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The effect of the hog-corn ratio on swine production in Iowa

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by

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INTRODUCTION

This study examines the hog-corn ratio and how it affects the number of sows farrowed in Iowa. After establishing the importance of swine production in both Iowa and the United States, the geographic relationship of hog production to corn production will be discussed. Since the main cost of producing hogs is feed, it has traditionally been accepted that the hog-corn ratio is a good predictor of the future supply of hogs. But since the cost structure of the swine industry is continually changing, this study will determine if the hog-corn ratio is still a significant factor in predicting the future supply of hogs. Other studies in this area have used annual or semi-annual data. This study will use quarterly data to take a closer look at this relationship.

Background

Before the hog-corn ratio is analyzed, some of the trends in swine production will be examined to give background for and meaning to the analysis which follows.

Swine production is an important industry in the United States. Of the $53 billion cash receipts from farming in 1970, 8.5 percent, over $4.5 billion, was from swine. This value was exceeded only by the value of cattle and calves, $13.7 billion, and dairy products, $6.5 billion.

The relative importance of swine production in United States agriculture has decreased slightly in the past 45 years. In 1926 the cash receipts from swine were $1.4 billion, representing 13.2 percent of the total farm receipts which compares to only 8.5 percent in 1970. In spite of this, the total cash receipts from swine were $4.5 billion in 1970, over three times as large as in 1926. This trend can be seen in Table 1.

Per capita consumption of all foods has decreased slightly over the past 45 years. But the importance of meat in the diet has increased from 138.0 pounds in 1926 to 186.3 pounds in 1970. This is primarily due to an increase in beef consumption. Over this time total pork consumed and pork consumed as a percent of all foods have remained relatively constant (Table 2). Thus, the increase in swine production discussed earlier is more the reflection of an increased population, 125 million in 1930 as compared to 208 million in 1970, than an increased preference for pork (15).

While pork consumed as a percent of all foods has been relatively constant at a little over four percent, there have been significant year to year variations. This is due in part to fluctuations in the price of pork. For example, the consumption of pork in 1934 was only 3.14 percent of all foods, a drop from 4.26 percent in 1933.

Table 1. Five year average of cash receipts from farming for the United States[a]

	Hogs, pork and lard ($1,000,000)	Cattle, calves beef and veal ($1,000,000)	Total farm receipts ($1,000,000)	Swine % of total receipts
1926-30	1,259	1,368	10,530	11.9
1931-35	589	787	6,218	9.5
1936-40	886	1,236	8,756	10.1
1941-45	2,298	2,490	18,370	12.5
1946-50	3,368	4,908	28,560	11.8
1951-55	3,397	5,670	31,497	10.7
1956-60[b]	2,943	6,800	33,095	8.9
1961-65	3,215	8,116	39,001	8.2
1966-70[c]	4,183	11,676	48,956	8.5

[a]Source: (22).

[b]Includes Alaska and Hawaii beginning with 1960.

[c]Preliminary.

Table 2. Five year average of per capita consumption of pork, meats and all food[a]

	Pork[b] (lb.)	All meats[c] (lb.)	All foods (lb.)	Pork as a % of all meats	Pork as a % of all foods
1926-30	67.9	132.9	1,575	51.2	4.25
1931-35	64.5	131.8	1,527	48.7	4.22
1936-40	61.5	132.0	1,549	46.5	3.96
1941-45	71.4	146.0	1,621	48.9	4.40
1946-50	70.0	148.8	1,580	47.1	4.43
1951-55	66.9	151.4	1,514	44.2	4.42
1956-60	64.2	159.5	1,481	40.1	4.33
1961-65	62.9	166.8	1,430	37.7	4.40
1966-70[d]	63.8	179.9	1,436	35.4	4.44

[a]Source: (22).

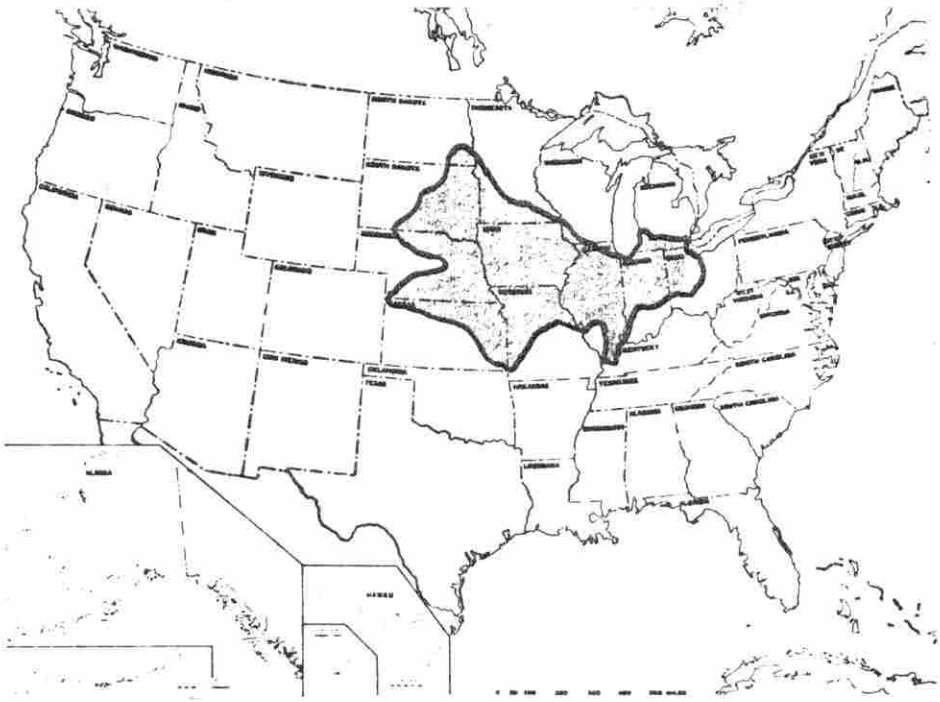
[b]Excluding lard.

[c]No adjustments made for cost of hogs shipped in and charges in inventory values.

[d]Preliminary.

The market price of hogs more than doubled from $4.05 per hundredweight in 1933 to $8.70 per hundredweight in 1934. In 1958 consumption of pork was 4.12 percent of all foods with a price of $19.40 per hundredweight. Then when price dropped to $13.50 in 1959, the consumption increased to 4.60 percent. The price of pork is not the only factor in the determination of the amount of pork consumed, but it explains part of the variation.

Swine production in the United States has been concentrated in the middle west. This region extends from Ohio to Nebraska and corresponds very closely to a region commonly referred to as the Corn Belt. Iowa, Illinois, Indiana and Ohio, as well as parts of North Dakota, South Dakota, Nebraska, Kansas, Minnesota, Missouri, Wisconsin and Michigan are included in this area (Figure 1). In 1964 these twelve states contained only 34.5 percent (30) of all farmland in the United States, but in 1970, they produced 85.2 percent of the corn (24) and 76.9 percent of the total pig crop (22). This implies that there is a high correlation between the production of corn and swine. This is even more obvious in Table 3, which shows that swine are produced where corn is grown. The reason for this is simple, hogs are a major consumer of concentrates and the Corn Belt is the leading producer of concentrates. Jennings, in a research report, estimates that it requires



Produces:
76.9 percent of the total U. S. pig crop
85.2 percent of the total U. S. corn crop

Figure 1. The Corn Belt of the United States (3)

Table 3. Pig crop and corn production for 1970 by states

	Pig Crop[a,b] (1000's)	Corn Production[c] (1000 bu.)	Percent of U. S. Pig Crop	Percent of U. S. Corn Production
Iowa	22,871	859,140	22.35	20.905
Illinois	11,881	744,884	11.61	18.125
Missouri	8,283	173,057	8.09	4.211
Indiana	7,281	371,998	7.11	9.052
Minnesota	6,102	290,490	5.96	9.501
Nebraska	5,968	367,275	5.83	8.937
Ohio	4,226	232,078	4.13	5.646
Wisconsin	3,690	143,520	3.60	3.492
North Carolina	3,496	67,250	3.41	1.636
South Dakota	3,375	102,336	3.29	2.490
Kansas	3,245	79,670	3.17	1.939
Georgia	2,807	44,206	2.74	1.076
Kentucky	2,635	49,400	2.57	1.202
Tennessee	2,012	22,760	1.96	.554
Texas	1,987	32,331	1.94	.778
Alabama	1,721	12,535	1.68	.305
Michigan	1,242	114,076	1.21	2.776
Virginia	963	31,144	.94	.758
Mississippi	945	6,944	.92	.169
Pennsylvania	881	80,155	.86	1.950
South Carolina	880	10,854	.86	.264
Oklahoma	772	4,758	.75	.116
Arkansas	650	1,575	.63	.040
North Dakota	611	6,500	.59	.161
Colorado	557	31,872	.54	.776
Florida	535	8,050	.52	.196
Montana	321	288	.31	.007
Louisiana	303	4,998	.29	.122
Maryland	278	40,172	.27	.977
Idaho	228	2,430	.22	.005
California	222	21,168	.21	.515
Oregon	195	864	.19	.023
New York	150	22,041	.14	.534
Washington	139	3,952	.13	.096
Arizona	126	336	.12	.008

[a]Source: (22).

[b]Preliminary.

[c]Source: (24).

Table 3. Continued

	Pig Crop[a,b] (1000's)	Corn Production[c] (1000 bu.)	Percent of U. S. Pig Crop	Percent of U. S. Corn Production
West Virginia	109	3,120	.10	.076
Massachusetts	100	-----	.09	----
New Mexico	88	1,071	.08	.028
New Jersey	84	5,070	.08	.123
Utah	82	-----	.08	----
Hawaii	76	-----	.07	----
Delaware	72	13,690	.07	.333
Wyoming	53	1,674	.05	.043
New Hampshire	16	-----	.01	----
Nevada	14.9	-----	.01	----
Maine	13.0	-----	.01	----
Conneticutt	12.7	-----	.01	----
Rhode Island	9.7	-----	.01	----
Vermont	9.0	-----	.01	----
Alaska	1.7	-----	---[d]	----
U. S. (total)	102,319	4,109,792	100.00	100.000

[d]Less than .01.

100 pounds of corn in a balanced ration to produce 23 pounds of live hog, or 13.6 pounds of boneless pork and lard (10). This gives swine production a liveweight conversion ratio of about 4 to 1, which means it requires about four pounds of concentrates, primarily corn, to produce one pound of live hogs. This means that the hogs will be raised near the source of the major input, corn (Figures 2 and 3). The basic principle behind this is that the cost of transporting the raw material, corn, is much larger than the cost of transporting the finished goods, pork, because of the reduction in weight.

Of these twelve Corn Belt states, Iowa is the leading producer of both corn and hogs. In 1970 Iowa accounted for 22.35 percent of the total United States pig crop (22) and 20.9 percent of the corn production (24). In the last 45 years, Iowa's share of the United States pig crop has been slowly increasing. The lowest percent was in 1936 with 16.5 percent and the high was in 1966 and 1968 at 24.1 percent (Table 4). The five year average for 1926-1930 was 18.1 percent and after a slight decline in the 1930's, the average has increased to 23.4 percent for the period 1966-1970 (Table 5). Iowa has been the leading producer of swine by a large margin for many years, and has usually been the leading producer of corn. Iowa's pig crop has been approximately twice that of the second leading swine producing

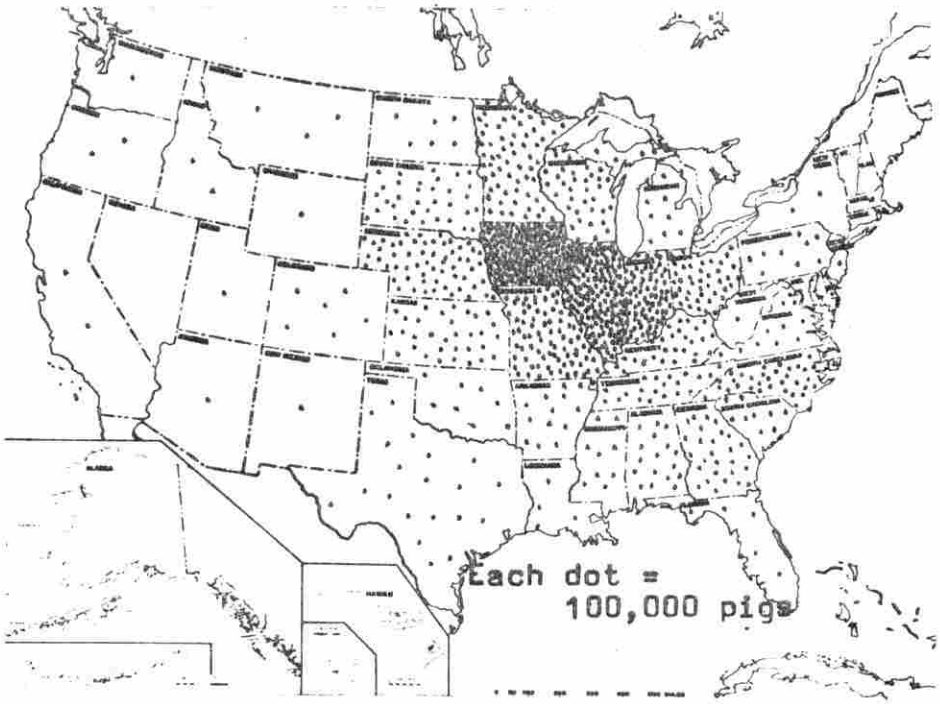


Figure 2. Distribution of the United States pig crop by states for 1970 (22)

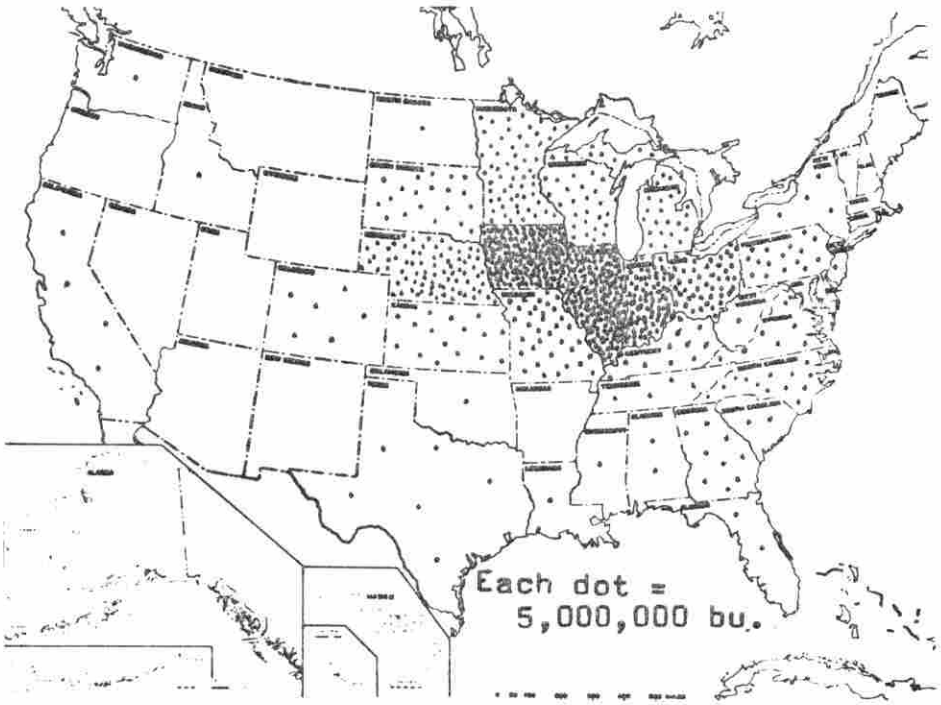


Figure 3. Distribution of the United States corn crop by states for 1970 (24)

Table 4. Annual pig crops

	Iowa[a] (1,000,000's)	U. S.[b]	Iowa Percent of U. S.
1926	13.94	75.44	18.5
1927	14.73	81.25	18.1
1928	14.38	78.68	18.3
1929	14.43	76.13	19.0
1930	14.80	74.14	20.0
1931	15.95	83.18	19.2
1932	14.24	82.53	17.3
1933	14.43	84.20	17.1
1934	9.64	56.77	17.0
1935	9.77	56.14	17.4
1936	10.85	65.73	16.5
1937	10.92	62.52	17.5
1938	12.38	71.86	17.1
1939	14.96	86.95	17.2
1940	14.02	79.87	17.6
1941	15.88	84.95	18.7
1942	18.52	104.90	17.7
1943	20.95	121.81	17.2
1944	15.54	86.66	17.9
1945	16.60	86.83	19.1
1946	15.57	82.69	18.9
1947	15.95	83.29	19.1
1948	16.11	83.83	19.2
1949	18.68	93.24	20.1
1950	20.30	97.38	20.9
1951	21.30	100.59	21.2
1952	19.44	88.83	21.9
1953	18.07	77.91	23.2
1954	19.67	86.83	22.6
1955	21.33	85.73	22.3
1956	19.12	89.43	21.4
1957	18.82	87.36	21.5
1958	20.28	93.53	21.7
1959	21.07	99.40	21.2
1960	18.71	88.22	21.2

[a]Source: (19).

[b]Source: (22).

Table 4. Continued

	Iowa[a] (1,000,000's)	U. S.[b] (1,000,000's)	Iowa Percent of U. S.
1961	20.21	92.72	21.8
1962	20.09	93.61	21.5
1963	20.80	94.06	22.1
1964	20.49	87.54	23.4
1965	18.78	78.94	23.8
1966	21.12	87.56	24.1
1967	21.72	91.75	23.7
1968	22.72	94.22	24.1
1969	20.14	88.95	22.6
1970	22.87	102.32	22.4

Table 5. Five year average of the annual pig crops[a]

	Five year average Iowa (1,000,000's)	Five year average U. S. (1,000,000's)	Iowa Percent of U. S.
1926-30	14.46	77.13	18.8
1931-35	12.81	72.56	17.6
1936-40	12.63	73.39	17.2
1941-45	17.50	97.03	18.1
1946-50	17.32	88.09	19.6
1951-55	20.00	87.98	22.2
1956-60	19.60	91.59	21.4
1961-65	20.07	89.37	22.5
1966-70	21.71	92.96	23.4

[a]Compiled from Table 4.

state. Illinois, the second leading state since 1932, had a pig crop of 11.9 million in 1970 compared to Iowa's 22.9 million (Table 6). The cash receipts from the sale of swine in Iowa were $1.14 billion in 1970 (22). This was 29.2 percent of Iowa's total farm receipts of $3.9 billion (30), and about three and one-half times the 8.5 percent average for the United States (22).

Even though Iowa's pig crop has been increasing, there has been a decrease in the percent of Iowa farmers producing swine (Table 7). In 1930, 85.1 percent of all farmers in Iowa were producing swine, but in 1970 only 59.5 percent were engaged in swine production. When this declining percent is combined with the fact that the total number of farms decreased from 214,928 to 140,354 during the same period, it is obvious that there has been a sharp decline in the total number of hog producers in Iowa. It also is obvious that since the pig crops have been increasing, each producer is farrowing more sows. In 1969 the average number of farrowings per producer who farrowed sows was 37.7 compared to only 15.3 in 1930 (27).

Since there have been large changes in the size of producers there also have been changes in the cost of producing swine. These changes are mainly in the form of labor saving and environmentally controlled capital investments. While this increases the fixed cost associated with

Table 6. Iowa's pig crop as compared to the second leading state in the United States[a]

	Iowa's Pig Crop[b] (1000's)	Second state's Pig Crop (1000's)	Second leading state
1926	13,935	6,357	Illinois
1927	14,725	6,584	Illinois
1928	14,378	6,715	Nebraska
1929	14,431	6,551	Nebraska
1930	14,803	6,262	Nebraska
1931	15,951	7,158	Nebraska
1932	14,239	7,542	Illinois
1933	14,426	7,932	Illinois
1934	9,638	5,028	Illinois
1935	9,781	4,750	Illinois
1936	11,268	5,563	Illinois
1937	11,349	5,412	Illinois
1938	12,375	6,332	Illinois
1939	14,358	7,429	Illinois
1940	14,020	7,999	Illinois
1941	15,879	8,512	Illinois
1942	16,159	8,809	Illinois
1943	16,469	8,919	Illinois
1944	19,097	10,023	Illinois
1945	20,306	10,653	Illinois
1946	21,304	11,064	Illinois
1947	19,574	10,210	Illinois
1948	18,314	9,756	Illinois
1949	19,665	10,175	Illinois
1950	21,326	11,325	Illinois
1951	19,116	11,218	Illinois
1952	18,819	11,236	Illinois
1953	20,072	11,987	Illinois
1954	21,072	12,549	Illinois
1955	18,714	11,422	Illinois

[a]Source: (22).

[b]Pigs raised to weaning.

Table 6. Continued

	Iowa's Pig Crop[b] (1000's)	Second state's Pig Crop (1000's)	Second leading state
1956	20,205	12,512	Illinois
1957	20,093	12,738	Illinois
1958	20,695	13,061	Illinois
1959	19,906	12,306	Illinois
1960	18,854	11,049	Illinois
1961	20,205	12,512	Illinois
1962	20,093	12,738	Illinois
1963	20,695	13,061	Illinois
1964	19,906	12,306	Illinois
1965	18,854	11,049	Illinois
1966	21,115	11,233	Illinois
1967	21,716	11,826	Illinois
1968	22,718	11,584	Illinois
1969	20,141	10,255	Illinois
1970	22,871	11,881	Illinois

Table 7. Percent of Iowa farmers producing swine[a,b]

	% of farmers farrowing sows	% with swine on farm	Farrowings per producer
1930	76.5	85.1	15.3
1935	62.4	83.4	11.8
1940	76.0	85.0	14.1
1945	69.0	81.2	18.1
1950	76.5	84.0	19.9
1954	71.5	78.9	20.3
1959	69.9	78.3	24.2
1964	60.2	70.7	30.1
1969	52.3	59.5	37.7

[a]Source: (31).

[b]Census was taken on January 1, 1935 and 1945, and on April 1, 1930, 1940 and 1950-60.

swine production, it decreases the relative importance of variable costs. Since feed, primarily corn, makes up almost half the total cost of producing swine, this change in the cost structure of swine could cause changes in the effect of the hog-corn ratio on swine production.

Both corn and hogs have been profitable for Iowa farmers in the past. In a study done by H. B. Howell (6), the returns to various crop and livestock enterprises were compared. The hourly returns to swine were far above the hourly returns from other livestock with all costs included (Table 9). In this period from 1967-1969, swine gave returns of an average of $6.13 per hour. Corn gave returns of $2.84 per hour of labor. This was higher than for any other crop during this period (Table 8). Since corn is the major input in swine production, the production of corn and hogs are complementary. Farmers can usually increase their returns from their corn crop by feeding the corn to swine or other livestock. The enterprise that a farmer chooses to employ his resources depends upon the profits associated with each. Since the hog-corn ratio compares the price of corn with the price of hogs it should be a strong indicator of the profits to be made from producing swine.

Table 8. Hourly returns for major Iowa crops, 1967-1969 average[a]

Crop	Per Acre				
	Income over operating costs[b]	Land charge	Labor Earnings	Hours of Labor	Income per hour of labor
Corn	$50.36	$34.72	$15.64	5.5	$2.84
Soybeans	45.83	34.72	11.11	4.4	2.52
Oats & Straw	21.98	20.05	1.93	5.3	.36
Alfalfa hay	22.28	20.05	2.23	8.8	.25

[a]Source: (6).

[b]Does not include charge for land, no labor cost included.

Table 9. Hourly returns for Iowa livestock, 1967-1969 average[a]

Enterprise Unit	Income over Costs[b]	Hours of Labor	Income per hour	
			All costs included[c]	Forages Complementary[d]
Dairy cow	$110	62.5	$1.75	$2.91
Beef cow	18	7.5	2.42	6.98
Ewe (10 head)	48	26.0	1.83	3.93
Fed cattle	18	6.8	2.67	4.18
Hogs (litter)	105	17.5	6.00	6.13
Hens (100 birds)	- 7	39.3	- .19	- .19

[a]Source: (6).

[b]No labor cost included.

[c]All feeds at market price including forages and pasture.

[d]Only harvesting costs included as cost of forages and pasture.

Objectives

A high hog-corn ratio has traditionally been associated with an increase, and a low ratio with a decrease, in the number of sows farrowed. This study will examine these relationships and show how they have changed over time. The specific hypotheses to be examined are:

1. The hog-corn ratio that corresponds to no change in the number of sows farrowed, the break even point, has been increasing over time.

2. Hog-corn ratios above the break even point lead to increases in farrowings, and ratios below the break even point lead to decreases in farrowings.

3. The largest impact of a change in the hog-corn ratio occurs in the first quarter in which the hog-corn ratio drops below or rises above the break even point.

4. The variation in quarterly farrowings is decreasing.

Procedures

The following procedures will be used to examine these hypotheses:

1. Development of a model of the change in the number of sows farrowed in Iowa to examine the factors affecting swine production, including the:

   a. expected price of fed cattle,
   b. price of corn,
   c. expected price of slaughter hogs,
   d. ratio between hog prices and corn prices, and
   e. effect of time.

2. Use the model to examine the hypotheses with respect to:

   a. the break even hog-corn ratio,
   b. the predictability of the amount of change,
   c. the effect of high and low hog-corn ratios, and
   d. the variations in the number of farrowings.

LITERATURE REVIEW

There have been several studies which have examined the effect of the hog-corn ratio on the number of farrowings. Some of these studies will now be reviewed.

In a study by Dean and Heady (3) a supply function for hogs was developed. They divided their analysis into two periods, one from 1924-1937 and the other from 1938-1956. This was to allow estimates of structural changes over time. Single-equation least-squares methods were used to analyze spring and fall farrowings in the United States and the North Central Region for each of the two periods. The variables included in their equations were:

1. Hog-corn ratio at breeding time.

2. Production of oats, barley and grain sorghum as a percentage of corn production in the previous year.

3. Various measures of the relative profitability of hogs and beef cattle at breeding time.

The coefficient for the hog-corn ratio was positive. It was the most important factor in explaining the variation in the number of sows farrowed.

In a report by Bundy and Diggins the average hog-corn ratio from September to December was compared to the changes in the number of sows farrowing spring pigs (1). The data used were from 1950 through 1959 for the United States. They observed that a ratio above 13.5 leads to an increase

in the number of sows farrowed while a ratio below 13.5 corresponds to a decrease in the number of farrowings. They called the point that represented no change in the number of farrowings the break even price ratio. This ratio, 13.5, represents the point where all production costs are just covered. The importance of the hog-corn ratio as an estimator of the profitability of swine production lies in the fact that corn is the basic feed used in producing hogs and feed costs represented about 80 percent of all production costs during this period.

The effect of the hog-corn ratio on the supply of hogs was examined by Arthur A. Harlow (5). He says that the supply of hogs is a direct function of the supply of corn. This is because hogs are the largest and in many respects the most adjustable user of corn, and therefore their production is affected most sharply by the variability in the supply of corn. The fall hog-corn ratio was again compared to the change in farrowings the following spring. A ratio above normal was followed by an increase in the number of sows farrowed and a low ratio preceded a decrease in farrowings. The reason for this is that a high ratio indicates that the price of hogs is relatively high compared to the price of corn, the major cost in producing swine. This increases the profitability of feeding hogs and encourages producers to farrow more sows. During this period from 1924 through 1960, the normal ratio or break even point was

about 12.7. The conclusions of this study were that while the direction of the change in farrowings predicted by the ratio is extremely reliable, the percentage changes in farrowings can be only roughly forecast from the ratio.

Shepherd and Thompson-Barakona examined the long run changes in the demand for pork and the supply of hogs (17). The objective of their study was to measure the long run changes that have been taking place in the supply and demand for pork. Changes in beef consumption and the demand for beef were the most important factors affecting the demand for pork. The supply of pork was related to the supply of concentrate feeds. Therefore, through the control of the supply of concentrate feeds the supply of pork can be indirectly controlled. The supply of concentrates is controlled through the emergency feed grain programs which control the price of corn. This is possible because concentrates make up a higher percentage of the total cost of producing hogs than for most other livestock. According to this study a reduction in the price of corn would reduce the cost handicap that has existed for hogs. Cost of producing cattle, dairy products, and poultry have been reduced by technological improvements in breeding, pastures, and feeding practices, but the cost of hogs, chiefly the cost of the concentrate feed that is put into them, have not been reduced correspondingly. A reduction in corn prices would reduce the

cost of producing hogs more than beef cattle or dairy products and put hogs in a stronger competitive position. This analysis looked at the September-December hog-corn ratio and spring farrowings. They concluded that there is a relationship between the hog-corn ratio and the number of farrowings but not a close relationship. There are many other factors which must also be considered such as the cattle price and the cyclical pattern of farrowings.

The short term price structure of the hog-pork sector of the United States was examined by Myers, Havlicek and Henderson (13). They developed a model to describe the structure of the hog-pork sector of the economy in the United States for the period 1949-1966.

They developed a model for the supply of pork in total liveweight of hogs commercially slaughtered in the United States which included:

1. the average price of barrows and gilts sold,
2. the total number of hogs on farms six months and older, other than beeeding stock,
3. the discount on prime 90-day bankers acceptances at New York City,
4. the average price of corn, and
5. a measure of cyclical production patterns.

This model had a coefficient of determination of .87.

Each of these studies used annual or semi-annual data. This was appropriate 15 to 20 years ago since a very large

percent of all farrowings were in the spring. In 1934, 76.0 percent of all farrowings in Iowa were in the month of April (19). The trend has been toward a more even distribution of farrowings throughout the year. This study will use quarterly data to determine if there is still a relationship between the hog-corn ratio and the number of farrowings. Quarterly data will also enable this study to determine the lag between a change in the hog-corn ratio and a change in the number of farrowings.

DEVELOPMENT OF A STATISTICAL MODEL

In order to test the effect the hog-corn ratio has on the production of swine it is necessary to develop a statistical model which will allow measuring the effect the independent variables have on the dependent variable. The dependent variable is the change in the number of farrowings from the same quarter of the previous year. The independent variables are the hog-corn ratio, cattle prices, time, and dummy variables for the intercepts and slopes for the number of farrowings each quarter. This model will explain the changes in the number of farrowings between quarters. Quarterly data for Iowa will be used for the period 1950-1970. After the model is developed the other independent variables can be held constant to permit the hog-corn ratio to be examined independently. This will be done by setting each of the other variables equal to its mean value for the period. Since there are many factors besides the hog-corn ratio which are important in determining the number of sows farrowed, each must be considered as the model is developed.

Factors Affecting Swine Production

The following is a discussion of the variables important in explaining the changes in swine production which later will enter the model.

There are many factors that influence a farmer's decision

influence a farmer's decision of what farm commodities to produce. Bundy and Diggins listed the following (1):

1. Size of farm
2. Type and productivity of the soil
3. Kinds and quantities of crops grown
4. Types, sizes and conditions of buildings
5. Availability of water
6. Availability of markets
7. Availability of transportation
8. Availability of breeding and feeding stock
9. Investments required in breeding or feeding stock
10. Investments required in housing and equipment
11. Labor requirements
12. Diseases and other hazards
13. Rapidity of income
14. Income per hundred dollars invested
15. Efficiency of animals to convert feeds into food for human consumption
16. Stability of demand for the products
17. Personal preference

Even though all of these factors may affect a farmer's decision to produce swine, some are more important than others. One of the most important advantages of swine production over other livestock is rapidity of income. Returns from an added investment in swine are generally realized with 10 to 12 months. This rapid turnover makes swine production very favorable for a small farmer or a young farmer with limited capital since he will be receiving returns on his investment in a relatively short time. Another important factor is the initial investments necessary to get into swine production which are small. Hogs do not require expensive housing and equipment. However, with the increased opportunity cost of labor and technological developments swine production is becoming more capitalized. As a result

ratio of fixed to variable costs has changed such that fixed costs are a more important element. Also, new technology has allowed a shift in production from the warmer months to the colder ones. These changes affect the relationship of the hog-corn ratio to swine production.

The ease of entry and quick profits can prove to be a disadvantage. A high hog-corn ratio means that the price of hogs is high relative to the price of corn and swine producers are realizing larger profits. If large profits are being made, farmers can enter and consequently flood the market. This will cause the price to decline and result in possible losses for swine producers. This price decline will result in a lower hog-corn ratio and will discourage swine production.

These factors help explain a farmer's decision to produce swine or to increase or decrease his swine production. Once the decision to produce swine has been made, a farmer next must decide on a specific quantity. This will vary from year to year unless he is insensitive to market influences. There are several factors which affect the changes in the number of hogs a producer sells each year. In a survey conducted by the Department of Economics, Iowa State University, some of these factors were examined (21). Each of the 489 farmers interviewed was asked to rate, on a range of 1 to 99, the importance of a list of factors which may cause

changes in the number of hogs marketed each year. A score of 99 was used to indicate highest importance. The factors were rated for each year in which a producer had a significant increase or decrease in the number of slaughter hogs sold. Table 10 lists the factors and the average scores for each factor. Four of these factors:

1. the expected price of slaughter hogs,
2. the ratio between hog and corn prices,
3. the corn price, and
4. the expected price of fed cattle

are believed to affect a farmer's decision as to how many hogs to produce in the future, whereas, the other factors tend to explain the number of hogs produced in the past and present periods. The four factors listed above influence the profitability of swine production and will be included in the model.

Expected price of fed cattle

The production of beef is in competition with the production of hogs on many farms and for the industry in total. This is because both feeder cattle and hogs require the same basic resources for production. The primary resource is feed in the form of concentrates made up mostly of corn. If the market price of cattle is high compared to the market price of hogs, farmers in general should produce more cattle and less hogs. Assuming a constant hog price, as the price of cattle declines, the number of farrowings should increase. However, the farmers interviewed did not rate cattle prices as an important factor (Table 10). They gave

Table 10. Factors causing a change in the number of hogs marketed and their degree of importance[a]

Factor	Increase	Decrease	Mean[b]
a. EXPECTED PRICE OF SLAUGHTER HOGS	35	27	31
b. disease problems	28	33	30
c. litter sizes	27	27	27
d. RATIO BETWEEN HOG AND CORN PRICES	30	22	26
e. CORN PRICES	24	22	23
f. feed supply	29	16	23
g. conception rates	22	22	22
h. labor supply	22	17	20
i. price of feeder pigs	18	16	17
j. capital supply	24	11	17
k. EXPECTED PRICE OF FED CATTLE	13	10	12
l. health of operator	9	8	8
m. other reasons	16	14	15

[a]Source: (21).

[b]Weighted mean of all scores for increases and decreases in number of hogs marketed during the period 1967-1971.

cattle prices a mean score of only 12. So this factor, although important by itself, is relatively less important than the other factors rated.

High cattle prices do not necessarily quarantee large profits for cattle feeders. If the price of feeder cattle is high, the profit margin is lessened considerably. But, generally, a high cattle price will encourage the feeding of cattle. Therefore, an inverse relationship between cattle price and swine production is expected.

The price of corn

A low corn price makes it attractive for farmers to market their corn through livestock. Most farmers can usually receive more for their corn crops by feeding hogs or cattle than by selling the corn as a cash crop. A high corn price will result in more corn sold without being fed to livestock. Corn typically comprises 40 to 45 percent of all costs in hog production (20). The price of corn is therefore a good indicator of the relative profitability of swine. The relationship of corn price to changes in swine production is expected to be negative.

Expected price of slaughter hogs

As the price of swine increases, the number of sows and gilts farrowed in each period is expected to increase. Farmers seem to base their production on the price they

expect to receive and the best indicator of the future price appears to be the present price. Farmers seem to assume that the present price will continue into the future. So, they plan their production for the next period according to the price in the present period. The relationship of the price of slaughter hogs to changes in the number of hogs marketed is expected to be positive.

The amount of pork produced can be varied not only by changing the number of hogs sold, but by increasing or decreasing their market weight. When a producer feeds hogs longer and increases their weight, more pork is produced.

Ratio between hog prices and corn prices

The hog-corn ratio places the influences of the price of feed and the price of hogs into one measure. Since it is a combination of the price of hogs and the price of corn, it has some of the same effects already described. A relatively high ratio means that the price of hogs is high compared to corn and generally all farmers are better off to feed the corn to hogs than to sell it for cash. Likewise, a low ratio discourages the production of swine. The hog-corn ratio of today should effect the production of swine today and for several months in the future. This is because swine production can be increased by increasing market weight and the decision to breed more sows and gilts. These sows and gilts will farrow 112 to 115 days later. Their pigs will

not enter the market for another six months. Thus, it takes about ten months between the farmer's decision to produce more swine until the actual sale of the hogs. In other words, the hog-corn ratio affects the decision made today and today's decision affects production about 10 months later. A positive relationship is anticipated between the hog-corn ratio and the decision to increase swine production.

Time

Time allows changes to take place. Changes in swine production can be either within the year (seasonal) or over a period of several years (trend) or both. Table 11 shows that even though there are some large variations from one year to the next in the number of sows farrowed, a linear trend is not obvious. There was a decrease in the 1930's due to the depression, but the range for the other years is from a low of 2,475,000 in 1941 to a high of 3,382,000 two years later in 1943. The five year averages seem to indicate that there was an increase during the period between 1930 and 1955 with a leveling off of the number of farrowings since 1955.

Even though the total number of sows farrowed each year has remained relatively constant during the past 20 years, there have been significant changes in the pattern of the farrowings during the year (Table 12). There has been an upward trend in the number of farrowings for each quarter,

Table 11. Number of sows farrowed in Iowa and five year averages[a]

	Number of sows farrowed (1000)	Five year average
1926[b]	2,571	
1927	2,757	
1928	2,584	2,605
1929	2,600	
1930	2,511	
1931	2,674	
1932	2,471	
1933	2,500	2,190
1934	1,668	
1935	1,639	
1936	1,827	
1937	1,752	
1938	1,927	2,047
1939	2,446	
1940	2,284	
1941	2,475	
1942	2,938	
1943	3,382	2,797
1944	2,579	
1945	2,610	
1946	2,364	
1947	2,587	
1948	2,431	2,667
1949	2,856	
1950	3,095	
1951	3,219	
1952	2,860	
1953	2,622	2,913
1954	2,823	
1955	3,040	

[a]Source: (19).

[b]Year runs from December 1 of previous year to November 30.

Table 11. Continued

	Number of sows farrowed (1000)	Five year average
1956	2,657	
1957	2,548	
1958	2,798	2,727
1959	2,968	
1960	2,666	
1961	2,803	
1962	2,835	
1963	2,896	2,793
1964	2,828	
1965	2,605	
1966	2,898	
1967	2,986	
1968	3,060	2,978
1969	2,769	
1970	3,176	

Table 12. Percent of annual farrowings each quarter[a]

	D - F	M - M	J - A	S - N
1931	3.5	71.8	9.1	15.6
1932	4.6	69.0	10.3	16.1
1933	5.2	66.6	12.2	16.0
1934	5.3	76.0	9.1	9.6
1935	2.7	66.2	15.7	15.4
1936	3.9	74.3	11.7	10.1
1937	2.4	72.4	11.0	14.2
1938	2.9	71.3	9.8	16.0
1939	3.9	70.5	9.3	16.3
1940	4.4	70.2	8.7	16.7
1941	3.1	65.7	10.4	20.8
1942	3.2	65.9	11.4	19.5
1943	3.0	69.6	12.5	14.9
1944	2.9	72.3	11.5	13.3
1945	2.5	68.1	13.7	15.7
1946	2.4	71.6	11.3	14.7
1947	5.0	70.1	12.4	12.5
1948	3.1	65.6	15.6	15.7
1949	5.3	64.9	14.6	15.2
1950	4.9	63.7	14.6	16.8
1951	6.4	62.2	15.4	16.0
1952	6.3	60.1	18.5	15.1
1953	8.4	58.3	19.6	13.7
1954	11.6	54.6	19.5	14.3
1955	13.5	52.3	19.1	15.1
1956	14.7	49.3	19.0	18.3
1957	14.0	48.1	19.6	18.3
1958	16.4	41.8	12.8	10.0
1959	18.1	41.7	21.8	18.4
1960	14.9	41.7	21.9	21.5
1961	15.8	41.3	21.7	21.2
1962	16.1	39.8	22.4	21.7
1963	16.1	40.5	22.5	20.9
1964	15.5	40.3	23.5	20.7
1965	16.4	40.7	22.0	20.9

[a]Source: (19).

Table 12. Continued

	D - F	M - M	J - A	S - N
1966	14.8	38.8	23.9	22.5
1967	15.5	39.4	22.3	22.8
1968	15.7	37.7	23.5	23.1
1969	17.3	37.1	22.6	23.0
1970	15.7	37.3	22.6	24.4

except the March-May period which has shown a very large decrease. In 1930, 73.1 percent of all farrowings were in this period, but only 37.3 percent in 1970. Since 1930 there has been an increase in the number of farrowings during this period in only 10 of the 40 years and in only 4 of the 20 years since 1950. This trend is most apparent since the late 1940's, so the data from 1950 through 1970 were used for a closer analysis of these trends.

A least-squares regression was run on the number of farrowings each quarter. The equation to be developed is as follows:

$$\hat{Y} = B_1 + B_2X + B_3X^2 + B_4X^3 \ldots$$

Where:

$\hat{Y}$ = Predicted number of farrowings each quarter

X = Time in years, 1950 = 1

$B_1, B_2 \ldots$ = Coefficients of each term

The data for each quarter were run first for a linear equation and then for a second degree polynomial and if the

the results were still significant, for a third degree polynomial. This was continued until the F-value was no longer significant. For example, in the December-February quarter, the F-value for the third degree polynomial was 6.96 and the critical value was 4.49. This means that a significant position of the variation for this quarter was explained by the third degree, X^3, term. The coefficient .167 was significant. The F-value for the fourth degree term was only 1.13 which is less than the critical value of 4.54. It is therefore concluded that this term is not significant and that an equation of the third degree is the best in explaining the variation in the number of farrowings in this quarter. The best fit was also obtained by a third degree polynomial for the second quarter, while a linear equation best described the last two quarters. The yearly figures were not significant for even a linear equation, again supporting the assumption that there has not been any significant changes in the annual totals. The results of these regressions are shown in Table 13. Figure 4 depicts graphically the number of farrowings each quarter in Iowa. The trend lines from Table 13 are also drawn in this graph. It is obvious that there has been a large downward trend in the March-May quarter which has been matched by small upward trends in each of the other three quarters. Since these trends are significant, the model for the number of farrow-

Table 13. Results of regression on farrowings by quarters

	Degree	F-value	Significant*	R^2
D - F	1	28.20	yes	.6104
	2	13.79	yes	.7848
	3	6.96	yes	.8501
	4	1.13	no	.8606
M - M	1	32.70	yes	.6450
	2	46.26	yes	.9045
	3	6.28	yes	.9314
	4	0.19	no	.9323
J - A	1	44.46	yes	.7126
	2	0.13	no	.7148
S - N	1	70.23	yes	.7959
	2	0.59	no	.8028
Yearly totals	1	0.49	no	.0265

*Degree 1 = F_{95} (1,18) = 4.41 Degree 3 = F_{95} (1,16) = 4.49
Degree 2 = F_{95} (1,17) = 4.45 Degree 4 = F_{95} (1,15) = 4.54

EQUATIONS

December - February =

$$69.31 + 87.24X - 6.63X^2 + .167X^3$$

March - May =

$$2125.27 - 198.45X + 12.90X^2 - .274X^3$$

June - August =

$$495.27 + 10.30X$$

September - November =

$$387.70 + 16.21X$$

Where:

X = Time in years

Yearly totals (Mean) = 2797.66

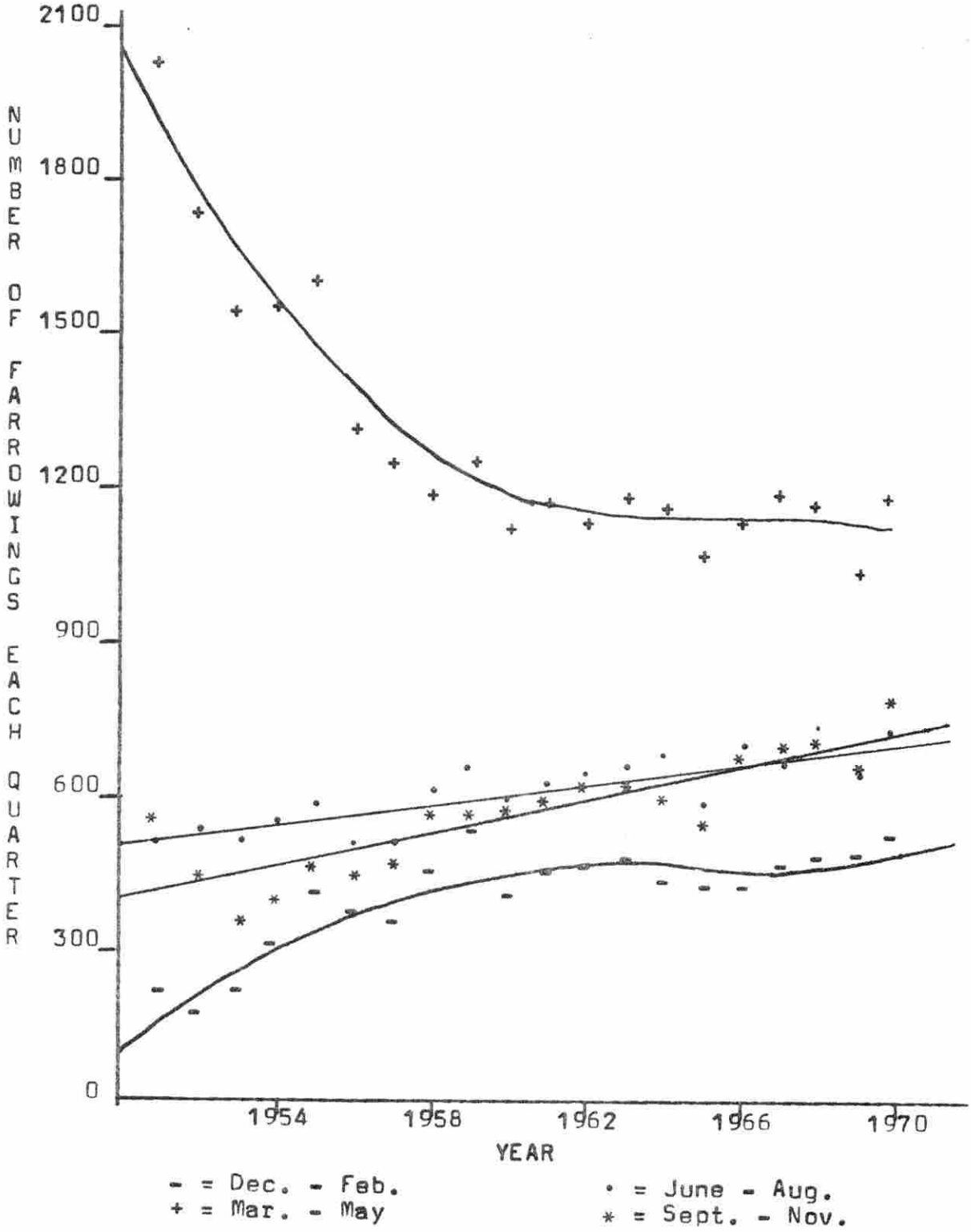


Figure 4. Farrowings each quarter and each quarter's trend line

ings each quarter must include variables to compensate for these trends each quarter. The effect of the hog-corn ratio can not be examined until after this trend is removed.

The Model

A model will be used to explain changes in the number of farrowings which occur from one quarter to the next. It was developed by using the least-squares regression method to determine the coefficients of the independent variables in the following equation:

$$\hat{F} = B_1 + B_2X_1 + B_3X_2 + B_4X_3 + B_5T + B_6Y_1 + B_7Y_2 + B_8Y_3 + B_9R + B_{10}P_c$$

Where:

$\hat{F}$ = The predicted percent change in farrowings from the same quarter of the previous year.

$X_{1, 2, 3}$ = Dummy variables for intercepts of each quarter's trend line.

T = Time in years, 1950 = 1.

$Y_{1, 2, 3}$ = Dummy variables for slopes of each quarter's trend line ($Y_1 = (X_1)T$, etc.).

R = Hog-corn ratio, lagged three quarters.

P_c = Price of cattle, lagged three quarters.

$B_{1, 2...}$ = Coefficients.

The dependent variable, the percentage change in the number of farrowings from the same quarter of the preceding year (Table 14) is being used instead of the absolute number of farrowings since the end result will be to examine the change

Table 14. The percent change in the number of farrowings from the same quarter of the previous year in Iowa[a]

	D - F	M - M	J - A	S - N
1950	0.0	6.5	8.4	19.0
1951	35.8	1.6	9.5	- .8
1952	-12.2	-14.2	6.5	-16.3
1953	21.7	-11.1	- 2.3	-16.7
1954	47.5	.9	7.0	12.0
1955	26.9	3.2	5.4	13.9
1956	- 9.5	-17.7	-13.1	- 1.5
1957	- 4.0	- 6.4	-15.0	3.5
1058	29.2	- 4.8	22.0	19.9
1959	16.7	6.0	6.1	- 2.5
1960	-25.9	- 9.3	- 9.6	4.8
1961	11.3	4.1	4.1	3.8
1962	2.9	- 2.5	4.3	3.7
1963	2.0	4.0	3.0	- 1.9
1964	- 6.0	- 3.0	2.0	- 3.0
1965	- 2.1	- 7.0	-14.0	- 7.0
1966	0.0	6.0	20.9	20.0
1967	7.9	5.0	- 4.0	4.0
1968	3.9	- 2.0	8.0	4.0
1969	0.0	-11.0	-13.0	-10.0
1970	4.0	15.0	15.0	22.0
1971	2.0	-10.0	-12.9	-10.1

[a]Source: (19).

in the number of farrowings related to a specific hog-corn ratio. It is necessary to find the percentage change from the same quarter of the previous year because of the large differences in the mean number of farrowings each quarter. During this 21 year period there were about four times as many farrowings in the March-May quarter as in the December-February period and twice the June-August average (Table 15).

Table 15. Average number of farrowings per quarter in Iowa during 1950-1970[a]

	Average number of farrowings
D - F	389.9
M - M	1,320.8
J - A	596.2
S - N	556.1

[a]Source: (19).

There would always be a large positive change from quarter one to quarter two and a large decrease to quarter three if the change was for consecutive quarters. For this reason the change was figured from the same quarter of the previous year.

In the previous section several factors were examined which cause a change in the number of sows and gilts farrowed.

These factors will become the independent variables. These variables are time, the hog-corn ratio (Table 16), and the price of cattle (Table 17). Dummy variables were included in the model for both the intercepts and the slopes of the number of farrowings each quarter. The use of these dummy variables allows different time trends for each quarter. This is necessary because of the trend toward fewer farrowings in the second quarter and larger farrowings in each of the other quarters and the large difference in the mean number of farrowings each quarter. There has been an average decrease of about 41,000 farrowings in the second quarter since 1950. This decrease has been matched by increases in the other three quarters leaving the yearly total about constant. The dummy variables allow only linear time trends. It was determined in the previous section that a third degree equation best explained the first two quarters, but for consistency and simplicity, a linear trend will be assumed for all four quarters.

The hog-corn ratio is used as a single variable instead of using the price of hogs and the price of corn separately. Since the hog-corn ratio is found by dividing the price of hogs by the price of corn, the results obtained are about equal, regardless of which method is used. The use of the ratio applies equal weights to both prices which may not be an accurate representation of the way producers weigh the

Table 16. Hog-corn ratio (hog price/corn price) by quarters[a,b]

	D - F	M - M	J - A	S - N
1950	13.17	13.22	13.92	14.46
1951	13.42	13.18	12.70	11.89
1952	11.29	10.87	11.76	12.13
1953	12.77	15.40	16.64	16.04
1954	17.13	18.05	13.97	13.15
1955	11.97	11.80	11.65	11.37
1956	8.98	11.55	10.81	11.66
1957	14.26	14.66	15.90	17.70
1958	22.79	21.30	19.42	19.25
1959	16.56	14.48	12.87	13.05
1960	14.50	17.07	15.78	18.20
1961	18.88	17.72	16.31	17.48
1962	18.41	16.60	17.02	18.01
1963	15.80	13.73	14.79	14.18
1964	13.73	12.77	14.37	14.27
1965	14.08	15.45	20.13	22.15
1966	24.57	20.09	19.35	16.83
1967	15.26	15.52	18.21	17.77
1968	17.62	17.78	19.69	18.69
1969	17.78	19.07	22.02	23.69
1970	25.05	22.14	19.28	13.64

[a]Source: (23).

[b]Includes all hogs.

Table 17. Price of beef by quarters for Iowa[a]

	D - F	M - M	J - A	S - N
1950	21.20	23.97	26.66	27.17
1951	29.23	31.77	31.57	31.23
1952	28.67	29.37	28.10	25.90
1953	21.13	18.87	19.63	19.13
1954	18.60	19.70	19.73	20.10
1955	19.60	19.43	19.37	18.53
1956	16.20	16.97	19.17	20.13
1957	17.13	19.20	21.50	21.07
1958	22.07	24.83	24.37	24.43
1959	24.63	26.20	25.60	23.63
1960	22.53	24.10	22.90	21.97
1961	23.07	22.23	21.23	22.17
1962	22.83	23.27	23.67	25.27
1963	23.57	21.30	22.60	21.67
1964	19.63	19.37	20.80	22.00
1965	21.17	20.83	21.83	22.00
1966	23.47	25.20	23.87	23.27
1967	22.37	22.97	24.77	24.03
1968	23.80	25.03	25.67	25.50
1969	25.33	28.73	27.10	26.70
1970	27.07	29.87	29.16	27.00

[a]Source: (23).

factors in their minds as they decide how many farrowings to have. It also ignores the absolute level of each of the prices. But even with these disadvantages it is probably better to use the ratio since it gives similar results while eliminating the intercorrelation between the two prices and at the same time conserving one degree of freedom.

The prices today are what producers use to determine how many sows and gilts to farrow in the future. There is a lag between the time a farmer makes the decision to farrow sows and the actual farrowing. Once a farmer decides to farrow sows, he must obtain the breeding stock and breed the sows and gilts. After they are bred it will require 112-115 days before they will farrow (1). This means there should be a lag of at least four months, or into the second quarter. This would be the earliest effect of a price change could be felt, and the strongest effect would probably be a little later. The highest correlation between prices and the number of farrowings is expected to be from a two or three quarter lag.

To determine the length of this lag, correlation coefficients were found for the percent change in farrowings and the price of cattle, and for the percent change in farrowings and the hog-corn ratio. The farrowings were lagged 0 through 5 quarters. These correlation coefficients are presented in Table 18. The highest coefficient was obtained by lagging the percent change in farrowing with the hog-corn ratio three

Table 18. Lagged correlation coefficient for the percent change in farrowings and the hog-corn ratio and the percent change in farrowings and the price of cattle

Quarter lag	Hog-corn ratio	Cattle price
0	.12	.08
1	.20	.07
2	.34	-.01
3	.37	-.14
4	.26	-.19
5	.14	-.05

quarters. These results confirmed previous expectations. The price of cattle gave slightly better results by lagging the data four quarters. But, for consistency, all data will be lagged three quarters in this model.

The resulting equation is:

$$\hat{F} = 4.12 - 24.48X_1 - 14.95X_2 - 18.29X_3 - 1.83T + 1.23Y_1 + .70Y_2 + 1.01Y_3 + 2.78R - .81P_c$$

Where:

$\hat{F}$ = The predicted percent change in farrowings from the same quarter of the previous year.

X_1, X_2, X_3 = Dummay variable for intercepts of each quarter's trend in number of farrowings.

T = Time in years, 1950 = 1.

Y_1, Y_2, Y_3 = Dummy variable for slopes of each quarter's trend in number of farrowings ($Y_1 = (X_1)T$, etc)

R = Hog-corn ratio, lagged three quarters.

P_c = Price of cattle, lagged three quarters.

As expected, the coefficients for the hog-corn ratio and

the price of cattle are positive and negative, respectively. The coefficient of determination for this model is .4941, and for the hog-corn ratio it is .2912.

This model will now be used to examine the effects of the hog-corn ratio on the number of farrowings in Iowa.

APPLICATIONS OF THE MODEL

The Break Even Hog-Corn Ratio

The break even hog-corn ratio in this study will be defined as the ratio which corresponds to no change in the number of farrowings from the same quarter of the previous year. Normally the marginal producer will jump into the hog business when the hog-corn ratio is above the break even point and drops out when the ratio drops below this point. It doesn't represent "break even" in terms of profit since most producers will still be making profit at this point and will not leave the industry. But their profits may be small compared to the profits from other enterprises and therefore discourage larger investments in swine production.

In the period 1950 through 1970 the break even hog-corn ratio was 14.74. It was found by:

1. setting each of the independent variables in the model, with the exception of the hog-corn ratio, equal to its mean value for this period,
2. setting the change in farrowings equal to zero, and
3. solving for the hog-corn ratio.

This represents the hog-corn ratio that generated no change in the number of farrowings, holding the other variables constant.

The break even hog-corn ratio of 14.74 corresponds to 13.5 found by Bundy and Diggins for the period of 1950 through 1959 (1) and 12.7 found by Harlow for the 1924 through

1960 time period (5). These other studies did not develop a model to determine the break even point. They each examined a listing of the ordered hog-corn ratios and the corresponding change in the number of farrowings and estimated the point where the change was zero. The other studies differed also in that they used United States data, while this study used only Iowa data. Since Iowa produces a large share of the total United States production of swine, it is assumed the relationships for each is similar. From these three studies it appears that the break even hog-corn ratio has been increasing.

To look at this closer a moving five-year regression was run using the same variables as in the model developed previously. The first equation was for the period of 1950 through 1954, the second was for a period beginning one year later, 1951 through 1955. This was continued until 17 equations had been developed. Using these equations a break even point was determined for each period in a manner similar to that used for the full model. The coefficient of determination and the break even point for each five year period are listed in Table 19.

This series of points seems to support the hypothesis that the break even hog-corn ratio has been increasing over time. A simple regression of these values using time as the

Table 19. Break even points of moving five year regression for Iowa

Period	R^2	Break even hog-corn ratio
1950-54	.766	16.93
1951-55	.567	12.36
1952-56	.845	12.58
1953-57	.632	12.65
1954-58	.625	13.49
1955-59	.697	14.66
1956-60	.652	14.87
1957-61	.703	15.27
1958-62	.671	16.48
1959-63	.579	16.30
1960-64	.715	20.82
1961-65	.771	16.19
1962-66	.872	16.41
1963-67	.801	16.13
1964-68	.764	17.20
1965-69	.645	17.84
1966-70	.550	17.99

independent variable gives the following equation:

$$B = 13.098 + .297T$$

Where:

B = The break even hog-corn ratio.

T = Time in five year periods, 1950-1954 = 1.

Figure 5 is a graph showing the break even points and the trend line. There has been an average increase of .297 each year since 1950. The coefficient of determination for this equation was .457.

Predictability of the Amount of Change

Arthur A. Harlow (5) concluded in his study that only the direction of the change in the number of farrowings can be predicted using the hog-corn ratio and not the amount of change. To examine this, two regressions were run on the data used to establish the model. The first was using the data for the quarters in which the hog-corn ratio was above the break even point, and the second for the quarters in which it was below. By testing for the significance of the coefficient of the hog-corn ratio in each resulting equation the ability of the ratio as a predictor of the amount of the change in farrowings can be examined. If the coefficients are significant it can be assumed the hog-corn ratio is a predictor of both the direction and the

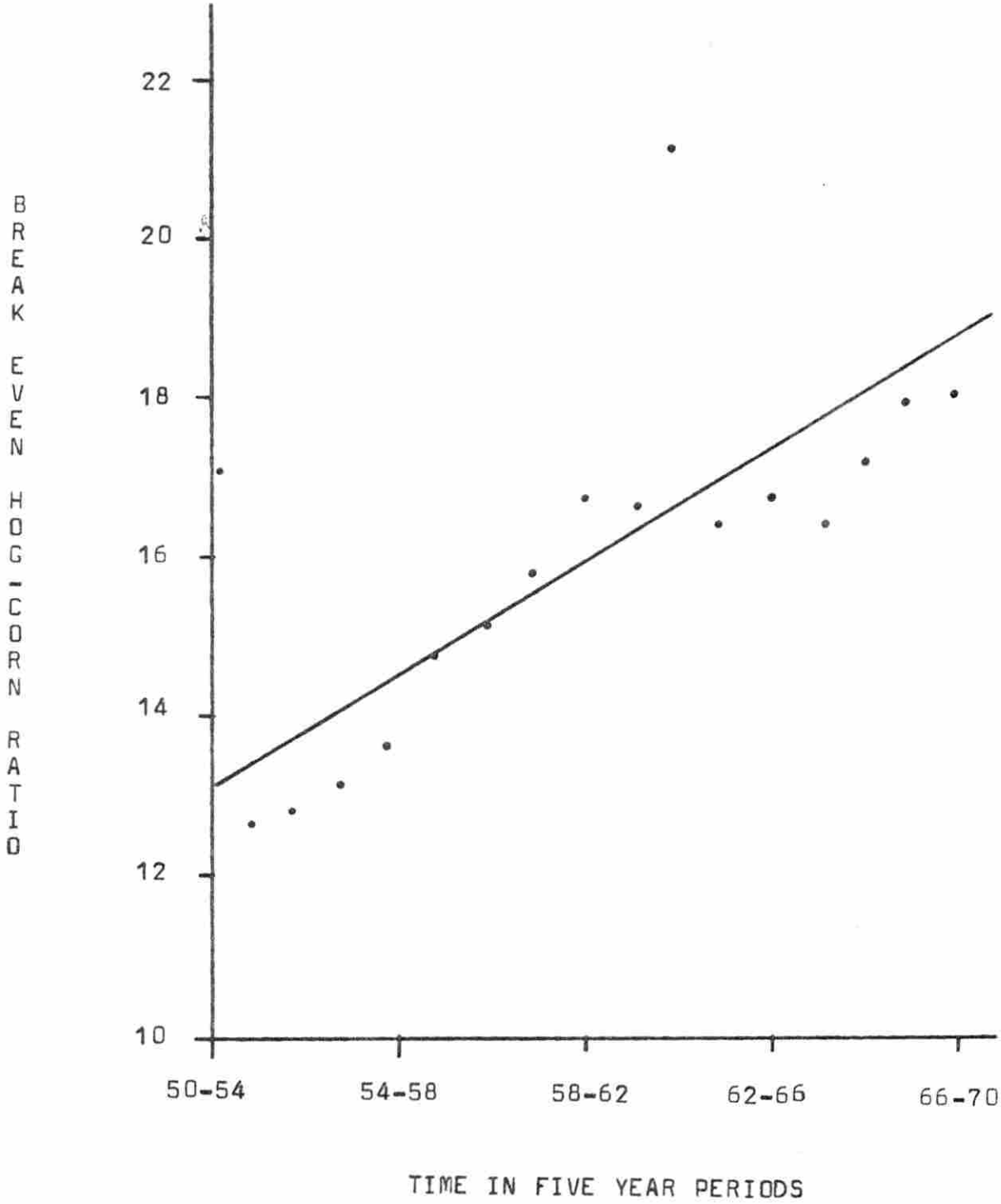


Figure 5. Break even points and trend line of moving five year regression for Iowa

amount of the change. The resulting equations were:

Hog-corn ratio below the break even point:

$$\hat{F} = -7.83 - 22.69X_1 - 12.10X_2 - 15.44X_3 - 1.51T + 1.35Y_1 + .55Y_2 + .91Y_3 + 2.72R - .46P_c$$

Hog-corn ratio above the break even point:

$$\hat{F} = 6.68 - 17.51X_1 - 8.61X_2 - 5.55X_3 - 1.51T + .65Y_1 + .18Y_2 - .62Y_3 + 2.97R - 1.22P_c$$

Where:

$\hat{F}$ = The percent change in farrowings from the same quarter of the previous year.

X_1, X_2, X_3 = Dummy variables for intercepts of each quarter's trend in number of farrowings.

T = Time in years, 1950 = 1.

Y_1, Y_2, Y_3 = Dummy variables for slopes of each quarter's trend in numbers of farrowings.

R = Hog-corn ratio, lagged three quarters.

P_c = Price of cattle, lagged three quarters.

The T-values for the coefficients for the hog-corn ratio were 1.826 and 2.576 respectively. The critical value at the .05 level is 1.694 (18). Since both values are larger than the critical value it can be assumed that the coefficient for the hog-corn ratio is not zero. This supports the hypothesis that the amount of the change in the number of farrowings can be predicted as well as the direction.

Effect of High and Low Hog-Corn Ratios

It already has been established that there is a direct relationship between the hog-corn ratio and the number of farrowings. But do farmers react the same to ratios above and below the break even point? Does it require more than one quarter of high or low ratios before a farmer will significantly change the number of sows he farrows? These questions will now be examined. Figure 6 is a graph of the average Iowa hog-corn ratio each quarter since 1950, and the trend line for the break even point. Since 1950 there have been six periods in which the hog-corn ratio has been above the break even trend line for several consecutive quarters and five periods in which the hog-corn ratio has been below the break even point. Tables 20 and 21 were constructed to examine the characteristics of these periods. They show the percent change in the number of farrowings corresponding to the hog-corn ratio in each period above and below the break even ratio. The average number of quarters in each period was seven for high ratios and eight for low. The average percent change in farrowings was determined for each quarter of chronological equivalence. For example, the average change was 11.33 percent for the six quarters which were the first quarters in which the hog-corn ratio rose above the break even point. Similarly, the average for the second quarters of all periods above the break even point was 11.78

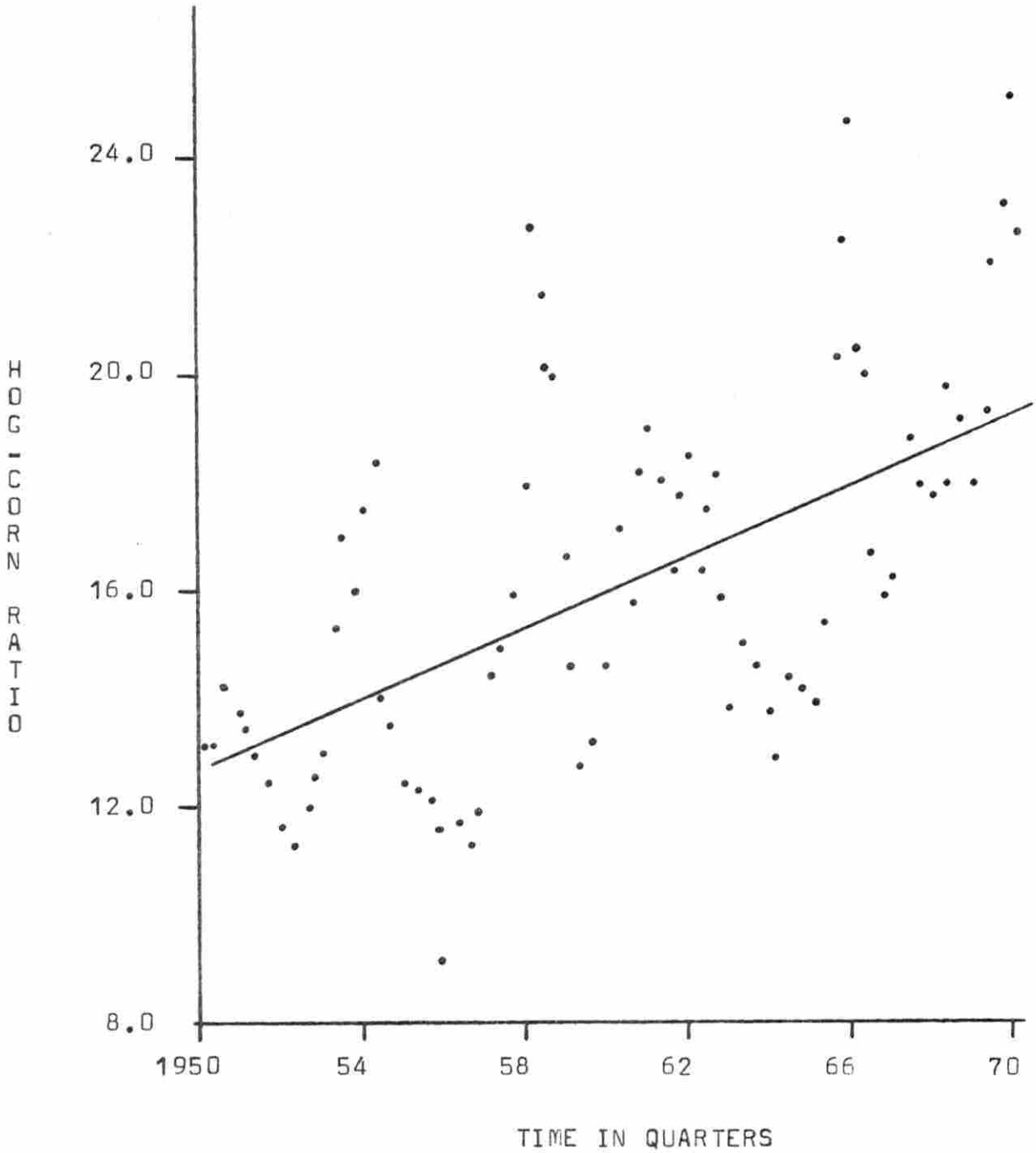


Figure 6. Average Iowa hog-corn ratio each quarter since 1950 and trend line for the break even point

Table 20. The percent change in the number of farrowings corresponding to the hog-corn ratios above the break even ratio

Quarter	Period I	II	III	IV	V	VI	Average
1	19.0	47.5	- 4.8	11.3	6.0	-11.0	11.33
2	35.8	.9	22.0	4.1	20.9	-13.0	11.78
3	1.6	7.0	19.9	4.1	20.0	-10.0	7.10
4	9.5	12.0	16.7	3.8	7.9	4.0	8.98
5	- .8	26.9	6.0	2.9	5.0	15.0	9.17
6	-12.2		6.1	-2.5		22.0	1.07
7			- 2.5	4.3		2.0	3.97
8				3.7		-10.0	1.90
9				2.0			- 4.00
10				4.0			4.00
11				3.0			3.00

Table 21. The percent change in the number of farrowings corresponding to the hog-corn ratios below the break even ratio

Quarter	Period I	II	III	IV	V	Average
1	-14.2	3.2	-25.9	- 1.9	- 4.0	- 8.56
2	6.5	5.4	- 9.3	- 6.0	-4.0	.12
3	-16.3	13.9	- 9.6	- 3.0	3.9	- 2.22
4	21.7	- 9.5	4.8	2.0	- 2.0	3.40
5	-11.1	-17.7		- 3.0	8.0	- 5.64
6	- 2.3	-13.1		- 2.1	4.0	- 3.38
7	-16.7	- 1.5		- 7.0	0.0	- 6.30
8		- 4.0		-14.0		- 9.00
9		- 6.4		- 7.0		- 6.70
10		15.0		0.0		- 7.50
11		3.5				3.50
12		29.2				29.20

percent. From these averages in Table 20 it appears that farmers react immediately to a high hog-corn ratio. They continue to increase their farrowings as long as the ratio remains high, but the percent increase decreases. The trend in changes when the hog-corn ratio is below the break even point is not as obvious. There is a large immediate decrease in the number of farrowings but the next three quarters fail to show any trend. But there is another large decrease in quarters five through nine.

A possible explanation of this may be that there are two types of producers, the marginal and the non-marginal. The marginal producer is one who is continually jumping in and out of swine production. He will jump in when the hog-corn ratio is above the break even point, and immediately jump out when it drops below. The non-marginal producer expects to raise hogs every year. He has larger investments in buildings, feeding systems, and manure disposal systems. This large capital investment produces a situation where he can't afford to drop out and leave his facilities set idle. It will be recalled that his total costs are made up of a relatively large portion of fixed costs. He will continue to produce swine even with a relatively low hog-corn ratio. Production will continue for the non-marginal producer as long as he covers his relatively low variable costs, independent of his high fixed costs in buildings and equipment.

In summary, as the hog-corn ratio rises above the break even point, the marginal producers begin to raise swine. The non-marginal producers also begin to increase the number of sows they are farrowing. As long as the hog-corn ratio remains high they continue to increase their swine production. When the hog-corn ratio drops below the break even point, the marginal producer again is the first to drop out. He continues to produce as long as he can cover his variable costs, but practically all of his costs are variable. The non-marginal producer has higher fixed costs but relatively lower variable costs. Since his variable costs are lower than for the marginal producer, he will continue to produce swine longer. But after several quarters of small profits and not covering his fixed costs he too must drop out. This seems to occur during quarters five through nine of the hog-corn ratios below the break even point. This is only one possible explanation of the way farmers react to high and low hog-corn ratios. Further analysis in this area should be done using more data over a longer time period.

Variations in the Number of Farrowings

Another hypothesis is that the variation in the number of sows farrowed each quarter is decreasing. To examine this the percentage change for each quarter from the same quarter of the previous year was again used. A moving average was determined for the absolute value of the percent changes for

five year periods. These averages are shown in Table 22. From this table it does appear that the average change has been decreasing. But there was a sharp decline each period up to the 1961-1965 period. Since that time the average change has actually been increasing. The least-squares trend line for this period is:

$$Y = 13.554 - .502X \qquad R^2 = .661$$

Where:

Y = Average absolute percent change in the number of farrowings.

X = Time in years, 1950-1954 = 1.

Figure 7 is a plot of these average values and the trend line. The T-value of the coefficient for the time is 5.41. Since the critical value is 1.75 for 16 degrees of freedom at the .05 level, it can be assumed that time is a significant factor in explaining the average change in the number of farrowings. The hypothesis that the average absolute change in the number of farrowings is decreasing is therefore accepted. The slope of the trend line shows that in Iowa during this period the variations in the number of sows farrowed has been decreasing on the average by one half percent each year.

Table 22. Moving five year average of the absolute percent change in farrowings

	Total change	Average change
1950-54	270.6	13.53
1951-55	258.9	12.94
1952-56	252.1	12.60
1953-57	260.2	13.01
1954-58	236.8	11.84
1955-59	236.6	11.83
1956-60	206.7	10.33
1957-61	193.3	9.66
1958-62	146.5	7.32
1959-63	110.7	5.53
1960-64	89.5	4.47
1961-65	99.1	4.96
1962-66	122.5	6.13
1963-67	127.7	6.39
1964-68	142.8	7.14
1965-69	160.7	8.04
1966-70	156.7	7.84

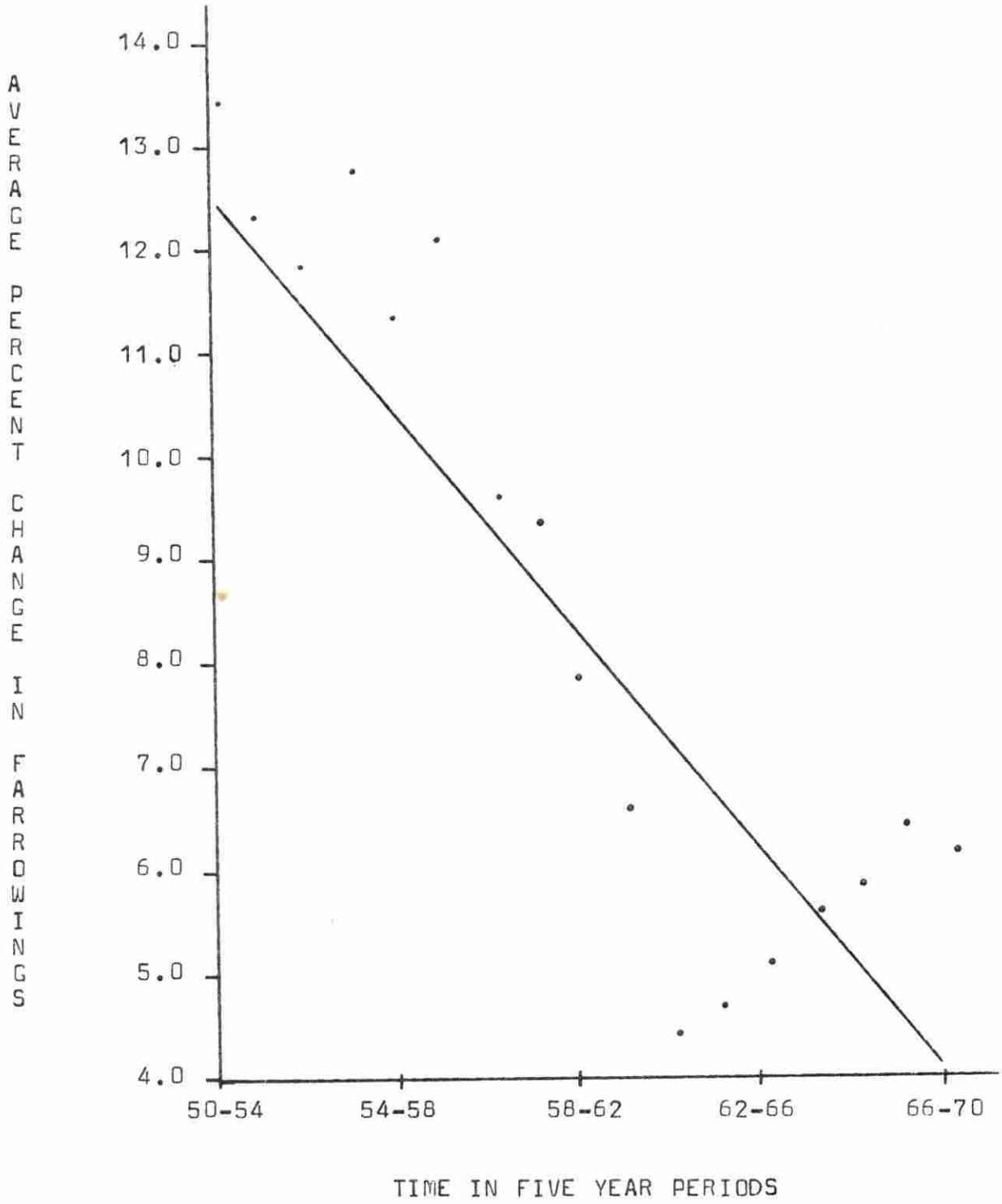


Figure 7. Average percent change in the number of farrowings over time

CONCLUSION

In the United States there is a strong correlation between the production of corn and hogs. The reason for this is that corn comprises 40-45 percent of the cost of producing swine, and it is more economical to raise the hogs where the corn is grown than to transport corn to the area where the pork is consumed. Since Iowa is the leading corn producing state, it follows that it is also the leader in swine production.

In formulating production plans, swine producers must decide how many sows to breed to produce market hogs in the future. Iowa farmers tend to use current prices to determine the relative future profitability of hog production. Some of the prices compared are market prices of hogs, beef and other livestock, and the price of corn. After examining these prices, a farmer will make his decision as to which commodity to produce and how much to produce.

The price relationship between corn and hogs is called the hog-corn ratio and it has traditionally been accepted as a good indicator of the future number of sows farrowed. It was hypothesized that a high hog-corn ratio today will cause an increase in the number of farrowings in later periods. Likewise, a low ratio will cause future decreases in the number of sows farrowed. To examine this relationship it was necessary to develop a model to explain the variations in

the number of farrowings each quarter. The independent variables included in the model were dummy variables for the intercepts and slopes of each quarter, time, the price of cattle and the hog-corn ratio. It was necessary to use dummy variables because of the differences in the mean number of farrowings and the different trends in the number of farrowings each quarter.

The dependent variable was the percent change in the number of farrowings from the same quarter of the previous year. Changes from one quarter to the next were not used because of the difference in the mean number of farrowings each quarter. Since there is a lag between the decision to change the number of sows farrowed and the actual time of farrowing, the independent variables were lagged. To determine the length of this lag correlation coefficients were calculated and it was discovered that a lag of three quarters would give the best results.

After the model was developed, it was used to analyze the effect of the hog-corn ratio. One of the hypotheses was that the break even hog-corn ratio has been increasing over time. The break even point was defined as the hog-corn ratio which corresponds to a zero change in farrowings. This was determined by setting each of the independent variables equal to their mean value during the period 1950-1970 and solving for the hog-corn ratio with the change in farrowings equal to

zero. The break even ratio for this period was 14.74.

The trend in the break even ratio was determined by using a moving five year regression of the data. It was discovered that the break even ratio has increased .297 each year during this period. This rising ratio is due in part to the changing cost structure of swine production. Larger capital investments in buildings and equipment have forced producers to demand a higher price for their pork.

It has long been accepted that the hog-corn ratio is a good indicator of the direction of the change in the number of sows farrowed, but the predictability of the amount of the change has been questioned. Separate regressions were run on the quarters with hog-corn ratios above and on those below the break even point. Since the coefficients for the hog-corn ratio were significant in both equations it can be assumed that the ratio not only predicts the direction of the change in farrowings, but also the amount of the change.

Another question which was examined was the effect of the hog-corn ratio being above or below the break even point for several consecutive quarters. It was hypothesized that the marginal producer jumps in and out of swine production during the first quarter in which the hog-corn ratio goes above or drops below the break even point. The other producers appear to react quickly to a rise in the hog-corn ratio but are hesitant to decrease their farrowings until the ratio has been

below the break even point for four or five consecutive quarters. This is also a result of large capital investments in swine production. These investments have reduced the variable costs but increases the fixed costs. The producer continues to produce swine as long as he is covering his variable cost. He will not stop producing swine until the inability to meet his fixed costs catches up with him.

The last hypothesis was that the variation in the number of farrowings has been decreasing. The method used to examine this was to determine a moving five year average of the absolute percent change in the number of farrowings. It was determined that there has been an average decrease of .502 in the percent change in the number of farrowings each year during the period 1950-1970.

The hog-corn ratio has been an important factor in determining the amount of pork produced. High ratios have caused increases in the number of sows farrowed and low ratios have caused decreases. As long as corn remains a major input in the production of swine, this relationship will probably continue.

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