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An analysis of producers' decisions to change slaughter-hog production levels

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by

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I. INTRODUCTION

The production of hogs historically has been an important enterprise on Iowa farms and likely will remain so in the future. Iowa has been the leading hog producing state in each of the last 45 years, and in recent years it has accounted for approximately 25 percent of the annual U.S. production.

Though Iowa hog production has trended upward since 1925, there have been significant year-to-year fluctuations in the number of slaughter-hogs sold. These fluctuations occur because of fluctuations in production levels. Fluctuations in production levels are illustrated in Figure 1.1. The annual Iowa pig crop from 1925 to 1970 is compared with a linear trend line to show the major year-to-year fluctuations that have occurred.

A. Problem

Information that would provide better explanations and predictions of fluctuations in hog production would be useful to producers, packers, retailers, and policy makers.

Year-to-year fluctuations in slaughter-hog marketings contribute to year-to-year changes in hog prices and thus profits from hog production. Information that would help a producer anticipate changes in levels of hog production would be useful in making management decisions.

Packers also need to know when there will be a need to either increase or decrease slaughter rates to plan employment and construction of plant facilities. Retailers need to know what the supply of pork will be

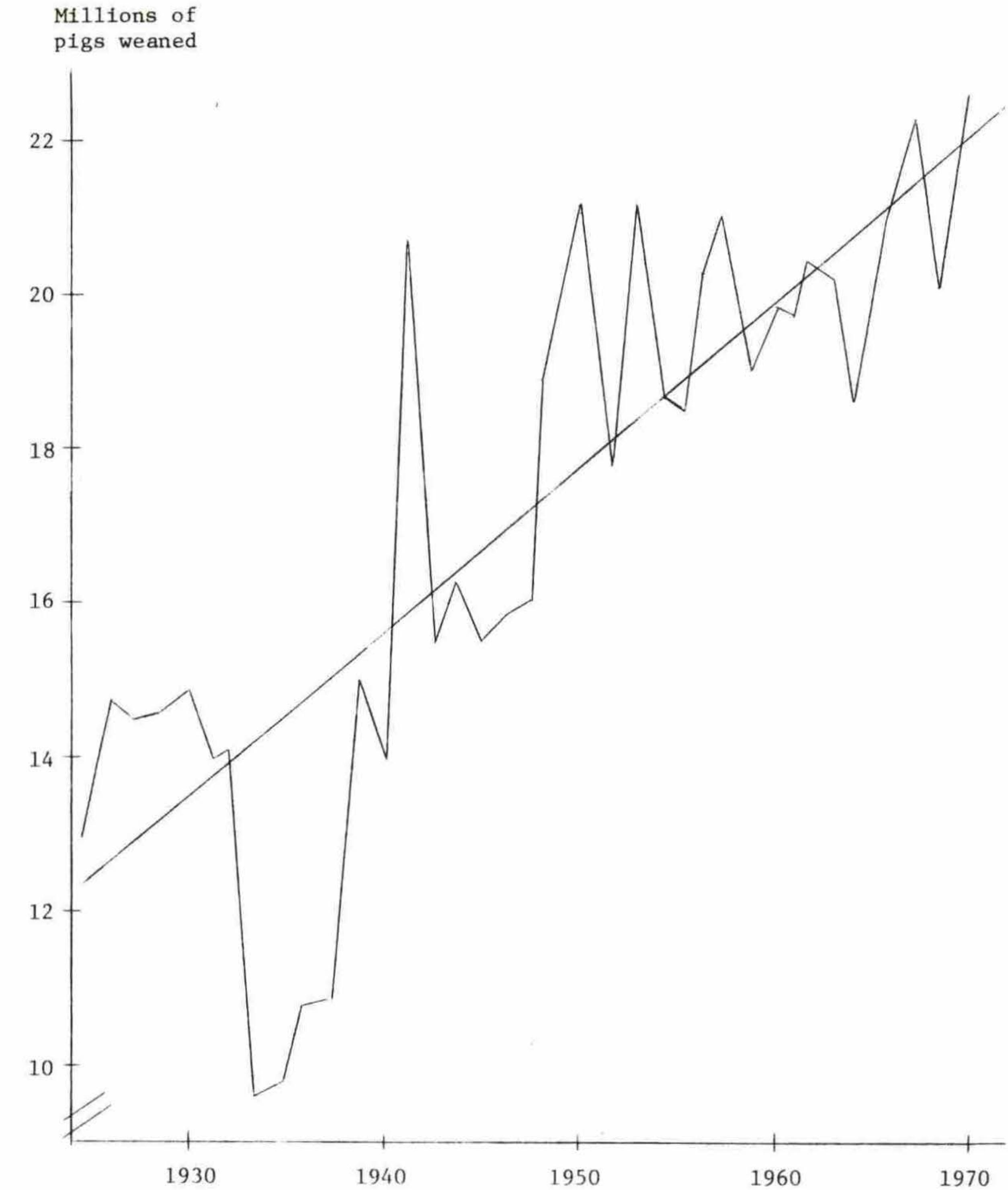

Figure 1.1. Annual pig crop for Iowa with a linear fitted trend line [17]

so that they can plan pricing policies and advertising programs.

Policy makers are concerned with the fluctuations in slaughter-hog production because the levels of hog production affect feed grain consumption and prices, employment in the packing industry, tax revenues, and investment in machinery and equipment.

Much of the previous research on this topic has focused on the relationship between hog prices or expected hog price and aggregate hog production. Burnham [7] studied the effect of the hog to corn price ratio on hog production in Iowa. He concluded that the hog to corn price ratio has been an important factor in determining the amount of pork produced and should remain so as long as corn remains a major hog-production input. In the past, high ratios have caused an increase in the number of sows farrowed and low ratios have caused a decrease.

James and Beneke [18] suggest that fluctuations in hog production occur because price plays a major role in dictating future production for a hog producer, but it takes approximately one year for the results of a producer's decision to increase hog production to be realized and slightly less time for the results of a decision to decrease hog production to be realized.

Results of previous research suggest that change in actual or expected prices are one cause, but not the only cause, of changes in slaughter-hog production levels. To better explain and predict these changes more information is needed about:

(1) Which producers make changes and which producers do not make changes,

(2) What characteristics (i.e., type of operation, type of facilities, size, etc.) distinguish producers who make changes from those who do not make changes,

(3) Which producers make cyclical and which make countercyclical changes,

(4) What factors, prices and others, are important in causing the producers who do make changes to increase or to decrease production levels, and

(5) What factors affect the size of changes made.

This information should provide a better understanding of fluctuations in hog production, and it may identify factors that would make better predictions of changes possible and provide insight as to whether the patterns of fluctuations are changing.

B. Objectives and Scope

The objectives of this study are:

(1) To identify characteristics of producers who made and who did not make slaughter-hog production level changes from 1967 to 1971,

(2) To determine if the probability that a producer in a given size class will change his level of slaughter-hog production stays the same over time,

(3) To determine if producers with certain types of hog operations are more likely to change their levels of slaughter-hog production,

(4) To determine what factors producers consider when deciding whether to change levels of slaughter-hog production and the amounts of

changes, and

(5) To determine if the same factors are considered in different change periods.

This study will not involve an attempt to quantify a supply function for slaughter-hogs, where quantity supplied is related to price level. Rather, the emphasis will be on determining the extent to which price is a factor considered by producers changing their slaughter-hog production levels.

C. Procedure

The general approach of this study will be to formulate and test hypotheses. Data used in testing the hypotheses were obtained from a survey of 489 Iowa hog producers.

D. Outline of Remaining Chapters

In Chapter II five hypotheses are stated and previous research that relates to each hypothesis is discussed. The data sources, the specific data needed, and the analytical procedures used to test each hypothesis are discussed in Chapter III. Chapter IV presents the results of tests for the five hypotheses and Chapter V summarizes the conclusions of the analyses.

II. STATEMENT OF HYPOTHESES AND LITERATURE REVIEW

In this study five hypotheses about year-to-year changes in producers' levels of slaughter-hog production are developed and tested. In this chapter the hypotheses are stated and discussed and previous research pertaining to each hypothesis is reviewed.

A. Hypothesis I

Producers with the following characteristics made the following kinds of changes in their levels of slaughter-hog production during the period from 1967 to 1971: producers who were tenant operators, had less education than the average producer, had hogs as their only livestock enterprise, were middle to older aged, did not have excess capacity in their hog facilities at the end of 1971, sold fewer slaughter-hogs in 1967 than did the average Iowa producer, operated less than the average number of acres, had capital intensive hog facilities, and had less management ability than the average producer did not make substantial changes in their levels of slaughter-hog production during the period from 1967 to 1971. Producers who were owner-operators, had an average or an above average amount of education, had two or more livestock enterprises, were young to middle aged, had excess capacity in their hog facilities at the end of 1971, sold more slaughter-hogs in 1967 than the average Iowa producer, operated an average or above average number of acres, did not have capital intensive hog facilities, and had an average or above average amount of management ability made substantial changes in their levels of slaughter-hog production in one or more of the four change periods

1967-68, 1968-69, 1969-70, and 1970-71.

An owner-operator is more likely to make changes in his slaughter-hog production levels than is a tenant operator. The owner-operator has only to convince himself that he should change his level of slaughter-hog production. A tenant operator, on the other hand, may be able to change his production level only if both he and the landowner decide that a change would be desirable.

The greater the number of years of education a producer has the more likely he will study materials relating to all phases of hog production. This, in turn, should make him aware of the factors that should affect his planned production levels. If he is aware that some or all factors are less (more) favorable to hog production, he will probably be more inclined to make changes in his slaughter-hog production levels.

The greater the number of livestock enterprises on a farm, the greater the chance a producer will make changes in his slaughter-hog production levels. With more livestock enterprises there is more opportunity to shift available resources, e.g., labor and feed, from one enterprise to another.

As the age of a producer increases it is expected that he will be less likely to make changes in his slaughter-hog production levels. Older producers will usually have their facilities and operation established and may pay less attention to some of the decision making factors that might cause younger producers to change their slaughter-hog production levels. Older producers may not try to outguess the market as much and may produce nearly the same number of hogs every year, because they are financially more able to withstand the bad years.

Producers with excess hog facility capacity at the end of 1971 are more likely to have changed their production levels over the previous five years. Producers with excess capacity in 1971 may have always maintained excess capacity, added capacity in a previous period, or decreased production in a previous period. The last possibility seems most likely. Thus a producer with excess capacity in 1971 is likely to have substantially decreased hog production in a previous period.

The smaller the number of hogs sold for slaughter in 1967 the less likely is a producer to have made changes in his slaughter-hog production levels. A producer who sold a small number of hogs in 1967 but continued production through 1971 is less likely to have decreased production but no more likely to have increased production than a producer who sold a larger number in 1967. Thus the likelihood of a change is less for the producer who sold fewer hogs in 1967.

As the number of acres operated increases, it is more likely that a producer will make changes in his slaughter-hog production levels. The larger the number of acres operated, the greater is the opportunity to shift resources, e.g., labor, from livestock to crop activities, or vice versa. Also, producers who farm more acres may depend primarily on crops for their income and choose to produce hogs only when opportunities for profit appear to be exceptionally good.

Producers who have permanent capital-intensive swine facilities may not be as capable of making adjustments in their slaughter-hog production levels. Producers with capital-intensive facilities may have higher fixed costs but lower variable costs than other producers. Thus it is more likely that the capital-intensive facilities will be operated at capacity when producers with lower fixed cost facilities decrease production because price falls below variable cost.

To evaluate a hog producer's management ability, two categories of management factors will be analyzed. The categories are attentiveness and progressiveness. An attentive hog producer is considered to be a producer who keeps himself abreast of the latest swine information and current market situation. A progressive hog producer is considered to be a producer who has taken steps to improve his management ability.

The following factors are expected to provide information as to the progressiveness and attentiveness of Iowa slaughter-hog producers: the use of computer records, the quality of swine records, the number of bids received when selling slaughter-hogs, the number of different outlets sold to when marketing hogs, and use of the futures market.

The use of computer records and quality of swine records indicate progressiveness. A producer who kept his farm records with the use of a computer and who keeps a good set of swine records is considered to be very management oriented and would be more likely to make changes in his slaughter-hog production levels than would a producer who does not keep these types of records. A producer was judged to have kept a good set of swine records if records were kept for two or more of the following items: the weight and/or number of pigs sold, amount of feed fed, and the amount of labor used.

Three factors will be used to reflect a producer's attentiveness to the market situation and other aspects of his hog enterprise and farm operation. The greater the number of bids received for slaughter-hogs, the greater the number of outlets sold to from 1967-1971, and the greater the use of futures markets, the more likely is a producer to make changes in his slaughter-hog production levels.

Hypothesis II is concerned with the system of changes that occur from year-to-year for a given "type" of hog operation. The type of hog operation is determined by the way in which feeder pigs were acquired. Feeder pigs are pigs that are just entering the growing stage of slaugher-hog production.

B. Hypothesis II

Hog producers in certain size classes are more likely to make changes in production levels than are producers in other size classes, and the system of year-to-year changes in levels of slaughter-hog production varies over time. More specifically, the probability that a producer in size class j in year t will move to size class i in year t+1 is different than the probability that a producer in size class k in year t will move to size class i in year t+1, and is also different than the probability that a producer in size class j in year t+1 will move to size class i in year t+2. A producer's size class is determined by the number of slaughter-hogs sold.

Judge and Swanson [20] studied the pattern of changes from 1946 to 1958 of 83 hog-producing firms in Illinois. The number of litters of hogs produced by each firm in a year was the variable used in classifying firms by size.

Seven size classes were defined and movements between these size classes for pairs of consecutive years reflect the pattern of changes in the number of litters of hogs produced by the firms.

The results indicate that there was a strong tendency for the hog firms to remain in the same size class from one year to the next. Part of the reason for this result may have been the arbitrary definition of the class ranges. If there had been more classes and smaller class ranges the number of producers changing size classes would have been larger.

Judge and Swanson also concluded that of the producers who did make year-to-year changes, most moved to adjacent size classes. Most entering producers entered the smallest size class and most exiting producers exited from the smallest size class.

Results of tests of hypothesis II will provide information about whether probabilities of changes in slaughter-hog production differ among producers in different size classes and whether these probabilities vary over time. These results will not provide information about whether probabilities of change vary between producers with different types of hog operations. The latter information will be obtained from tests of hypothesis III.

C. Hypothesis III

The system of year-to-year changes in levels of slaughter-hog production varies between different types of producers within a change period. More specifically, the probability that a producer engaged in X type of hog production and in size class i in year t, will move to size class j in year t+1 different than the probability that a producer engaged in Y type of hog production and in size class i in year t will move to size class j in year t+1.

Four types of hog operations were distinguished. They were operations that farrowed-finished only, purchased feeder pigs only, farrowed-finished and sold feeder pigs only, and a diversified group. The diversified group includes operations that combine two or more of the first three types. These types of hog operations will be discussed in more detail in Chapter III.

Hypothesis I was developed to identify characteristics that are associated with producers who make changes in their slaughter-hog production levels. Hypothesis II and III were developed to gain insights into the system of changes in slaughter-hog production. The last two hypotheses will deal with the reasons changes occur in slaughter-hog production and factors affecting the sizes of changes.

D. Hypothesis IV

In order of importance, factors contributing to the sizes of increases and the sizes of decreases in individual producers' levels of slaughter-hog production are the expected profitability of hog production (economic variables), luck and management factors (chance variables), and availability of hog production inputs (resource variables). Producer, farm, and enterprise characteristics along with the economic, chance, and resource variables affected the direction and sizes of year-to-year changes in slaughter-hog production for the years 1967-1971.

Following World War II Likert [40] initiated a USDA study of the reasons why hog producers change production levels. Two questions considered in the study were:

"(1) What factors do farmers say determine the number of spring pigs they usually raise?

(2) What factors do farmers say cause them to change the number of spring pigs they raise?" [40, p. 2]

It was generally recognized by agricultural economists and others that price was a motivating factor in the production plans of farmers, but Likert felt that there were other factors influencing the production plans by farmers.

The objectives of the USDA study were: (1) to test the interview-survey method of collecting data, (2) to determine some of the factors that influence the spring production and marketing decisions of hog farmers, (3) to determine what relative importance hog farmers attached to the factors identified.

A survey of farmers who raised spring pigs was conducted in the spring of 1946. A total of 378 farmers in eight states; Iowa, Nebraska, Minnesota, Missouri, Wisconsin, Illinois, Indiana, and Ohio, were interviewed. The survey design permitted comparisons among groups of producers but not among regions of the country.

In the USDA study farmers were asked questions that pertained to their production practices and changes in production levels they had made since 1940. This was not a "normal" time period. World War II and other factors related to the war probably had some influence upon hog farmers' plans. During this period the Government asked farmers to produce as much as possible. Hogs were in great demand and there were unusual patriotic and profit incentives for raising hogs. Because of this great demand, new production and marketing practices developed. Hog farmers responded during this period by exceeding in every year the previous 10-year average spring pig crop. An all-time record spring crop of pigs was produced in 1943.

Prices rose rapidly during 1941 and 1942 and price ceilings were established in 1943. The price structure did change for a short time in 1943 and 1944 when hog prices fell below the price-support level. Except during this short time period, the hog-corn price ratio was favorable.

During the war there was a shortage of equipment, machinery, labor, and transportation, and after the war at the time the USDA survey was conducted the Government was paying a $.30/bu. bonus for corn. Undoubtedly these factors and others prevailing during and shortly after the war had some effect upon the hog farmers' production levels.

Figures 2.1 and 2.2 show the factors that hog farmers surveyed in the USDA study considered to be important in determining production levels and in causing changes in production levels. The variables identified in hypothesis four correspond closely with the factors mentioned by hog farmers after World War II. Tests of hypothesis four will reveal whether the same factors were considered in both time periods and whether the importance of each factor is the same.

The results indicate that, for this period, producers did not consider price factors to be very important in determining either their usual production levels or changes from their usual levels. Figure 2.1 shows that resource factors were the most important determinant of usual

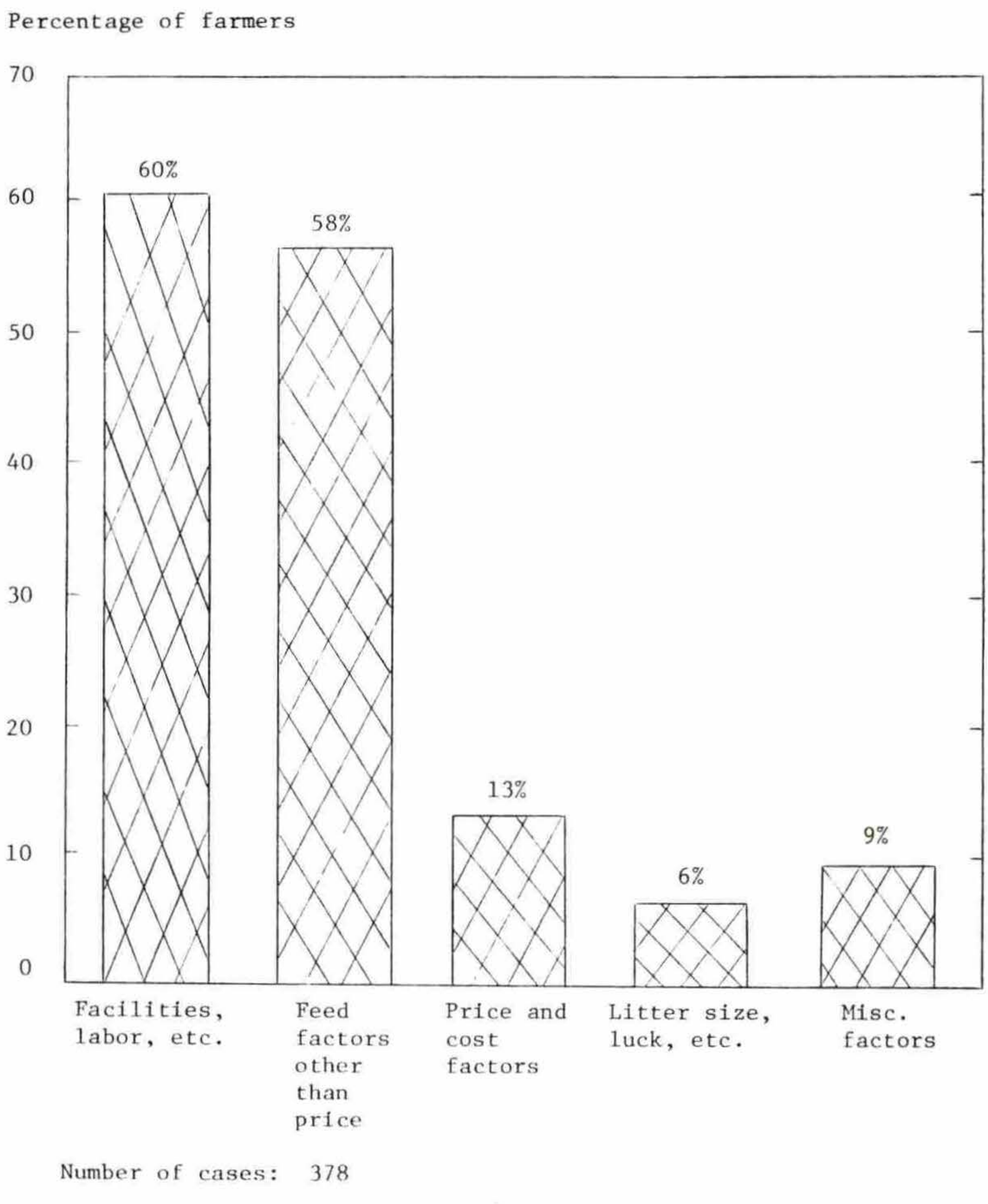

Figure 2.1. What factors do farmers say determine the number of spring pigs they usually raise? [40, p. 7]

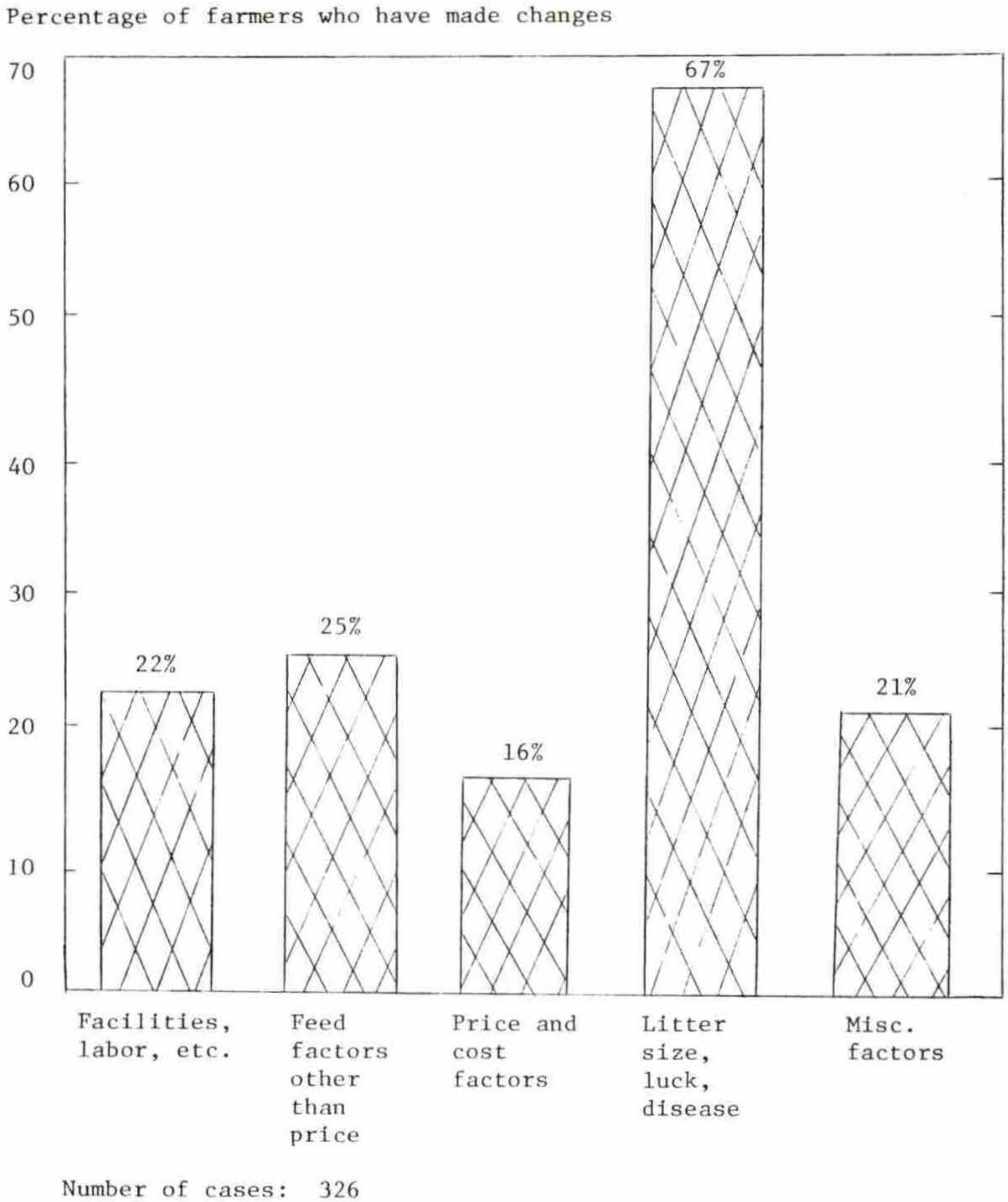

Figure 2.2. What factors do farmers say have caused them to change the number of spring pigs they raised? [40, p. 9]

production levels. Chance factors caused producers to deviate from their usual production levels more than any other factors (Figure 2.2).

The percentages in both figures add to more than 100 percent because some producers mentioned more than one factor when responding to the questions. Miscellaneous factors include personal economic and other personal factors, supply and demand situations, habits, and government requests. The USDA study did not attempt to measure managerial efficiency or ability.

Tilley [38] found that producer attitudes and other characteristics affected decisions about what market outlet to use. It is likely that producers' attitudes toward economic, chance, and resource variables would also explain changes in the number of slaughter-hogs sold.

Hypothesis V deals with comparisons of the importance of the factors affecting changes in slaughter-hog production levels between the four different change periods for a given type of hog operation and between different types of hog operations for a given time period.

E. Hypothesis V

The impacts of economic, resource, and chance factors, and producer, farm, and enterprise characteristics on the size of year-to-year changes vary over time for a given type of hog operation and over the types of hog operations for a given change period.

In the USDA study [40] the number of times a factor was mentioned was used to determine the relative importance farmers attach to a factor in determining the number of spring pigs usually fattened. Table 2.1 gives the relative importance of factors mentioned by hog farmers. The number of times a factor was mentioned, divided by the number of farmers mentioning the factor gave a percentage figure indicating the importance of a factor.

Table 2.1 again indicates that producers felt that resource factors were the most important factors in determining the number of spring pigs usually fattened; compare Table 2.1 with Figures 2.1 and 2.2. The percentage of producers indicating that price factors were important in determining the number of spring pigs usually fattened rose from 22 percent at the beginning of the interview to 35 percent at the end of the interview. The percentage of producers mentioning factors that were of a resource nature declined from 116 percent at the beginning of the interview to 102 percent at the end of the interview.

In the USDA survey the producers were not given a list of factors that they could use in identifying factors that usually determine the number of spring pigs usually fattened. The interview might have stressed the importance of price factors and thus led producers to mention that these factors influence their hog production decisions. This might have caused the differences in percentage figures from the beginning to the end of the interview.

The relative importanct of the variables identified in hypothesis V will be determined. The interview was handled differently than in the USDA study. A producer was given a list of potential factors that could have had some importance in cuasing him to change his slaughter-hog production level. The producer was then asked to assign a score to each of the factors to indicate how important that particular factor was in

Table 2.1. Measure of importance farmers attach to factors determining the number of spring pigs usually fattened [40, p. 34]

	Farmers who gave factors:			
	At start of interview		At end of interview	
Facilities, labor, and other farm activities		60%		41%
Availability of facilities	28%		21%	
Adjustment of hog enterprise to other operations ("I keep a balance," etc.)	17		12	
Availability of labor (including own labor)	16		12	
"All I can handle" (reason not determined)	7		2	
Adjustment of hog enterprise to purebred hog production	2		2	
Feed factors other than price		56		61
Quantity of corn on hand or produced	54		55	
Quantity of other feed	2		3	
Use of pasture	3		5	
Current crop conditions and outlook	-		4	
Quality of corn	-		1	
Price and cost factors		22[a]		35
Price of hogs			20	
Price of corn			2	
Relation of price of corn to price of hogs			13	
Cost of production in general (not including cost of feeder pigs)			7	
Cost of feeder pigs			**[b]	
Litter size, luck, etc.		6		6
Size of litters (no other factors mentioned)	3		4	
Luck with pigs	2		2	
Availability of feeder pigs or shoats	**[b]		1	

Miscellaneous factors		9		17
Personal economic factors (taxes, rent, etc.)	3		2	
Other personal factors (health, old age, etc.)	4		3	
"Supply and demand"	1		4	
Habit (no other factors mentioned)	1		3	
Government requests	**[b]		1	
General economic conditions	-		4	
Not ascertained		-		3
		***[c]		***[c]
Number of cases		378		378

Table based on questions below: the first two were asked at beginning, the third at end of interview. Interview contained more than 70 questions relating to hog production and marketing, production and marketing difficulties, corn availability, corn and hog prices, and alternative farm enterprises. "How many spring pigs have you fattened per year in the last 50 years, that is since 1940? Why?" "How does it happen you usually fatten ___ hogs?" "Now in putting together what we've been talking about, just what things do you consider in making your plans from year to year on how many hogs to fatten? How do you mean? Any others?"

[a]This 22 percent includes farmers who gave price and cost factors as a reason for the number of spring pigs they usually raise or for changes made in recent years.

[b]Less than 1 percent.

[c]Percentages total to more than 100 and subtotals may add to more than the sum of their constituent percentages because many farmers gave more than one reason.

causing him to make his production level change. Because producers needed only to determine what score to assign each factor, the reliability of the results should be an improvement over the results obtained in the USDA study.

F. Summary

Five hypotheses have been presented in this chapter. Hypothesis I is concerned with identifying characteristics of producers who make changes in their slaughter-hog production levels. Hypotheses II and III are concerned with the system of changes between periods for a given type of hog operation and the system of changes within a period for different types of hog operations, respectively. Hypothesis IV is concerned with identifying factors that affect the size of changes in slaughter-hog production. Tests of hypothesis V will reveal whether the importance of these factors changes over time for a given type of hog operation and between different types of hog operations within a given change period.

Chapter III will discuss the data, and the methods and procedures to be used to test the five hypotheses presented in this chapter.

III. DATA, METHODS, AND PROCEDURES

In the first part of this chapter the data source and the data collected are discussed. Following this will be a discussion of the three analytical procedures to be used to test the five hypotheses presented in Chapter II.

A. Data

The data source for this study is an Iowa swine production and marketing practices survey, which was conducted in February of 1972. The data for this study differ from the data used in the USDA study in that they were obtained only from Iowa hog producers. To obtain a reliable sample and to reduce sampling costs, the following procedure was followed [4]. Counties in Iowa were arranged geographically and every third county was selected until one-third of the state's 99 counties were selected. Then each selected county was divided into subareas. One-fourth of these subareas were randomly selected and the initial sample of producers was drawn from eligible producers in these selected subareas.

To be eligible for the initial sample of producers, a producer must have sold some type of hogs, not necessarily slaughter-hogs, in 1970 as recorded in the 1970 state farm census. Producers meeting this criteria were stratified according to the number of hogs marketed in 1970. The size categories corresponding to each of the seven strata are shown in the center column of Table 3.1.

A random subsample of producers was drawn from those classified in each strata. The different strata were sampled at different rates;

Table 3.1. Strata for grouping producers by the number of hogs marketed in 1970.

Strata	Hogs Marketed[a]	Weights [4]
1	1-99	369.1
2	100-249	258.0
3	250-349	126.6
4	350-499	92.9
5	500-999	50.5
6	1000-2499	23.5
7	2500 and over	3.8

[a]Hogs marketed was defined to include all slaughter hogs, feeder pigs, and breeding stock.

producers in strata 1 were sampled at the lowest rate and those in strata 7 were sampled at the highest rate. Because different sampling rates were used, observations in the various strata must be weighted to obtain estimates of population parameters. The weights for observations in each strata are shown in the right hand column of Table 3.1.

Interviews were completed only for those producers in the sample that sold butcher hogs in 1971. Four hundred eighty-nine interviews were completed.

The survey was designed to provide information about a hog producer's farming operation, production and planning practices, market outlets and decisions, selling practices, hog buildings and facilities, swine health, feeding practices, swine labor requirements, production costs, use of market information, anticipated changes in the hog operation, and personal characteristics.

Data collected on changes in levels of slaughter-hog production and reasons for these changes were of central importance in this study. The number of slaughter-hogs sold for slaughter from 1967 to 1971 was recorded in the survey for each producer. Year-to-year increases and decreases in levels of slaughter-hog production were calculated and compared with "tolerance" levels of change. A different tolerance level of change was used for producers in each strata as shown in Table 3.2. For example, if the number of hogs sold for slaughter in period t was 250, line 4, then, in period t+1, this producer would have had to either increase or decrease the number of slaughter-hogs sold by 30 head or more to be considered to have exceeded the tolerance level of change.

Table 3.2. Criterion for determining tolerance change

The change in the number of slaughter hogs sold exceeds tolerance if:

	The number of slaughter-hogs sold in period t is:	And the number of slaughter-hogs sold in period t+1 increased or decreased by:
(1)	0	any amount
(2)	1-99	10 or more
(3)	100-199	20 or more
(4)	200-299	30 or more
(5)	300-399	40 or more
(6)	400-499	50 or more
(7)	500- +	75 or more

For each change a producer made that exceeded the tolerance level for his strata, the producer was asked to indicate the importance of each of several variables in causing the change. The variables were of three types: economic, resource, and chance. A producer was asked to indicate importance as precisely as possible by assigning a number from 1 to 99 to each variable. The importance associated with each number is shown in Table 3.3.

Table 3.3. Importance scores

Score	Importance
1 – – –	No Importance
10 – – 20 – – 30 – –	Slight Importance
40 – – 50 – – 60 – –	Moderate Importance
70 – – 80 – – 90 – – –	Considerable Importance
99	Maximum Importance

This section includes a brief discussion of the survey and a general overview of the type of information that was obtained. The analytical procedures used to test the five hypotheses and the specific data requirements for each hypothesis are discussed in the rest of this chapter.

B. Discriminant Analysis

Discriminant analysis will be used to test hypothesis I. Discriminant analysis is an analytical procedure that may be used to determine whether it is possible to classify individuals into different groups by using characteristics of each individual. Discriminant analysis is similar to regression analysis, except that the dependent variable is discontinuous.

An example of application of discriminant analysis would be to discriminate between Hereford and Angus steers. Let carcass weight and height at the shoulders be two characteristics of each steer that were measured. Measurements of these characteristics would be used as independent variables in the discriminant function. Once the function has been estimated, the estimated function and the values for the independent variables could be used to predict the classification of each observation. The predicted numbers of Hereford and Angus steers could be compared to the actual number of Hereford and Angus steers to determine how well the discriminant function has classified the steers into each group. The procedure can also be used when one wants to discriminant between more then two groups and wants to use more than two independent variables.

1. Theory of discriminant analysis

a. Assumptions The following assumptions underlie the derivation of the discriminant function. Assume that n_i observations are available for each of the variables $X_1, X_2, \ldots, X_V$ for each of two groups. Also, following Hallberg [13], assume that:

1. The variables $X_1, X_2, \ldots, X_V$ for each of the two groups follow a multivariate normal distribution.

2. The mean values for $X_1, X_2, \ldots, X_V$ for group 1 are statistically different from those for group 2, and

3. The variance and covariances of $X_1, X_2, \ldots, X_V$ for each group are not statistically different.

b. Discriminant function The criterion used to derive the discriminant function is maximization of the between-group variance relative to the within group variance. To show how this criterion is applied, first define the discriminant function

$$G_{it} = X'_{Vt} D_{ij} \tag{3.1}$$

where

G_{it} = the discriminant function index value for the t-th observation in group i,

X'_{Vt} = a column vector of observations for V independent variables for the t-th observation, and

D_{ij} = a V × 1 column vector of coefficients.

Ladd [23] has shown that the variance between groups may be represented by the square of the difference between the mean values of G in the two groups:

$$(\bar{G}_1-\bar{G}_2)^2 = (d_{12}D_{12})^2 = D'_{12}d_{12}d'_{12}D_{12} \tag{3.2}$$

where:

$\bar{G}_i = \bar{X}'_{Vi} D_{ij}$ $\quad i, j = 1, 2$ and $i \neq j$

$\bar{X}_{Vi}$ = the vector of mean values for group i, and

$d_{12} = (\bar{X}_{V1} - \bar{X}_{V2})$ = the column vector of V variable mean differences for groups 1 and 2.

The within-group variance is given by

$$\sum_{t=1}^{n_i} \sum_{i=1}^{2} (G_{it} - \bar{G}_i)^2 = D'_{12} C D_{12} \qquad (3.3)$$

where C is the VxV pooled sum of cross-products matrix. The elements of the C matrix are of the form:

$$C_{\ell m} = \sum_{i=1}^{2} \sum_{t=1}^{n_i} (X_{it\ell} - \bar{X}_{im})(X_{it\ell} - \bar{X}_{i\ell})$$

where:

$\ell, m = 1, 2, \ldots, V$

n_i = the number of observations in the i-th group, and $X_{i\ell}$ and X_{im} are the means of variables ℓ and m about group means.

Thus the ratio that is desired to be maximized with respect to D_{12} is:

$$\frac{D'_{12} d_{12} d'_{12} D_{12}}{D'_{12} C D_{12}} \qquad (3.4)$$

A solution to 3.4 is $\overset{*}{D}_{12}$. If $\overset{*}{D}_{12}$ maximizes 3.4 then so will $\overset{**}{D}_{12} = \overset{*}{D}_{12} p$, where p is a scalar. The substitution of $\overset{**}{D}_{12}$ for $\overset{*}{D}_{12}$ will in effect multiply both the denominator and numerator by p^2 [23]. It has been determined that the value of D_{12} which maximizes 3.4 is the same, except for an arbitrary multiplying constant, as the value which maximizes $D'_{12} d_{12} d'_{12} D_{12}$ subject to $D'_{12} C D_{12} = z$, where z is any arbitrary nonzero constant [19]. The Lagrangian function is defined by equation 3.5. Let λ be a Lagrange multiplier and set z equal to one.

$$F = D'_{12}d_{12}d'_{12}D_{12} - \lambda(D'_{12}CD-1) \quad (3.5)$$

The solution D^*_{12} can be obtained by setting the first order derivatives of Y with respect to D_{12} equal to zero,

$$\partial F/\partial D_{12} = 0 = 2d_{12}d'_{12}D_{12} - 2\lambda CD_{12} \quad (3.6)$$

The product $d'_{12}D_{12}$ is a scalar, say π, therefore equation 3.6 can be written as

$$\lambda/\pi \; CD_{12} = d_{12} \quad (3.7)$$

A solution to 3.7 is

$$\lambda/\pi \; D_{12} = C^{-1}d_{12} = B_{12}, \text{ say,} \quad (3.8)$$

which is proportional to D_{12}. Therefore $\lambda/\pi \; D_{12}$ and B_{12} are both solutions to equation 3.6.

Ladd [23] has shown that another set of discriminant function coefficients can be derived using a different variance-covariance matrix. Let this matrix be represented by K, where this K matrix has elements of the form:

$$k_{rs} = 1/N-2 \sum_{i=1}^{2} \sum_{t=1}^{n_i} (X_{its}-\bar{X}_{ir})(\bar{X}_{its}-\bar{X}_{is})$$

where:

$r, s = 1, 2, \ldots, V,$

n_i = the number of observations in the i-th group, and $\bar{X}_{ir}$ and $\bar{X}_{is}$ are the means of the variables r and s over all groups.

This is the variance-covariance matrix Hallberg [13] used to derive a set of coefficients that maximized the Lagrangian function. Substituting this K matrix for the C matrix in the ratio 3.4 and following through the rest of the procedure equation 3.6 becomes:

$$\partial F/\partial D_{12} = 0 = 2d_{12}d'_{12}D_{12} - 2\lambda KD_{12} \quad (3.9)$$

where $d'_{12}D_{12}$ is a scalar, say π. Equation 3.9 can then be written as

$$\lambda/\pi \, KD_{12} = d_{12} \tag{3.10}$$

A solution to 3.10 is

$$\lambda/\pi \, D_{12} = K^{-1}d_{12} = \hat{D}_{12}, \text{ say,}$$

which is proportional to D_{12}. It is the $\hat{D}_{12}$ set of discriminant function coefficients that will be estimated in this study. The discriminant function coefficients are equal to the inverse variance-covariance matrix times the column vector of mean differences for the V variables for groups 1 and 2.

2. Classification

The criterion used to classify individuals into groups, is to minimize the expected losses due to misclassification. In essence, this criterion is used to define the best set of regions in which to classify an individual. Given the assumptions:

1. That the probability that an individual drawn at random comes from group 1 or 2 is unknown,

2. That the cost of misclassification is equal for each group,

3. That the population parameters μ_1, μ_2, and Σ are known, and

4. That one is discriminating between only two groups, Ladd [23] shows that the expected losses due to misclassification are minimized by using the following classification rule. An individual will be classified into group 1 if

$$\begin{aligned} g_1&: \; X'D \geq \tfrac{1}{2}(\mu_1+\mu_2)'D, \text{ or group 2 if} \\ g_2&: \; X'D < \tfrac{1}{2}(\mu_1+\mu_2)'D \end{aligned} \tag{3.11}$$

where $X'D$ is the discriminant function, and $D = \Sigma^{-1}(\mu_1-\mu_2)$, where Σ is the variance-covariance matrix, and μ_1 and μ_2 are column mean vectors.

If one does not know the population parameters and must rely on sample estimates $\bar{X}_1$, $\bar{X}_2$, and K it seems reasonable that a producer will be classified into group 1 if

$$g_1:\ X'K^{-1}(\bar{X}_1-\bar{X}_2) \geq \tfrac{1}{2}(\bar{X}_1+\bar{X}_2)'K^{-1}(\bar{X}_1-\bar{X}_2) \text{ or group 2 if}$$
$$g_2:\ X'K^{-1}(\bar{X}_1-\bar{X}_2) < \tfrac{1}{2}(\bar{X}_1+\bar{X}_2)'K^{-1}(\bar{X}_1-\bar{X}_2). \quad (3.12)$$

This may be stated differently by writing

$$\hat{C}_{ij} = \tfrac{1}{2}(\bar{X}_1+\bar{X}_2)'\hat{D}_{12} \quad (3.13)$$

where $\hat{C}_{ij}$ is equal to the right hand side of 3.12 and

$$\hat{D}_{12} = K^{-1}(\bar{X}_1-\bar{X}_2). \quad (3.14)$$

Then a producer will be classified into group 1 if

$$g_1:\ X'\hat{D}_{12} \geq \hat{C}_{12} \text{ or group 2 if}$$
$$g_2:\ X'\hat{D}_{12} < \hat{C}_{12}. \quad (3.15)$$

If the probabilities that an individual drawn at random comes from group 1 and 2 are known by a priori information or if these probabilities are determined by the number of producers in the sample that were in groups 1 and 2, adjustments must be made to the classification procedure. Given this situation Rao [30] and Anderson [1] have shown that the classification procedure which minimizes the cost of misclassification is to classify an individual in group 1 if

$$A_{12} \geq \log_e[p_2/p_1] \text{ for all i and j, } i \neq j,$$

and to classify the individual in group 2 if

$$A_{12} < \log_e[p_2/p_1] \quad (3.16)$$

where

$$A_{12} = -\hat{C}_{12} + X'\hat{D}_{12} \quad (3.17)$$

and the p_1 and p_2 are the probabilities of randomly drawing a producer from groups 1 and 2, respectively. The A_{ij} are used in defining the best set of regions for classifying individuals into a group. Notice that, if $p_i = p_j$, then the right hand side of 3.16 will equal zero and the classification procedure in 3.16 is exactly the same as the classification procedure in 3.15.

3. Testing the discriminant function

Once the discriminant function is estimated it may be tested for its predictability and significance. One test for predictability involves comparing the predicted classifications of sample individuals with actual classifications. The discriminant function will be 100 percent accurate in predicting the classification of producers if all producers are classified into their proper (original) group. The discriminant function is accurate in that it can accurately predict to which group a producer belongs on the basis of the variables used to measure characteristics of each producer. P^2 is used to indicate the predictability of the discriminant function and is given by 3.18 [28].

$$P^2 = \frac{\text{Number of producers classified correctly}}{\text{Total number of producers classified}} \qquad (3.18)$$

When one has prior knowledge of the number of producers belonging in each group a standard against which to compare P^2 is needed in order to determine if one should use the estimated discriminant function for classification purposes or if one could do a better job of classifying merely by chance. A standard of comparison given by Morrison [28] is known as the percent correctly classified by random chance. That is, if one had two groups of producers, how well could these producers be classified into their respective groups by chance as opposed to using the estimated discriminant function. If the discriminant function does not correctly classify a higher percentage of producers than the random chance procedure, one would conclude that the discriminant function is not a good discriminator.

To determine the random chance probabilities, the known number of producers in group 1 and group 2 in the sample can be used. y_1 is the proportion of individuals in group 1 and y_2 is the proportion of individuals in group 2. ${y_1}^2$ and ${y_2}^2$ are the probabilities that individuals from groups 1 and 2 will be correctly classified if they are randomly selected and assigned to groups 1 and 2. The probability that a producer is in group 1 (2), but is classified into group 2 (1) is equal to $y_{1(2)}$ $y_{2(1)}$. Thus, $y_{1(2)}y_{2(1)}$ is the probability of misclassification. The sum of the probabilities for the correct classifications and misclassifications is equal to one and is given by equation 3.19.

$$1 = \sum_{i=1}^{2} \sum_{j=1}^{2} y_i y_j \qquad (3.19)$$

A table of random chance probabilities will be constructed from these probabilities to compare with the classification table generated by using the discriminant function with known probabilities. This table will be presented in the discriminant analysis results section in Chapter IV.

If one assumes unknown prior probabilities then a random chance classification criterion table cannot be constructed and therefore a comparison between the actual classification and a random chance basis classification cannot be made.

Ladd [23] presents a procedure for testing the overall significance of a two group discriminant function. Ladd uses an $R_D{}^2$ value given by 3.20.

$$R_D{}^2 = \hat{D}'_{12}/N\text{-}g\ nd_{12} \tag{3.20}$$

where

$$n = \frac{N_1 N_2}{N_1+N_2}$$

N_1 = is the original number of producers in group 1,

N_2 = is the original number of producers in group 2,

$N = N_1 + N_2$, and

g is the number of groups, and $\hat{D}'_{12}$ and d_{12} are given by equations 3.14 and 3.2, respectively.

An F-ratio given by equation 3.21 is used to test the overall significance of the two group discriminant function.

$$F = \frac{R_D{}^2}{1-R_D{}^2}\ \frac{N-V-1}{V} \tag{3.21}$$

where V is the number of independent variables used in the discriminant function.

If the calculated F value exceeds the tabulated F value with N-V-1 degrees of freedom in the numerator and V degrees of freedom in the denominator then one concludes that the discriminant function is significant. If the tabulated F value exceeds the calculated F value then one concludes that the discriminant function is not significant.

The discussion just completed dealt with a method of analyzing the overall predictability and significance of the discriminant function. How to analyze the importance of each of the V independent variables in a discriminant function is the next topic that will be dealt with.

Once the $\hat{D}_{12}$ coefficients are estimated, the size and sign of a coefficient must be considered for purposes of analyzing the variable in question. The size of the coefficient will be affected by the unit of measurement used in quantifying the variables. Therefore if all the variable coefficients are standardized the coefficients of an equation will be directly comparable, and the values of the coefficients can be used to rank the variables as to their relative importance.

The independent variables can be standardized by dividing each observation of each variable by the standard deviation of the variable computed over all g groups. An alternative and easier procedure for standardizing large numbers observations is to first estimate the discriminant function and then multiply the estimated coefficient times the standard deviation for that variable [13].

4. Significance of the coefficients

Once the discriminant function has been estimated, then one needs to determine the significance of each estimated coefficient. The assumption that all V variables are multivariate normally distributed among groups is untenable. If nonnormally distributed variables were to be used as independent variables then they could present a problem. However, Gilbert [12] studied this problem and found that the loss from using Fisher's linear discriminant function as opposed to some other procedure is not enough to be of any importance.

Asymptotic variances will be calculated for each coefficient. An asymptotic variance is the variance of a variable as the number of observations approach infinity. The use of asymptotic variances will help solve the problem of nonnormally distributed variables because at least the estimates of the variances will be consistent. From equation 3.14 consider one of the elements of $\hat{D}_{12}$, say $\hat{D}_W$. The asymptotic variance is defined by equation 3.22.

$$\mathrm{Var}(\hat{D}_W) = \hat{D}_W{}^2/N + \ell WW/N\ \hat{D}_{12}'[X_{V1}-X_{V2}] + (1/n_1 + 1/n_2)L_W'B_{12}L_W \quad (3.22)$$

where

ℓWW is the variance of the W-th independent variable,

L_W is the W-th column of K^{-1}, and

B_{12} is the V square matrix of variances and covariances consisting of elements b_{rs}; where r, s = 1, 2, ..., V for groups 1 and 2.

For a detailed derivation see Hallberg [13, pp. 5-6].

A t value will be calculated for each coefficient using the asymptotic variance. Even though the asymptotic variance is not a totally unbiased estimator, the t-test will still give a reliable test as to the significance of the coefficient [13]. The calculated t value is

$$t_{n-k-1} = \frac{\hat{D}_W - D_W}{\sqrt{\mathrm{Var}\ (\hat{D}_W)}} \quad (3.23)$$

In the appendix a two variable, two group numerical example of discriminant analysis is presented to illustrate the procedures presented so far in the discriminant analysis section, except the calculation of $R_D{}^2$.

For a two-group discriminant analysis, Ladd [23] presents a procedure to test the significance of adding u additional variables after one has used V variables to estimate a discriminant function. V variables would represent a reduced model and V + u would represent a full model. Equation 3.24 defines the F-ratio used to test the significance of adding u additional variables to the discriminant function.

$$F = \frac{R_{D_{V+u}}^2 - R_{D_V}^2}{1 - R_{D_{V+u}}^2} \; \frac{N - V - u - 1}{u} \qquad (3.24)$$

where

$R_{D_V}^2 = R_D^2$ calculated by using equation 3.20 with V variables, and

$R_{D_{V+u}}^2 = R_D^2$ calculated from equation 3.20 by using V+u variables.

Hypothesis I deals with identifying characteristics of producers who did and did not exceed tolerance levels of change in the number of slaughter-hogs sold in either the 1967-68, 1968-69, 1969-70, and/or 1970-71 change periods. Two groups will be used in the discriminant analysis procedure: (1) the no change group which includes producers who did not exceed the tolerance level of change in any one of the four periods and (2) the change group which includes producers who exceeded the tolerance level of change in one or more of the four periods.

The idea behind the development of hypothesis I is that producers in the two groups will have different characteristics. Table 3.4 identifies the variables that will be used in testing hypothesis I and indicates the expected signs of the $\hat{D}_V$ coefficients.

A plus (minus) sign implies that the larger (smaller) the value of the independent variable, the greater (smaller) the probability of being classified into the change (no change) group.

Table 3.4. Producer characteristic variables to be used in the discriminant function estimation.

Row Number	Variable and Symbol	Expected Sign of the Coefficient
1	Owner-operator (OO)	+
2	Number of years of education (ED)	+
3	Number of livestock enterprises (LVSE)	+
4	Age of producer (AGE)	-
5	Excess capacity in 1971 (EC)	+
6	Number of hogs sold in 1967 (NS67)	+
7	Number of acres operated (AO)	+
8	Capital-intensive hog facilities (BLDG)	-
9	Use of computer records (COMRD)	+
10	Quality of swine records (QSR)	+
11	Number of bids received (NBR)	+
12	Number of outlets sold to (NOS)	+
13	Use of futures contracts (FC)	+

A one tailed t-test will be used in testing the significance of a coefficient. The generalized H_0 and H_a are:

$H_0 - \hat{D}_V = 0$ for expected negative sign

$H_a - \hat{D}_V < 0$ for expected negative sign

$H_0 + \hat{D}_V = 0$ for expected positive sign

$H_a + \hat{D}_V > 0$ for expected positive sign

For the discriminant function model, tests for measuring the overall explanatory and discriminatory power of the model, the relative importance of each variable compared to all variables used, and the significance of each coefficient have been presented. The following results will be presented for the discriminant model:

(1) $\hat{D}_{12}$ and $\hat{C}_{12}$ defined in equation 3.17,

(2) t value for each of the $\hat{D}_{12}$ coefficients using the asymptotic variance calculated by using equation 3.22,

(3) Importance ranking of the variables,

(4) Summary table showing the results of the classification procedure, and

(5) F-ratio value to determine the significance of the discriminant function model.

Markov chain analysis will be used to test hypotheses II and III and will be discussed next.

C. Markov Chain Analysis

The first-order Markov chain process will be used to test hypotheses II and III. In a first-order Markov process the probability that a producer is assigned to state C_i in period t+1 is conditional only upon the state the producer is assigned to in period t. These conditional probabilities are referred to as transition probabilities.

States are size classes in this study. A size class is defined by a range in the number of slaughter-hogs sold in the t-th period. Table 3.5 defines the ranges for each size class used in the Markov analysis.

1. Transition probabilities

A transition probability P_{ij} is the probability of moving to state

C_j in the t+1 period from state C_i in the t-th period where i, j = 1, 2, ..., S and S is equal to the total number of states. Referring to Table 3.5, S is equal to seven.

Table 3.5. Definition of size class ranges

Size Class	Hogs Marketed[a]
0	0
1	1-99
2	100-249
3	250-349
4	350-499
5	500-999
6	1000 and over

[a]Hogs marketed was defined as the number of slaughter-hogs marketed in period t.

Transition probabilities for Iowa slaughter-hog producers can be estimated by using equation 3.25.

$$\hat{P}_{i_t j_{t-1}} = N_{i_t j_{t-1}} / \sum_{k=1}^{S} N_{k_t j_{t-1}} \qquad (3.25)$$

where

$\hat{P}_{i_t j_{t-1}}$ = the estimated transition probability between size class j in period t-1 and size class i in period t,

$N_{i_t j_{t-1}}$ = the number of producers in class j in period t-1 who are in class i in period t,

$N_{k_t j_{t-1}}$ = the number of producers in class j in period t-1 who are in class k in period t, and

S = the number of size classes.

Transition probabilities may be summarized in a transition probability matrix. The following example will illustrate how a transition probability and a transition probability matrix are calculated. Figure 3.1 presents a matrix in which the notation in each cell represents a number of producers. A cell is the intersection of two classes, one

		Period t-1		
		C_1	C_2	C_3
	C_1	n_{11}, t	n_{12}, t	n_{13}, t
Period t	C_2	n_{21}, t	n_{22}, t	n_{23}, t
	C_3	n_{31}, t	n_{32}, t	n_{33}, t

Figure 3.1. Notational example for a transition matrix

from each period. Using the intersection of C_1 in period t and C_2 in period t+1, n_{21}, t is the representative notation at the intersection of these two classes and is equal to the number of producers in class C_2 in period t who were in class C_1 in period t-1. By using equation 3.25 the $\hat{P}_{i_t i_{t-1}}$ for a producer in class C_1 in period t-1 who is in class C_2 in period t is

$$\hat{P}_{21} = \frac{n_{21}, t}{n_{11}, t + n_{21}, t + n_{31}, t}$$

The transition probability matrix P is a matrix of the $\hat{P}_{i_t j_{t-1}}$ obtained by using equation 3.25 and is illustrated in Figure 3.2.

$$P = \begin{bmatrix} \hat{P}_{11} & \hat{P}_{12} & \hat{P}_{13} \\ \hat{P}_{21} & \hat{P}_{22} & \hat{P}_{23} \\ \hat{P}_{31} & \hat{P}_{32} & \hat{P}_{33} \end{bmatrix}$$

Figure 3.2. P matrix

2. Stationary transition probabilities

If the transition probabilities $\hat{P}_{i_t j_{t-1}}$ are dependent on the states i and j but not on time, then the transition probabilities are said to be stationary or constant probabilities. A conclusion that transition probabilities for Iowa slaughter-hog producers are stationary would be a conclusion that the transition probabilities between size classes are the same over time. The other conclusion, that the transition probabilities are nonstationary, would be a conclusion that the transition probabilities between given size classes are not the same over time.

To determine if the transition probabilities are either stationary or nonstationary, stationary transition probabilities are estimated over all T periods and then used in a testing procedure. Stationary transition probabilities are defined by equation 3.26.

$$\hat{P}_{ij} = \sum_{t=1}^{T} N_{i_t j_{t-1}} \Big/ \sum_{t=1}^{T} \sum_{k=1}^{S} N_{k_t j_{t-1}} \tag{3.26}$$

where

$\hat{P}_{ij}$ = the estimated stationary transition probability for $\hat{P}_{i_t j_{t-1}}$ from equation 3.25 over T periods, and

T = the total number of periods considered.

$\hat{P}_{ij}$ and $\hat{P}_{i_t j_{t-1}}$ are estimated exactly the same way except that $\hat{P}_{ij}$ is estimated by using information from all T periods, whereas $\hat{P}_{i_t j_{t-1}}$ is estimated by using information from only one of the T periods, t.

3. Test for stationarity

Hypothesis II is a statement that the transition probabilities are nonstationary. To test this hypothesis the statistic $-2\log_e\lambda$ is calculated where $-2\log_e\lambda$ is given by equation 3.27.

$$-2\log_e\lambda = 2[\sum_{i=1}^{S} \sum_{j=1}^{S} \sum_{t=1}^{T} N_{i_t j_{t-1}} \Sigma (\log \hat{P}_{i_t j_{t-1}} - \log \hat{P}_{ij})] \qquad (3.27)$$

The statistic $(-2\log_e\lambda)$ has a X^2 distribution with (T-1)(S)(S-1) degrees of freedom.

If the calculated X^2 is greater than the tabulated X^2, then the conclusion is that the transition probabilities are nonstationary and a separate transition matrix must be calculated for each time period. If the calculated X^2 is less than the tabulated X^2, then the estimated transition probabilities $\hat{P}_{i_t j_{t-1}}$ and estimated transition probabilities $\hat{P}_{ij}$ will not differ significantly and the stationary transition probabilities can be used for all periods.

4. Test for homogeneity

The stationarity test is a test for equality of transition probabilities over time. The statistic in equation 3.27 can also be used to test for homogeneity. A homogeneous transition probability can be calculated by using equation 3.26. The only difference between the stationary and homogeneous probability is that the stationary probability is calculated over T periods whereas the homogeneous probability is calculated for one period over g types of hog operations.

To test for stationarity over T periods and for homogeneity over g types of hog operations for a given period, a producer type classification was defined to distinguish producers' hog operations. Producers were grouped on the basis of the type of hog operation they had in 1970 and 1971. Four types of operations were distinguished:

(A) Those that farrow-finish only, i.e., farrow sows and raise all the pigs farrowed for slaughtering purposes minus replacement gilts,

(B) Those that purchase feeder pigs only, i.e., all the pigs raised are purchased,

(C) Those that farrow-finish and sell feeder pigs, i.e., farrow sows and raise a portion of the pigs farrowed for slaughtering purposes and the other portion of the pigs farrowed are sold as feeder pigs, and

(D) Those that have a diversified program, i.e., any combination of the first three types.

To be classified into type A, B, or C, a producer must have had the same type of hog operation in both 1970 and 1971. An example of a diversified type of hog operation, (D), would be a producer who farrowed sows in 1970 and then, in 1971, purchased feeder pigs. There are other combinations that would also classify a producer into the diversified group.

From the information collected in the survey, the type of hog operation a producer had can only be determined for 1970 and 1971. But slaughter-hog production data are available back to 1967. Therefore, it was assumed that if a producer had the same type of hog operation in both 1970 and 1971 he had this same type of hog operation in the years 1967-69.

The results of tests of hypotheses II and III will be used to determine if changes in slaughter-hog production are stationary or nonstationary for producers with the same type of hog operation. For each change period a test for homogeneity will be used to determine if producers with different types of hog operations make different changes in their slaughter-hog production levels. Also, each transition matrix will be analyzed to determine what percentage of the producers have either increased or decreased their size class by one, or two, or more size classes in each change period.

Tests of hypotheses IV and V will provide information about the reasons why producers change their number of slaughter-hogs produced. Multiple regression analysis will be used to test these two hypotheses and will be discussed next.

D. Multiple Linear Regression Analysis

Multiple linear regression analysis will be used to test hypotheses IV and V. Multiple linear regression analysis may be used to predict the size of a dependent variable Y by using V independent variables. The linear regression model is:

$$Y = X\beta_V + u \qquad (3.28)$$

where

u = an $n\times 1$ vector of error terms,

β_V = an $V\times 1$ vector of coefficients,

X = a $n\times V$ matrix of n observations for V independent (explanatory) variables, and

Y = a n×1 vector of observations for the dependent variable,

where it is assumed that

(1) the error terms have zero mean, constant variance, and are not serially correlated,

(2) the number of independent variables V is less than the number of observations, and

(3) the X_{iV} are fixed or are distributed independently of the error term.

The X_{iV} can be either continuous or discontinuous numerical variables. A column of ones is included in the first column of the X matrix when an intercept value is desired in the model.

A linear regression model is estimated by fitting the best straight line to an observed set of data. The criterion of best fit is the least squares criterion, which requires that the sum of the squares of distance between the observed data and the regression line be minimized. The deviation between the observed data and the regression line is referred to as the residual.

To estimate a linear regression model let $\hat{\beta}_V$ be an estimate for the β_V coefficients and Z be an estimate for u. Then equation 3.28 can be written as

$$Y = X\hat{\beta}_V + Z \tag{3.29}$$

Solving for Z by using equation 3.29 results in equation 3.30.

$$Z = Y - X\hat{\beta}_V \tag{3.30}$$

The least squares estimator is obtained by minimizing Z'Z defined in equation 3.31.

$$Z'Z = (Y' - \hat{\beta}_V'X')(Y - X\hat{\beta}_V) \tag{3.31}$$

Expanding equation 3.31 results in equation 3.32.

$$Z'Z = Y'Y - 2Y'X\hat{\beta}_V + \hat{\beta}_V'X'X\hat{\beta}_V \quad (3.32)$$

Taking the first order derivatives of 3.32 with respect to $\hat{\beta}_V$ results in equation 3.33.

$$\partial Z'Z/\partial\hat{\beta}_V = -2Y'X + X'X\hat{\beta}_V + \hat{\beta}_V'X'X = 0 \quad (3.33)$$

Rearranging and combining the last two terms in equation 3.33 results in equation 3.34.

$$\partial Z'Z/\partial\hat{\beta}_V = -2Y'X + 2X'X\hat{\beta}_V = 0 \quad (3.34)$$

Equation 3.34 will reduce to equation 3.35 and these first order equations are termed the normal equations.

$$(X'X)\hat{\beta}_V = (X'Y) \quad (3.35)$$

The normal equations are solved for the $\hat{\beta}_V$ coefficients, but in order to do this the inverse of the (X'X) matrix must exist. If the inverse of the (X'X) matrix does exist, then the solution is given by equation 3.36.

$$\hat{\beta}_V = (Y'X)^{-1}(X'Y) \text{ [10]} \quad (3.36)$$

Once the $\hat{\beta}_V$ coefficients are estimated, then X can be used to estimate or predict the $\hat{Y}_i$ values as defined in 3.37. $\hat{Y}_i$ is a column vector of predicted Y's.

$$\hat{Y}_i = X\hat{\beta}_V \quad (3.37)$$

The total sum of squares of Y(Y'Y) can be partitioned into two parts.

$$Y'Y = \hat{Y}'\hat{Y} + Z'Z \quad (3.38)$$

where

$\hat{Y}'\hat{Y}$ = the sum of squares explained by the regression, and

$Z'Z$ = the sum of squares of deviations.

The portion of the total sum of squares that is determined by Z'Z will affect the explanatory power of the regression model. R_m^2 given by equation 3.39 is a statistic that is used to analyze the explanatory power of a regression model.

$$R_m^2 = \frac{\hat{Y}'Y - n\bar{Y}^2}{Y'Y - n\bar{Y}^2} \qquad (3.39)$$

The R_m^2 is commonly referred to as the coefficient of determination. It indicates how much of the variance in Y is explained by the variance of the X. The greater the R_m^2 the greater will be the explanatory power of the regression model. R_m^2 ranges from zero to one.

In most applications of regression analysis it is also desirable to test hypotheses concerning the significance of one or more coefficients in the model. Hypotheses may be tested by using an F-test, a t-test, or both. To test hypotheses an additional assumption must be introduced. The assumption is that the u_i's are normally distributed.

1. <u>F-test</u>

An F-test may be used to test the overall significance of a regression model or to determine if one or more variables are adding to the explanatory power of the model. The explanatory power of a model or of a variable can be examined by comparing the explained sum of squares for $Y(\hat{Y}'\hat{Y})$ with the total sum of squares for Y. If by including a variable in the regression model the $\hat{Y}'\hat{Y}$ increases by a significant amount, then this additional variable should be included in the regression model because more of the total sum of squares can be explained.

The F-ratio given by 3.40 will give a calculated F-ratio that may be used to make a test of contribution by one or more variables.

$$F = \frac{(\hat{\beta}_f'X_f'Y - \hat{\beta}_r'X_r'Y)/(V_f - V_r)}{Z_f'Z_f/n - V_f} \qquad (3.40)$$

where

$\hat{\beta}_f'X_f'Y$ = the regression (explained) sum of squares for the full model,

$\hat{\beta}_r'X_r'Y$ = the regression (explained) sum of squares for the reduced model,

V_f = the number of independent variables in the full model,

V_r = the number of independent variables in the reduced model, and

$Z_f'Z_f$ = the residual sum of squares for the full model.

The calculated F value is compared to a tabulated F value with $V_f - V_r$ degrees of freedom in the numerator and $n - V_f$ degrees of freedom in the denominator for an assigned probability (significance) level. The significance level for all F-tests and t-tests will be 10% in this study unless otherwise stated. If the tabulated F value is greater than the calculated F value, then one rejects the H_a. If the calculated F value is greater than the tabulated F value then one rejects the H_0. The gneralized H_0 and H_a for comparing full and reduced models are given by 3.41A and 3.41B.

(3.41A) H_0: $\hat{\beta}_V = r_V$; the additional variable(s) added to the regression model has (have) no explanatory power;

(3.41B) H_a: $\hat{\beta}_V = r_V$; the additional variable(s) added to the regression model does (do) make a significant contribution to explaining the total sum of squares in Y_i;

where

$\hat{\beta}_V$ = the estimated value of β_V for the full model, and

r_V = the hypothesized value of β_V and is equal to zero in this case and in all tests in this study.

2. t-test

The t-test is used to determine if a coefficient differs significantly from zero. If the sign of the coefficient was hypothesized to be either positive or negative then a one tailed t-test will be used. If the hypothesized sign of the coefficient is questionable or the actual sign of the coefficient is different than was expected, then a two tailed t-test will be used.

The calculated t-value is defined by equation 3.42.

$$t = \frac{\hat{\beta}_V - r_V}{S\sqrt{b_{ii}}} \qquad (3.42)$$

where

b_{ii} = the i-th diagonal element of the $(X'X)^{-1}$ matrix, and

S = the $\sqrt{S^2}$, where S^2 is the variance of the residual term in the regression model. S^2 is given by equation 3.43.

$$S^2 = \frac{Z'Z}{n-V} \qquad (3.43)$$

The calculated t-value is compared to a tabulated t-value with n-V-1 degrees of freedom. If the tabulated t-value is greater than the calculated value then one rejects the alternative (H_a) hypothesis. If the calculated t-value is greater than the tabulated t-value the H_0 is rejected.

(3.44A) H_0: $\hat{\beta}_V = r_V$; coefficient is equal to zero

(3.44B) H_a: $\hat{\beta}_V \neq r_V$; coefficient is not equal to zero

3. Constrained regression

Constrained regression analysis may be used to test the hypothesis that two or more data sets can be combined to estimate a regression model. An example will be used to illustrate constrained regression analysis. Assuming one has data set 1 and data set 2, a regression model can be constructed using each data set seaprately to estimate model 1 and model 2, respectively. Both models will have β_V coefficients and an intercept value. The question one asks is can data 1 and data 2 be combined into one data set and then be used to estimate a regression model for this new combined data set, call it data set 3. If the residual sum of squares from using data set 3 does not differ significantly from the sum of the residual sum of squares from the separate regressions using data set 1 and data set 2, then one can conclude that the β_V coefficients for data set 1 and data set 2 do not differ significantly. Therefore, one may combine data sets 1 and 2 and use the new data set 3 to estimate the regression model. If the residual sums of squares do differ significantly, then one cannot constrain the coefficients to be the same and the conclusion would be that the β_V coefficients are not the same for the two data sets.

The regression models estimated by using data set 1 and data set 2 will have unrestricted residual sums of squares. Rearranging equation 3.38 the unrestricted residual sum of squares for model 1 and for model 2 is given by 3.45.

$$Z_i'Z_i = Y_i'Y_i - \hat{Y}_i'\hat{Y}_i \qquad (3.45)$$

where i = 1, 2, ..., i; number of data sets. The pooled unrestricted residual sum of squares is equal to the summation of the unrestricted residual sum of squares from model 1 and from model 2 and is given by 3.46.

$$Z'Z = \sum_{i=1}^{2} Z_i{}'Z_i \tag{3.46}$$

The constrained residual sum of squares is equal to the residual sum of squares from model 3, which is a regression on the combined data sets 1 and 2, and is calculated by using equation 3.31.

The F-ratio that uses these different residual sum of squares to test whether the data sets in question can be combined is given by 3.47.

$$F^{(G-1)p}_{(n-Gp)} = \frac{Z_{*c}{}'Z_{*c} - Z'Z/(G-1)p}{Z'Z/(n-Gp)} \tag{3.47}$$

where

$Z_{*c}{}'Z_{*c}$ = the constrained residual sum of squares,

G = the number of data sets being combined,

p = the number of variables being constrained, and

n = the total number of observations.

The calculated F value is compared to a tabulated F value with (G-1)p degrees of freedom for the numerator and (n-Gp) degrees of freedom for the denominator. If the tabulated F value is greater than the calculated F value then one rejects the H_a. If the calculated F value is greater than the tabulated F value then one rejects the H_0. The generalized H_0 and H_a for testing coefficients are given by 3.48.

$$\begin{aligned} H_0&: \hat{\beta}_i = \hat{\beta}_j \\ H_a&: \hat{\beta}_i \neq \hat{\beta}_j \end{aligned} \tag{3.48}$$

where

$\hat{\beta}_i$ = the estimated set of coefficients for data set i, and

$\hat{\beta}$ = the estimated set of coefficients for data set j.

Hypotheses four and five deal with the differences in the factors that cause producers with different types of hog operations to change production levels, with comparing producers who increase and decrease their slaughter-hog production levels, and the differences in the factors that cause producers to change their slaughter-hog production levels between the four different change periods.

Constrained regression analysis will be used to determine (1) if the data can be combined within one change period for producers with different types of hog operations, (2) if data can be combined within one change period for producers who changed production levels in the opposite direction, and (3) if the same sets of data from the four different change periods can be combined to estimate one model over time.

a. Steps of constrained regression analysis The constrained regression analysis procedure involves several steps. Later steps will be completed only if the results of previous steps so dictate.

The first three steps of constrained regression analysis are a procedure for determining if all the data for a given change period can be combined to estimate one model. The steps are:

(1) Estimate four separate unrestricted regression equations for each change period and calculate the residual sum of squares for each by using equation 3.49.

$$Z_{ijt}'Z_{ijt} = Y_{ijt}'Y_{ijt} - \hat{Y}_{ijt}'\hat{Y}_{ijt} \qquad (3.49)$$

where Z_{ijt} is the vector of residuals for the i-th type of hog operation, the j-th change direction, and the t-th time period. There are k equations to be estimated where

k = (i)(j)(t);

i = F, C

where F = the farrow only type of hog operation, and

C = the combination type of hog operation;

j = I, D

where I = increased production, and

D = decreased production; and

T = 1, 0, 9, 8

where 1 = the 1970-71 change period,

0 = the 1969-70 change period,

9 = the 1968-69 change period, and

8 = the 1967-68 change period.

For example, the k equations to be estimated in step one for the 1970-71 change period are:

1) FI1,

2) FD1,

3) CI1, and

4) CD1.

Another example would be CD8, which represents the combination type of hog operations which decreased slaughter-hog production levels in the 1967-68 change period.

(2) Estimate one pooled restricted equation using all the data for year t with intercept dummy variables for type and change direction and calculate the residual sum of squares by using equation 3.49. The

equation for the T-th change period is denoted by: FCIDT = FIT + FDT + CIT + CDT. Step (2) will restrict the slope coefficients $\hat{\beta}_{ijt}$ to be the same for all the data for the T-th change period.

(3) Calculate an F-ratio for FCIDT by using equation 3.47. If the calculated F-value is greater than the tabulated F-value then one rejects the H_0 that the slope coefficients are equal. If the calculated F-value is less than the tabulated F-value then one rejects the H_a.

If the results of step (3) lead to rejection of the H_0 then further steps will be carried out to determine if there are other ways in which the data could be combined for a particular year.

(4) Estimate two pooled restricted equations over the same change direction (j) with an intercept dummy variable for type and calculate the residual sum of squares by using equation 3.49. The equations to be estimated for the T-th change period are denoted by: (1) FCIT = FIT + CIT, and (2) FCDT = FDT + CDT. Step (4) will restrict the slope coefficients $\hat{\beta}_{ijt}$ to be the same for the combined data sets.

(5) Calculate F-ratios for FCIT and FCDT by using equation 3.47. If the calculated F value is greater than the tabulated F-value then one rejects the H_0 that the slope coefficients are equal. If the calculated F-value is less than the tabulated F-value then one rejects the H_a. Steps (6) and (7) will be carried out only if H_a in step (5) is rejected.

(6) Estimate two pooled restricted equations over the same change direction, (j), without including an intercept dummy variable for type and calculate the residual sum of squares by using equation 3.49. By not having a dummy variable in the equation to indicate type, one is restricting the intercept value to be the same for the two producer

types.

(7) Calculate F-ratios for FCIT and FCDT by using equation 3.40. If the calculated F-value is greater than the tabulated F-value then one rejects the H_0 that the intercept values are the same for the two data sets. If the calculated F-value is less than the tabulated F-value then one rejects the H_a.

Steps eight through eleven are carried out to determine if data can be combined for hog operations of the same type that change production levels in different directions.

(8) Estimate two pooled restricted equations over the same type of hog operation, (i), with an intercept dummy variable for the change in direction and calculate the residual sum of squares by using equation 3.49. The equations to be estimated for the T-th change period are denoted by: (1) FIDT = FIT + FDT, and (2) CIDT = CIT + CDT. Step (8) will restrict the slope coefficients to be the same for the combined data sets.

(9) Calculate F-ratios for FIDT and CIDT by using equation 3.40. The H_0, H_a, and conclusions from comparing the calculated F-values versus the tabulated F-values are the same as stated in step (5). If the H_a in step (9) is rejected only when will steps (10) and (11) by completed.

(10) Estimate two pooled restricted equations over the same type of hog operation, (i), without using an intercept dummy variable for the change in direction and calculate the residual sum of squares by using equation 3.49.

(11) Calculate F-ratios for FIDT and CIDT by using equation 3.40.

The H_0, H_a, and conclusions from comparing the calculated F-values versus the tabulated F-values are the same as stated in step (7).

(12) Estimate pooled restricted equations over different time periods with intercept dummy variables for type and change direction. Calculate the residual sum of squares by using equation 3.49. Step (12) will restrict the slope coefficients to be the same for the combined data sets.

(13) Calculate the appropriate F-ratios using equation 3.40. The H_0, H_a, and conclusions from comparing the calculated F-values versus the tabulated F-values are the same as stated in step (5). Steps (14) and (15) will be completed only if the H_a in step (13) is rejected.

(14) Estimate pooled restricted equations over different time periods without intercept dummy variables for type and change direction. Calculate the residual sum of squares by using equation 3.49.

(15) Calculate the appropriate F-ratios by using equation 3.40. The H_0, H_a, and conclusions from comparing the calculated F-values versus the tabulated F-values are the same as stated in step (7).

Depending upon the outcome of steps 3, 5, 7, 9, 11, 13, and 15, the appropriate data sets will be used to estimate regression models to predict changes in the number of slaughter-hogs sold. Variables will be deleted from the regression models until all the variables in the model are significant at the 10% probability level.

b. Data Assumption (3) for the regression analysis states that the number of explanatory variables must be less than the number of observations. It was not possible to build a regression model for each one of the types of hog operations because of the lack of a sufficient number of observations. Therefore, two groups of hog operation types will be used in the constrained regression analysis. They are: (1) the farrow only group and (2) those who do not farrow only or groups B, C, and D combined from the previous type breakdown on page 43. The latter will be referred to as the combination type of hog operation.

The variables used to measure the economic, resource, and chance factors referred to in hypotheses IV and V are given in Table 3.6. The dependent variable is the change in the number of slaughter-hogs produced.

Table 3.6. Economics, resource, and change importance-scored variables

A. Economic factors
   1) Price of feeder pigs
   2) Expected price of slaughter-hogs
   3) Expected price of fed cattle
   4) Corn prices
   5) Hog-corn ratio
B. Resource factors
   1) Labor supply
   2) Feed supply
   3) Capital supply
C. Chance factors
   1) Average conception rates
   2) Average litter size
   3) Disease problems
   4) Health of operator

These twelve variables are a special kind of variable called importance scored variables that employ the concepts of economic psychology to measure economic behavior. Economic and psychological variables are both used in the field of economic psychology to explain human behavior. By using economic psychology concepts, one should be able to predict human behavior more accurately.

Tilley [38] used economic psychology to determine the psychological factors influencing hog marketing decisions. Two specific marketing activities were analyzed. They were selection of outlet and choice of market weight. The results of the study are hypotheses about the determinants of the relative importance of psychological factors that affect producers' hog outlet type choices and choices of market weight. Other applied research work employing the theory of economic psychology has been done by Skinner [34], Ladd [21], and Ladd and Oehrtman [26].

It must be realized that incorporating psychological variables will not make the analysis perfect. Problems still remain in that the assumption must be made that producers will react consistently to the factors that cause changes in their economic and psychological variable evaluation. On the other hand, the learning process may change ones perception of the economic and psychological conditions presented him. He may make different decisions at a later date to a situation that was perceived to be the same as before.

In this study, importance scored variables will be used to measure how important a producer feels a particular variable was in causing him to make changes in his slaughter-hog production levels. This is an improvement over the method used in the USDA study. In the USDA study, importance of a variable was measured by just totalling the number of times a given variable was mentioned. That method permits no differentiation in the relative importance of a variable between the producers who mentioned that variable. This study will allow two producers to mention the same variable and to assign a different importance to that variable if so desired.

The importance scores for the economic, resource and chance variables were converted to standard normal deviates before the responses were used in the regression models. Table 3.7 gives the standard normal deviate for each importance score. The justification for converting the importance scores to standard normal deviates rests on the proposition that respondents assigning scores near either end of the scale understate differences in beliefs about importance as compared to respondents assigning scores near the middle of the scale [27b]. Both the standard normal deviates and the non-importance scored variables for producers who decreased production were multiplied by a negative one so that signs of coefficients would be comparable (i.e., all coefficients would indicate impacts on absolute amount of change).

4. Variables used to test hypothesis IV

This section will discuss the expected signs of the importance and non-importance scored variables. Table 3.8 identifies the variables that will be used in testing hypothesis IV and indicates the expected signs of the $\hat{\beta}_V$ coefficients.

Economic importance scored variables were included to give an indication of how important economic conditions are in affecting a

Table 3.7. Standard normal deviates of responses [4]

Response	Deviate	Response	Deviate	Response	Deviate	Response	Deviate	Response	Deviate
1	-2.33	21	-0.81	41	-0.23	61	0.28	81	0.88
2	-2.05	22	-0.77	42	-0.21	62	0.31	82	0.92
3	-1.88	23	-0.74	43	-0.18	63	0.33	83	0.95
4	-1.75	24	-0.71	44	-0.15	64	0.36	84	0.99
5	-1.64	25	-0.67	45	-0.13	65	0.39	85	1.04
6	-1.55	26	-0.64	46	-0.11	66	0.41	86	1.08
7	-1.48	27	-0.61	47	-0.08	67	0.44	87	1.13
8	-1.41	28	-0.58	48	-0.05	68	0.47	88	1.17
9	-1.34	29	-0.55	49	-0.03	69	0.49	89	1.23
10	-1.28	30	-0.52	50	-0.00	70	0.52	90	1.28
11	-1.23	31	-0.49	51	0.03	71	0.55	91	1.34
12	-1.17	32	-0.47	52	0.05	72	0.58	92	1.41
13	-1.13	33	-0.44	53	0.08	73	0.61	93	1.48
14	-1.08	34	-0.41	54	0.11	74	0.64	94	1.55
15	-1.04	35	-0.39	55	0.13	75	0.67	95	1.64
16	-0.99	36	-0.36	56	0.15	76	0.71	96	1.75
17	-0.95	37	-0.33	57	0.18	77	0.74	97	1.88
18	-0.92	38	-0.31	58	0.21	78	0.77	98	2.05
19	-0.88	39	-0.28	59	0.23	79	0.81	99	2.33
20	-0.84	40	-0.25	60	0.25	80	0.84		

Table 3.8. Variables to be tested in the multiple regression analysis. Dependent variable is the change in the number of slaughter-hogs sold from year to year.

Variable & Symbol	Hypothesized Sign of the Coefficient
I. Importance Scored Variables	
A. Economic	
1. Price of feeder pigs (PFP)	+
2. Expected price of slaughter-hogs (EPSH)	+
3. Expected price of fed cattle (EPFC)	+
4. Corn prices (CP)	+
5. Ratio between hog prices and corn prices (RHC)	+
B. Resource	
6. Labor supply (LS)	+
7. Feed supply (FS)	+
8. Capital supply (CS)	+
C. Chance	
9. Average conception rates (ACR)	+
10. Average litter size (ALS)	+
11. Disease problems (DP)	+
12. Health of operator (HO)	+
II. Nonimportance Scored Variables	
A. Producer Characteristics	
13. Age of producer (AGE)	–
14. Number of years of education (ED)	?
15. Tenant or owner operator (00)	?

Table 3.8 (Continued)

	Variable & Symbol	Hypothesized Sign of the Coefficient
	16. Number of acres owned in 1971 (AW71)	?
B.	Farm Characteristics	
	17. Number of livestock enterprises (LVSE)	?
	18. Total number of acres operated in 1971 (AP71)	?
C.	Enterprise Characteristics	
	19. Excess capacity in 1971 (EC)	+
	20. % of gross farm sales from hog enterprise in 1971 (PFS71)	+
	21. Number of hogs sold in period t-1	+
	22. Type of hog operation	?
	23. Direction of change in production level	?

producer's decision to change slaughter-hog production levels.

Resource importance scored variables were included to reflect the possibility that producers can change slaughter-hog production levels due to increased or decreased resource levels. Certain levels of resources are needed for all size hog operations and a change in labor, capital, and/or feed supplies will have an effect upon production levels.

Chance importance scored variables were includes to determine how luck and management ability play a role in changed slaughter-hog production levels. Average conception rates, average litter size, and disease problems are related to both luck and management. A better managed herd of hogs should have less problems with these three variables. Health of the operator is also considered to be a luck factor.

All of the importance scored variables are expected to have a positive coefficient. However, it is also recognized that there are certain conditions in which the sign of the coefficient could be negative. Therefore, an importance scored variable with a negative coefficient will be retained in the final model if the coefficient is significant by using a two tailed t-test. Figures 3.3 and 3.4 will be used to illustrate the possible relationships that could take place.

Figure 3.3 illustrates the possible relationships that could take place between the size of the increase in the number of slaughter-hogs sold and the importance scores for producers increasing production.

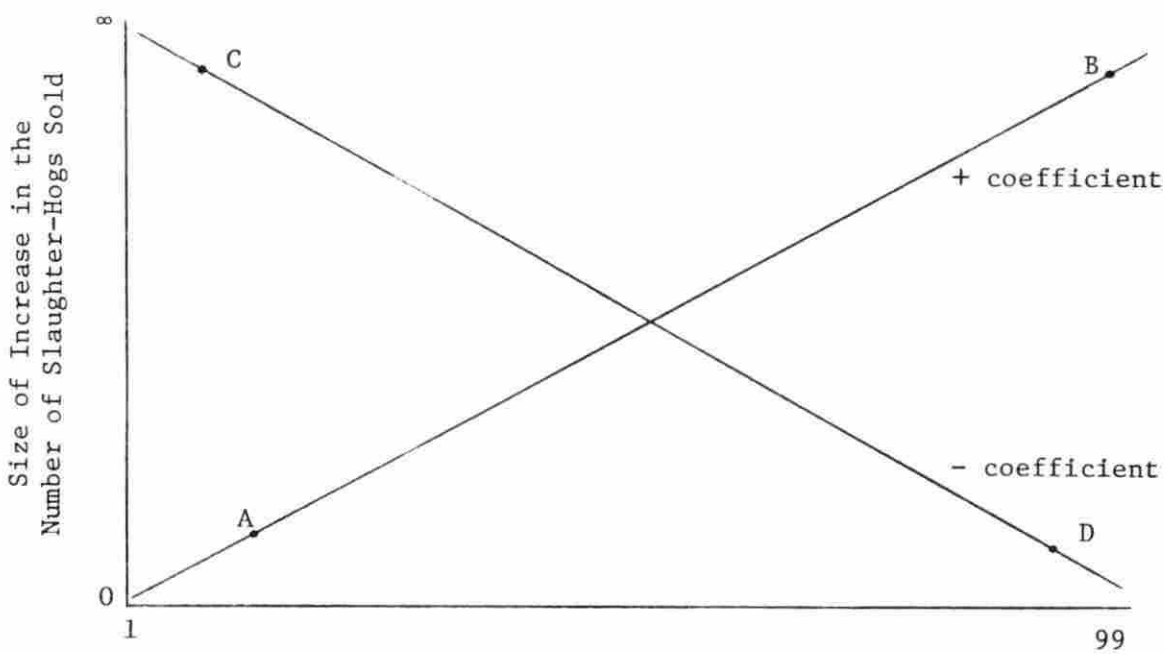

Figure 3.3. Relationships for increased production

Line AB represents a positive relationship. As the importance score of a variable increases the greater will be the increased number of hogs sold for slaughter. This relationship would result in variables having positive coefficients. Line CD represents a negative relationship. As the importance score of a variable increases, the smaller will be the increase in the slaughter-hog production level.

Figure 3.4 illustrates the possible relationships that could take place between the size of the decrease in the number of slaughter-hogs sold and the importance scores for producers decreasing production. The vertical axis of the graph is reversed to illustrate the decreased production levels. Also, notice that the importance scores are reversed from Figure 3.3 and multiplied by a negative one (see p. 62).

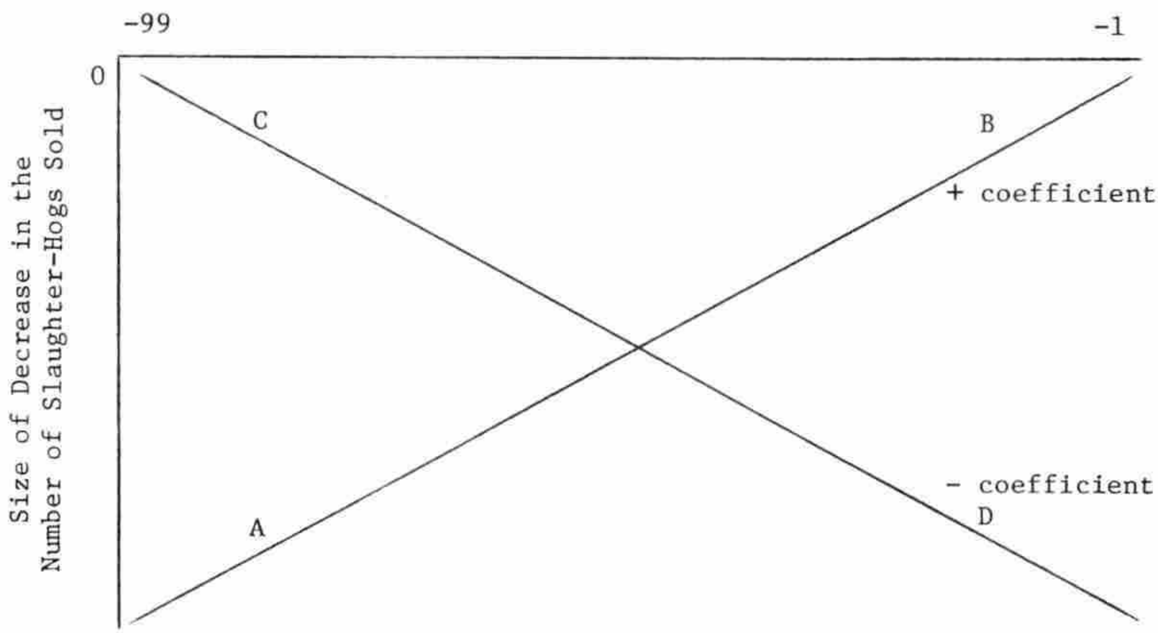

Figure 3.4. Relationship for decreased production

Line AB represents a positive relationship. As the importance score of a variable increases the greater will be the decrease in the number of hogs sold for slaughter. This relationship would result in variables having positive coefficients.

Line CD represents a negative relationship. As the importance score of a variable increases the smaller will be the decrease in the slaughter-hog production level.

A positive coefficient indicates that the variable is more important in causing large changes and less important in causing small changes. A negative coefficient, on the other hand, indicates that the variable is more importance in causing small changes, but less important in causing large changes. The hypothesized positive signs for the importance scored variables are based on the assumption that higher importance scores for these variables will be associated with larger increases and decreases in slaughter-hog production levels.

The expected signs of the producer characteristic coefficients are questionable expept for the age of the producer. Age of the producer is expected to have a negative coefficient because a producer reaching retirement age would be more likely to make small changes in his slaughter hog production.

Expected signs of coefficients of number of years of education (ED), tenant or owner operator (OO), number of acres owned in 1971 (AW71), number of livestock enterprises (LVSE), total number of acres operated in 1971 (AP71), type of hog operation, and direction of change in the slaughter-hog production are not specified.

Excess capacity (EC) is expected to have a positive coefficient. If a producer had excess capacity at the end of 1971, it seems most reasonable that he made a large change in his production level in the past year. It is assumed that, in most cases, producers keep their facilities at or near peak production levels.

Percentage of gross farm sales from the hog enterprise in 1971 (PFS71) and the number of hogs sold in period t-1 (HS) are both expected to have a positive coefficient. As PFS71 increases, the more likely a producer is to have made a large change in his slaughter-hog production during 1971. As HS becomes larger the greater is the chance a producer made a large change in his slaughter-hog production level.

It is realized that the producer, farm, and enterprise characteristics will be actual for 1971 but not for 1967 through 1970. But if any of these variables are significant in the 1971 change period then they will be included in the other three change-period regression models. The assumption will be made that the 1971 data are good estimates of the values of these variables in the other four years.

For each regression model the following results will be presented.

(1) The variables that are significant at the 10% probability level.

(2) $\hat{\beta}_V$ coefficients from using equation 3.36.

(3) t value for each $\hat{\beta}_V$ coefficient from using equation 3.42.

(4) R_m^2 value from using equation 3.99.

(5) The F values from using equation 3.33 that were calculated in steps 3, 5, 7, 9, 11, 13, and 15 of the constrained regression analysis for the 1971 data.

E. Chapter Summary

The first part of this chapter discussed the data source and data collected. Next the methods, procedures, and specific data requirements needed to test each one of the hypotheses in Chapter II were presented. The three methods presented were discriminant analysis, Markov-chain analysis, and multiple regression analysis.

Chapter IV will present the results of testing each of the hypotheses by using the three analytical procedures.

IV. RESULTS

This chapter will present the results of tests of the five hypotheses presented in Chapter II. First, the results obtained by using discriminant analysis to test hypothesis I will be presented. Second, the results obtained by using Markov chain analysis to test hypotheses II and III will be presented. Third, the results obtained by using constrained multiple regression analysis to test hypotheses IV and V will be presented.

A. Discriminant Analysis Results

The thirteen variables listed in Table 3.4 were used initially to estimate the discriminant function. The variables that did not have a significant t-value at the .10 probability level were deleted from the initial function. Table 4.1 presents the variables in the final model, the coefficient, and t value for each variable and the importance ranking of each of the variables.

The F-ratio given by equation 3.24 was used to determine if there was a significant difference between the full model using thirteen independent variables and the reduced model using four independent variables.

$$F = \frac{.069 - .058}{1 - .069} \times \frac{473 - 4 - 9 - 1}{9} = .6025$$

The tabulated F-value with 459 degrees of freedom in the numerator and 9 degrees of freedom in the denominator is equal to 2.16 at the .10 probability level. The tabulated F-value is greater than the calculated F-value, therefore the hypothesis that the additional variables do not

Table 4.1. Variables in the final discriminant function

	Coefficient	t-value	Standardized Coefficient	Importance Ranking
X_0 -- $\hat{c}_{ij}$	+1.8177			
X_1 -- capital-intensity of swine facilities (CI)	-0.4211	-1.4215*	-.1604	4
X_2 -- number of slaughter-hogs sold in 1967 (HS67)	-0.0008	-2.9040***	-.3351	2
X_3 -- number of different market outlets sold to (NOST)	0.2476	1.9054**	.2175	3
X_4 -- number of years of education (EDUC)	0.1964	3.8010***	.4517	1

*P < .10.
**P < .05.
***P < .01.

contribute to the discriminant function is not rejected.

To determine if the final discriminant function is significant, the F-ratio given by equation 3.21 was used. The $R_D{}^2$ value for the final discriminant function is equal to .058.

$$F = \frac{.058}{1 - .058} \times \frac{473 - 4 - 1}{4} = 7.204$$

The tabulated F-value, with 468 and 4 degrees of freedom in the numerator and denominator, respectively, is equal to 3.76 at the .10 probability level. The calculated F-value is greater than the tabulated F-value, therefore the null hypothesis that the function is not significant is rejected.

1. Coefficient interpretation

The coefficient of capital-intensity of swine facilities (CI) has a negative sign. The negative sign indicates that producers with capital-intensive swine facilities are more likely not to make changes in their slaughter-hog production levels. The CI variable was coded as a 1 or 0 dummy variable. A 1 meant that a producer had capital-intensive swine facilities and a 0 meant that a producer did not have capital-intensive swine facilities. If a producer had either total or partial confinement buildings designed specifically for swine, then he was considered to have capital-intensive swine facilities. If a producer was using facilities not permanently designed for swine, then he was considered not to have capital intensive swine facilities. If CI is equal to one rather than zero, the left hand side of expression 3.15 is decreased and, consequently, the chance a producer will be classified into the group (2) that made not changes in slaughter-hog production level is increased.

CI is the least important discriminating variable of the four variables in the discriminant function because it had the smallest standardized coefficient. The relative importance of CI in the function is also exemplified by the fact that it is the only variable not significant at a probability level less than .10.

The coefficient of number of hogs sold in 1967 (HS67) had a negative sign. This sign indicates that, as the number of hogs sold for slaughter in 1967 increases, the less likely is a producer to have made a substantial change in his slaughter-hog production level from 1967 to 1971. This conclusion is the opposite of what was hypothesized. It was hypothesized that the fewer slaughter-hogs a producer sold in 1967 the less likely he would have made a substantial change in his slaughter-hog production level from 1967 to 1971. HS67 was the second most important discriminating variable in the discriminant function. Its t-value was significant at the .01 probability level.

The coefficient of number of outlets sold to (NOST) had a positive sign. The positive sign indicates that, as the number of market outlets sold to from 1967 to 1971 increases, the more likely a producer is to have made a tolerance level change in his slaughter hog production level from 1967 to 1971. NOST was used to indicate a producer's attentiveness to the market situation and to other aspects of his hog enterprise and farming operation. NOST was the third most important discriminating variable and the coeffient for NOST was significant at the .05 probability level.

The coefficient of number of years of education [EDUC] had a positive sign. The positive sign indicates that, as the number of years of education increases, the more likely a producer will have made changes in his slaughter-hog production level from 1967 to 1971. EDUC was the most important discriminating variable in the discriminant function. It had the largest standardized coefficient and the coefficient was significant at the .01 probability level.

Table 4.2 presents the variables that were not significant in the initial discriminant function at the .10 probability level. The number of acres operated (AO) was significant at the .15 probability level and was the most important variable among the nonsignificant variables. Age of producer (AGE) and excess capacity (EC) at the end of 1971 were significant at the .20 probability level and were the second and third most important variables among the nonsignificant variables. The sign of the coefficient for the age of producer was negative and the sign of the coefficient for the excess capacity was positive. In both cases the signs of the coefficients were as expected. The use of computer records (COMRD) was significant at the .25 probability level and was the fourth most important variable. Quality of swine records (QSR), use of futures contracts (FC), owner-operator (OO), number of bids received (NBR), and number of livestock enterprises (LVSE) were not significant at a probability level less than .25. QSR, OO, NBR, and LVSE were all found to have positive coefficients as was expected.

Table 4.2. Nonsignificant variables at the .10 probability level in the initial discriminant function

	Coefficient	t-value	Std. Coefficient	Importance Ranking
Acres Operated	-.0006	-1.1051*	-.1463	1
Quality of Swine Records	.0228	.0816	.0093	9
Futures Contracts	-.1179	-.2035	-.0237	8
Computer Records	-.3244	-.7161***	-.0861	4
Owner-Operator	.1762	.6583	.0778	5
Number of Bids	.05800	.3914	.0515	7
Excess Capacity	.2223	.9621**	.1104	3
AGE	-.0110	-.9216**	-.1176	2
Livestock Enterprises	.0776	.6571	.0767	6

*P > .15.
**P > .20.
***P > .25.

2. Classification

The most appropriate classification criterion to use for a two-group analysis with unknown probabilities is given by expression 3.15. From 3.14

$$\hat{D}_{12} = \begin{bmatrix} -0.4211 \\ -0.0008 \\ 0.2476 \\ 0.1964 \end{bmatrix}_{4\times 1},$$

and, from 3.13

$$\hat{C}_{12} = \tfrac{1}{2} \left[\begin{pmatrix} .8127 \\ 401.281 \\ 1.7466 \\ 11.2755 \end{pmatrix} + \begin{pmatrix} .8636 \\ 503.473 \\ 1.5727 \\ 10.3727 \end{pmatrix} \right]' \begin{bmatrix} -0.4211 \\ -0.0008 \\ 0.2476 \\ 0.1964 \end{bmatrix}$$

$$= 1.8177$$

Then 3.15 can be rewritten as

$$g_1: \quad X' \hat{D}_{12} > \hat{C}_{12} = 1.8177$$

$$g_2: \quad X' \hat{D}_{12} < \hat{C}_{12} = 1.8177$$

The results obtained by applying the classification criterion are presented in table 4.3. 235 of the 363 producers actually in group 1 were correctly classified into group 1. 128 producers who were actually in group 1 were misclassified into group 2. 69 of the 100 producers who were actually in group 2 were classified into group 2. 41 producers who were actually in group 2 were misclassified into group 1.

The P^2 defined by equation 3.16 is calculated in expression 4.1.

Table 4.3. Results of classification using the classification criterion in 3.15.

		Classified Type		
		1	2	
Actual Type	1	235* .497**	128 .271	363
	2	41 .087	69 .145	110
		276	197	

[a]actual number of producers.
[b]proportion of total.

$$P^2 = \frac{235 + 69}{473} = .6427 \tag{4.1}$$

P^2 is the percentage of producers that the discriminant function correctly classified. The discriminant function does a pretty good job of classifying producers into either group 1 or 2 when using the most appropriate classification criterion.

If one knows the probabilities of drawing a producer from either group 1 or 2 on random chance basis, then 3.16 should be used as the classification criterion. Table 4.4a presents the results when these probabilities are assumed to be known. 359 of the 363 producers actually in group 1 were correctly classified into group 1. Four producers who were actually in group 1 were misclassified into group 2. One producer of the 110 producers in group 2 was correctly classified into group 2. 109 of the 110 producers in group 2 were misclassified into group 1. The proportion of correct classifications is equal to .762, and the proportion of misclassifications is equal to .238.

Table 4.4a. Results of classification using the classification criterion in 3.16.

		Classified Type 1	Classified Type 2	
Actual Type	1	359 .760	4 .008	363
	2	109 .230	1 .002	110
		468	5	

Table 4.4b is a random chance classification table that can be constructed when one assumes known prior probabilities of drawing a producer from either group 1 or 2 on a random chance basis. 363 producers in the sample are in group 1, therefore $y_1 = 363/473 = .77$. 110 producers in the sample are in group 2, therefore $y_2 = 110/473 = .23$.

Table 4.4b. Random chance classification criterion

		Classified Type 1	Classified Type 2	
Actual Type	1	$y_1^2 = .59$	$y_1y_2 = .18$	.77
	2	$y_2y_1 = .18$	$y_2^2 = .05$	.23
		.77	.23	1.00

When comparing Table 4.4a with Table 4.4b, it can be seen that the random chance probabilities are quite different than the probabilities generated from the discriminant analysis classification results. Assuming one has known probabilities there is a strong tendency to classify producers into group 1.

P^2 from equation 3.18, when assuming known probabilities, is calculated in 4.2.

$$P^2 = \frac{359 + 1}{473} = .76 \tag{4.2}$$

This procedure assuming known probabilities correctly classified 76 percent of the producers. From Table 4.4b it can be seen that, on a random chance basis, one would expect to correctly classify 64 percent of the producers. The discriminant function correctly classified 76 percent of the producers. This is 12 percent better than if a random chance basis was used to determine classification.

This same type of comparison between the P^2 for the discriminant function that assumed unknown prior probabilities could not be made as eluded to in the discriminant analysis section in Chapter III.

Comparing the P^2 for the discriminant function assuming known and unknown prior probabilities shows that, when known prior probabilities are assumed, 12 percent more producers are correctly classified. But it is not clear that it is appropriate to use the percentage of producers in each group in the sample as the random probabilities. Second, use of this classification procedure severely misclassifies those producers in group 2. It would seen reasonable that, even though the P^2 is higher if this classification procedure is used, there should be more producers classified into group 2 to make the results seem more believable.

These results suggest that Hypothesis I should be partially rejected. Four of the thirteen variables were significant at the .10 probability level. The $R_D{}^2$ for the discriminant function was equal to .058, and the P^2 for the appropriate classification procedure was equal to .64. The P^2 in discriminant analysis is analogous with the R^2 in regression analysis, while the R_D^2 is simply interpreted as the amount of the variance that was explained [28]. Due to the relatively large sample size, this relatively small R_D^2 is significant.

3. Summary of discriminant analysis results

The four variables that can be used to discriminate between slaughter-hog producers who made changes and those who did not make changes from 1967 to 1971 in their production levels are:

(1) Amount of capital invested in swine facilities,

(2) The number of slaughter-hogs sold for slaughter in 1967,

(3) The number of different market outlets sold to from 1967 to 1971, and

(4) The number of years of education.

The number of years of education was found to be the best discriminator, the number of slaughter-hogs sold in 1967 the second best discriminator, the number of different market outlets sold to to be the third best discriminator, and the capital-intensity of swine facilities was found to be the fourth best discriminator.

The number of acres operated, the type of swine records, the use of futures markets, the use of farm computer records, whether the producer was an owner or tenant operator, the number of different bids received when selling slaughter-hogs, the amount excess swine facility capacity at the end of 1971, the age of the producer, and the number of different livestock enterprises on the farm were other variables tested. None of these nine variables were significant discriminators at the .10 probability level or less and, therefore, it was concluded that they are not good characteristics to use to distinguish producers who make changes in slaughter-hog production levels and those producers who do not make changes in slaughter-hog production levels.

B. Markov Chain Analysis Results

First, sixteen transition probability matrices were estimated; a transition matrix was estimated for each of the four hog production types for each of the four change periods. These sixteen matrices were used in the stationarity test for hypothesis II and the homogeneity test for hypothesis III. The following notation was devised to identify the matrices. T_{ij} denotes the transition matrix for change period i and hog operation type j where:

i = 78 for the 1967 to 1968 change period,

i = 89 for the 1968 to 1969 change period,

i = 90 for the 1969 to 1970 change period,

i = 01 for the 1970 to 1971 change period,

and

j = F for the farrow only type of hog operation,

j = PO for the purchase feeder pigs only type of hog operation,

j = FS for the farrow and sell feeder pigs type of hog operation, and

j = D for the diversified type of hog operation.

The weights given in Table 3.1 were used when estimating the transition matrices so that the results are statewide estimates. Twelve producers gave slaughter-hog production information for one or more years that could not be used and were therefore eliminated in the analysis.

The sixteen matrices were used to estimate four stationary transition probability matrices, one for each type of hog operation. Equation 3.24 was used to estimate each stationary transition probability in the matrix. The stationary transition probability matrices are identified by $ST._j$ where . indicates that the matrix is estimated over all i change periods and j represents the type of hog operation.

1. Results of test for stationarity

To test for stationarity, stationary transition matrices were estimated for the farrow only type of hog operation ($ST._{,F}$), the purchase feeder pigs only type of hog operation ($ST._{,PO}$), the farrow sows and sell feeder pigs type of hog operation ($ST._{,FS}$), and the diversified type of hog operation ($ST._{,D}$). The four matrices are given in Tables 4.6, 4.7, 4.8 and 4.9.

Equation 3.25 was used to test for stationarity for each of the four types of hog operations. The results of the tests are presented in Table 4.5.

Table 4.5. Results of tests for stationarity

Type of Hog Operation	Calculated X^2	Standardized X^2	Probability of a type 1 error
Farrow Only	24136.50	203.8682	$P < .01$
Purchase Only	8828.198	117.0344	$P < .01$
Farrow and Sell Feeder Pigs	8553.0238	114.9471	$P < .01$
Diversified	18772.376	177.9217	$P < .01$

Table 4.6. Matrix $ST_{.,F}$ -- Farrow only type of hog operation

Size t	Size t-1 0	1	2	3	4	5	6	Row total
0	4931 59.8	0 0.0	496 1.1	127 .6	0 0.0	0 0.0	0 0.0	5554 4.5
1	1194 14.5	11404 83.7	3282 7.4	258 11.2	0 0.0	0 0.0	0 0.0	16138 13.2
2	880 10.7	1968 14.4	35219 79.4	3368 15.7	1364 8.9	143 .8	0 0.0	42942 35.2
3	813 9.9	258 1.9	3709 8.4	13323 62.2	2056 13.5	245 1.5	0 0.0	20404 16.7
4	93 1.1	0 0.0	1382 3.1	3588 16.8	9347 61.2	1755 10.4	0 0.0	16165 13.2
5	333 4.0	0 0.0	282 .6	747 3.5	2503 16.4	14128 83.8	367 15.5	18360 15.0
6	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	586 3.5	1996 84.5	2582 2.1
Column total	8244 6.7	13630 11.2	44370 36.3	21411 17.5	15270 12.5	16857 13.8	2363 1.9	122145

Table 4.7. Matrix $ST._{,PO}$ -- Purchase feeder pigs only type of hog operation

Size t	Size t-1: 0	1	2	3	4	5	6	Row total
0	761	0	258	258	0	0	0	1277
	35.0	0.0	2.5	6.0	0.0	0.0	0.0	5.1
1	369	2952	627	258	0	0	0	4206
	17.0	78.0	6.0	6.0	0.0	0.0	0.0	16.7
2	952	738	8639	765	93	51	0	11238
	43.8	19.5	82.9	17.6	4.0	3.5	0.0	44.7
3	93	93	892	2244	512	143	0	3977
	4.3	2.5	8.6	51.8	21.8	9.9	0.0	15.8
4	0	0	0	617	1416	102	0	2135
	0.0	0.0	0.0	14.2	60.3	7.1	0.0	8.5
5	0	0	0	194	328	1000	24	1546
	0.0	0.0	0.0	4.5	14.0	69.2	3.9	6.2
6	0	0	0	0	0	149	590	739
	0.0	0.0	0.0	0.0	0.0	10.3	96.1	2.9
Column total	2175	3783	10416	4336	2349	1445	614	25118
	8.7	15.1	41.5	17.3	9.4	5.8	2.4	100.2

Table 4.8. Matrix $ST._{FS}$ -- Farrow sows and sell feeder pigs type of hog operation

Size t	Size t-1: 0	1	2	3	4	5	6	Row total
0	1306	0	0	0	51	0	0	1357
	60.2	0.0	0.0	0.0	2.1	0.0	0.0	6.9
1	789	2706	519	51	93	0	0	4158
	36.4	59.6	10.1	2.3	3.9	0.0	0.0	21.1
2	75	1785	4169	726	270	0	0	7025
	3.5	39.3	80.8	32.2	11.2	0.0	0.0	35.7
3	0	0	355	1106	321	24	0	1806
	0.0	0.0	6.9	49.1	13.3	1.0	0.0	9.2
4	0	51	93	346	1424	203	0	2117
	0.0	1.1	1.8	15.4	59.0	8.8	0.0	10.7
5	0	0	24	24	253	1935	75	2311
	0.0	0.0	.5	1.1	10.5	83.6	8.9	11.7
6	0	0	0	0	0	153	772	925
	0.0	0.0	0.0	0.0	0.0	6.6	91.1	4.7
Column total	2170	4542	5160	2253	2412	2315	847	19699
	11.0	23.1	26.2	11.4	12.2	11.8	4.3	100.0

Table 4.9. Matrix $ST._{,D}$ — Diversified type of hog operation

Size t	Size t-1: 0	1	2	3	4	5	6	Row total
0	1237 33.5	369 5.7	1107 4.1	0 0.0	0 0.0	51 .5	0 0.0	2764 4.2
1	916 24.8	4533 70.5	1816 6.7	478 4.7	528 5.7	0 0.0	0 0.0	8271 12.4
2	1123 30.4	1352 21.0	20259 75.3	1822 17.9	273 3.0	587 6.2	0 0.0	25416 38.2
3	194 5.2	127 2.0	2547 9.5	5004 49.2	1559 16.9	537 5.7	24 3.2	9992 15.0
4	102 2.8	51 .8	1124 4.2	2526 24.8	5179 56.2	670 7.1	0 0.0	9652 14.5
5	125 3.4	0 0.0	51 .2	346 3.4	1676 18.2	7059 75.0	51 6.8	9308 14.0
6	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	508 5.4	672 90.0	1180 1.8
Column total	3697 5.6	6432 9.7	26904 40.4	10176 15.3	9215 13.8	9412 14.1	747 1.1	66583 100.0

For each type of hog operation the X^2 value exceeds the critical value for the .01 probability level. Therefore, the H_0 that the transition probabilities are stationary over the time period from 1967 to the end of 1971 for each i type of hog operation is rejected. The transition probabilities are nonstationary. Therefore, each transition matrix must be estimated separately. This result leads to the conclusion that the portion of hypothesis II that states that the transition probabilities are different between time periods is not rejected.

2. Results of test for homogeneity

The four transition probability matrices estimated for each type of hog operation were used to make a test for homogeneity among hog operation types for each change period. The procedure used is similar to that for the stationarity test. The difference is that the over-all transition probability matrix used to test for homogeneity is constructed from the four hog operation type matrices for one change period, whereas in the staionarity test the over-all matrix was constructed from one type of hog operation over all the change periods. Again, equation 3.24 was used to estimate the transition probabilities in the matrices used to test for homogeneity.

The stationary transition probability matrices are identified by HT_{i},., where i represents the change period and . indicates that the matrix is estimated over all j types of hog operations. The four estimated matrices are shown in Tables 4.10, 4.11, 4.12, and 4.13.

Equation 3.25 was used to test for homogeneity for each of the four change periods. The results of the test are presented in Table 4.14.

Table 4.10. Matrix $HT_{78,.}$ -- 1967-68 Change period

Size t	Size t-1: 0	1	2	3	4	5	6	Row total
0	4387	0	1492	385	51	51	0	6366
	82.3	0.0	6.7	3.9	.8	.8	0.0	10.9
1	547	5621	0	0	0	0	0	6168
	10.3	77.8	0.0	0.0	0.0	0.0	0.0	10.6
2	127	1507	18315	891	152	0	0	20992
	2.4	20.9	82.6	8.9	2.4	0.0	0.0	36.0
3	194	93	1593	6428	714	202	0	9224
	3.6	1.3	7.2	64.3	11.5	3.1	0.0	15.8
4	51	0	710	2086	4554	506	0	7907
	1.0	0.0	3.2	20.9	73.3	7.7	0.0	13.5
5	24	0	51	203	741	5631	75	6725
	.5	0.0	.2	2.0	11.9	85.7	8.3	11.5
6	0	0	0	0	0	177	831	1008
	0.0	0.0	0.0	0.0	0.0	2.7	91.7	1.7
Column total	5330	7221	22161	9993	6212	6567	906	58390
	9.1	12.4	38.0	17.1	10.6	11.2	1.6	100.0

Table 4.11. Matrix $HT_{89,.}$ -- 1968-69 Change period

Size t	Size t-1: 0	1	2	3	4	5	6	Row total
0	2750	369	0	0	0	0	0	3119
	43.2	6.0	0.0	0.0	0.0	0.0	0.0	5.3
1	1047	5219	996	127	0	0	0	7389
	16.4	84.6	4.7	1.4	0.0	0.0	0.0	12.7
2	1943	579	17688	1811	659	0	0	22680
	30.5	9.4	84.3	19.6	8.3	0.0	0.0	38.8
3	144	0	1821	5886	1158	258	0	9267
	2.3	0.0	8.7	63.8	14.6	3.8	0.0	15.9
4	51	0	464	1097	5055	296	0	6963
	.8	0.0	2.2	11.9	63.9	4.4	0.0	11.9
5	434	0	24	300	1036	5893	47	7734
	6.8	0.0	.1	3.3	13.1	87.7	4.7	13.2
6	0	0	0	0	0	273	960	1233
	0.0	0.0	0.0	0.0	0.0	4.1	95.3	2.1
Column total	6369	6167	20993	9221	7908	6720	1007	58385
	10.9	10.6	36.0	15.8	13.5	11.5	1.7	100.0

Table 4.12. Matrix $HT_{90,.}$ -- 1969-70 Change period

Size t	Size t-1: 0	1	2	3	4	5	6	Row total
0	1098	0	369	0	0	0	0	1467
	35.2	0.0	1.6	0.0	0.0	0.0	0.0	2.5
1	627	5810	865	309	0	0	0	7611
	20.1	78.6	3.8	3.3	0.0	0.0	0.0	13.0
2	909	1143	17666	948	351	0	0	21017
	29.1	15.5	77.9	10.2	5.0	0.0	0.0	36.0
3	393	385	2923	5216	676	102	0	9695
	12.6	5.2	12.9	56.3	9.7	1.3	0.0	16.6
4	93	51	600	2450	4444	528	0	8166
	3.0	.7	2.6	26.4	63.8	6.8	0.0	14.0
5	0	0	258	346	1493	6815	98	9010
	0.0	0.0	1.1	3.7	21.4	88.1	7.9	15.4
6	0	0	0	0	0	290	1135	1425
	0.0	0.0	0.0	0.0	0.0	3.7	92.1	2.4
Column total	3120	7389	22681	9269	6964	7735	1233	58391
	5.3	12.7	38.3	15.9	12.0	13.2	2.1	100.0

Table 4.13. Matrix $HT_{01,.}$ -- 1970-71 Change period

Size t	Size t-1: 0	1	2	3	4	5	6	Row total
0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
1	1047 71.4	4945 65.0	4383 20.9	609 6.3	621 7.6	0 0.0	0 0.0	11605 19.9
2	51 3.5	2614 34.3	14617 70.0	3031 31.3	838 10.3	781 8.7	0 0.0	21932 37.6
3	369 25.2	0 0.0	1166 5.5	4147 42.8	1900 23.3	387 4.3	24 1.7	7993 13.7
4	0 0.0	51	825 .7	1444 14.9	3313 40.6	1400 15.5	0 0.0	7033 12.0
5	0 0.0	0 0.0	24 .1	462 4.8	1490 18.3	5783 64.2	297 20.8	8056 13.8
6	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	656 7.3	1104 77.5	1760 3.0
Column total	1467 2.5	7610 13.0	21015 36.0	9693 16.6	8162 14.0	9007 15.4	1425 2.4	58379 99.9

Table 4.14. Results of tests for homogeneity

Change Period	Calculated X^2	Standardized X^2	Probability of a type 1 error
1967-68	8,361.6542	113.47565	P .01
1968-69	8,617.9524	115.44261	P .01
1969-70	11,587.132	136.38798	P .01
1970-71	10,305.984	127.72571	P .01

For each change period the X^2 value exceeds the critical value for the .01 probability level and, therefore, the H_0 that the transition probabilities are homogeneous between the four types of hog operations for each change period is rejected. The transition probabilities are nonhomogeneous, therefore, the transition matrix for each type of hog operation must be estimated separately. This result leads to the conclusion that hypothesis III is not rejected.

From the results of tests of a portion of hypothesis II and hypothesis III it was concluded that a separate transition probability matrix must be estimated for each type of hog operation for each change period.

3. Individual transition matrix analysis

Each of the sixteen transition probability matrices will be analyzed separately to determine if producers in certain size classes are more likely to change size classes than producers in other size classes. The results of this analysis will be used to test the portion of hypothesis II that deals with the probabilities of making changes being different for different size classes.

Matrix $T_{01,F}$, which is given in Table 4.15, will be used to explain the interpretation of the sixteen matrices to be presented in this section. The number of producers in a size class i in the t-1-th period and size class j in the t-th period is the top number in each cell. For example, 258 producers were in class 0 in 1970 and in class 1 in 1971. The bottom number in each cell is the percentage of producers in size class i in period t-1 that the top number represents. For example, 258 producers represented 41.1 percent of the producers in class 0 in 1970. The column total for size class 0 in 1970 is 627 which represents the total number of producers in class 0 in 1970. The 2.1 under the 627 is the percentage 627 is of the total number of producers represented in the matrix. The total number of producers represented in the matrix is 30,535. Under the row total, 6013 represents the number of producers in class 1 in 1971 and the 19.7 under 6013 is the percentage that 6013 was of the total number of producers represented. The numbers along the top and in the left column of the matrix are the seven different size classes in 1970 and 1971, respectively.

Matrix $T_{01,F}$: This matrix is for the farrow only type of hog operation for the 1970 and 1971 change period. All the producers in the sample who sold no slaughter-hogs in 1970 sold slaughter-hogs in 1971. This is because the only producers included in the sample were those who sold slaughter-hogs in 1971. 41.1 percent of the surveyed producers who sold no slaughter hogs in 1970 entered in class 1, while 58.9 percent entered in class 3. Slightly more than 30 percent of the producers in size classes 2, 5, and 6 in 1970 changed their size class in 1971. Approximately 60 percent of the producers in size classes 3 and 4 and 20 percent of the producers in size class 1 in 1970 changed their size class

Table 4.15. Matrix $T_{01, F}$

Size 71	Size 70: 0	1	2	3	4	5	6	Row total
0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
1	258 41.1	2842 81.9	2655 25.4	258 4.4	0 0.0	0 0.0	0 0.0	6013 19.7
2	0 0.0	627 18.1	6993 67.0	2047 34.8	489 11.8	143 2.7	0 0.0	10300 33.7
3	369 58.9	0 0.0	477 4.6	2467 42.0	1178 28.5	143 2.7	0 0.0	4635 15.2
4	0 0.0	0 0.0	309 3.0	735 12.5	1760 42.5	1156 22.0	0 0.0	3960 13.0
5	0 0.0	0 0.0	0 0.0	369 6.3	709 17.1	3628 68.9	222 30.6	4928 16.1
6	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	195 3.7	503 69.4	698 2.3
Column total	627 2.1	3469 11.4	10434 34.2	5876 19.2	4137 13.5	5266 17.2	725 2.4	30535 100.0

in 1971.

<u>Matrix $T_{90, F}$:</u> This matrix is for the farrow only type of hog operation for the 1969 to 1970 change period and is given in Table 4.16. Slightly more than 60 percent of the producers surveyed who sold no slaughter-hogs in 1969 sold slaughter-hogs in 1970. 22.6 percent of these producers entered in class 3, while 21.2 and 14.8 percent entered classes 2 and 1 respectively. Roughly 20 percent of the producers in size classes 1 and 2 in 1969 changed size classes in 1970. Approximately 30 percent of the producers in size classes 3 and 4 in 1969 and roughly 12 percent of the producers in size classes 5 and 6 in 1969 changed size classes in 1970. None of the producers in the sample who were producing in 1969 quit producing slaughter-hogs in 1970.

<u>Matrix $T_{89,F}$:</u> This matrix is for the farrow only type of hog operation for the 1968 to 1969 change period and is given in Table 4.17. 4.5 percent of the producers in class 0, 39.2 percent of the producers in class 4, and 26.2 percent of the producers in class 3 in 1968 changed size classes in 1969. Roughly 13 percent of the producers in size classes 1, 2, and 6 and 2.8 percent of the producers in size class 5 in 1968 moved to a different size class in 1969. Of the 45.4 percent of the producers starting to sell slaughter-hogs in 1969, 19.7 percent entered in class 1, 16.0 percent entered in class 2, and 9.7 percent entered in class 5. None of the producers in the sample who were producing slaughter-hogs in 1968 quit producing slaughter-hogs in 1969.

<u>Matrix $T_{78,F}$:</u> This matrix is for the farrow only type of hog operation for the 1967 to 1968 change period and is given in Table 4.18. Slightly more than 35 percent of the producers in size class 3 and 22

Table 4.16. Matrix $T_{90, F}$

Size 70	Size 69: 0	1	2	3	4	5	6	Row total
0	627	0	0	0	0	0	0	627
	36.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1
1	258	2842	369	0	0	0	0	3469
	14.8	78.6	3.2	0.0	0.0	0.0	0.0	11.4
2	369	516	9241	51	258	0	0	10434
	21.2	14.3	81.2	1.0	7.4	0.0	0.0	34.2
3	393	258	1457	3625	93	51	0	5876
	22.6	7.1	12.8	71.9	2.7	1.1	0.0	19.2
4	93	0	51	1317	2398	279	0	4137
	5.3	0.0	0.4	26.1	68.9	6.0	0.0	13.5
5	0	0	258	51	733	4151	74	5266
	0.0	0.0	2.3	1.0	21.1	88.8	12.2	17.2
6	0	0	0	0	0	195	530	725
	0.0	0.0	0.0	0.0	0.0	4.2	87.8	2.4
Column total	1740	3616	11376	5042	3482	4675	604	30535
	5.7	11.8	37.3	16.5	11.4	15.3	2.0	100.0

Table 4.17. Matrix $T_{89, F}$

	Size 68							
Size 69	0	1	2	3	4	5	6	Row total
0	1740	0	0	0	0	0	0	1740
	54.6	0.0	0.0	0.0	0.0	0.0	0.0	5.7
1	627	2731	258	0	0	0	0	3616
	19.7	89.8	2.4	0.0	0.0	0.0	0.0	11.8
2	511	309	9276	764	516	0	0	11376
	16.0	10.2	85.6	15.8	11.3	0.0	0.0	37.3
3	0	0	913	3581	549	0	0	5042
	0.0	0.0	8.4	73.8	12.0	0.0	0.0	16.5
4	0	0	363	329	2790	0	0	3482
	0.0	0.0	3.3	6.8	60.8	0.0	0.0	11.4
5	309	0	24	175	732	3389	47	4675
	9.7	0.0	0.2	3.6	16.0	97.2	8.5	15.3
6	0	0	0	0	0	98	507	604
	0.0	0.0	0.0	0.0	0.0	2.8	91.5	2.0
Column total	3186	3039	10833	4850	4586	3487	554	30535
	10.4	10.0	35.5	15.9	15.0	11.4	1.8	100.0

percent of the producers in size class 4 in 1967 changed size classes in 1968. Roughly 15 percent of the producers in size classes 1 and 2 and 5 percent of the producers in size classes 0 and 6 in 1967 changed size classes in 1968. The producers who started selling slaughter-hogs in 1968 entered into size classes 1 and 3. 4.2 percent of the producers in class 2 and 2.2 percent of the producers in class 3 in 1967 quit producing slaughter-hogs in 1968. Except for size classes 3 and 4, more than 80 percent of the producers remained in the same size class during the 1967-1968 change period.

a. Summary of the farrow only type of hog operation In 3 out of the 4 change periods the percentage of producers making changes was highest for those in size class 0 in period t-1. Producers who were in size classes 3 and 4 in period t-1 ranked second in the percentage making size class changes in period t. The producers who quit producing slaughter-hogs in 1968 were in size classes 2 and 3 in 1967. In none of the other change periods did any producer in the sample quit producing slaughter-hogs. Producers starting to produce slaughter-hogs in one of the four change periods, entered classes 1, 2, or 3. Thus the producers who either started or exited from slaughter-hog production over this period did so in the smaller size classes.

Matrix $T_{01,\ PO}$: This matrix is for the purchase feeder pigs only type of hog operation for the 1970 to 1971 change period and is given in Table 4.19. 100 percent of the producers in size class 0 in 1970 started producing slaughter-hogs in 1971 and all the producers entered in size class 2. 68.3 percent of the producers in size class 3, 49.5 percent of

Table 4.18. Matrix $T_{78,\ F}$

Size 68	Size 67: 0	1	2	3	4	5	6	Row total
0	2564 95.4	0 0.0	496 4.2	127 2.2	0 0.0	0 0.0	0 0.0	3186 10.4
1	51 1.9	2989 85.3	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	3039 10.0
2	0 0.0	516 14.7	9709 82.8	506 9.0	101 3.3	0 0.0	0 0.0	10833 35.5
3	51 1.9	0 0.0	862 7.4	3650 64.7	236 7.7	51 1.5	0 0.0	4850 15.9
4	0 0.0	0 0.0	659 5.6	1207 21.4	2399 78.3	320 9.3	0 0.0	4586 15.0
5	24 0.9	0 0.0	0 0.0	152 2.7	329 10.7	2960 86.3	24 4.9	3487 11.4
6	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	98 2.8	456 95.1	554 1.8
Column total	2689 8.8	3505 11.5	11727 38.4	5642 18.5	3065 10.0	3428 11.2	480 1.6	30535 100.0

Table 4.19. Matrix $T_{01, PO}$

Size 71	Size 70: 0	1	2	3	4	5	6	Row total
0	0	0	0	0	0	0	0	0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	0	738	258	258	0	0	0	1254
	0.0	66.7	9.4	23.1	0.0	0.0	0.0	20.0
2	51	369	2361	380	0	51	0	3211
	100.0	33.3	86.0	34.0	0.0	10.2	0.0	51.1
3	0	0	127	354	127	143	0	751
	0.0	0.0	4.6	31.7	21.4	29.1	0.0	12.0
4	0	0	0	127	363	0	0	489
	0.0	0.0	0.0	11.3	61.5	0.0	0.0	7.8
5	0	0	0	0	101	249	0	350
	0.0	0.0	0.0	0.0	17.1	50.5	0.0	5.6
6	0	0	0	0	0	51	172	222
	0.0	0.0	0.0	0.0	0.0	10.2	100.0	3.5
Column total	51	1107	2745	1119	590	493	172	6278
	0.8	17.6	43.7	17.8	9.4	7.9	2.7	100.0

the producers in size class 5, roughly 37 percent of the producers in size classes 1 and 4 and 14 percent of the producers in size class 2 in 1970 changed size classes in 1971. None of the producers in the sample in size class 6 in 1970 changed size classes in 1971.

<u>Matrix $T_{90, PO}$:</u> This matrix is for the purchase feeder pigs only type of hog operation for the 1969 to 1970 change period and is given in Table 4.20. 83.6 percent of the producers in the sample that were in size class 0 in 1969 entered size class 2 in 1970. Approximately 45 percent of the producers in size classes 3 and 4 and roughly 15 percent of the producers in size classes 2, 5, and 6 in 1969 changed size classes in 1970. None of the producers in size class 1 in 1969 changed size class in 1970. None of the producers in the sample quit producing slaughter-hogs in 1970.

<u>Matrix $T_{89, PO}$:</u> This matrix is for the purchase feeder pigs only type of hog operation for the 1968 to 1969 change period and is given in Table 4.21. Slightly more than 65 percent of the sampled producers who sold no slaughter-hogs in 1968 started producing slaughter-hogs in 1969. 56.2 percent of these producers entered in size class 2 and 10.1 percent entered in size class 3. Approximately 50 percent of the producers in size class 3 and roughly 20 percent of the producers in size classes 2, 4, and 5 in 1968 changed size classes in 1969. None of the producers sampled in size classes 1 and 6 in 1968 changed size classes in 1969. None of the producers in the sample who were producing hogs in 1968 quit producing slaughter-hogs in 1969.

<u>Matrix $T_{78, PO}$:</u> This matrix is for the purchase feeder pigs only type of hog operation for the 1967 to 1968 change period and is given in

Table 4.20. Matrix $T_{90,\ PO}$

Size 70	Size 69: 0	1	2	3	4	5	6	Row total
0	51	0	0	0	0	0	0	51
	16.4	0.0	0.0	0.0	0.0	0.0	0.0	0.8
1	0	1107	0	0	0	0	0	1107
	0.0	100.0	0.0	0.0	0.0	0.0	0.0	17.6
2	258	0	2268	127	93	0	0	2745
	83.6	0.0	81.6	14.4	13.6	0.0	0.0	43.7
3	0	0	511	481	127	0	0	1119
	0.0	0.0	18.4	54.8	18.5	0.0	0.0	17.8
4	0	0	0	127	413	51	0	590
	0.0	0.0	0.0	14.4	60.5	15.5	0.0	9.4
5	0	0	0	143	51	276	24	493
	0.0	0.0	0.0	16.3	7.4	84.5	12.0	7.9
6	0	0	0	0	0	0	172	172
	0.0	0.0	0.0	0.0	0.0	0.0	88.0	2.7
Column total	309	1107	2779	877	683	327	195	6278
	4.9	17.6	44.3	14.0	10.9	5.2	3.1	100.0

Table 4.21. Matrix $T_{89,\ PO}$

Size 69	Size 68: 0	1	2	3	4	5	6	Row total
0	309 33.6	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	309 4.9
1	0 0.0	738 100.0	369 14.8	0 0.0	0 0.0	0 0.0	0 0.0	1107 17.6
2	516 56.2	0 0.0	2005 80.2	258 21.0	0 0.0	0 0.0	0 0.0	2779 44.3
3	93 10.0	0 0.0	127 5.1	658 53.6	0 0.0	0 0.0	0 0.0	877 14.0
4	0 0.0	0 0.0	0 0.0	312 25.4	320 86.4	51 13.5	0 0.0	683 10.9
5	0 0.0	0 0.0	0 0.0	0 0.0	51 13.6	276 73.9	0 0.0	327 5.2
6	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	47 12.6	148 100.0	195 3.1
Column total	917 14.6	738 11.8	2501 39.8	1228 19.6	371 5.9	374 5.9	148 2.4	6278 100.0

Table 4.22. Matrix $T_{78,\ PO}$

Size 68	Size 67: 0	1	2	3	4	5	6	Row total
0	401	0	258	258	0	0	0	917
	44.7	0.0	10.8	23.2	0.0	0.0	0.0	14.6
1	369	369	0	0	0	0	0	738
	41.4	44.4	0.0	0.0	0.0	0.0	0.0	11.8
2	127	369	2005	0	0	0	0	2501
	14.1	44.4	83.9	0.0	0.0	0.0	0.0	39.8
3	0	93	127	751	258	0	0	1228
	0.0	11.2	5.3	67.7	36.7	0.0	0.0	19.6
4	0	0	0	51	320	0	0	371
	0.0	0.0	0.0	4.6	45.6	0.0	0.0	5.9
5	0	0	0	51	125	199	0	374
	0.0	0.0	0.0	4.6	17.7	79.7	0.0	5.9
6	0	0	0	0	0	51	98	148
	0.0	0.0	0.0	0.0	0.0	20.3	100.0	2.4
Column total	897	831	2390	1110	703	249	98	6278
	14.3	13.2	38.1	17.7	11.2	4.0	1.6	100.0

Table 4.22. Approximately 55 percent of the producers in size classes 0, 1, and 4 in 1967 made a size class change in 1968. 41.1 percent of the producers in the sample who started producing slaughter-hogs in 1968 entered in class 1 and 14.1 percent entered in class 2. 30 percent of the producers in class 3 and approximately 20 percent of the producers in size classes 2 and 5 in 1967 changed their size class production level in 1968. None of the producers in size class 6 in 1967 changed their size class in 1968. 10.8 percent of the surveyed producers in class 2 and 23.2 percent of the producers in class 3 in 1967 quit producing slaughter-hogs in 1968.

b. Summary of purchase feeder pigs only type of hog operation In all four change periods producers in size class 0 in period t-1 made the largest percentage of changes from period t-1 to t. Producers who were in size classes 3 and 4 in period t-1 ranked second and third in terms of the percentages making size class changes in period t. In 3 out of the 4 change periods, producers in size class 6 in period t-1 made the fewest percentage of changes in period t. Producers who quit producing slaughter-hogs in 1968 were in size classes 2 and 3 in 1967. None of the producers in the sample quit producing slaughter-hogs in 1969, 1970, or 1971. Producers starting to produce slaughter-hogs during one of the four change periods, entered in either size class 1, 2, or 3, with size class 2 being the most frequent entering level. Producers starting to produce slaughter-hogs entered in one of the smaller size classes. Producers exiting from producing slaughter-hogs exited from one of the smaller size classes.

Matrix $T_{01,\ FS}$: This matrix is for the farrow sows and sell feeder pigs type of hog operation for the 1970 to 1971 change period and

Table 4.23. Matrix $T_{01,\ FS}$

	Size 70							
Size 71	0	1	2	3	4	5	6	Row total
0	0	0	0	0	0	0	0	0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	51	258	150	0	93	0	0	551
	100.0	18.2	9.7	0.0	15.7	0.0	0.0	11.2
2	0	1107	1323	253	219	0	0	2903
	0.0	78.2	85.5	53.6	37.2	0.0	0.0	59.0
3	0	0	51	0	101	0	0	152
	0.0	0.0	3.6	0.0	17.1	0.0	0.0	3.1
4	0	51	0	219	177	101	0	548
	0.0	3.6	0.0	46.4	30.0	16.9	0.0	11.1
5	0	0	24	0	0	445	24	492
	0.0	0.0	1.5	0.0	0.0	74.6	9.4	10.0
6	0	0	0	0	0	51	226	277
	0.0	0.0	0.0	0.0	0.0	8.5	90.6	5.6
Column total	51	1416	1547	473	590	596	250	4923
	1.0	28.8	31.4	9.6	12.0	12.1	5.1	100.0

is given in Table 4.23. All of the producers sampled who were in size classes 0 and 3 in 1970 changed size classes in 1971. 100 percent of the producers in size class 0 in 1970 started in class 1 in 1971. 53.6 percent of the producers in class 3 in 1970 decreased their production level to class 2 in 1971, while the remaining 46.4 percent of the producers increased their production level to class 4 in 1971. Roughly 80 percent of the producers in size class 1, 70 percent of the producers in size class 4, 25.4 percent of the producers in size class 5 and 14.5 percent of the producers in size class 2 in 1970 changed size classes in 1971. 9.4 percent of the producers in size class 6 in 1970 decreased their production level to size class 5 in 1971. Again, as always is the case in the 1970 to 1971 change period because of the nature of the sample, none of the producers quit producing slaughter-hogs in 1971.

Matrix $T_{90,\ FS}$: This matrix is for the farrow sows and sell feeder pigs type of hog operation for the 1969 to 1970 change period and is given in Table 4.24. Almost 90 percent of the producers in the sample who were in size class 0 in 1969 started selling slaughter-hogs in 1970. 83.3 percent of the producers started in class 1 and 5.3 percent started in class 2. Roughly 50 percent of the producers in size classes 1, 2, and 3, 30.9 percent of the producers in size class 4, and 11.9 percent of the producers in size class 5 in 1969 changed size classes in 1970. None of the producers in size class 6 in 1969 changed size classes in 1970. None of the producers surveyed who produced hogs in 1969 quit producing slaughter-hogs in 1970.

Matrix $T_{89,\ FS}$: This matrix is for the farrow sows and sell feeder pigs type of hog operation for the 1968 to 1969 change period and is given

Table 4.24. Matrix $T_{90, FS}$

Size 70	Size 69 0	1	2	3	4	5	6	Row total
0	51 11.4	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	51 1.0
1	369 83.3	627 50.0	369 27.2	51 9.1	0 0.0	0 0.0	0 0.0	1416 28.8
2	24 5.3	627 50.0	770 56.7	127 22.7	0 0.0	0 0.0	0 0.0	1547 31.4
3	0 0.0	0 0.0	127 9.3	253 45.5	93 20.0	0 0.0	0 0.0	473 9.6
4	0 0.0	0 0.0	93 6.8	127 22.7	320 69.1	51 8.1	0 0.0	590 12.0
5	0 0.0	0 0.0	0 0.0	0 0.0	51 10.9	546 88.1	0 0.0	596 12.1
6	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	24 3.8	226 100.0	250 5.1
Column total	443 9.0	1254 25.5	1359 27.6	557 11.3	464 9.4	620 12.6	226 4.6	4923 100.0

Table 4.25. Matrix $T_{89,\ FS}$

Size 69	Size 68: 0	1	2	3	4	5	6	Row total
0	443 51.4	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	443 9.0
1	369 42.8	885 94.6	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	1254 25.5
2	51 5.9	51 5.4	1038 85.4	219 35.2	0 0.0	0 0.0	0 0.0	1359 27.6
3	0 0.0	0 0.0	177 14.6	380 61.0	0 0.0	0 0.0	0 0.0	557 11.3
4	0 0.0	0 0.0	0 0.0	0 0.0	413 80.4	51 8.4	0 0.0	464 9.4
5	0 0.0	0 0.0	0 0.0	24 3.8	101 19.6	495 82.5	0 0.0	620 12.6
6	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	54 9.1	172 100.0	4923 4.6
Column total	863 17.5	936 19.0	1215 24.7	623 12.7	514 10.4	600 12.2	172 3.5	4923 100.0

in Table 4.25. Almost 50 percent of the producers in the sample who were in size class 0 in 1968 started producing slaughter-hogs in 1969. 42.8 percent entered in class 1 and 5.9 percent entered in class 2. 39 percent of the producers in size class 3, approximately 17 percent of the producers in size classes 2, 4, and 5 and 5.4 percent of the producers in size class 1 in 1968 changed size classes in 1969. None of the producers in size class 6 in 1968 changed size classes in 1969. None of the producers who were sampled quit producing slaughter-hogs in 1969.

Matrix $T_{78,\ FS}$: This matrix is for the farrow sows and sell feeder pigs type of hog operation for the 1967 to 1968 change period and is given in Table 4.26. Approximately 40 percent of the producers in size class 4, roughly 25 percent of the producers in size classes 3 and 6, and 9.5 percent of the producers in size class 5 in 1967 changed size classes in 1968. None of the producers in size classes 0, 1 and 2 in 1967 changed size classes in 1968. 6.0 percent of the producers in size class 4 in 1967 quit producing slaughter-hogs in 1968.

c. Summary of the farrow and sell feeder pigs type of hog operation

In three out of the four change periods producers in size class 0 in period t-1 made the largest percentage of changes in period t. Producers who were in size classes 3 and 4 in period t-1 ranked second or third as the most frequent size classes from which producers changed. In the last two change periods a larger percentage of producers in size class 1 changed size classes than did producers in size class 4. In three out of the four change periods, producers in size class 6 made the fewest size class changes. Producers who quit producing slaughter-hogs in 1968 were in class 4 in 1967. Producers starting to produce slaughter-hogs

Table 4.26. Matrix $T_{78,\ FS}$

Size 68	Size 67: 0	1	2	3	4	5	6	Row total
0	812 100.0	0 0.0	0 0.0	0 0.0	51 6.0	0 0.0	0 0.0	863 17.5
1	0 0.0	936 100.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	936 19.0
2	0 0.0	0 0.0	1038 100.0	127 21.1	51 6.0	0 0.0	0 0.0	1215 24.7
3	0 0.0	0 0.0	0 0.0	473 78.9	127 15.0	24 4.7	0 0.0	623 12.7
4	0 0.0	0 0.0	0 0.0	0 0.0	514 61.0	0 0.0	0 0.0	514 10.4
5	0 0.0	0 0.0	0 0.0	0 0.0	101 12.0	449 90.5	51 25.4	600 12.2
6	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	24 4.7	148 74.6	172 100.0
Column total	812 16.5	936 19.0	1038 21.1	599 12.2	843 17.1	496 10.1	199 4.0	4923 100.0

entered in either class 1 or 2.

Matrix $T_{01, D}$: This matrix is for the diversified type of hog operation for the 1970 to 1971 change period and is given in Table 4.27. All of the producers in size class 0 in 1970 started producing slaughter-hogs in class 1 in 1971. None of the producers quit producing slaughter-hogs in 1971. As mentioned before, these results are due to the nature of the survey. 64.4 percent of the producers in class 4, roughly 43 percent of the producers in size classes 3 and 5, approximately 35 percent of the producers in size classes 1 and 2, and 26.8 percent of the producers in size class 6 in 1970 changed size classes in 1971.

Matrix $T_{90, D}$: This matrix is for the diversified type of hog operation for the 1969 to 1970 change period and is given in Table 4.28. 69.3 percent of the producers in size class 3, approximately 43 percent of the producers in size classes 0 and 4, 24.8 percent of the producers in size classes 1 and 5 in 1969 changed size classes in 1970. 41.1 percent of the producers who sold no slaughter-hogs in 1969 entered slaughter-hog production in 1970 in size class 2. 5.1 percent of the producers in size class 2 in 1969 quit producing slaughter-hogs in 1970.

Matrix $T_{89, D}$: This matrix is for the diversified type of hog operation for the 1968 to 1969 change period and is given in Table 4.29. Over 80 percent of the producers in the sample who were in size class 0 in 1968 entered slaughter-hog production in 1969, with 61.8 percent entering in class 2, 3.6 percent entering in classes 1, 3 and 4, and 8.9 percent entering in class 5. 49.7 percent of the producers in size class 3, roughly 40 percent of the producers in size classes 1 and 4, and

Table 4.27. Matrix $T_{01, D}$

	Size 70							
Size 71	0	1	2	3	4	5	6	Row total
0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0
1	738 100.0	1107 68.4	1320 21.0	93 4.2	528 18.6	0 0.0	0 0.0	3787 22.7
2	0 0.0	511 31.6	3940 62.7	351 15.8	130 4.6	587 22.1	0 0.0	5520 33.2
3	0 0.0	0 0.0	511 8.1	1326 59.6	494 17.4	101 3.8	24 8.5	2456 14.8
4	0 0.0	0 0.0	516 8.2	363 16.3	1013 35.6	143 5.4	0 0.0	2035 12.2
5	0 0.0	0 0.0	0 0.0	93 4.2	680 23.9	1461 55.1	51 18.3	2285 13.7
6	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	359 13.5	203 73.2	562 3.4
Column total	738 4.4	1618 9.7	6288 37.8	2226 13.4	2845 17.1	2651 15.9	278 1.7	16644 100.0

Table 4.28. Matrix $T_{90, D}$

Size 70	Size 69: 0	1	2	3	4	5	6	Row total
0	369 58.9	0 0.0	369 5.1	0 0.0	0 0.0	0 0.0	0 0.0	738 4.4
1	0 0.0	1234 87.4	127 1.8	258 9.3	0 0.0	0 0.0	0 0.0	1618 9.7
2	258 41.1	0 0.0	5387 75.2	643 23.0	0 0.0	0 0.0	0 0.0	6288 37.8
3	0 0.0	127 9.0	828 11.6	857 30.7	363 15.6	51 2.4	0 0.0	2226 13.4
4	0 0.0	51 3.6	456 6.4	879 31.5	1313 56.3	147 7.0	0 0.0	2845 17.1
5	0 0.0	0 0.0	0 0.0	152 5.4	658 28.2	1842 87.3	0 0.0	2651 15.9
6	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	71 3.3	207 100.0	278 1.7
Column total	627 3.8	1411 8.5	7167 43.1	2788 16.8	2334 14.0	2110 12.7	207 1.2	16644 100.0

Table 4.29. Matrix $T_{89,\ D}$

Size 69	Size 68: 0	1	2	3	4	5	6	Row total
0	258 18.4	369 25.4	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	627 3.8
1	51 3.6	865 59.5	369 5.7	127 5.0	0 0.0	0 0.0	0 0.0	1411 8.5
2	865 61.8	219 15.1	5369 83.3	570 22.6	143 5.9	0 0.0	0 0.0	7167 43.1
3	51 3.6	0 0.0	604 9.4	1267 50.3	609 25.0	258 11.4	0 0.0	2788 16.8
4	51 3.6	0 0.0	101 1.6	456 18.1	1532 62.9	194 8.6	0 0.0	2334 14.0
5	125 8.9	0 0.0	0 0.0	101 4.0	152 6.2	1733 76.7	0 0.0	2110 12.7
6	0 0.0	0 0.0	0 0.0	0 0.0	0 0.0	74 3.3	133 100.0	207 1.2
Column total	1399 8.4	1453 8.7	6443 38.7	2521 15.1	2436 14.6	2259 13.6	133 0.8	16644 100.0

approximately 20 percent of the producers in size classes 2 and 5 in 1968 changed size classes in 1969. None of the producers who were surveyed and who were in size class 6 in 1968 changed size classes in 1969. 25.4 percent of the producers in size class 1 in 1968 quit producing slaughter-hogs in 1969.

Matrix $T_{78,\ D}$: This matrix is for the diversified type of hog operation for the 1967 to 1968 change period and is given in Table 4.30. Approximately 33 percent of the producers in size classes 0 and 1, 41.2 percent of the producers in size class 3, and roughly 20 percent of the producers in size classes 2, 4, and 5 in 1967 changed size classes in 1968. 13.6 and 15.4 percent of the producers in size class 0 in 1967 entered slaughter-hog production in size classes 1 and 3, respectively, in 1968. None of the producers who were surveyed and who were in size class 6 in 1967 changed size classes in 1968. 10.5 percent of the producers in size class 2 and 2.1 percent of the producers in size class 5 in 1967 quit producing slaughter-hogs in 1968.

d. Summary of the diversified type of hog operation The predominant tendency is for producers in either classes 0 or 3 in period t-1 to make the largest percentage of changes in period t. Producers in size class 4 in period t-1 also made frequent changes in their size class in period t. In all four change periods producers in size class 6 in period t-1 made the smallest percentage of changes in period t. Producers who started producing slaughter hogs, usually entered in either classes 1, 2, or 3. Producers who quit producing slaughter-hogs usually were in classes 1 or 2 in period t-1. Therefore, it is concluded that most of the

Table 4.30. Matrix $T_{78, D}$

Size 68	Size 67: 0	1	2	3	4	5	6	Row total
0	610	0	738	0	0	51	0	1399
	65.6	0.0	10.5	0.0	0.0	2.1	0.0	8.4
1	127	1327	0	0	0	0	0	1453
	13.6	68.1	0.0	0.0	0.0	0.0	0.0	8.7
2	0	622	5563	258	0	0	0	6443
	0.0	31.9	79.4	9.8	0.0	0.0	0.0	38.7
3	143	0	604	1554	93	127	0	2521
	15.4	0.0	8.6	58.8	5.8	5.3	0.0	15.1
4	51	0	51	828	1321	186	0	2436
	5.4	0.0	0.7	31.4	82.6	7.8	0.0	14.6
5	0	0	51	0	186	2023	0	2259
	0.0	0.0	0.7	0.0	11.6	84.6	0.0	13.6
6	0	0	0	0	0	4	129	133
	0.0	0.0	0.0	0.0	0.0	0.2	100.0	0.8
Column total	931	1949	7006	2640	1600	2389	129	16644
	5.6	11.7	42.1	15.9	9.6	14.4	0.8	100.0

diversified type of hog operations either start or quit producing slaughter-hogs in the lower size classes.

4. Summary of size class changes

Table 4.31 summarizes the size class changes that occurred for each of the sixteen matrices just discussed. The two left-hand columns give the estimated number and percentage of producers remaining in the same size class. The two middle columns give the estimated number and percentage of producers moving up or down one size class. The two right-hand columns give the estimated number and percentage of producers moving up or down more than one size class. Comparing columns 2, 4, and 6, it can be seen that the greatest tendency is for producers to remain in the same class. On the average, 23 percent of producers either increased or decreased production by one size class. Less than 13 percent of the producers in all sixteen cases increased or decreased production by more than one size class, and, in 12 out of the 16 cases, the percentage is less than 10 percent.

Table 4.32 summarizes the percentages of producers entering and exiting from slaughter-hog production and the percentage of producers increasing and decreasing their production level. The first and last columns contain the numbers that are used in the denominator to calculate the percentages. The estimated number of producers entering, exiting, increasing, and decreasing their slaughter-hog production are given in columns 2, 4, 6, and 9, respectively. The percentages of producers entering production, exiting from production, increasing and decreasing production based on the estimated total number of producers are given in

Table 4.31. Summary of size class changes

Change Period and Hog Operation Type	Estimated Number and Percentage of Producers Remaining in the Same Size Class		Estimated Number and Percentage of Producers Moving Up or Down One Size Class		Estimated Number and Percentage of Producers Moving Up or Down More Than One Size Class	
	Number	%	Number	%	Number	%
78, F	24,727	80.97	4,149	13.58	1,661	5.44
89, F	24,014	78.64	4,626	15.15	1,898	6.22
90, F	23, 414	76.68	5,342	17.49	1,782	4.74
01, F	18,193	59.58	10,259	33.60	2,080	6.81
78, PO	4,143	65.99	1,350	21.50	787	12.53
89, PO	4,454	70.95	1,215	19.35	609	9.70
90, PO	4,768	75.95	1,018	16.22	494	7.87
01, PO	4,237	67.75	1,540	24.53	503	8.01
78, FS	4,370	88.77	430	8.73	126	2.56
89, FS	3,826	77.72	1,022	20.76	75	1.52
90, FS	2,793	56.73	1,965	39.91	168	3.41
01, FS	2,429	49.34	2,108	42.82	387	7.86
78, D	12,527	75.26	2,908	17.47	1,212	7.28
89, D	11,157	67.03	3,667	22.03	1,822	10.95
90, D	11,209	67.35	3,716	22.33	1,722	10.35
01, D	9,050	54.37	5,521	33.17	2,072	12.45

Table 4.32. Summary of percentages for producers exiting, entering, increasing, and decreasing their slaughter-hog production

Change period and hog operation type	Estimated total number of producers 1	Estimated number of producers entering slaughter-hog production 2	Percentage based on column 1 3	Estimated number of producers exiting slaughter-hog production 4	Percentage based on column 1 5	Estimated number of producers increasing production 6
78, F	30,537	126	0.41	623	2.04	3,949
89, F	30,538	1,447	4.74	0	0.00	4,390
90, F	30,538	1,113	3.64	0	0.00	5,949
01, F	30,532	627	2.05	0	0.00	4,048
Average for F Type			2.71		0.51	
78, PO	6,280	496	7.90	516	8.22	1,363
89, PO	6,278	609	9.70	0	0.00	1,146
90, PO	6,280	258	4.12	0	0.00	1,090
01, PO	6,280	51	0.81	0	0.00	826
Average for PO Type			5.63		2.06	
78, FS	4,926	0	0.00	51	1.04	125
89, FS	4,923	420	8.53	0	0.00	827
90, FS	4,926	393	7.98	0	0.00	1,442
01, FS	4,924	51	1.04	0	0.00	1,554
Average for FS Type			4.39		0.26	
78, D	16,647	321	1.93	789	4.74	2,667
89, D	16,646	1,143	6.87	369	2.22	2,850
90, D	16,647	258	1.55	369	2.22	3,480
01, D	16,643	738	4.43	0	0.00	3,771
Average for D Type			3.70		2.30	
Total Number	233,473	8,051		2,717		39,477

Percentage increasing based on the last column	Percentage increasing based on column 1	Estimated number of producers decreasing production	Percentage decreasing based on the last column	Percentage decreasing based on column 1	Estimated total number of producers making production level changes
7	8	9	10	11	12
67.97	12.93	1,861	32.03	6.09	5,810
67.29	14.38	2,134	32.71	6.99	6,524
83.51	19.48	1,175	16.49	3.85	7,124
32.81	13.26	8,291	67.19	27.16	12,339
62.90	15.01		37.11	11.02	
63.78	21.70	774	36.22	12.32	2,137
62.83	18.25	678	37.17	10.80	1,824
72.09	17.36	422	27.91	6.72	1,512
40.43	13.15	1,217	59.57	19.38	2,043
59.78	17.62		40.22	12.31	
22.48	2.54	431	77.52	8.75	556
75.39	16.80	270	24.61	5.48	1,097
67.60	29.27	691	32.40	14.03	2,133
62.28	31.56	941	37.72	19.11	2,495
56.94	20.04		43.06	11.84	
64.73	16.02	1,453	35.27	8.73	4,120
51.92	17.12	2,639	48.08	15.85	5,489
63.99	20.90	1,958	36.01	11.76	5,438
49.66	22.66	3,822	50.34	22.96	7,593
57.58	19.18		42.43	14.83	
		28,757			68,234

columns 3, 5, 8, and 11, respectively. The percentage of producers increasing and decreasing their production level based on the estimated number making changes in column 12 are given in columns 7 and 10, respectively. An average percentage figure is given for all percentages calculated for each type of hog operation. On the average, more producers started producing slaughter-hogs than quit production. Also, on the average, the percentage of producers increasing production levels exceeded those producers decreasing production. More conclusions from the results given in Tables 4.31 and 4.32 will be presented in Chapter V.

5. Markov chain analysis results summary

Tests for stationarity of transition probabilities were made for each of the four types of hog operations. It was concluded that the transition probabilities are nonstationary. Tests for homogeneity of transition probabilities were made for each of the four different change periods. It was concluded that the transition probabilities are not homogeneous. These two results lead to the conclusion that each individual transition matrix must be estimated and analyzed separately.

The conclusion that the transition probabilities are nonstationary supports part of hypothesis II. The conclusion that the transition probabilities are not homogeneous over types of hog operations supports part of hypothesis III.

The portion of hypothesis II that deals with producers in certain size classes making more changes was tested by analyzing each matrix. There is a general tendency for producers in size classes 0, 3, and 4 to make the greatest percentage of changes from period t-1 to the following period t. The results from size class 0 are less reliable than those for size classes 3 and 4 because to be included in the survey producers had to have produced slaughter-hogs in 1971. Also, because in 1971 all producers in the sample sold slaughter-hogs in the earlier four years, there is probably an exaggerated tendency to enter and increase slaughter-hog production. Producers in size class 6 in period t-1 tend to make the smallest percentage of changes in their size class in the following period t. This seems reasonable because class 6 is the largest class and it has an infinite upper bound. For example, a producer could have produced 1,000 slaughter-hogs in period t-1 and increased this by 1,000 head or decreased by 500 head in period t without changing size classes. Producers in size classes 1, 2, and 5 fall in between the other size classes already mentioned as to the percentage of producers making size class changes from period t-1 to period t. Producers either getting into or out of slaughter-hog production did so most frequently in size classes 1, 2, or 3. This would lead to the conclusion that most producers either getting into or out of hog production do so at a production level of 349 head or less. On the basis of these results, the portion of hypothesis II dealing with different probability changes from different size classes was not rejected.

C. Multiple Regression Results

The multiple regression results will be presented by change period, starting with the most recent. The four change periods will be referred to by the last year of the change period. For example, the 1970 to 1971 change period will be referred to as the 1971 change period.

The constrained regression procedure outlined in Chapter III was applied to several data sets. Three characteristics distinguish the data sets: (1) the type of hog operation, (2) the change direction (i.e., increase or decrease), and (3) the change period. The following notation will be used to identify the characteristics of each data set.

Type of hog operation: F -- Farrow only type of hog operation

C -- Combination type of hog operation

Change direction: I -- Increased production of slaughter-hogs

D -- Decreased production of slaughter-hogs

Change period: 1 -- 1970 to 1971 change period

0 -- 1969 to 1970 change period

9 -- 1968 to 1969 change period

8 -- 1967 to 1968 change period

For example, FD1 is the data set for the farrow only type of hog operation for producers who decreased their slaughter-hog production level in 1971. FCI0 is the combined data set from data sets FI0 and CI0.

The constrained regression procedure will first be applied to the 1971 data. Results of the constrained regression procedure will be presented in the same order that the procedure was outlined in Chapter III.

1. Results for 1971 data

In step (1) separate regression models were estimated for each of the four 1971 data sets. The left hand column in Table 4.33 identifies these data sets. The middle column gives the number of observations in each data set and the right column gives the residual sum of squares for each of the four regression models estimated.

Table 4.33. Results of constrained regression analysis for step (1) for 1971 data

Data Set	Number of Observations	Residual Sum of Squares
FD1	71	329,325.06
CD1	55	1,496,249.90
FI1	42	150,171.94
CI1	44	232,340.48

In step (2) one pooled restricted regression model was estimated using all of the 1971 data. Intercept dummy variables were included for type and change direction. Table 4.34 presents the data set, number of observations, and the residual sum of squares for the constrained regression model.

Table 4.34. Results of constrained regression analysis for step (2) for 1971 data

Data Set	Number of Observations	Sum of Squares for the Constrained Regression Models
FCID1	212	3,306,213.98

In step (3) the F-ratio from equation 3.47 was used to test the equality of the slope coefficients for the pooled constrained regression model.

$$F_{FCID1} = \frac{3,306,213.98 - 2,208,087.28/(4-1)(21)}{2,208,087.28/[212-(4)(21)]} = 1.01$$

The tabulated F-value at the .10 probability level is 1.24.

The tabulated F-value is greater than the calculated F-value, therefore, the null hypothesis that the slope coefficients could be constrained to be equal for all the 1971 data was not rejected. Therefore, only one model, the FCID1, is needed to predict and explain slaughter-hog production level changes for 1971. The conclusion from steps (12) and (13) was that the 1971 data must be used alone in estimating a pooled constrained regression model for 1971, i.e., 1971 data could not be combined with all or any of the 1970, 1969, or 1968 data.

a. 1971 regression model Slope and intercept coefficients can be constrained to be equal for producers with different types of hog operations and for producers who made opposite changes in their slaughter-hog production levels. In step (15) the F-ratio from equation 3.47 was used to test the equality of the intercept values for the types of hog operations and the different change directions.

$$F_{FCID1} = \frac{9,654,975.24 - 9,627,469.75/(23-21)}{9,627,469.75/(212-23)} = .7861$$

The tabulated F-value at the .10 probability level is 2.30. The tabulated F-value is greater than the calculated F-value, therefore the conclusion that the intercept dummy variables are not needed in the model.

Table 3.8 presents all of the independent variables initially used in the regression models. Variables not significant were deleted by using the following procedure. First, approximately one half of the insignificant variables in the initial models were deleted and then these models were reestimated. The insignificant variables in these reestimated models were then deleted one, two, or three at a time until all variables in the models were significant at the .10 probability level. The F-ratio given by equation 3.40 was used to compare the full and reduced models to determine the significance of the variables deleted.

Table 4.35 presents the results for the FCID1 model. As was expected, the change in the number of slaughter-hogs sold in the 1971 change period was found to be positively related to PFP, EPFC, HO, and HS70.

Table 4.35. FCID1 model results

Variable	Coefficient	t-value
Importance Scored Variables		
(1) Price of feeder pigs (PFP)	21.3633	2.6513*
(2) Expected price of slaughter-hogs (EPSH)	-12.7811	-1.7253**
(3) Expected price of fed cattle (EPFC)	15.0917	1.6132*
(4) Labor supply (LS)	-12.0230	-1.8060**
(5) Health of operator (HO)	20.0787	2.6034*
Nonimportance Scored Variables		
(6) Number of years of education (ED)	5.0680	2.1740**
(7) Number of livestock enterprises (LVSE)	24.7665	3.0665**
(8) Number of hogs sold in 1970 (HS70)	0.2439	13.6635*
(9) Intercept	1.2459	0.1335

*P < .10, one tailed test.
**P < .10, two tailed test.

These factors were important for producers making large changes in the number of slaughter-hogs sold in 1971. ED and LVSE were also found to have positive relationships with the dependent variable. As the number of years of education increased and as the number of livestock enterprises increased, the larger were the changes in slaughter-hog production in 1971. EPSH had a significant negative coefficient which was opposite of what was expected. The interpretation of this result is that EPSH influenced producers making small changes in their slaughter-hog production levels. LS also had a significant negative coefficient which was opposite of what was expected. The interpretation of this result is that the producers who changed their slaughter-hog production and considered LS to be important, made small changes in their production levels. Because the sign of the EPSH and LS were opposite of what was expected, the coefficients were tested by using a two tailed t-test.

The R_m^2 is .736 for the FCID1 model. The interpretation is that 73.6 percent of the variance in the changes in slaughter-hog production for the FCID1 model is explained by the variables presented in Table 4.35.

2. Results for 1970 and 1969 data

It was intended that the constrained regression procedure would be applied to the 1970 and 1969 data in the same manner as the 1971 data. But, due to insufficient data, certain reasonable assumptions had to be made in order to carry through with the procedure. Only 3 of the necessary 4 initial models in step (1) could be estimated for the 1970 data and 1969 data. Therefore, the outlined procedure could not be followed in determining if all the 1970 data and all the 1969 data could be pooled to estimate one model for each change period.

Steps (4) and (5) were carried out to determine if portions of the data could be combined. The actual models tested were the FCI0 and FCI9 models. The data sets used for the FCI0 model were the FI0 and CI0 data sets. The restricted FCI0 model was compared to the FIo and CI0 unrestricted models in step (5). This same procedure was followed for the 1969 data. The results of this test indicated that the FCI0 and FCI9 models could be estimated. The FCD0 and FCD9 models could not be tested because of insufficient data to estimate the FD0 and FD9 (unrestricted) models. Therefore, the assumptions were made that the FCD0 and FCD9 models could be estimated. These assumptions seemed reasonable because: (1) the FCD1 model could be estimated for the 1971 data, and (2) all the increase data could be combined for the 1971, 1970, and 1969 change periods.

The FCI0, FCD0, FCI9, and FCD9 models were used in making the test for combining all the data in each change period. It was determined that all the 1970 data could be combined to estimate the FCID0 model and that all the 1969 data could be combined to estimate the FCID9 model.

After it was determined that the FCID0 and FCID9 models could be estimated, a test was performed to determine if the 1970 and 1969 data could be combined to estimate the FCID09 model. The results indicated that the data could be combined and, therefore, only one model was needed to predict and explain the changes in the number of slaughter-hogs sold in 1970 and 1969 change periods.

The procedure used to eliminate the insignificant variables was the same as was used for the 1971 model.

a. <u>1970 and 1969 regression model</u> Table 4.36 presents the results for the FCID09 model. As was expected, the change in the number

Table 4.36. FCID09 model results

Variable	Coefficient	t-value
Importance Scored Variables		
(1) Price of feeder pigs (PFP)	12.1635	1.8243*
(2) Feed supply (FS)	-23.8847	-3.5030**
(3) Capital supply (CS)	22.2601	2.8545*
(4) Average litter size (ALS)	-11.8306	-1.9984**
Nonimportance Scored Variables		
(5) Age of producer (AGE)	-1.8305	-3.0936*
(6) Number of years of education (ED)	5.6188	2.1115**
(7) Percentage of gross farm sales from the hog enterprise (PFS)	1.6082	4.1062*
(8) Total number of acres operated (AP)	0.1275	2.9817**
(9) Excess capacity (EC)	33.5868	2.0509**
(10) Number of hogs sold in period t-1 (HS_{t-1})	0.1236	5.5327
(11) Intercept	18.5797	1.8920

*$P < .10$, one tailed t-test.
**$P < .1o$, two tailed t-test.

of slaughter-hogs sold in the 1970 and 1969 change periods was found to be positively related to PFP, CS, PFS, ED and HS_{t-1} and negatively related to AGE. FS and ALS were found to have coefficients with negative signs, which was unexpected. FS was important for producers making small changes in their slaughter-hog production levels. ALS was a factor affecting producers making small changes but not large changes in their slaughter-hog production levels. ED and AP were both found to have a positive relationship with the dependent variable. As the number of years of education increased the larger were the changes in slaughter-hog production for the 1970 and 1969 change periods. As the number of acres operated increased the larger were the changes in the number of slaughter-hogs produced.

The R_m^2 is .674 for the FCID09 model.

3. Results for 1968 data

The same constrained regression procedure that was used to analyze the 1971 data was used to analyze the 1968 data. Alterations were made in the procedure when necessary because of insufficient data. Only two of the four initial models could be estimated. It was determined that the slope coefficients for the FI8 and CI8 models could be constrained to be equal. Therefore, the FCI8 model was used for the increase data. The FD8 and CD8 models could not be estimated and, therefore, the hypothesis that the slope coefficients are equal could not be tested. Consequently, it was assumed that the FCD8 could be estimated.

A pooled model using all of the 1968 data, the FCID8 model, was estimated and used to test the hypothesis that the increase and decrease data slope coefficients could be constrained to be equal. The results indicated that the slope coefficients could not be constrained to be equal and, therefore, separate models for FCI8 and FCD8 were needed to predict the changes in slaughter-hog production levels in 1968. Neither model required a dummy variable for the type of hog operation.

The procedure used to eliminate the insignificant variables was the same as the procedure used for the 1971 models.

a. <u>1968 regression models</u> Table 4.37 presents the results for the FCI8 model. As was expected, the change in the number of slaughter-hogs sold in the 1968 change period was found to be positively related to LS, ALS, and PFS. All three were important in causing large increases in the number of slaughter-hogs sold. EDUC and AW were also found to be positively related to the dependent variable. The greater the number of years of education and the greater the number of acres owned, the greater was the increased production level. OO was found to be negatively related to the dependent variable. Producers who were owner-operators made

Table 4.37. FCI8 model results

Variable
Importance Scored Variables
(1) Price of feeder pigs (PFP)
(2) Labor supply (LS)
(3) Average conception rates (ACR)
(4) Average litter size (ALS)
Nonimportance Scored Variables
(5) Number of years of education (EDUC)
(6) Percentage of gross farm sales from the hog enterprise (PFS)
(7) Number of acres owned in 1971 (AW)
(8) Owner or tenant operator (OO)
(9) Intercept

*P < .10, one tailed t-test.
**P < .10, two tailed t-test.

smaller changes in production levels than did tenant operators. PFP and ACR were expected to have positive coefficients, but they were found to be negative. The price of feeder pigs and average conception rates were important factors for producers making small increases, but were of lesser importance for producers making large production increases. The R_m^2 is .475 for the FCI8 model.

Table 4.38 presents the results for the FCD8 model. As was expected, the change in the number of slaughter-hogs sold in the 1968 change period was found to be positively related to EPSH, CP, and PFS. These were important factors for producers making large decreases in their production level. LVSE was found to be negatively related to the dependent variable.

Table 4.38. FCD8 model results

Variable	Coefficient	t-value
Importance Scored Variables		
(1) Expected price of slaughter-hogs (EPSH)	22.6339	2.3077*
(2) Corn price (CP)	19.6259	2.0351*
Nonimportance Scored Variables		
(3) Percentage of gross farm sales from hog enterprise (PFS)	+1.1941	+1.8862
(4) Number of different livestock enterprises (LVSE)	-26.3549	-1.9537**
(5) Intercept	-189.2381	-4.0800

*P < .10, one tailed t-test.
**P < .10, two tailed t-test.

As the number of livestock enterprises increases the less likely is a producer to make a major decrease in his slaughter-hog production level. The R_m^2 is .474 for the FCD8 model.

Comparing the two models for the 1968 change period only one variable, PFS, was significant in both models. This indicates that the producers increasing and decreasing production from 1967 to 1968 considered very few of the same factors that might have caused them to change their slaughter-hog production level.

4. Summary of multiple regression results

Many variables were significant in the four regression models estimated. Table 4.39 summarizes the number of times the three types of importance scored variables were significant in each period analyzed, the number of times each type of variable was positive and negative in each period, and the totals for all four periods. The following procedure was used to make these comparisons.

In the 1971, 1970, and 1969 change periods, models could be estimated for both producers increasing and decreasing their slaughter-hog production level, while in 1968 a separate model was needed for the increase and decrease data. Therefore, when determining the number of times a particular type of importance scored variable was significant in 1971 the actual number of variables in the FCID0 model was doubled because the model was estimated for both increase and decrease data. For 1970-69 and 1969-68 change periods, only one model was needed for the two change periods and for both the increase and decrease data. Therefore, the actual number of importance scored variables in the FCID09 model was quadrupled.

Table 4.39. Summary of significance of three categories of importance scored variables

Type of Variable	Number of significant coefficients for change period: 1971-70 +	-	Total	1970-68 +	-	Total	1968-67 +	-	Total	Total +	-	Total
Economic	4	2	6	4	0	4	2	1	3	10	3	13
Resource	0	2	2	4	4	8	1	0	1	5	6	11
Chance	2	0	2	0	4	4	1	1	2	3	5	8

The economic importance scored variables were significant a greater number of times than either the resource or chance variables. This indicates that producers more often consider the economic factors of slaughter-hog production, when making decisions about changing their slaughter-hog production levels, than either the resource or chance factors. Resource factors ranked second in the number of times being significant, while the chance factors ranked third. This indicates that chance factors have the smallest effect upon changed production levels, and consequently one could conclude that a sizeable percentage of the major changes in slaughter-hog production are planned.

One or more of the producer, enterprise, or farm characteristics were significant in all the models estimated. There were no variables that were significant in all the models. ED and PFS were significant in three models, while LVSE and HS in year t-1 were significant in two models.

From the results of testing hypothesis IV, it can be concluded that the economic, resource, and chance importance scored variables along with the producer, farm, and enterprise characteristics, do affect the changes in slaughter-hog production levels. Therefore, hypothesis IV is not rejected.

5. Comparison of models over time

Although different variables affected slaughter-hog production level changes in different change periods, at least one of the five economic variables was significant in all four models. This indicates that one or more of the economic factors were considered by producers when making slaughter-hog production level decisions in each change period. PFP was significant in three of the four models and was the most frequently occurring significant economic variable.

Resource factors were significant in three of the four models. Labor supply was significant twice and feed supply and capital supply were each significant once. There is no general trend of significance for any one resource factor between change periods.

Chance factors were significant in three of the four models. Average litter size was significant twice, once with a positive coefficient and once with a negative coefficient. There is no general trend of significance for any one chance factor between change periods.

The number of years of education and the percentage of gross farm sales from the hog enterprise were the nonimportance scored variables that were significant the greatest number of times. PFS was significant in three change periods whereas ED was significant in all four change periods analyzed. ED had a positive coefficient every time it was significant, making it the most consistent variable for sign and significance. HS in year t-1 was significant in the 1971 and 1970-68 change periods. Both times the coefficient had a positive coefficient. LVSE was significant in two models with one positive and one negative coefficient. On the basis of these comparisons, there is an indication of consistency of the size of the coefficients of the ED, HS_{t-1}, PFS, and LVSE when these variables are significant. The R_m^2 for the four regression models ranged from .736 to .474.

In conclusion, the economic, resource, and chance factors along with the producer, farm, and enterprise factors were found to be significant in explaining the changes in slaughter-hog production levels. But the same variables were not always found to be significant in different models for the same or different change periods. On the basis of comparisons of models over time and within one change period, hypothesis V was not rejected.

V. CONCLUSIONS

The purpose of Chapter V is fourfold; (1) to summarize the results of tests of the hypotheses, (2) to pose questions that one might ask about changes in levels of hog production and use the results of this study to answer these questions, (3) to cite limitations of the study, and (4) to suggest topics for additional research.

A. Summary of Hypotheses

Hypothesis I dealt with identifying characteristics of producers who did and did not make slaughter-hog production level changes from 1967 through 1971. Four characteristics were identified to be significant discriminators between the two groups of producers. The four characteristics were the capital-intensity of swine facilities, the number of slaughter-hogs sold in 1967, the number of different market outlets hogs were sold to, and the number of years of education. The number of years of education was found to be the best discriminating characteristic of the variables tested.

Tests of hypothesis II led to the conclusion that producers with the same type of hog operation did not have stationary transition probabilities for size class changes from 1967 through 1971. The conclusion from results of tests of hypothesis III was that producers with different types of hog operations did not have homogeneous transition probabilities for size class changes for a given change period. The overall conclusion drawn from results of tests of hypotheses II and III was that the pattern of size class changes was not constant over time or across different types of producers.

Results of tests of hypothesis IV showed that economic, resource, and chance importance scored factors along with producer, farm, and enterprise characteristics affect producers' changes in slaughter-hog production levels. No single factor or characteristic was consistently significant in the four models estimated to explain the changes in slaughter-hog production levels from 1967 through 1971. This conclusion was based on the results of tests of hypothesis V. The economic factors were significant with the highest degree of frequency. This result is in contrast with the results of the USDA study [40] cited earlier in Chapter II. In the USDA study the economic factors were the least important.

B. Interpretation of the Results

To provide further interpretation of the results obtained by testing the five hypotheses, questions will be posed and answered on the basis of the results of this study. Two groups of questions will be posed. The first group includes questions about changes individual hog producers make. The second group of questions will deal with identifying combinations of individual changes that lead to aggregate increases and decreases in slaughter-hog production levels.

The first group of questions will be dealt with first because answers to these questions will help in explaining aggregate changes. Each of the following paragraphs contains a question and answer.

What proportion of the producers changed their size classes between years? The percentage of producers making size class changes rose steadily from 1967 through 1971. In the 1967-68 change period 21.6 percent of the producers made changes. In the 1968-69 and 1969-70 change periods, 25.6 percent and 27.8 percent of the producers made changes, respectively. In the final period 41.9 percent of the producers made changes. On the average, 29.2 percent of the producers made size class changes from 1967 to 1971.

What were the relative frequencies of the different size class changes made by producers who changed their production levels? On the average, from 1967 through 1971, 74.5 percent of the producers who changed their size class between years did so by either increasing or decreasing their production level by one size class. 25.5 percent of the producers who changed their size class between years did so by either increasing or decreasing their production level by 2 or more size classes. The percentage of producers changing production by 1 size class rose steadily from 70 percent in 1967-68 to 79.4 percent in 1970-71. The percentage of producers changing production by 2 or more size classes declined steadily from 30 percent in 1967-68 to 20.6 percent in 1970-71.

The conclusion drawn from answers to the first two questions is that the percentage of producers making size class changes increased steadily over the five year period while at the same time there was a steady decline in the number of producers making more than a one size class change. Thus, in later years, more producers were making changes, but these changes were not as drastic as in the earlier years of the time period analyzed.

Of the producers making size class changes from year to year, what were the frequencies of producers increasing and decreasing size classes? On the average, 16.91 percent of the producers increased their size class from 1967 through 1971. 12.32 percent of the producers on the average decreased their size class from 1967 through 1971. The percentage of producers increasing size classes rose steadily from 13.3 percent in 1968 to 21.75 percent in 1970 and then dropped to 20.16 percent in 1971. From 1968 to 1970 the percentage of producers decreasing size classes was relatively constant at 9 percent. In 1971 22.15 percent of the producers were classified into a smaller size class and 1970-71 was the only change period in which the percentage decreasing size classes exceeded the percentage increasing size classes.

How important are changes caused by producers entering and exiting slaughter-hog production as compared to changes caused by continuing producers who increase or decrease their size class? From 1967 through 1971, on the average, the percentage of producers starting to produce slaughter-hogs was 3.45 percent, while the percentage exiting from slaughter-hog production was 1.16 percent. Based on the number of producers changing size classes, on the average, 11.8 percent started producing slaughter-hogs, while 3.98 percent quit producing slaughter-hogs. On the average 15.78 percent of those producers changing size classes were producers either entering or exiting from slaughter-hog production. Therefore, on the average from 1967 through 1971, 84.22 percent of the size class changes were made by producers who continually produced slaughter-hogs.

How do the different types of hog operations compare in the size class changes made in slaughter-hog production levels? On the average, 26 percent of the farrow only type of hog operations changed size classes. This type of producer made the smallest proportion of changes. The purchase feeder pigs only and farrow sows and sell feeder pigs types of hog operations changed size classes on the average of 29.92 and 31.88 percent over the five year period, respectively. The diversified type of hog operation changed size classes on the average of 34 percent over the five-year period. The diversified type of hog operations made the largest proportion of size class changes.

What were the prominent characteristics of producers who did make substantial changes? The characteristics that were found to be significant in this study were the number of different market outlets that slaughter-hogs were sold to, the number of years of education a producer has, the capital-intensity of swine facilities and the number of slaughter-hogs sold in 1967. The more markets a producer sold his slaughter-hogs to and the greater the number of years of education a producer has, the more likely was a producer to make size class changes. Also, the fewer the dollars invested in swine facilities and the fewer the number of slaughter-hogs sold in 1967 the more likely was a producer to make size class changes.

What were the prominent characteristics of producers who did not make substantial changes? The characteristics that were found to be significant are the same ones that were cited in the answer to the previous question, but the interpretation is different. The larger the number of dollars invested in swine facilities and the greater the number of hogs sold in 1967 the smaller was the chance a producer would have made substantial changes. Also, the fewer the number of different market outlets slaughter-hogs were sold to and the fewer the number of years of education the smaller was the chance a producer would have made substantial changes.

What factors cause producers to make changes? Economic, resource, and chance factors along with producer, farm, and enterprise characteristics all cause producers to make production level changes. These are generalized categories made up of more specific characteristics and factors. No one factor was consistently significant, but generally the economic, resource, and chance factors had a greater effect upon changed production levels than did producer, farm, and enterprise characteristics. The economic factors most frequently affected decisions to change production levels. Resource factors were second and chance factors were third in importance. Generally speaking, the economic factors were more important in causing large changes in production levels. The resource and chance factors were relatively more important in causing small changes in production, and less important for causing larger changes in production.

Are these factors the same in different time periods? No one specific variable in any of the three categories of factors was significant in all four change periods.

The questions just posed have dealt with individual changes in slaughter-hog production and with producer size class changes. The following discussion will attempt to provide further insight into the aggregate changes in slaughter-hog production.

Figure 5.1 shows the estimates changes in slaughter-hog production levels for the sample of producers surveyed. The estimate of aggregate slaughter-hog production based on the survey information rose steadily until 1971 when the estimated number of hogs marketed decreased slightly more than 3 percent.

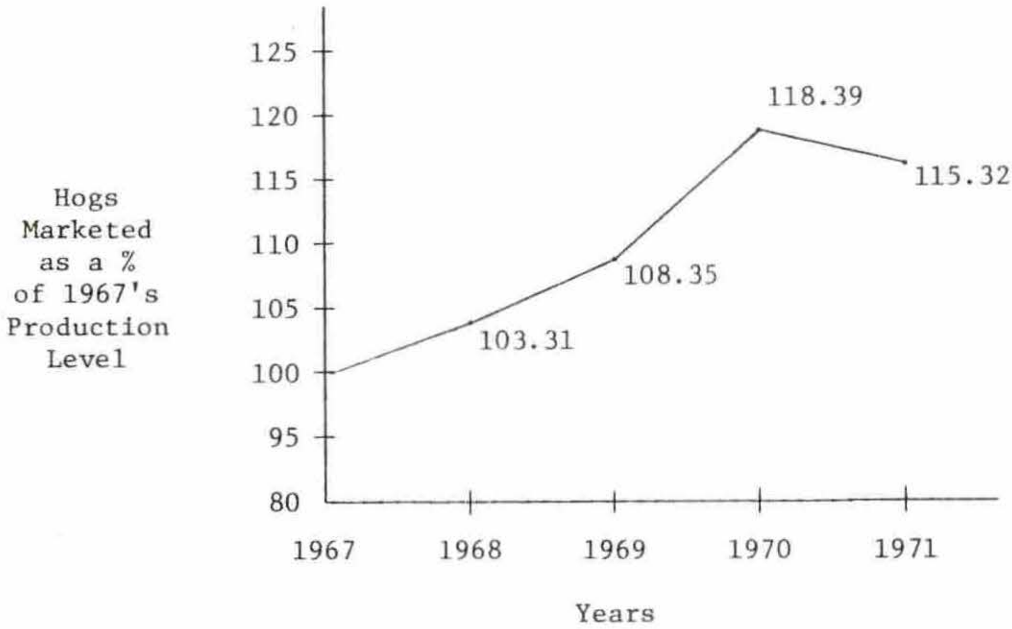

Figure 5.1. Estimate of aggregate changes in slaughter-hogs marketed from 1967 through 1971

What insights do the results generate about magnitude of aggregate changes in slaughter-hog production? A review of the significance of the economic, resource, and chance factors and the number of times significant factors had either positive or negative coefficients will provide some insight (see table 4.39 on page 131). Economic factors were significant thirteen times in the four change periods studied. Ten of these times the coefficient of the significant variable was positive. Resource factors were significant eleven times with six of the coefficients being negative. Eight times the chance factors were significant with three positive and five negative coefficients. From the results of the signs of significant factors, it could be concluded that economic factors cause larger changes more often than do the resource or chance factors.

Resource and chance factors cause more of the smaller changes in production levels.

The majority of the changes in slaughter-hog production levels are made by producers who continually produce slaughter-hogs, and not producers who get in and out of slaughter-hog production.

As the characteristics of producers change, changes in slaughter-hog production levels will be affected. The results indicate that, as producers' years of education increase and as their managerial abilities improve, the more likely they are to make substantial year-to-year changes in their slaughter-hog production levels.

As the characteristics of producers' hog enterprises change, changes in slaughter-hog production levels will be affected. As the capital intensity of swine facilities increases, there should be a decline in the number of slaughter-hog production level changes made by producers.

As the level of specialization in the hog enterprise changes, so will the magnitude of year-to-year changes in production levels. As a group, producers who farrow sows and sell all pigs farrowed as butcher hogs make the smallest proportion of changes in their slaughter-hog production levels.

What insights do the results provide about prediction of direction and size of changes? Accurate predictions of the direction and size of changes are likely to be difficult because: (1) the proportion of producers changing production levels is not constant, (2) many different factors cause changes, and (3) both specific factors cuasing changes and their quantitative impacts change over time. Although the results of this study underscore the importance of economic conditions of slaughter-hog production in causing slaughter-hog production level changes, the results also suggest that there are other factors that have major impacts on changes in slaughter-hog production levels.

C. Limitations of the Study

One problem in this study concerns the interpretation of the importance scored variables. It could not be determined with certainty just how a hog producer had interpreted the importance scored variables in relationship to the direction of change in his slaughter-hog production level. This in turn made it difficult to interpret the scores assigned these variables. A variable could have been given either a high or low importance score by a producer depending upon how the variable was interpreted. The intended effect upon the changes in his production level could have been the same in either case depending upon the initial interpretation of the variable. Therefore, using a survey in which importance scores are assigned to variables, the variables used should have only one interpretation.

Another problem was that slaughter-hog production level information went back to 1967 but the producer, farm, and enterprise characteristics were applicable to 1971 only. Consequently, an assumption had to be made that this information was relevant from 1967 to 1970, which more than likely was not always the case.

D. Additional Research

A study that might provide additional information about slaughter-hog production level changes would be to identify personal, farm, and enterprise characteristics of producers who assigned high, medium, and low importance scores to each of the importance scored variables. The results would allow one to make comparisons between the characteristics of producers assigning different importanct scores.

Another idea would be to use the importance scored variables in discriminating between producers making and not making slaughter-hog production level changes. This would provide further information about whether the economic factors are more important for producers making larger changes in production. Also, more information about whether the resource and chance factors are of more importance in causing smaller changes could be obtained.

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VIII. APPENDIX

The objective of this appendix is to illustrate discriminant analysis by use of a hypothetical numerical example. The illustration follows Hallberg's [13] procedure.

A discriminant function will be estimated to discriminate between barrows and gilts on the basis of carcass characteristics.

Groups: (1) Barrow

(2) Gilt

$i, j = 1, 2, \ldots, g; i \neq j$

In this example $g = 2$

Variables (Characteristics):

(1) Backfat

(2) Loin eye area (LEA)

$r, s = 1, 2$

Data:

Barrow Group (1)			Gilt Group (2)		
obs. (i, n)	Backfat	LEA	obs. (j, n)	Backfat	LEA
11	1.54	3.93	21	1.44	4.43
12	1.50	4.00	22	1.40	4.35
13	1.43	4.15	23	1.36	4.70
14	1.37	4.20	24	1.30	4.95
15	1.35	4.30	25	1.22	5.10
Σ	7.19	20.58	Σ	6.72	23.53

The column vector of means of the two variables for groups 1 and 2 are as follows:

$$\bar{X}_i = \bar{X}_1 = \begin{pmatrix} 1.44 \\ 4.12 \end{pmatrix}, \text{ and } \bar{X}_j = \bar{X}_2 = \begin{pmatrix} 1.34 \\ 4.71 \end{pmatrix}$$

The overall means of the two variables are as follows:

$$\text{Backfat} = \frac{1.44 + 1.34}{2} = \frac{278}{2} = 1.39 = \bar{X}_{ir}$$

$$\text{LEA} = \frac{4.12 + 4.71}{2} = \frac{8.83}{2} = 4.41 = \bar{X}_{is}$$

$\bar{X}_{ir}$ and $\bar{X}_{is}$ are needed to estimate the variance-covariance matrix given on page 28. The calculation of the KXK variance-covariance matrix would be as follows: First, the covariance between variables 1 and 2 is

$$\begin{aligned} k_{12} = k_{21} = 1/10-2\ [&(1.54 - 1.39)(3.93 - 4.41) + \\ &(1.50 - 1.39)(4.00 - 4.41) + \\ &(1.43 - 1.39)(4.15 - 4.41) + \\ &(1.37 - 1.39)(4.30 - 4.41) + \\ &(1.35 - 1.39)(4.30 - 4.41) + \\ &(1.44 - 1.39)(4.43 - 4.41) + \\ &(1.40 - 1.39)(4.35 - 4.41) + \\ &(1.36 - 1.39)(4.70 - 4.41) + \\ &(1.30 - 1.39)(4.95 - 4.41) + \\ &(1.22 - 1.39)(5.10 - 4.41)] \end{aligned}$$

$$k_{12} = k_{21} = 1/8[-.2931] = -.0366375$$

The variance of variable 1 is

$$\begin{aligned} k_{11} = 1/10-2[&(.15)^2 + (.11)^2 + (.04)^2 + (-.02)^2 + (.04)^2 + \\ &(.05)^2 + (.01)^2 + (-.03)^2 + (-.04)^2 + (-.17)^2] \end{aligned}$$

$$k_{11} = 1/8[.0787] = .0098375$$

The square root of k_{11} = .0991841 is the standard deviation of variable 1. The variance of variable 2 is

$$k_{22} = 1/10\text{-}2[(-.48)^2 + (-.41)^2 + (-.26)^2 + (-.21)^2 + (.11)^2 + (.02)^2 + (-.06)^2 + (.29)^2 + (.54)^2 + (.69)^2]$$

$$k_{22} = 1/8[1.3781] = .1722625$$

The standard deviation is .4150451.

The k_{12}, l_{21}, k_{11}, and k_{22} values are used to construct the variance-covariance matrix.

$$K = \begin{bmatrix} .0098375 & -.0366375 \\ -.0366375 & .1722625 \end{bmatrix}$$

The inverse of K is needed to estimate the discriminant function coefficients.

$$K^{-1} = \begin{bmatrix} 489 & 104 \\ 104 & 28 \end{bmatrix}$$

By using equation 3.14 the D_{12} coefficients are estimated.

$$\hat{D}_{12} = \underset{2\times 2}{\begin{bmatrix} 489 & 104 \\ 104 & 28 \end{bmatrix}} \underset{2\times 1}{\left[\begin{pmatrix} 1.44 \\ 4.12 \end{pmatrix} - \begin{pmatrix} 1.34 \\ 4.71 \end{pmatrix} \right]}$$

$$\hat{D}_{12} = \underset{2\times 1}{\begin{bmatrix} -12.46 \\ -\ 6.12 \end{bmatrix}} \quad \begin{matrix} \text{coefficient for backfat } (\hat{B}_1) \\ \text{coefficient for LEA } (\hat{B}_2) \end{matrix}$$

So that the $\hat{D}_{12}$ coefficients will be directly comparable for relative importance, each variable is multiplied by its variance so that the coefficients are standardized for the original unit of measurement. The standardizing procedure for each variable would be as follows.

Backfat = (-12.46)(.0098375)

= -.1225752 round to -.123

$$LEA = (-6.12)(.1722625)$$

$$= -1.0542465 \text{ round to } -1.054$$

By using equation 3.13, $\hat{C}_{12}$ is estimated as follows:

$$\hat{C}_{12} = -0.5 \left[\begin{pmatrix} 1.44 \\ 4.12 \end{pmatrix} - \begin{pmatrix} 1.34 \\ 4.71 \end{pmatrix}_{2\times 1} \right]' \begin{bmatrix} -12.46 \\ -\ 6.12 \end{bmatrix}_{2\times 1}$$

Taking the transpose of the first 2×1 matrix results in

$$\hat{C}_{12} = -0.5 \; \underset{1\times 2}{[2.78 \quad 8.83]} \begin{bmatrix} -12.46 \\ -\ 6.12 \end{bmatrix}_{2\times 1}$$

$$\hat{C}_{12} = -0.5\ [-88.6784]$$

$$\hat{C}_{12} = 44.3392$$

From equation 3.17, the estimated A_{ij} is

$$A_{12} = 44.3392 + \underset{1\times 2}{[\text{X matrix}]} \begin{bmatrix} -12.46 \\ -\ 6.12 \end{bmatrix}_{2\times 1}$$

A test for predictability of the discriminant function is the next step. The data from each i and j group will be plugged into the A_{12} equation to determine an A_{12} value for each observation in each group. The classification procedure given in equation 3.16 will be used. The p_1 and p_2 probabilities given in equation 3.16 will be .50 and, therefore, this classification is exactly the same as the one Ladd [23] uses for unknown prior probabilities given in equation 3.15. In this example then:

If $A_{12} \geq \ln 1 = 0$, then the observation will be classified into group 1, or

If $A_{12} < \ln 1 = 0$, then the observation will be classified into group 2.

Table of A_{12} values for each observation and each observation's discriminant and original classification:

obs. (i or j, n)	A_{12}	Discriminant Classification	Original Classification
11	1.0992	1	1
12	1.1692	1	1
13	1.1234	1	1
14	1.5650	1	1
15	1.2022	1	1
21	-0.7148	2	2
22	.2732	1	2
23	-1.3704	2	2
24	-2.1528	2	2
25	-2.0740	2	2

The classification table and the predictability percentage are presented and determined as follows:

Classification Table

		Original Classification 1	Original Classification 2	
Discriminant Classification	1	5	1	6
	2	0	4	4
		5	5	10

$$R^2 = \text{Predictability \%} = \frac{\text{\# of correct classifications}}{\text{Total \# classified}}$$

$$= 9/10 = 90\%$$

The calculation of the asymtotic variance for variables 1 and 2 would be as follows using equation 3.22.

$$\text{Var }(\hat{B}_1) = \frac{(-12.46)^2}{10} + \frac{(.0098375)^2}{10} \underset{1\times 2}{[-12.46 - 6.12]} \left[\begin{pmatrix}1.44\\4.12\end{pmatrix} \underset{2\times 1}{-} \begin{pmatrix}1.34\\4.71\end{pmatrix}\right]$$

$$+ \left(\frac{1}{5}+\frac{1}{5}\right)\left[\underset{1\times 2}{(489104)} \underset{2\times 2}{\begin{pmatrix}.0098375 & -.0366375\\ -.0366375 & .1722625\end{pmatrix}} \underset{2\times 1}{\begin{pmatrix}489\\104\end{pmatrix}}\right]$$

Var $(\hat{B}_1)$ = 213.31564, the standard deviation would equal 14.605329.

Var $(\hat{B}_1)$ = 14.984217, the standard deviation would equal 3.8709452.

Interpretation of Results:

$\hat{B}_1$: -.123: As the size of the backfat measurement increases, the more likely the measurement came from a gilt.

$\hat{B}_2$: -1.054: As the size of the LEA measurement increases, the more likely the measurement came from a gilt.

LEA $(\hat{B}_2)$ is a better discriminator between barrows and gilts than is the backfat measurement, thus its relative importance is higher.

Significance of Coefficients:

The t-test given in equation 3.23 is used to make the test of significance.

Degrees of freedom = n - g - 1

= 10 - 2 - 1 = 7

A two-tailed test is used because one wants to know if the coefficient is significantly different from zero.

For $\hat{B}_1$:

$$t_1 = \frac{-12.46}{14.605329} = |-.8531132|$$

Tabulated t-value at 10% probability level = 1.895

Tabulated > Calculated $\therefore H_0$ is not rejected that the coefficient is not significantly different from zero.

For $\hat{B}_2$:

$$t_2 = \frac{-6.12}{3.8709452} = |-1.5810092|$$

Tabulated > Calculated $\therefore H_0$ is not rejected that the coefficient is not significantly different from zero.

Neither one of the variables are significant.