>
<td>16</td>
<td>Uses livestock scale</td>
<td>N/A</td>
<td>-</td>
</tr>
<tr>
<td>17</td>
<td>Percent sold live (PL)</td>
<td>-</td>
<td>+**</td>
</tr>
</tbody>
</table>

---

*From Table 5.2.

**From Table 6.20.

** Significant at the 0.10 level.

*** Significant at the 0.05 level.

**** Significant at the 0.01 level.
Table 6.21 (Continued)

<table>
<thead>
<tr>
<th>Line</th>
<th>Variable</th>
<th>Hypothesis</th>
<th>Coefficient</th>
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<tbody>
<tr>
<td></td>
<td><strong>Inclination Toward Varying Weight (GVR)</strong></td>
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<td></td>
</tr>
<tr>
<td>18</td>
<td>GVR1</td>
<td>N/A</td>
<td>-***</td>
</tr>
<tr>
<td>19</td>
<td>GVR2</td>
<td>N/A</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td><em><em>Attitude Variables (PATW</em>)</em>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Importance of sorting properly (SP*)</td>
<td>?</td>
<td>-</td>
</tr>
<tr>
<td>21</td>
<td>Need facilities for other livestock (FN*)</td>
<td>-</td>
<td>-****</td>
</tr>
<tr>
<td>22</td>
<td>Labor available (LA*)</td>
<td>+</td>
<td>+***</td>
</tr>
<tr>
<td>23</td>
<td>Supply of home grown feed (HF*)</td>
<td>?</td>
<td>+</td>
</tr>
<tr>
<td>24</td>
<td>Time available to market (TA*)</td>
<td>?</td>
<td>-</td>
</tr>
<tr>
<td>25</td>
<td>Lack of labor (LL*)</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

* Significant at the 0.15 level.
VII. CONCLUSIONS AND SUGGESTIONS FOR ADDITIONAL RESEARCH

The purpose of Chapter VII is to answer the following questions:

1. Have the theoretical models been successful in asking questions whose answers are relevant to the objectives stated in Chapter I?

2. Do the empirical results provide adequate answers to the question suggested by the theoretical models?

3. How can the results be used by the people interested in the hog-pork marketing channel?

4. What kinds and types of additional research do the results suggest?

Section A addresses the first three questions for the outlet selection decision model and results and Section B addresses the first three questions for the weight decision model and results. In Section C suggestions for additional research are given.

A. Outlet Selection

The outlet selection model asked some of the right questions, the empirical analysis provided reasonable answers and people interested in the hog-pork marketing channel can make use of the results.

The psycho-physical sales constraints seem to be an appropriate mechanism for adding realism to the otherwise somewhat sterile utility maximization theory. The hypotheses center around how different variables constrain producers using the different types of outlets.
The theoretical model was able to place in a rather complete theoretical context the simple empirical hypothesis that people acting in a certain manner in the marketing channel have common characteristics. In a sense, the theoretical model transforms the problem of specifying producers' utility functions into a problem of specifying the nature of the psycho-physical constraint. Another strength of the model is its flexibility for handling problems where a seller has alternative outlets with different prices, and differences in the esoteric aspects of selling at the different outlets. Revised formulations of the model can be used to study a variety of problem situations.

The model does have weaknesses. Perhaps the most significant failing of the general and simplified models is the assumption that producers have single valued expectations about prices and production costs. Because the outlet selection model can be viewed as a single period comparison of known outlet characteristics and prices, the lack of a formal way of introducing uncertainty was not felt to be a serious problem. Fortunately, prices and other relationships between outlet types are relatively consistent.

Although the outlet decision model's empirical results do provide adequate answers to the questions suggested by the theoretical model, one can envision better types of data. A substantial recall problem is encountered when reasons for decisions made months ago are requested. Apparently, the reasons for choosing outlet types are firmly in mind and do not vary from one outlet decision to the next. The significance levels for the many ratings of importance have to be one of the most
gratifying empirical results. The importance variables for the most part did successfully measure the producers' feelings toward selling at the alternative outlet types.

Several uses of the results can be envisioned by individuals interested in the hog-pork marketing channel. Most certainly, the results are useful for those interested in working with extension marketing education programs. The results could be used by procurement people for planning procurement strategies. It also suggests that buyers could profitably examine why their particular customers use their facilities.

In addition, the results at least partially explain why relatively expensive buying stations are maintained. For 249 producers interviewed buying stations are the only type of outlet used and only 91 producers did not use buying stations at all. For those producers who sold part of their hogs to buying stations, number sold to buying stations was positively related to N, CV*, CR and DIST and negatively related to FPP, BSS and QP*. Those producers who sold all to buying stations were found to have

1. been selling hogs more years;
2. sold fewer hogs;
3. less education;
4. rated high the importance of personal attention received;
5. rated low the importance of marketing costs;
6. rated the importance of length of wait for payment high; and
7. hauled hogs a shorter weighted average distance.
Several of the relationships can be interpreted as indicating eventual decline in the importance of buying stations. If older producers retire, the education level increases, producers begin producing more hogs per farm, quality premiums become more important, hog producers become more specialized (FPP increases, CR decreases) it is likely that buying stations will become less important.

B. Weight Decisions

The weight decision model was much less successful, with both theoretical and empirical problems causing difficulty. The simplified theoretical model did not have multiple periods and as a consequence could not handle uncertainty. The nature of the weight decision is one of deciding between selling now or later where prices later are not known with certainty.

The data available to test the hypotheses suffers from similar difficulties. While farmers could be expected to make outlet decisions based on a consistent set of factors, most of the factors affecting a producer's weight decision are expected to vary throughout the year. Therefore, the inability to associate the reasons for a weight decision with a particular weight decision is a severe problem. At the point of every weight decision, we would need to know what information the producer is evaluating, how certain he is that prices will rise or fall and what other factors influence his choice.

The empirical evidence does suggest that some of the factors do consistently affect the weight decision throughout the year and were
appropriately measured. The evidence suggests that producers who try to sell in a preferred weight range (answered a to question 32), feel they sort hogs properly, and do not sell to terminals, sell lighter hogs. That labor availability, LA*, and need of facilities for other livestock, FN*, had positive and negative significant coefficients indicates that those are factors that also consistently affect the producers weight decisions.

C. Suggestions for Additional Research

Perhaps the lasting merit of this thesis is the kinds and types of research that are suggested by the results.

First, economists should learn to use psychology as a tool rather than an excuse when explaining economic behavior. This is especially true for livestock marketing economists in a time when price movements are sometimes unexplainable using traditional types of analyses. The potential for measuring the psychological aspects of the behavior causing the extreme price movements is exciting. Until we begin to measure and understand motivation for economic behavior, economists are going to have continued problems predicting behavior. This is especially true when the traditional, mechanistic behavioral assumptions no longer yield reasonable predictions.

Second, since uncertainty has meaning as a state of mind and feelings about price increases on decreases can be measured, it is possible to incorporate uncertainty into a multiple period version of the theoretical model. In particular, a producer making a decision as to what weight of hogs to sell might be asked to state his agreement or disagreement with.
statements about price increases or decreases using the 1-99 scaling system.

The concept of measuring states of mind when participants in a marketing channel are making decisions has a great many broad applications. We must, to be sure, continue to maintain that human decisions are governed by laws that are not arbitrary, unpredictable or indeterminant.

But psychology and economics are only two of the social sciences. The economist may be able to use the techniques of sociologists, political scientists and others when studying human behavior. The social scientist cannot control the experimental environment in which he works, therefore his best alternative is to measure as much of the relevant environment as he can. The relevant environment does not consist of economic variables alone.

There are at least three ways hog marketing systems research could be expanded. First, the variables used in the discriminant models and regression equations do not exhaust the list of potential variables. In particular, the sections on production costs and prices (Section VII of the questionnaire in Appendix B) may provide information useful for explaining why producers market at alternative weights.

Second, a panel of producers could be established so that a time series of attitudes and reasons for decisions could be collected and analyzed. Because the weight decision is primarily concerned with timing and expected price movements, knowledge of why producers make each decision at the time the decision is made would be better able to explain why a particular weight of hogs is sold.
Third, information about the objectives, characteristics and attitudes of participants at other levels in the marketing channel should be sampled. In particular, the ideas, characteristics and feeling of procurement facility operators are relevant to the problem of determining the future structure of the hog marketing channel.
VIII. BIBLIOGRAPHY


IX. ACKNOWLEDGMENTS

Research is never easy, but if it were it wouldn't be research. A great many people have had a hand in making this volume and my graduate program possible.

I would first like to acknowledge the key role played by Dr. George W. Ladd. Dr. Ladd read and commented on nearly every chapter at least once prior to the final draft. His encouragement and advice have kept me learning throughout the development of this thesis. I recommend Dr. Ladd to any student wanting to learn the art and science of doing research.

In addition to Dr. Ladd, other members of my committee and the faculty at Iowa State have provided me funding, statistical advice and a diversity of opinions to draw on. The Statistical Laboratory under the direction of Dr. Roy Hickman provided the necessary technical assistance that made the survey possible. Dr. Marvin Skadberg provided some valuable practical insights on how to approach the empirical questions. Dr. Han and Dr. Fuller from the Department of Statistics provided excellent resources to answer statistical questions.

My graduate program has been more than a research program. Dr. Ray Beneke and Dr. J. T. Scott were instrumental in providing me with the privilege of teaching and learning from Iowa State undergraduates.

In general, I have found the Economics Department and Iowa State University a good place to learn, teach and do research.

Perhaps my family deserves the most credit for the success of my
graduate program. Marcia and Alec have given me a better sense of perspective about what should receive priority. As a graduate student, I often needed the reminder that the next exam was not the most important goal in life. Also, my parents deserve a great deal of credit for instilling in me respect for education, the feeling that no goal is too high and the drive to follow through something I begin. Thank you.
X. APPENDIX A: NOTATION FOR CHAPTER IV

\[ C_{T+1,i} \] carryover of the \( i \) different qualities into the next planning horizon

\[ \overline{C}_{11} \] carryin of lightweight hogs into the first period of the planning horizon

\[ \overline{C}_{12} \] carryin of heavier weight hogs into the first period of the planning horizon

\[ D_j \] distance in miles to outlet type \( j \)

\[ h_{tk} \] price of input \( k \) in period \( t \). Input prices for the first period are known, those in other periods are expectations

\( I \) number of different weights of hogs produced, \( i=1,2,\ldots,I \)

\( J \) number of different outlet types, \( j=1,2,\ldots,J \)

\( K \) number of different inputs, \( k=1,2,\ldots,K \)

\( L \) Lagrangian function or the augmented objective function

\[ M_{Ctj} \] marketing costs to market type \( j \) in period \( t \)

\( M\text{CHAR} \) vector of market characteristics

\[ M_{Sj} \] marketing services at outlet type \( j \) for which there is a cost

\[ M_{Wt} \] money withdrawals or net income from the hog enterprise in period \( t \)

\[ OCL_t \] opportunity cost of labor in time period \( t \)

\[ P_{tij} \] output prices in period \( t \) for quality \( i \) at outlet \( j \). Prices in the first period are known, those in the future are expectations

\( \text{PATO}^* \) vector of producers' ratings of importance of outlet factors

\( \text{PATW}^* \) vector of variables rated on importance that may influence a producer's choice of weight

\[ q_{tki} \] quantity of variable input \( k \) used in the production of output \( i \) in period \( t \)

\[ S_{tij} \] number of hogs of weight \( i \) sold to outlet type \( j \) in period \( t \)
\( T \) number of weeks in the planning horizon \( t=1,2,\ldots,T \)

\( T_{M_j} \) time required to market at outlet type \( j \)

\( X_{ti} \) production in period \( t \) of weight \( i \)

\( \gamma \) Lagrangian multipliers for sales constraints

\( \alpha \) Lagrangian multipliers for accounting relationships

\( \lambda \) Lagrangian multipliers for production function constraints

\( \mu \) Lagrangian multipliers for marketing cost constraints

\( \Gamma_{tij} \) sales functional form for sales in period \( t \) of weight \( i \) to market \( j \)

\( \psi_{ti} \) weight gaining (production) function in period \( t \) for quality \( i \)

\( \theta_{tj} \) marketing cost functional form in period \( t \) at outlet type \( j \)

\( \phi \) functional notation for the utility function
XI. APPENDIX B: QUESTIONNAIRE
Hello, I am _______ and I am working for Iowa State University at (state name) Ames. The Department of Economics at ISU is doing research on how Iowa farmers produce and market hogs. As a part of this project, we are contacting randomly selected farmers in this area in order to find out what types of production and marketing systems are being used and what sort of changes are being made to adjust to changing economic conditions. Knowledge gained from this study will enable the researcher to better advise pork producers about production and marketing practices thus helping them to retain control of family-farm production units. All information will be kept confidential and used only for research purposes. Your
Hello, I am ________ and I am working for Iowa State University at ________ (state name) Ames. The Department of Economics at ISU is doing research on how Iowa farmers produce and market hogs. As a part of this project, we are contacting randomly selected farmers in this area in order to find out what types of production and marketing systems are being used and what sort of changes are being made to adjust to changing economic conditions. Knowledge gained from this study will enable the researcher to better advise pork producers about production and marketing practices thus helping them to retain control of family-farm production units. All information will be kept confidential and used only for research purposes. Your assistance will be greatly appreciated.

Could we start by asking if you sold any butcher hogs in 1971?

Yes (Go to page 2)          __________ No (continue)

Did you sell hogs of any type in 1971?  Yes  No

in 1970?  Yes  No

TERMINATE INTERVIEW, since no butcher hogs were sold in 1971.
SECTION I. GENERAL FARMING OPERATION

First, we would like some general information about your farming operation in 1971.

1. (a) How many acres of land did you own in 1971? Include land owned by your wife, or by your partners if any. ________ (a)

   (b) Of these ________ acres, how many did you rent to others in 1971? ________ (b)

   (c) Acres owned and operated (a - b) ________ (c)

   (d) How many acres of land did you rent from others and operate in 1971? Include any land operated in partnership or as a corporation. ________ (d)

   (e) Then, that makes a total of ________ acres operated in 1971. Does that sound about right? ________ (e)

   [If operator owned all land, go to Q. 4]
   [If operator rented all land, go to Q. 3]

2. Thinking about the hogs you had in 1971, were any of these hogs on the ________ acres you rented and operated? ________ Yes ________ No

3. We would like to know the type of leasing arrangement on the ________ acres that were rented from others. Of these ________ acres, were any rented for ... 

<table>
<thead>
<tr>
<th>Arrangements</th>
<th>Yes</th>
<th>No</th>
<th>If yes, how many acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) crop share only?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If yes, how many acres
2. Thinking about the hogs you had in 1971, were any of these hogs on the acres you rented and operated?

(entry in l.d)

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. We would like to know the type of leasing arrangement on the acres that were rented from others. Of these acres, were any rented for...

<table>
<thead>
<tr>
<th>Arrangements</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) crop share only?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) crop share plus cash?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) cash only?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d) a share of the livestock?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(e) other type of arrangement</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

If yes, how many acres

Did this include your hogs?

Yes ___ No ___

*If yes, describe below.

Total

*Please describe that part of the livestock share lease that included the swine.
4. Now we would like to ask about the uses made of your ______ acres during 1971? How many acres did you have in ______?

[NOTE: Record crops by total acres if R recalls totals, or if R reports by tract, record separately.]

<table>
<thead>
<tr>
<th>Land use</th>
<th>Total acres in place</th>
<th>Owned acres</th>
<th>Rented acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Corn (for all purposes)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) Soybeans</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) Oats</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d) Hay and rotated pasture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(e) Government program (diverted)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(f) Other cropland (specify)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(g) Permanent pasture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(h) Farmstead, roads, wasteland, etc.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TOTAL ACRES

5. Are any of your farm records kept by computer?

Yes
5. Are any of your farm records kept by computer?
   ___ Yes
   ___ No—>(Go to B)

A. Who keeps your computerized records?
   ___ (a) bank
   ___ (b) farm cooperative
   ___ (c) private organization
   ___ (d) accountant
   ___ (e) lawyer
   ___ (f) other ___ (specify)

B. Do the records you keep on your swine operation show:

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>N.A.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(a) Weight and number of pigs purchased?
(b) Weight and number of pigs sold?
(c) Number of pigs weaned?
(d) Amount of feed fed?
(e) Amount of labor used?
(f) Identification of pigs with their sire and/or dam?
Throughout the rest of the questionnaire, we will be talking mostly about your swine operation. If you have records which show sales, purchases, and/or production, we would very much appreciate it if you could get those records to use them from time to time in answering some of the remaining questions.

SECTION II. SWINE PRODUCTION PRACTICES

This section relates to the practices you follow in producing swine.

6. How many of each of the following kinds of swine did you have on hand on December 31, 1971?

<table>
<thead>
<tr>
<th>Kind</th>
<th>No. on hand Dec. 31, 1971</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Sows and gilts</td>
<td></td>
</tr>
<tr>
<td>(b) Boars</td>
<td></td>
</tr>
<tr>
<td>(c) Unweaned pigs</td>
<td></td>
</tr>
<tr>
<td>(d) Pigs purchased and being fed for slaughter</td>
<td></td>
</tr>
<tr>
<td>(e) Home-farrowed pigs being fed for slaughter</td>
<td></td>
</tr>
</tbody>
</table>

[If sows, gilts or boars were on hand ASK:]

A. Of the (sows and gilts)(boars) on hand on December 31, 1971, how many were:

(a) raised from your own herd?
(b) purchased from a purebred herd?
(c) purchased from a crossbred or hybrid herd?
A. Of the \((\text{sows and gilts})(\text{boars})\) on hand on December 31, 1971, how many were:

(a) raised from your own herd?

(b) purchased from a purebred herd?

(c) purchased from a crossbred or hybrid herd?

(d) purchased from other sources?

<table>
<thead>
<tr>
<th>Type of stock</th>
<th>(a) Raised</th>
<th>(b) Purebred herds</th>
<th>(c) Crossbred or hybrid herds</th>
<th>(d) Other*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sows and gilts</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boars</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Describe ____________________________

[If some were purchased, ASK:]

B. (1) How many of these sows and gilts were purchased as bred sows or gilts?

(2) How many of these boars were purchased from a testing station?
7. In 1971, did you:
   (a) sell either bred sows or gilts?
   (b) purchase either bred sows or gilts?
   (c) purchase feeder pigs?
   (d) sell feeder pigs (as feeder pigs)?
   (e) farrow either sows or gilts?

(Continue in same manner for 1970)

<table>
<thead>
<tr>
<th></th>
<th>(a) Sell bred sows or gilts</th>
<th>(b) Purchase bred sows or gilts</th>
<th>(c) Purchase feeders</th>
<th>(d) Sell feeders</th>
<th>(e) Farrow sows or gilts</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>1971</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1970</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[If no feeder pigs were purchased in 1971, Q. 7.c, go to Q. 9]

8. Now thinking of the feeder pigs you purchased in 1971:
   (a) How many feeder pigs did you purchase?
   (b) How many of these did you purchase from (read sources)?
   (c) How many of these pigs were born in Iowa?

<table>
<thead>
<tr>
<th>(a) Number purchased?</th>
<th>(b) Sources</th>
<th>(c) No. born in Iowa?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Another farmer</td>
<td>A local auction</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


9. Next we would like some information about your sales of swine during 1971.

(a) How many butcher hogs did you sell in [insert month]?

If any sold,
(1) What was the average weight of the butcher hogs sold? (or total weight)
(2) On how many different days did you sell butcher hogs that month?

(b) How many sows and boars did you sell for slaughter in [insert month]?

(c) How many sows and gilts did you sell as breeding stock during [insert month]?

(d) How many boars did you sell as breeding stock during [insert month]?

(e) How many feeder pigs did you sell during [insert month]?

[NOTE: Roughly tabulate totals and ask if they seem correct]

<table>
<thead>
<tr>
<th>Month</th>
<th>Slaughter hogs</th>
<th>Breeding stock</th>
<th>Feeders</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(a) Butcher hogs</td>
<td>(1) Average weight</td>
<td>(b) No. of days hogs sold</td>
</tr>
<tr>
<td>January</td>
<td></td>
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<td></td>
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<tr>
<td>February</td>
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<td>March</td>
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<td>September</td>
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<td></td>
</tr>
<tr>
<td>Month</td>
<td>Hogs</td>
<td>Weight</td>
<td>Hogs Sold</td>
</tr>
<tr>
<td>----------</td>
<td>------</td>
<td>--------</td>
<td>-----------</td>
</tr>
<tr>
<td>January</td>
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<td>February</td>
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<td>November</td>
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<tr>
<td>December</td>
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<tr>
<td>Total</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

[If no feeder pigs were sold during 1971, (see Q. 9.e) go to Q. 11]

10. Of the feeder pigs sold in 1971, how many were sold:

   (total Col. 9.e)

   _____ (a) directly to other farmers

   _____ (b) to dealers

   _____ (c) to auction barns

   _____ (d) to terminal markets

   _____ (e) to other outlets (specify) ____________________________
11. (a) How many sows did you farrow in (insert month) of 1971?

(b) Of the pigs farrowed in (insert month) what was the average number of pigs weaned per litter (or the total for the month)?

<table>
<thead>
<tr>
<th>Month</th>
<th>Sows farrowed</th>
<th>Pigs weaned</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td></td>
<td></td>
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<tr>
<td>February</td>
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<td>March</td>
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<tr>
<td>December</td>
<td></td>
<td></td>
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<tr>
<td>Total</td>
<td></td>
<td></td>
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</tbody>
</table>
### Hand R Card No. 1 (green)

12. Looking at this card which of these statements best describes your usual swine breeding practices during the past five years? (Read statements with R)

- (a) I have a well-defined schedule of breeding periods (e.g., spring and fall) and breed about the same number of sows (or gilts) during each of these periods.

- (b) I have a well-defined schedule of breeding periods but the number of sows bred during each period may vary depending on prevailing conditions.

- (c) Both the number of breeding periods and the number of sows bred in any particular period vary depending on prevailing conditions.

- (d) Other (specify) ____________________________

---

3. In 1971, which mating practice was used?

- (a) Turn boar(s) in with a group of sows?

- (b) Turn boar in with only one sow or gilt at a time?

- (c) Artificial insemination?
14. How soon do you usually rebreed your sows after weaning?

   (a) do not rebreed
   (b) first heat (estrus)
   (c) second heat (estrus)
   (d) other (specify)

   In the next three questions we would like to discuss how you handle your baby pigs until they are about 8 to 10 weeks of age.

15. Did you farrow any sows or gilts in confinement (not on pasture or in the brush) in 1971?

   Yes
   No —> (Go to Q. 17)

   A. For how many weeks did you hold the pigs in the farrowing house or unit with the sows? weeks

   B. For how many additional weeks did you hold the pigs in the farrowing house or unit after the sows were removed? weeks

   C. Were these sows fed inside the pens, outside the pens, or both inside and outside?

   Inside the pens
   Outside the pens
   Both inside & outside

   D. Were they watered inside, outside or both?

   Inside the pens
   Outside the pens
   Both inside & outside

16. Did you move your sows and/or baby pigs into a separate unit after farrowing which might be considered a nursery (a unit built or remodeled especially for caring for small pigs)?

   Yes
   No —> (Go to Q. 17)
B. For how many additional weeks did you hold the pigs in the farrowing house or unit after the sows were removed? ______ weeks

C. Were these sows fed inside the pens, outside the pens, or both inside and outside?
   ____ Inside the pens
   ____ Outside the pens
   ____ Both inside & outside

D. Were they watered inside, outside or both?
   ____ Inside the pens
   ____ Outside the pens
   ____ Both inside & outside

16. Did you move your sows and/or baby pigs into a separate unit after farrowing which might be considered a nursery (a unit built or remodeled especially for caring for small pigs)?
   ____ Yes
   ____ No —>(Go to Q. 17)

A. Approximately how many weeks were the pigs in the nursery with the sows? ______ weeks

B. Approximately how many weeks were the pigs in the nursery without the sows? ______ weeks

17. At what age do you usually wean your pigs? ______ weeks

18. On the average over the past five years, what percent of your sows were kept for:
   ____% 1 farrowing only
   ____% 2 farrowings only
   ____% 3 farrowings only
   ____% 4 farrowings only
   ____% 5 farrowings only
   ____% 6 or more farrowings
   100%
SECTION III. PRODUCTION PLANNING


[Obtain total for 1971 from page 6, Q. 9.a]

<table>
<thead>
<tr>
<th>Year</th>
<th>(a) No. hogs sold</th>
<th>(b) No. increased</th>
<th>(c) No. decreased</th>
<th>(d) Does this change exceed tolerance?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1971</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1970</td>
<td></td>
<td></td>
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<tr>
<td>1969</td>
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<tr>
<td>1968</td>
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<tr>
<td>1967</td>
<td>X X X X</td>
<td>X X X X</td>
<td>X X</td>
<td></td>
</tr>
</tbody>
</table>

Change exceeds tolerance if:

- Entry in Col. a is 0
- Entry in Col. b or c is anything
- 1 - 99, 10 or more
- 100 - 199, 20 or more
- 200 - 299, 30 or more
- 300 - 399, 40 or more
- 400 - 499, 50 or more
- 500 +, 75 or more

1. Enter in the table in Ques. 20, the years in which there was an increase in the number of hogs sold greater than the tolerance limit (i.e., an entry in Col. b and YES checked in Col. d).

2. Enter in the table in Ques. 21, the years in which there was a decrease (but not to zero) in the number sold greater than tolerance (i.e., a nonzero entry in Col. a, an entry in Col. c, and YES checked in Col. d).

3. Enter in the table in Ques. 22, the years in which no slaughter hogs were sold (i.e., a zero in Col. a).

4. Ask only those questions 20-22 in which years have been entered.

In some of the following questions I will be asking you to use this scale (hand Card No. 2 (buff) to R) to assess the importance of different factors.
(1) Enter in the table in Ques. 20, the years in which there was an increase in the number of hogs sold greater than the tolerance limit (i.e., an entry in Col. b and YES checked in Col. d)

(2) Enter in the table in Ques. 21, the years in which there was a decrease (but not to zero) in the number sold greater than tolerance (i.e., a nonzero entry in Col. a, an entry in Col. c, and YES checked in Col. d)

(3) Enter in the table in Ques. 22, the years in which no slaughter hogs were sold (i.e., a zero in Col. a)

(4) Ask only those questions 20-22 in which years have been entered.

In some of the following questions I will be asking you to use this scale (hand Card No. 2 (buff) to R) to assess the importance of different factors affecting decisions made by hog producers. You will note that "1" indicates it is of no importance, while "99" indicates maximum importance, with various degrees of importance between. We would appreciate your making the distinctions as fine as you are able for the questions on which we use this scale.

```
1 .......... No importance
10 .......... Slight importance
20 .......... Moderate importance
30 .......... Considerable importance
40 .......... Maximum importance
50 ..........
60 ..........
70 ..........
80 ..........
90 ..........
99 ..........
```

[For each year entered in the table below, ASK:]

20. In 19__ you showed a sizeable increase in the number of hogs you sold for slaughter. On this card [hand Card No. 3 (pink) to R] are some factors that may cause a farmer to increase production of slaughter hogs. Using the second card (buff) with the 99-point scale (1 = no importance and 99 = maximum importance), as I read each factor please indicate how important it was in causing you to market more hogs in 19__.

<table>
<thead>
<tr>
<th>FACTOR (re increasing production of slaughter hogs)</th>
<th>Degree of importance for 19_</th>
<th>19_</th>
<th>19_</th>
<th>19_</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Price of feeder pigs</td>
<td></td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>(b) Expected price of slaughter hogs</td>
<td></td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>(c) Expected price of fed cattle</td>
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</tr>
<tr>
<td>(d) Corn prices</td>
<td></td>
<td>-----</td>
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<td>-----</td>
</tr>
<tr>
<td>(e) Labor supply</td>
<td></td>
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</tr>
<tr>
<td>(f) Feed supply</td>
<td></td>
<td>-----</td>
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<td>-----</td>
</tr>
<tr>
<td>(g) Capital supply</td>
<td></td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>(h) Higher than average conception rates</td>
<td></td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>(i) Higher than average litter sizes</td>
<td></td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>(j) Fewer disease problems</td>
<td></td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>(k) Ratio between hog prices and corn prices</td>
<td></td>
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<td>-----</td>
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</tr>
<tr>
<td>(l) Improved health of operator</td>
<td></td>
<td>-----</td>
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<td>-----</td>
</tr>
</tbody>
</table>

[For each year entered in the table below, ASK:]

21. In 19__ you showed a sizeable decrease in the number of hogs you sold for slaughter. On this card [hand Card No. 3 (pink) to R] are some factors that may cause a farmer to increase production of slaughter hogs. Using the second card (buff) with the 99-point scale (1 = no importance and 99 = maximum importance), as I read each factor please indicate how important it was in causing you to market fewer hogs in 19__.
(f) Feed supply
(g) Capital supply
(h) Higher than average conception rates
(i) Higher than average litter sizes
(j) Fewer disease problems
(k) Ratio between hog prices and corn prices
(l) Improved health of operator

[For each year entered in the table below, ASK:]  

21. In 19 you showed a sizeable decrease in the number of hogs you sold for slaughter. [Hand Card 4 (yellow) to R] As I read each factor on this card, please indicate how important it was in causing you to market fewer hogs in 19 .

<table>
<thead>
<tr>
<th>FACTOR (re decreasing production of slaughter hogs)</th>
<th>Degree of importance for 19</th>
<th>19</th>
<th>19</th>
<th>19</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Price of feeder pigs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) Expected price of slaughter hogs</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>(c) Expected price of fed cattle</td>
<td></td>
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<tr>
<td>(d) Corn prices</td>
<td></td>
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<tr>
<td>(e) Labor supply</td>
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<tr>
<td>(f) Feed supply</td>
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<tr>
<td>(g) Capital supply</td>
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<tr>
<td>(h) Lower than average conception rates</td>
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<tr>
<td>(i) Smaller than average litter sizes</td>
<td></td>
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<td></td>
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<tr>
<td>(j) More disease problems</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>(k) Ratio between hog prices and corn prices</td>
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</tr>
<tr>
<td>(l) Poor health of operator</td>
<td></td>
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</tr>
</tbody>
</table>
[For each year entered in the table below, ASK:]

22. In 19__ you didn't sell any slaughter hogs at all. On Card No. 5 (blue) are factors that may influence a farmer's decision to cease production of slaughter hogs. How important was each of these factors in causing you to cease production in 19__, again using the score of 1 through 99.

<table>
<thead>
<tr>
<th>FACTOR (re ceasing production of slaughter hogs)</th>
<th>Degree of importance for</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>19_ 19_ 19_ 19_</td>
</tr>
<tr>
<td>(a) Price of feeder pigs</td>
<td>________________________</td>
</tr>
<tr>
<td>(b) Expected price of slaughter hogs</td>
<td>________________________</td>
</tr>
<tr>
<td>(c) Expected price of fed cattle</td>
<td>________________________</td>
</tr>
<tr>
<td>(d) Corn prices</td>
<td>________________________</td>
</tr>
<tr>
<td>(e) Labor supply</td>
<td>________________________</td>
</tr>
<tr>
<td>(f) Feed supply</td>
<td>________________________</td>
</tr>
<tr>
<td>(g) Capital supply</td>
<td>________________________</td>
</tr>
<tr>
<td>(h) Disease problems</td>
<td>________________________</td>
</tr>
<tr>
<td>(i) Condition of facilities</td>
<td>________________________</td>
</tr>
<tr>
<td>(j) General attitude toward producing hogs</td>
<td>________________________</td>
</tr>
<tr>
<td>(k) Ratio between hog prices and corn prices</td>
<td>________________________</td>
</tr>
<tr>
<td>(l) Poor health of operator</td>
<td>________________________</td>
</tr>
</tbody>
</table>

SECTION IV. SLAUGHTER HOG MARKET OUTLETS

Now we would like to talk about the markets where you sold slaughter hogs during 1971.

23. (a) Would you please tell me the name and city of each market to which
SECTION IV. SLAUGHTER HOG MARKET OUTLETS

Now we would like to talk about the markets where you sold slaughter hogs during 1971.

23. (a) Would you please tell me the name and city of each market to which you sold slaughter hogs in 1971?

[For each market named ASK:]

(b) What percentage of the hogs sold in 1971 were sold to _________?

(c) On the top half of Card No. 6 (white) is a list of different types of markets. What type is _________?

(d) Looking at the lower half of the white card, what method or methods were used to haul your hogs to this market?

(e) How far is this market from your farm?

<table>
<thead>
<tr>
<th>(a) Name</th>
<th>(b) Percentage</th>
<th>(c) *Type of market</th>
<th>(d) **Hauling method(s)</th>
<th>(e) Distance from farm (mi.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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</tbody>
</table>

INTERVIEWER: Record code number(s) only for Cols. c and d. You may have more than one entry in these two columns.

[See code on next page for "Type of market" and "Hauling method"]]
24. Thinking back over the last five years, have you sold hogs at any outlets other than the ones we have just talked about?

Yes
No ——> (Go to Q. 25)

(a) What are the names and locations of these markets?

[For each one named, ASK:]

(b) Referring again to the White card, what type of market is ________?

(c) Did you consider using this market at any time last year?

(d) How far is this market from your farm?

<table>
<thead>
<tr>
<th>(a)</th>
<th>(b)</th>
<th>(c)</th>
<th>(d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>City</td>
<td>*Type of market</td>
<td>Consider using last year?</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
</tr>
</tbody>
</table>
(b) Referring again to the White card, what type of market is ________?

(c) Did you consider using this market at any time last year?

(d) How far is this market from your farm?

<table>
<thead>
<tr>
<th>Name</th>
<th>City</th>
<th>Type of market</th>
<th>Consider using last year?</th>
<th>Distance from farm (mi.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td></td>
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</tbody>
</table>

25. Are there any (other) hog market outlets you considered using last year but didn't?

   Yes

   No —-> (Go to Q. 26)

(a) What are the names and locations of these markets?

   [For each one named, ASK:]

(b) What type of market is this? (White card)

(c) How far is this market from your farm?

<table>
<thead>
<tr>
<th>Name</th>
<th>City</th>
<th>Type of market</th>
<th>Distance from farm (mi.)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>
26. Card No. 7 (orange) lists characteristics of markets that might influence a person to choose a particular market outlet when selling slaughter hogs. You have said that in 1971 you sold hogs to (read markets given in Q. 23). For each factor on this card, please indicate, by giving me a number from 1 to 99, how important it was to you in deciding to patronize these markets.

<table>
<thead>
<tr>
<th>CHARACTERISTICS OF MARKETS</th>
<th>DEGREE OF IMPORTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Price received</td>
<td></td>
</tr>
<tr>
<td>(b) Nearness or convenient transportation</td>
<td></td>
</tr>
<tr>
<td>(c) Marketing cost</td>
<td></td>
</tr>
<tr>
<td>(d) Premium received for quality or weight of my hogs</td>
<td></td>
</tr>
<tr>
<td>(e) Reliability of weighing</td>
<td></td>
</tr>
<tr>
<td>(f) Amount of shrink</td>
<td></td>
</tr>
<tr>
<td>(g) Length of wait between sale of hogs and receipt of money</td>
<td></td>
</tr>
<tr>
<td>(h) Sorting or grading procedure used</td>
<td></td>
</tr>
<tr>
<td>(i) Amount of personal attention received</td>
<td></td>
</tr>
<tr>
<td>(j) Number of competing buyers</td>
<td></td>
</tr>
</tbody>
</table>

27. When you get ready to sell butcher hogs, from how many buyers or commission agents do you usually obtain bids or price quotations? __________

28. Within the past five years, have you ever divided your hogs into groups of similar number and quality and sold the lots to different buyers on the same day?

   _____ Yes
   _____ No

SECTION V. MARKETING DECISIONS
27. When you get ready to sell butcher hogs, from how many buyers or commission agents do you usually obtain bids or price quotations?  __________

28. Within the past five years, have you ever divided your hogs into groups of similar number and quality and sold the lots to different buyers on the same day?

   _Yes_
   _No_

SECTION V. MARKETING DECISIONS

29. Everyone wants to make as much money as possible when they sell their hogs. In your attempt to do this how important is each of the marketing decisions on Card No. 8 (green)? Please rate the importance to you of each marketing decision by assigning a number between 1 and 99.

<table>
<thead>
<tr>
<th>MARKETING DECISION</th>
<th>(29)</th>
<th>(30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Selecting the market outlet that pays the highest price</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) Properly sorting hogs so that I sell the weights or grades that bring the highest price</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) Selecting the day on which price is highest</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d) Selecting the time of day (e.g., A.M. or P.M.) when price is highest</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

30. Now referring to the same card, what percent of the time do you believe you make the right choice in each of these marketing decisions?

   [Record in table above]
31. Do you generally prefer to market your hogs on a certain day or days of the week?
   ______ Yes
   _____ No———> (Go to Q. 32)

A. Which day or days do you generally prefer?
   Mon. _____ Wed. _____ Fri. _____
   Tues. _____ Thurs. _____ Sat. _____

B. During 1971, what percent of the butcher hogs you sold did you market on your preferred day or days?
   _____ %

32. Which of these three statements best describes your marketing practice with respect to weight of butcher hogs? You may want to turn to Card No. 9 (buff) and read these with me.
   ____ (a) I try to market all butcher hogs in the same weight range.
       What is this weight range? _____ to _____ lbs. [Go to Q. 33]
   ____ (b) I change my preferred weight range for marketing from season to season but not from year to year.
       What are these weight ranges in the seasons in which you market?
       Winter
       Spring
       (Mar. Apr. May) _____ to _____ lbs.
       Summer
       (June July Aug.) _____ to _____ lbs. [Go to Q. 33]
       Fall
   ____ (c) I change my preferred weight range from season to season and from year to year according to current conditions. [Go to Q. 33]
(Dec. Jan. Feb.)

Spring  (Mar. Apr. May)  ____ to ____ lbs.  [Go to Q. 33]

Summer  (June July Aug.)  ____ to ____ lbs.

Fall  (Sept. Oct. Nov.)  ____ to ____ lbs.

(c) I change my preferred weight range from season to season and from year to year according to current conditions. [Skip to Q. 34]

You have indicated one (or more) preferred weight range(s) for marketing butcher hogs.

33. How important is each factor on the list shown on Card 10 (pink) in causing you to prefer this (or these) weight ranges, again using the 1 to 99 scale.

<table>
<thead>
<tr>
<th>FACTOR (re selecting preferred weight range)</th>
<th>DEGREE OF IMPORTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Need of facilities for other hogs or other livestock when hogs reach this weight</td>
<td>____</td>
</tr>
<tr>
<td>(b) Availability of labor to care for hogs until they reach this weight</td>
<td>____</td>
</tr>
<tr>
<td>(c) Lack of labor to care for heavier hogs</td>
<td>____</td>
</tr>
<tr>
<td>(d) Time available to market hogs when they reach this weight (sorting, hauling, finding buyer, etc.)</td>
<td>____</td>
</tr>
<tr>
<td>(e) Price differential for this weight range</td>
<td>____</td>
</tr>
<tr>
<td>(f) Cost of feeding to higher weights</td>
<td>____</td>
</tr>
<tr>
<td>(g) Good for total hog industry to market hogs in this weight range</td>
<td>____</td>
</tr>
<tr>
<td>(h) Supply of home grown feed</td>
<td>____</td>
</tr>
</tbody>
</table>

[Skip to Q. 35]
You have indicated that you change the weight range you prefer to market hogs according to current conditions.

### 34. How important is each factor on the list on Card No. 11 (yellow) in deciding what weight range to use? Please give a number between 1 and 99, as before.

<table>
<thead>
<tr>
<th>FACTOR (re deciding weight range to use)</th>
<th>DEGREE OF IMPORTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Need of facilities for other hogs or other livestock</td>
<td></td>
</tr>
<tr>
<td>(b) Availability of labor to care for hogs</td>
<td></td>
</tr>
<tr>
<td>(c) Lack of labor to care for heavier hogs</td>
<td></td>
</tr>
<tr>
<td>(d) Time available to market hogs (sorting, hauling, finding buyer, etc.)</td>
<td></td>
</tr>
<tr>
<td>(e) Need for money to pay due bills</td>
<td></td>
</tr>
<tr>
<td>(f) Hog prices</td>
<td></td>
</tr>
<tr>
<td>(g) Beef prices</td>
<td></td>
</tr>
<tr>
<td>(h) Corn prices</td>
<td></td>
</tr>
<tr>
<td>(i) Supply of home grown feed</td>
<td></td>
</tr>
<tr>
<td>(j) Ratio between hog prices and corn prices</td>
<td></td>
</tr>
</tbody>
</table>

### 35. Do you generally obtain advice on hog marketing from:

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) farm management advisors?</td>
<td></td>
</tr>
<tr>
<td>(b) hog buyers?</td>
<td></td>
</tr>
<tr>
<td>(c) commission agents or auction operators?</td>
<td></td>
</tr>
<tr>
<td>(d) feed salesmen?</td>
<td></td>
</tr>
</tbody>
</table>

[If advice obtained from at least one source in Q. 35, ASK:]

### 36. Would you say you follow the advice obtained:

<table>
<thead>
<tr>
<th>seldom</th>
<th>frequently</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>always</td>
</tr>
</tbody>
</table>

occasionally
35. Do you generally obtain advice on hog marketing from:

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(a) farm management advisors?</td>
</tr>
<tr>
<td></td>
<td>(b) hog buyers?</td>
</tr>
<tr>
<td></td>
<td>(c) commission agents or auction operators?</td>
</tr>
<tr>
<td></td>
<td>(d) feed salesmen?</td>
</tr>
</tbody>
</table>

[If advice obtained from at least one source in Q. 35, ASK:]

36. Would you say you follow the advice obtained:

<table>
<thead>
<tr>
<th>seldom</th>
<th>frequently</th>
</tr>
</thead>
<tbody>
<tr>
<td>occasionally</td>
<td>always</td>
</tr>
</tbody>
</table>

37. When you think your hogs are "ready to market," do you consider feeding them longer if you are not offered what you consider to be a minimum acceptable price?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

38. How important is each of the following factors in determining the lowest price you will accept? These are listed on your Card No. 12 (blue). Indicate importance by giving a number from 1 to 99 for each factor.

<table>
<thead>
<tr>
<th>FACTOR (re deciding lowest price acceptable)</th>
<th>DEGREE OF IMPORTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Price received by neighbors</td>
<td></td>
</tr>
<tr>
<td>(b) Prices received the last time you sold hogs</td>
<td></td>
</tr>
<tr>
<td>(c) Costs of producing butcher hogs</td>
<td></td>
</tr>
<tr>
<td>(d) Bids or price quotations by potential buyers</td>
<td></td>
</tr>
<tr>
<td>(e) Prices quoted over radio, television, or in newspaper</td>
<td></td>
</tr>
<tr>
<td>(f) Prices quoted in market newsletter</td>
<td></td>
</tr>
</tbody>
</table>
Now, we would like to talk about your selling practices.

39. During 1971, what percent of your butcher hogs was sold:
   (a) on a live basis at a single price for the entire lot? ___ %
   (b) on a live basis, generally at a single price but with a few poor hogs sorted out and sold at a lower price? ___ %
   (c) on a live basis but sorted out by grade and priced accordingly? ___ %
   (d) on the basis of carcass grade and yield? ___ %

Total 100%

SECTION VII. PRICES AND PRODUCTION COSTS FOR VARIOUS WEIGHTS AND GRADES

40. You have indicated that in 1971 you sold the largest percent of your butcher hogs at . Suppose that one day last week, the average price for 220-240 pound, U.S. No. 1 to 3 barrows and gilts was $20 per hundred weight at this market. What would you have expected to receive that day at that market for: (Read carcass weight only if R answered 39d with 100%; otherwise read live weight.) [Card No. 13 (white)]

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) U.S. No. 1 hogs</td>
<td>XXX</td>
<td>XXX</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) U.S. No. 2 hogs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) U.S. No. 3 hogs</td>
<td>XXX</td>
<td>XXX</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

41. Now, we would like to ask you about the relative costs of producing hogs of different grades. Suppose it cost you $16 per hundred weight to produce No. 2 hogs, weighing 220-240 lb. (This $16 cost includes all cost items: feed, labor, capital, building, equipment, breeding stock.) How much would it cost you per hundred weight to produce: [Card No. 13 again]
### Grade Carcass Wt. 130-144 lb. 144-160 lb. 160-174 lb. 174-197 lb.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) U.S. No. 1 hogs</td>
<td>XXX</td>
<td>XXX</td>
<td>XXX</td>
<td></td>
</tr>
<tr>
<td>(b) U.S. No. 2 hogs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) U.S. No. 3 hogs</td>
<td>XXX</td>
<td>XXX</td>
<td></td>
<td>XXX</td>
</tr>
</tbody>
</table>

41. Now, we would like to ask you about the relative costs of producing hogs of different grades. Suppose it cost you $16 per hundred weight to produce No. 2 hogs, weighing 220-240 lb. (This $16 cost includes all cost items: feed, labor, capital, building, equipment, breeding stock.) How much would it cost you per hundred weight to produce:  
(a) No. 1, 220-240 lb. hogs? 
(b) No. 2, 220-240 lb. hogs? $16/cwt. 
(c) No. 3, 220-240 lb. hogs? 

42. Next, we would like to look at the relative cost of producing hogs of different weights. Again suppose that it cost you $16 per hundred weight to produce No. 2, 220-240 lb. hogs. (This $16 again includes all cost items.) How much would it cost you per hundred weight to produce:  
(a) No. 2, 180-200 lb. hogs? 
(b) No. 2, 200-220 lb. hogs? 
(c) No. 2, 220-240 lb. hogs? $16/cwt 
(d) No. 2, 240-270 lb. hogs? 

### SECTION VIII. PREFERRED MARKET OUTLETS FOR VARIOUS WEIGHT AND GRADES

43. Assume you are marketing hogs that are uniform in weight and grade. Do you think you would receive more money by selling liveweight or selling by carcass grade and yield for each of these weights and grades. (Read carcass weight if R answered 39d with 100%; otherwise read live weight.)  
[Card No. 14 (orange)]

Code: L = liveweight; C = carcass

<table>
<thead>
<tr>
<th>Grade</th>
<th>Carcass wt. 130-144 lb.</th>
<th>144-160 lb.</th>
<th>160-174 lb.</th>
<th>174-197 lb.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) U.S. No. 1 hogs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) U.S. No. 2 hogs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) U.S. No. 3 hogs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
14. Assume you are marketing hogs of mixed grades. Do you think you would receive more money by selling liveweight or selling by carcass grade and yield for a mixed lot of these weight ranges? (Read carcass weight if R answered 39d with 100%; otherwise read liveweight.) [Card No. 14 again]

Code: L = liveweight
      C = carcass

<table>
<thead>
<tr>
<th>Grade</th>
<th>Carcass wt. 140-144 lb.</th>
<th>144-160 lb.</th>
<th>160-174 lb.</th>
<th>174-197 lb.</th>
</tr>
</thead>
</table>

(a) Mixed 1 & 2 grade hogs
(b) Mixed 2 & 3 grade hogs

SECTION IX. IMPRESSIONS REGARDING SEASONAL PRICE PATTERNS

Some farmers think there are certain months during the year when hog prices will be low and other months when they will be high.

45. Do you agree that there are certain months when the price of butcher hogs is usually higher?

   [ ] Yes
   [ ] No —>(Go to A)

(a) Which months? (Indicate by H)

   _____ Mar.  _____ July  _____ Nov.

A. Do you believe that there are certain months when the price of butcher hogs is usually lower?
45. Do you agree that there are certain months when the price of butcher hogs is usually higher?

   ___ Yes
   ___ No —> (Go to A)

(a) Which months? (Indicate by H)

   __ Jan.   __ May   __ Sept.
   __ Feb.   __ June  __ Oct.
   __ Mar.   __ July  __ Nov.
   __ Apr.   __ Aug.  __ Dec.

A. Do you believe that there are certain months when the price of butcher hogs is usually lower?

   ___ Yes
   ___ No —> (Go to Q. 46)

(a) Which months? (Indicate by L in table above)

SECTION X. LIVE HOG FUTURES MARKETS

46. Have you ever bought or sold live hog futures contracts?

   ___ Yes
   ___ No —> (Go to Q. 47)

A. Do you presently own any futures contracts? ___ Yes ___ No

47. What is your opinion regarding the amount of useful information that the live hog futures markets gives you regarding butcher hog prices in the coming months? Would you say it gives you:

   ___ (a) no useful information?
   ___ (b) some useful information?
   ___ (c) a great deal of useful information?
   ___ (d) [I have no opinion.]
SECTION XI. VALUE OF ADDITIONAL TIME SPENT ON HOG MARKETING

48. Suppose you spent an average of one hour per week (52 hours per year) more than you now spend in collecting and studying market information and in making decisions on when, where, and how to market your hogs. Do you think this would enable you to get a better price, on the average, for your butcher hogs?

   ___ Yes
   ___ No  ➝ (Go to Q. 51)

A. How large a price increase do you think you might be able to get if you spent this additional time?

   $_______ /cwt.

49. How large an increase in your gross income from hogs would you need to compensate you for spending an additional 52 hours per year making hog marketing decisions and marketing butcher hogs?

   $_______ /year

50. Let's suppose you did spend an average of one more hour per week making hog marketing decisions and marketing butcher hogs. Would you turn to Card 15 (green) and tell me if you think you would spend (1) no additional time, (2) some additional time, or (3) much additional time: [Read statements a through n]

<table>
<thead>
<tr>
<th>Activities related to hog marketing</th>
<th>No add. time</th>
<th>Some add. time</th>
<th>Much add. time</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Comparing price bids or quotations from several dealers?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) Checking with neighbors on prices they have recently received?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) Checking with (dealers) buyers or commission agents on whether it is a good time to market my hogs?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d) Studying forecasts and outlook information</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activities related to hog marketing</td>
<td>No add. time</td>
<td>Some add. time</td>
<td>Much add. time</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------------------------------</td>
<td>--------------</td>
<td>----------------</td>
<td>----------------</td>
</tr>
<tr>
<td>(a) Comparing price bids or quotations from several dealers?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) Checking with neighbors on prices they have recently received?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) Checking with (dealers) buyers or commission agents on whether it is a good time to market my hogs?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d) Studying forecasts and outlook information about current and future market conditions from radio, TV, newspapers, magazines or newsletters?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(e) Sorting hogs into lots of uniform weight and quality?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(f) Hauling hogs to market myself?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(g) Selling hogs in more distant markets?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(h) Selling hogs by grade and yield?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) Obtaining more information on price differentials for different weights and grades?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(j) Keeping track of live hog futures market?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(k) Investigating selling hogs through other market outlets that I do not now use?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(l) Investigating selling hogs on contracts?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(m) Keeping or analyzing records of swine operation?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(n) Any other? (specify)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
We would like now to talk about the buildings and facilities that you used for swine production during 1971. For purposes of classification, we have set up 5 general categories into which buildings can be placed. The definitions, which I will read through quickly, are given on this card.

Total-confinement buildings would be buildings enclosed on all four sides. While housed in these buildings, swine would usually be totally confined except possibly being let out for brief intervals. Such buildings might be used for farrowing, as a nursery, for finishing, or for the breeding herd. They should have been built or remodeled specifically for swine.

Partial-confinement buildings would be buildings having open fronts allowing swine access to a relatively small lot. They would be large enough to accommodate several sows and/or litters and might be used for any part of the swine operation. They should have been built or remodeled specifically for swine.

Unimproved facilities would generally be older buildings such as old barns, chicken houses, dwellings, etc., not built or remodeled specifically for swine but now being used for swine. Normally the swine would run loose in an open lot and use the building for protection and sleep.

Small houses at permanent central locations would usually accommodate only one or two sows and be used for farrowing, although other uses would be possible. They could be placed on concrete or the open ground. Usually a small open lot or pen would be adjacent.

Portable houses would normally be used in the pasture for a sow or for growing pigs. They might be moved to a central location for part of the year for farrowing or for other purposes.

51.A. Now, during 1971 did you use any building(s) that could be classified as total confinement building(s)?

_____ Yes How many? _____ (Enter each building on a separate line in the table, Q. 52)

_____ No

B. Did you use any partial-confinement buildings?

Yes How many? (Enter each building on a separate
Portable houses would normally be used in the pasture for a sow or for growing pigs. They might be moved to a central location for part of the year for farrowing or for other purposes.

51.A. Now, during 1971 did you use any building(s) that could be classified as total confinement building(s)?

____ Yes  How many? ____ (Enter each building on a separate line in the table, Q. 52)

____ No

B. Did you use any partial-confinement buildings?

____ Yes  How many? ____ (Enter each building on a separate line in the table, Q. 52)

____ No

C. Did you use any unimproved facilities for your swine?

____ Yes  How many? ____ (Enter each building on a separate line in the table, Q. 52)

____ No

D. Did you use any small houses at a permanent central location?

____ Yes

____ No —— (Go to E)

(a) How many were one-sow type?
(b) How many were two-sow type?
(c) How many were designed for more than two sows? ______

[Complete a separate line in the table, Q. 52, for each type.]

E. Did you use any portable housing?

____ Yes

____ No —— (Go to F)

(a) How many were one-sow type?
(b) How many were two-sow type?
(c) How many were designed for more than two sows? ______

[Complete a separate line in the table, Q. 52, for each type.]

F. During 1971, did you use any other type of housing for your swine?

____ Yes  (Enter description of each one named and complete a line in table, Q. 52, for each)

____ No
52. Now that all of the buildings are listed, let's start with (first entry) building. For some descriptive terms we will refer to the categories listed on Card No. 17 (pink).

Looking at list (a) on that card -

(a) What use(s) is (are) made of this building? (If more than one, circle the primary use)

1 - gestation 4 - growing, finishing
2 - farrowing 5 - Other ________________
3 - pig nursery

(b) What is the capacity of this building when it is being used for (primary use from a)? (number and kind)

S - Sows
P - Pigs
H - Hogs being fed for slaughter
O - Other ________________

(c) What would you estimate to be the dimension of this building?

(d) In what year was this building originally constructed?

(e) Has this building been remodeled for its present use? If Yes, in what year?

(f) [If the building was used for farrowing, ASK:] How many farrowing stalls or crates are available in this facility?

(g) How many pens (in addition to the stalls or crates) are in this facility?

[NOTE: For Cols. h through m, enter code number only]

(h) Referring to list (h) on your pink card: - What type of floor material does this building have?

1 - dirt 4 - steel
2 - wood 5 - Other ________________ (specify)
3 - concrete
(i) Is this floor slatted? (Do not record "Yes" or "No" answer)
   1 - No, floor is not slatted
   If YES, ASK: Is it partially slatted or completely slatted?
   2 - partial
   3 - complete

(j) Referring to list (j) on the pink card, what cooling system, if any, do you have in this facility?
   1 - natural air draft (none)
   2 - fan-forced air
   3 - water spray
   4 - refrigerated air
   5 - Other (specify)

(k) Now referring to list (k) on the pink card, what type of heating system, if any, do you have in this facility?
   1 - no heating system
   2 - heat lamps
   3 - space heater (floor or hanging)
   4 - furnace
   5 - electric floor heating
   6 - hot water floor heating
   7 - other (specify)

(l) Looking at list "l" on the pink card, what kind of bedding, if any, do you use in this building?
   1 - none used
   2 - straw
   3 - cobs
   4 - shavings
   5 - corn stalks
   6 - other (specify)

(m) Referring to list (m) on your pink card, what method(s) do you use for the disposal of manure in this facility?
   1 - pasture situation
   2 - liquids drain away naturally, solids are hauled away periodically
   3 - regularly cleaned by hand (could be hauled away by tractor)
   4 - regularly cleaned by tractor or other powered equipment
   5 - holding pit
   6 - aerobic lagoon
   7 - anaerobic lagoon
   8 - oxidation ditch
   9 - other (specify)
<table>
<thead>
<tr>
<th>Type of housing facility</th>
<th>(a) Bldg. No.</th>
<th>(b) Use</th>
<th>(c) Capacity</th>
<th>(d) Dimensions</th>
<th>(e) Year of orig. const.</th>
<th>(f) Year of remod.</th>
<th>(g) No. of stalls or crates</th>
<th>(h) No. of crates</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. A. Total confinement</td>
<td></td>
<td></td>
<td>X</td>
<td>19</td>
<td>19</td>
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<tr>
<td>B. Partial confinement</td>
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<td>X</td>
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<td></td>
<td></td>
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<tr>
<td>C. Unimproved facilities</td>
<td></td>
<td></td>
<td>X</td>
<td>19</td>
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<td>D. Small perm. houses</td>
<td></td>
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<td>X</td>
<td>19</td>
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<tr>
<td>1) one-sow type</td>
<td>XXXX</td>
<td>XXXXX</td>
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<td>19</td>
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<td>XXXX</td>
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<td>XXXX</td>
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<tr>
<td>2) two-sow type</td>
<td>XXXX</td>
<td>XXXXX</td>
<td>X</td>
<td>19</td>
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<tr>
<td>3) other</td>
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<td>E. Portable housing for pasture</td>
<td></td>
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<td>X</td>
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<tr>
<td>1) one-sow</td>
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<tr>
<td>2) two-sow</td>
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<td>3) other</td>
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<td>F. Other</td>
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<td>X</td>
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<tr>
<td>(e) Year of remod.</td>
<td>(f) No. of stalls or crates</td>
<td>(g) No. of pens</td>
<td>(h) Type of floor</td>
<td>(i) Is floor slatted?</td>
<td>(j) Cooling system</td>
<td>(k) Heating system</td>
<td>(l) Bedding</td>
<td>(m) Manure disposal</td>
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<td>xxxxxxxxx</td>
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</tbody>
</table>

*Note: The table continues with similar entries.*
53. How much exterior concrete space do you have adjacent to these swine buildings and facilities?

______ x ______

______ Total sq. ft. or ______ x ______

______ x ______

54. Do you use any of the following facilities:

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) Sorting pens for grouping hogs by weight or grade for sale?</td>
<td></td>
</tr>
<tr>
<td>(b) Livestock scale?</td>
<td></td>
</tr>
<tr>
<td>(c) Holding chute for ringing and marking breeding stock and hogs?</td>
<td></td>
</tr>
<tr>
<td>(d) Fixed loading chute?</td>
<td></td>
</tr>
<tr>
<td>(e) Portable loading chute?</td>
<td></td>
</tr>
</tbody>
</table>

SECTION XIII. ANIMAL HEALTH

Now we would like to talk about swine health problems that you may have encountered in 1971 and the preventive practices you use.

55. Do you purchase SPF (specific pathogen free) breeding stock as a disease preventive practice?

______ Yes

______ No—>(Go to Q. 56)

A. Are all breeding stock purchased SPF?

______ Yes  ______ No

56. During 1971, did you worm any of your swine?
Now we would like to talk about swine health problems that you may have encountered in 1971 and the preventive practices you use.

55. Do you purchase SPF (specific pathogen free) breeding stock as a disease preventive practice?

   ____ Yes
   ____ No → (Go to Q. 56)

A. Are all breeding stock purchased SPF?
   ____ Yes  ____ No

56. During 1971, did you worm any of your swine?

   ____ Yes
   ____ No → (Go to Q. 57)

A. How many sows were wormed one or more times? _____ sows
B. How many hogs that you marketed were wormed one or more times? _____ market hogs

57. During 1971, did you treat for mange or lice?

   ____ Yes
   ____ No → (Go to Q. 58)

A. How many sows were treated for mange or lice one or more times? _____ sows
B. How many hogs that you marketed were treated for mange or lice one or more times? _____ market hogs

S. During 1971, how many times did you...

   (a) have a veterinarian come to your farm to treat your swine? _____
   (b) take your swine to a veterinarian for examination? (including posting) _____
Now if you will turn to Card No. 18 (yellow). This is a list of diseases sometimes occurring in swine.

59. As I go over this list with you, please indicate if your swine had any serious or unusual difficulty with any of these diseases in 1971. [Read diseases and check (X) any YES responses in Col. a]

A. Which disease gave you the: most difficulty? (Enter a "1" in Col. b)
   second most difficulty? (Enter a "2" in Col. b)
   third most difficulty? (Enter a "3" in Col. b)

<table>
<thead>
<tr>
<th>Disease</th>
<th>(a) Occurrence difficulty</th>
<th>(b) Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) TGE (transmissible gastro-enteritis)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) Baby pig scours</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) Leptospiroses</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d) Erysipelas</td>
<td></td>
<td></td>
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<tr>
<td>(e) Brucellos</td>
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<td></td>
</tr>
<tr>
<td>(f) Atrophic Rhinitis</td>
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<td></td>
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<tr>
<td>(g) Pneumonia</td>
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<td></td>
</tr>
<tr>
<td>(h) PPLO (arthritis)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) Mastitis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(j) Swine dysentary (bloody)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(k) SMEDI (embrionic death)</td>
<td></td>
<td></td>
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<tr>
<td>(l) Other</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

60. Did you give shots, feed iron to, or otherwise treat your baby pigs to prevent anemia?
   ____ Yes  ____ No

SECTION XIV. FEEDING PRACTICES
60. Did you give shots, feed iron to, or otherwise treat your baby pigs to prevent anemia? 
   
   Yes  No

SECTION XIV. FEEDING PRACTICES

Now we would like some information about your swine feeding practices.

61.A. Did you feed (insert ration) (insert animal) last year?

[Write "Yes" or "No" as appropriate for each box]

<table>
<thead>
<tr>
<th>Ration</th>
<th>Gestating (a)</th>
<th>Nursing (b)</th>
<th>Suckling (c)</th>
<th>Growing (d)</th>
<th>Finishing (e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) A complete ration that was prepared by a commercial business?</td>
<td></td>
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<tr>
<td>(b) A ration of corn to which a supplement containing protein and premixes have been added?</td>
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<tr>
<td>or</td>
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<tr>
<td>(c) Some other (specify)</td>
<td></td>
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</tbody>
</table>

B. Does the ration include a vitamin supplement? 
C. Does the ration include trace minerals? 
D. Does the ration include antibiotics?
62. Now concerning the methods used in feeding your swine:
[Record "Yes" or "No" as appropriate for each category]

<table>
<thead>
<tr>
<th></th>
<th>Sows</th>
<th></th>
<th>Pigs</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Gestating</td>
<td>Nursing</td>
<td>Suckling</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(a)</td>
<td>(b)</td>
<td>(c)</td>
</tr>
<tr>
<td>A.</td>
<td>Did you use a system of conveyers or augers to feed your (insert animal)?</td>
<td></td>
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<tr>
<td>B.</td>
<td>Did you use an auger wagon or grinder mixer to feed your?</td>
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<tr>
<td>C.</td>
<td>Was the amount of feed you fed your limited?</td>
<td></td>
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<tr>
<td>D.</td>
<td>Was the feed fed to wet?</td>
<td></td>
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</tr>
</tbody>
</table>

63. Do you process any of your own feed?  
   | Yes | No  
   | --- | --- |
   | A. Was the feed mill custom operated?  
   | --- | --- |
   | or farmer operated?  
   | --- | --- |
   | B. Was the feed mill stationary?  
   | --- | --- |
   | or portable?  
   | --- | --- |

64. In 1971, did you buy any corn to feed your swine?  
   | Yes | No  
   | --- | --- |
   | A. What percent of the total corn fed did you purchase?  
   | --- | --- |
or farmer operated? ______

B. Was the feed mill stationary? ______
or portable? ______

64. In 1971, did you buy any corn to feed your swine? ______ Yes
______ No→(Go to Q. 65)

A. What percent of the total corn fed did you purchase? ______ %

SECTION XV. CONTRACTING

65. Did you sell butcher hogs on contract during 1971? ______ Yes
______ No→(Go to B)

A. What percentage of the butcher hogs you marketed in 1971 were sold on contract to a packer(s)?

(a) What is the name of the packer(s)?

______ % Name of packer(s) ________________________________

(b) Did you sell to any other buyer on contract, and if so, what percent?

______ % Name of "other buyer(s)?" ________________________________

B. During 1971, did anyone offer to buy some or all of your butcher hogs on contract?

______ Yes
______ No→(Go to Q. 66)

(a) What are the names of those making offers?

Packers ________________________________

Others (specify) ________________________________
Now we would like to talk about the labor used on your farm.

66. During 1971, did you do any work off the farm other than exchange work with neighbors?  
   __ Yes  __ No  => (Go to C)

A. For how many weeks in 1971 were you employed full-time off the farm? ____ weeks
   (a) During the time you were working full-time off the farm, how many hours per day on the average did you spend doing farm work on this place? ________
   [If answer to A is 52 weeks, go to Q. 67]

B. For how many weeks in 1971 were you employed part-time off the farm, including doing custom work for others? ____ weeks
   (a) During the time you were working part-time off the farm, how many hours per day on the average did you spend doing farm work on this place? ________
   [If answers to A and B total 52 weeks, go to Q. 67]

C. (During the time you were not working off the farm) During 1971 how many hours per day on the average did you spend doing farm work on this place? ________

67. (a) During 1971, who besides yourself did any farm work on this place? Include members of your family, partners, and both full-time and part-time hired labor, if any. [Enter names and/or "titles" (such as wife, son, hired hand) in Col. (a) of table]
   [For each person listed, ASK:]
   (b) For how many days in 1971 did ____ do farm work on this place?
   (c) For these ____ days, how many hours per day on the average did ____ spend doing farm tasks?
   (d) Was any of the work ____ did connected with your swine operation?

<table>
<thead>
<tr>
<th>(a) Name and/or &quot;title&quot;</th>
<th>(b) No. days worked on place</th>
<th>(c) Hrs./day</th>
<th>(d) Work with swine?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td>Yes            No</td>
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</tbody>
</table>
[For each person listed, ASK:]

(b) For how many days in 1971 did ____ do farm work on this place?

(c) For these ____ days, how many hours per day on the average did ____ spend doing farm tasks?

(d) Was any of the work ____ did connected with your swine operation?

<table>
<thead>
<tr>
<th>(a) Name and/or &quot;title&quot;</th>
<th>(b) No. days worked on place</th>
<th>(c) Hrs./day</th>
<th>(d) Work with swine?</th>
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</thead>
<tbody>
<tr>
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<td>Yes</td>
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</table>

68. (a) Now, thinking of all the time put in by all those who worked with the swine, including yourself, about how many hours per day would you say were spent during January, 1971, doing regular chores connected with your swine operation? (By regular chores I mean feeding, watering, cleaning, etc.)

(b) How many hours per day were spent in February, 1971? March? etc.

(c) As you know, in addition to these regular swine-related chores, other things come up from time to time that have to be taken care of - for example, vaccinating pigs, moving pigs, marketing, repairing swine facilities, etc. Approximately how many hours would you say were spent altogether by all of you doing these sorts of tasks during January, 1971? February, 1971? etc.

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<th>F</th>
<th>M</th>
<th>A</th>
<th>M</th>
<th>Ju</th>
<th>Jy</th>
<th>A</th>
<th>S</th>
<th>O</th>
<th>N</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>hrs./day, reg. chores</td>
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<tr>
<td>hrs./month, spec. tasks</td>
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</table>

(d) Was any other labor used in your swine operation that has not yet been accounted for?

____ No  ____ Yes —> What was the nature of this labor and how much time did it take during 1971?
69. Assuming your other farming operations remained the same, could you increase your swine operation over what it was in 1971 without adding any new facilities or hiring any more labor?

   Yes
   No—→(Go to Q. 70)

A. In 1971 you farrowed _______ litters, what is the maximum number of litters you could farrow per year using your present facilities and without hiring any more labor? _______ litters

B. In 1971 you marketed _______ butcher hogs, what is the maximum number of slaughter hogs you could market per year using your present facilities and without hiring any more labor? _______ market hogs

70. Do you plan to build or purchase any new swine housing facilities in the next three years?

   Yes [Please refer to Card No. 16 (buff) again]
   No—→(Go to Q. 71)

   (a) What type(s) of facilities do you plan to add? [Enter the code letter for each facility on a separate line.]

   (b) Will the primary use of _______ be mainly for sows and gilts (boars), for farrowing, as a nursery, or as a growing and finishing facility?

   [Check appropriate column.]

<table>
<thead>
<tr>
<th>(a)</th>
<th>Primary use of facility</th>
<th>(b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of facility</td>
<td>Sows &amp; gilts</td>
<td>Farrowing</td>
</tr>
<tr>
<td>A. Total confinement bldg.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. Partial confinement bldg.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. Small houses set at a permanent location</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
(b) Will the primary use of (each facility) be mainly for sows and gilts (boars), for farrowing, as a nursery, or as a growing and finishing facility? [Check appropriate column.]

<table>
<thead>
<tr>
<th>Type of facility</th>
<th>Primary use of facility</th>
<th>Growing - finishing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sows &amp; Gilts</td>
<td>Farrowing</td>
<td>Nursery</td>
</tr>
</tbody>
</table>

---

71. Do you plan to remodel any of your present building facilities within the next three years?

- Yes [Please refer to Card No. 16 (buff) again]
- No—> (Go to Q. 72)

(a) (1) What type of facility is it now? [Record the code letter for each facility on a separate line.]

(b) What will be the primary use of this facility after the remodeling is completed? Will it be used mainly for sows and gilts, for farrowing, as a nursery, or as a growing and finishing facility?

<table>
<thead>
<tr>
<th>Type of facility</th>
<th>Primary use after remodeling</th>
<th>Growing - finishing</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Now</td>
<td>(2) After Gestation</td>
<td>Farrowing</td>
</tr>
</tbody>
</table>

---

CODE FOR (a)

A. Total confinement bldg.
B. Partial confinement bldg.
C. Unimproved building
D. Small permanent bldg.
E. Portable houses
F. Other (specify)
72. Assuming all these changes are made, do you plan to change the number of swine you will produce? 
   ______ Yes 
   _____ No —> (Go to Q. 73)

A. How many litters do you expect to farrow per year? ___________
B. How many feeder pigs do you expect to purchase per year? ___________
C. How many feeder pigs do you expect to sell as feeder pigs per year? ___________
D. How many slaughter hogs do you expect to sell per year? ___________

73. Do you plan to make any changes in your manure disposal system within the next three years? 
   _____ Yes 
   _____ No —> (Go to Q. 74)

A. Do you plan to ________? (read changes a through f) 

   Next 3 yrs. 
   Yes | No

(a) add slatted floor to:
   gestation house? _______ _______
   farrowing house? _______ _______
   nursery house? _______ _______
   growing-finishing house? _______ _______
   other ____________ _______ _______

(b) add holding pit? _______ _______
(c) add aerobic lagoon? _______ _______
(d) add anaerobic lagoon? _______ _______
(e) add oxidation ditch _______ _______
(f) other _______ _______
Next 3 yrs.  
<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

(a) add slatted floor to:  
- gestation house?  
- farrowing house?  
- nursery house?  
- growing-finishing house?  
- other  
(f) other  
(specify)

(b) add holding pit?  
(c) add aerobic lagoon?  
(d) add anaerobic lagoon?  
(e) add oxidation ditch  
(f) other  
(specify)

74. Do you plan to make any change(s) in your feeding system within the next three years?  
Yes  
No → (Go to Q. 75)

A. Do you plan to  
(read changes a through e)?  
Next 3 yrs.  
<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

(a) go to a complete commercial ration?  
(b) start mixing own feed?  
(c) add automatic feed system?  
(d) add grinder-mixer unit?  
(e) other  
(specify)
75. Do you plan to make any changes in your breeding or farrowing practices within the next three years?
   ___ Yes
   ___ No → (Go to Q. 76)

A. Do you plan to __________________________?
   (read changes a thru g)

   (a) farrow earlier in the spring?  ___ ___
   (b) farrow later in the fall?  ___ ___
   (c) *increase the No. of farrowings per year?  ___ ___
   (d) decrease the No. of farrowings per year?  ___ ___
   (e) start cross breeding?  ___ ___
   (f) purchase SPF breeding stock?  ___ ___
   (g) other (specify)  ___ ___

   [*If R plans to increase the number of farrowings, (c above) ASK:]

B. How many farrowing periods per year do you now have?  ___

C. How many farrowing periods will you have after you make these changes?  ___

SECTION XVIII. ADDITIONAL INFORMATION ABOUT FARM AND FARM OPERATOR

Now could we have a little information about you, please.

76.A. In what year were you born?  ___

   B. What is the highest grade of school that you completed?  ___
[*If R plans to increase the number of farrowings, (c above) ASK:]

B. How many farrowing periods per year do you now have?

C. How many farrowing periods will you have after you make these changes?

SECTION XVIII. ADDITIONAL INFORMATION ABOUT FARM AND FARM OPERATOR

Now could we have a little information about you, please.

76. A. In what year were you born?

B. What is the highest grade of school that you completed?

C. How many years have you farmed since your 18th birthday?

D. During how many of these years, have you produced hogs?

77. In order to get an idea of the extent of your hog enterprise compared with the rest of your farming operation:

A. Would you look at Card No. 19 (blue) and tell me which letter represents your gross farm sales for the year 1971?

B. Approximately what percent of your gross farm sales in 1971 was from your hog enterprise?

A. Less than $10,000  G. $40,000 - $49,999
B. $10,000 - $14,999  H. $50,000 - $59,999
C. $15,000 - $19,999  I. $60,000 - $69,999
D. $20,000 - $24,999  J. $70,000 - $79,999
E. $25,000 - $29,999  K. $80,000 - $99,999
F. $30,000 - $39,999  L. $100,000 and over
78. At any time during 1971, did you have any dairy cattle on these acres?  

   ___ Yes  
   ___ No →(Go to B)

   (a) How many cows were in your milking herd on December 31, 1971?  
   ___

B. At any time during 1971, did you have any beef cattle on these acres?  

   ___ Yes  
   ___ No →(Go to C)

   (a) How many beef cows 2 years old or older did you have on hand on December 31, 1971?  
   ___

   (b) How many feeder cattle did you purchase during 1971?  
   ___

   (c) How many cattle did you sell as feeders during 1971?  
   ___

   (d) How many cattle did you sell as slaughter steers and heifers during 1971?  
   ___

C. At any time during 1971, did you have any sheep?  

   ___ Yes  
   ___ No →(Conclude interview)

   (a) How many ewes did you have on hand on December 31, 1971?  
   ___

   (b) How many feeder sheep did you purchase during 1971?  
   ___

   (c) How many sheep did you sell as feeders during 1971?  
   ___

   (d) How many sheep did you sell as slaughter lambs during 1971?  
   ___

Thank you very much for your time and cooperation.

Ending time ________
XII. APPENDIX C: SAMPLE DESIGN

The original sampling universe for the study of swine production and marketing consisted of all farm operators in the state of Iowa who were recorded in the 1970 state farm census as having sold some hogs in 1970. From this universe, a sample of operators was selected for interview, but at the time of interview, the operator was asked whether or not he had sold any butcher hogs in 1971. Interviews were completed only for those indicating they sold hogs in 1971. Thus, the ultimate universe consisted of those farm operators that were recorded in the 1970 state farm census as hog producers and sold butcher hogs in 1971.

One-third of the 99 counties in Iowa were selected in the sample with equal probability. The counties were ordered geographically and a systematic sampling scheme was used. For the 33 sample counties, the total number of operators reporting sales of hogs in 1970 was obtained broken down into 14 classes based on the number of hogs reported as sold. An estimate of the total number of hogs sold was obtained for each class by multiplying the midpoint of the class interval by the number of operators in the class. The 14 size classes were then consolidated into 7 size classes as follows:

<table>
<thead>
<tr>
<th>Class</th>
<th>Estimated number of hogs sold in 1970</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1-99</td>
</tr>
<tr>
<td>2</td>
<td>100-249</td>
</tr>
<tr>
<td>3</td>
<td>250-349</td>
</tr>
<tr>
<td>4</td>
<td>350-499</td>
</tr>
<tr>
<td>5</td>
<td>500-999</td>
</tr>
<tr>
<td>6</td>
<td>1000-2499</td>
</tr>
<tr>
<td>7</td>
<td>2500 and over</td>
</tr>
</tbody>
</table>

1 Dr. Harold Baker, Department of Statistics wrote the original description of the sample design.
About 500 interviews were desired. Since the interviewing was to take place approximately one year after the compilation of the list of operators, allowance was made for the fact that some operators would have died, moved away, gone out of business, etc. in the meantime. Allowance was also made for other anticipated nonresponse because of refusals, insufficient information to locate operators, inability to find operator at home and the like. Consequently, 600 names were drawn. Rather than sample at a uniform rate, the 600 names were allocated to the 7 size classes as follows:

(a) All 20 operators in class 7 in the sample counties were included in the sample.

(b) The remaining 580 were allocated to the remaining 6 classes in proportion to the estimated total numbers of hogs sold in 1970. This procedure would have resulted in a very small sample from class 1 (although large in terms of number of operators, class 1 was the smallest in terms of number of hogs sold) therefore the sample size in class 1 was doubled. The allocations to the other 5 classes were reduced accordingly to maintain the total allocation of 600.

To conserve field costs, each sample county was divided into 12, 16, or 20 subareas (corresponding roughly to townships). One-fourth of the subareas were selected in each county, again with equal probability and in a systematic manner. The selection of sample operators from classes 1 through 5 was then limited to these selected subareas. Because of the small number of operators in classes 6 and 7 the sample operators in classes 6 and 7 could be located anywhere within the sample counties.

Table C.1 summarizes the results of the sampling and the field work. In Figure C.1, the selected counties are identified by a number in the counties. The numbers indicate how many of the 489 interviews took place
Table C.1. Results of the sampling process by size category

<table>
<thead>
<tr>
<th>Size class</th>
<th>Total No. of operators (state farm census)</th>
<th>No. of names selected</th>
<th>No. eligible for interview</th>
<th>Number interviewed</th>
<th>Class weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>17,236</td>
<td>48</td>
<td>37</td>
<td>36</td>
<td>369.1</td>
</tr>
<tr>
<td>2</td>
<td>24,302</td>
<td>111</td>
<td>99</td>
<td>84</td>
<td>258.0</td>
</tr>
<tr>
<td>3</td>
<td>10,072</td>
<td>84</td>
<td>76</td>
<td>71</td>
<td>126.6</td>
</tr>
<tr>
<td>4</td>
<td>8,026</td>
<td>98</td>
<td>93</td>
<td>82</td>
<td>92.9</td>
</tr>
<tr>
<td>5</td>
<td>7,940</td>
<td>170</td>
<td>159</td>
<td>148</td>
<td>50.5</td>
</tr>
<tr>
<td>6</td>
<td>1,397</td>
<td>68</td>
<td>63</td>
<td>56</td>
<td>23.5</td>
</tr>
<tr>
<td>7</td>
<td>61</td>
<td>20</td>
<td>15</td>
<td>12</td>
<td>3.8</td>
</tr>
<tr>
<td>Total</td>
<td>69,034</td>
<td>599</td>
<td>542</td>
<td>489</td>
<td></td>
</tr>
</tbody>
</table>
Figure C.1. Location and number of producers interviewed in each of the 33 selected counties
in each county.

Since the sampling rates differed in each size class, estimates of overall totals and means required special weighting procedures. The weights were as given in the last column of Table C.1. The weighting procedure implicitly assumes that, with respect to the characteristics under investigation, those selected in the sample who were not interviewed did not differ as a group from those who were interviewed. The overall nonresponse rate was approximately 10 percent.
XIII. APPENDIX D: DETERMINANT EVALUATION

The determinant of $H$ is evaluated using Laplace expansion (21, 100). From Equation 5.23

$$
H = \begin{vmatrix}
0 & 0 & 0 & -1 & P_{111} - P_{112} & -P_{112} & -h_{11} \\
0 & 0 & 0 & 0 & -1 & \frac{\partial \Gamma_{111}}{\partial \sigma_{201}} & 0 \\
0 & 0 & 0 & 0 & 0 & 1 & \frac{\partial \psi_{11}}{\partial \sigma_{111}} \\
-1 & 0 & 0 & 0 & \frac{\partial^2 \phi}{\partial \mu \phi^2} & 0 & \frac{\partial^2 \phi}{\partial \mu \phi \sigma_{201}} & 0 \\
P_{11} - P_{112} & -1 & 0 & 0 & 0 & 0 & 0 \\
-P_{112} & \frac{\partial \Gamma_{111}}{\partial \sigma_{201}} & +1 & \frac{\partial^2 \phi}{\partial \mu \phi \sigma_{201}} & 0 & \frac{\partial^2 \phi}{\partial \mu \phi \sigma_{201}^2} & \frac{\partial^2 \Gamma_{111}}{\partial \sigma_{201}^2} & 0 \\
-h_{11} & 0 & \frac{\partial \psi_{11}}{\partial \sigma_{111}} & 0 & 0 & 0 & \lambda_1 \frac{\partial^2 \psi_{11}}{\partial \sigma_{111}^2} & 0 \\
\end{vmatrix}
$$

(D.1)

To avoid repeating complicated terms, letters are substituted for the nonzero or one elements. That is,
The Laplace expansion of \( D.2 \) is given by (dotted lines identify the row or column selected for expansion)
\[
\begin{align*}
\begin{bmatrix}
0 & -1 & a & b & c \\
0 & 0 & -1 & d & 0 \\
-1 & 0 & 0 & 0 & 0 & e \\
-1 & f & 0 & g & 0 \\
0 & 0 & 0 & 0 & j \\
\end{bmatrix} & +
\begin{bmatrix}
0 & -1 & a & b & c \\
0 & 0 & -1 & d & 0 \\
0 & 0 & 0 & 0 & 0 & e \\
-1 & f & 0 & g & 0 \\
0 & 0 & 0 & 0 & j \\
\end{bmatrix} +
\begin{bmatrix}
0 & -1 & a & b & c \\
0 & 0 & -1 & d & 0 \\
0 & 0 & 0 & 0 & 0 & e \\
0 & f & 0 & g & 0 \\
e & 0 & 0 & 0 & j \\
\end{bmatrix} =
\begin{bmatrix}
0 & -1 & a & b & c \\
0 & 0 & -1 & d & 0 \\
0 & 0 & 0 & 0 & 0 & e \\
0 & f & 0 & g & 0 \\
e & 0 & 0 & 0 & j \\
\end{bmatrix}
\end{align*}
\]

\[
\begin{align*}
\begin{bmatrix}
0 & -1 & a & b & c \\
0 & 0 & -1 & d & 0 \\
-1 & 0 & 0 & 0 & 0 & e \\
-1 & f & 0 & g & 0 \\
0 & 0 & 0 & 0 & j \\
\end{bmatrix} & -
\begin{bmatrix}
0 & -1 & a & b & c \\
0 & 0 & -1 & d & 0 \\
0 & 0 & 0 & 0 & 0 & e \\
-1 & f & 0 & g & 0 \\
0 & 0 & 0 & 0 & j \\
\end{bmatrix} +
\begin{bmatrix}
0 & -1 & a & b & c \\
0 & 0 & -1 & d & 0 \\
0 & 0 & 0 & 0 & 0 & e \\
0 & f & 0 & g & 0 \\
e & 0 & 0 & 0 & j \\
\end{bmatrix}
\end{align*}
\]

\[
\begin{align*}
\begin{bmatrix}
0 & -1 & a & b & c \\
0 & 0 & -1 & d & 0 \\
0 & 0 & 0 & 0 & 0 & e \\
-1 & f & 0 & g & 0 \\
0 & 0 & 0 & 0 & j \\
\end{bmatrix} & +
\begin{bmatrix}
0 & -1 & a & b & c \\
0 & 0 & -1 & d & 0 \\
0 & 0 & 0 & 0 & 0 & e \\
0 & f & 0 & g & 0 \\
0 & 0 & 0 & 0 & j \\
\end{bmatrix}
\end{align*}
\]

\[
\begin{align*}
\begin{bmatrix}
-1 & d & 0 \\
0 & 1 & e \\
0 & 0 & j \\
\end{bmatrix} & -
\begin{bmatrix}
-1 & d & 0 \\
0 & 1 & e \\
0 & 0 & j \\
\end{bmatrix} +
\begin{bmatrix}
a & b & c \\
e & -g & -1 & d & 0 \\
0 & i & 0 \\
0 & 1 & e \\
\end{bmatrix}
\end{align*}
\]

\[
\begin{align*}
\begin{bmatrix}
-1 & d & 0 \\
0 & 1 & e \\
0 & 0 & j \\
\end{bmatrix} & +
\begin{bmatrix}
(c+e & b-d & a & c & e \\
0 & 0 & 0 & 0 & 0 & e \\
0 & 0 & 0 & 0 & 0 & e \\
0 & 0 & 0 & 0 & 0 & e \\
\end{bmatrix}
\end{align*}
\]
\[-j - e^2 i - f(\alpha e - c + b) \alpha - 2e g(\alpha e - c + b) =
\]
\[-(\frac{\partial \phi}{\partial W_1})_{11} \left(\frac{\partial \gamma_{11}}{\partial q_{111}}\right) \left(\frac{\partial \psi_{11}}{\partial q_{111}}\right)^2 - (\frac{\partial \psi_{11}}{\partial q_{111}})^2 \left(\frac{\partial \alpha^2}{\partial c_{201}}\right) + (\frac{\partial \phi}{\partial W_1}) (\Gamma_{111} - \Gamma_{112}) \left(\frac{\partial \gamma_{111}}{\partial x_{11}}\right)\]

\[-(\frac{\partial \alpha}{\partial W_1}) \left(\frac{\partial \gamma_{111}}{\partial c_{201}}\right) (\Gamma_{111} \Gamma_{112} \frac{\partial \psi_{11}}{\partial q_{111}} + h_{11} \Gamma_{112} \frac{\partial \gamma_{111}}{\partial q_{111}}\right)\]

\[-2(\frac{\partial \psi_{11}}{\partial q_{111}}) \frac{\partial \phi}{\partial W_1} \left(\frac{\partial \gamma_{111}}{\partial c_{201}}\right) [(\Gamma_{111} - \Gamma_{112}) (\frac{\partial \psi_{11}}{\partial q_{111}})^2 + h_{11} \Gamma_{112} \frac{\partial \gamma_{111}}{\partial q_{111}}] \]

Note that the solutions (Equations 5.19, 5.20 and 5.20) for the Lagrangian multipliers have been appropriately substituted into the results.
XIV. APPENDIX E: DISCRIMINANT ANALYSIS PROOF

To show the equivalence of 6.25 and 6.29 a three group example will be presented. For the Rao procedure, three values of $I_m$ would be found for each observation.

$$I_1 = (\bar{Z}_k'S^{-1}Z_{ikm} - \frac{1}{2} Z_k'S^{-1}Z_k + \ln \pi_1)$$  \hspace{1cm} (E.1)

$$I_2 = (\bar{Z}_k'S^{-1}Z_{ikm} - \frac{1}{2} Z_k'S^{-1}Z_k + \ln \pi_2)$$  \hspace{1cm} (E.2)

$$I_3 = (\bar{Z}_k'S^{-1}Z_{ikm} - \frac{1}{2} Z_k'S^{-1}Z_k + \ln \pi_3)$$  \hspace{1cm} (E.3)

For the Hallberg and Anderson procedure $D_{12}$, $D_{13}$ and $D_{23}$ from 6.26 must be evaluated. Substituting 6.27 and 6.28 into 6.26 yields in the 3 groups case:

$$D_{12} = Z_{ikm}(S^{-1}Z_k) - Z_{ikm}(S^{-1}Z_k) - \frac{1}{2} [\bar{Z}_k'S^{-1}Z_k]$$

$$D_{12} = Z_{ikm}(S^{-1}Z_k) - Z_{ikm}(S^{-1}Z_k) - \frac{1}{2} [\bar{Z}_k'S^{-1}Z_k]$$

$$- Z_k'S^{-1}Z_k + Z_k'S^{-1}Z_k - Z_k'S^{-1}Z_k$$  \hspace{1cm} (E.4)

$$D_{13} = Z_{ikm}(S^{-1}Z_k) - Z_{ikm}(S^{-1}Z_k) - \frac{1}{2} [\bar{Z}_k'S^{-1}Z_k]$$

$$D_{13} = Z_{ikm}(S^{-1}Z_k) - Z_{ikm}(S^{-1}Z_k) - \frac{1}{2} [\bar{Z}_k'S^{-1}Z_k]$$

$$- Z_k'S^{-1}Z_k + Z_k'S^{-1}Z_k - Z_k'S^{-1}Z_k$$  \hspace{1cm} (E.5)

$^1 D_{21} = -D_{12}; D_{31} = -D_{13}$ and $D_{32} = -D_{23}$. 
The middle two terms in each set of brackets in Equations E.4, E.5 and E.6 cancel out. Also, only two of the three equations (E.4, E.5 and E.6) are independent. Each can be derived from the other two. For an observation to be classified in group one the following would have to be true according to 6.25:

\[ D_{12} \geq (\ln \pi_2 - \ln \pi_1) \]

and

\[ D_{13} \geq (\ln \pi_3 - \ln \pi_1). \]  \hspace{1cm} (E.7)

Using Rao's indices, an observation would be classified in group one if

\[ I_1 \geq I_2 \]

and

\[ I_1 \geq I_3 \]  \hspace{1cm} (E.8)

If \( I_1 \geq I_2 \), then \( I_1 - I_2 \) is nonnegative. Subtracting E.2 from E.1 yields.

\[
\begin{align*}
D_{23} &= Z_{ikm} \left( S^{-1}Z_{k2} \right) - Z_{ikm} \left( S^{-1}Z_{k3} \right) - \frac{1}{2} \left[ \tilde{Z}_{k2} S^{-1} \tilde{Z}_{k2} \right] \\
&\quad - \frac{1}{2} \left[ \tilde{Z}_{k3} S^{-1} \tilde{Z}_{k3} \right] \\
&= \frac{1}{2} \left[ \tilde{Z}_{k1} S^{-1} \tilde{Z}_{k1} \right] + \ln \pi_1 - \ln \pi_2 \geq 0 \hspace{1cm} (E.9)
\end{align*}
\]
Similarly, if $I_1 > I_3$, Equation E.10 is true:

$$\left( z_k's^{-1}\right)_{ikm} - \left( z_k's^{-1}\right)_{ikm}$$

$$- y_2\left[ z_k's^{-1}_l - z_k's^{-1}_k \right] + \ln \pi_1 - \ln \pi_3 \geq 0 \quad \text{(E.10)}$$

If $\ln \pi_1 - \ln \pi_2$ is subtracted from both sides of E.9 and $\ln \pi_1 - \ln \pi_3$ is subtracted from both sides of E.10, the right hand sides of E.9 and E.10 are the same as the right hand sides of E.7. The remaining left hand sides of E.9 and E.10 are equivalent to E.4 and E.5, the left hand sides of E.7. That is, E.7 and E.8 are equivalent and both criteria would classify the same producers in group one. Similarly, the criteria can be shown to classify the same producers in groups two and three.